Geodetic Glossary

National Geodetic Survey
Rockville, MD

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Charting and Geodetic Services

geodesy (1) #The science concerned with determining the size and shape of the Earth.#

This is essentially Helmert's definition of 1880. In practice, it is equivalent to determining, in some convenient coordinate system, the coordinates of points on the Earth's surface. For political and technological reasons, a large number of different coördinate systems are in use today.

(2) #The science that locates positions on the Earth and determines the Earth's gravity field.#

The definition can be extended to other planetary bodies.

(3) #The branch of surveying in which the curvature of the Earth must be taken into account when determining directions and distances.#

The above three definitions are not exclusive. The term "geodesy" is commonly understood to include them all.

Geodesy can be divided into lower geodesy that concerns mainly techniques, instrumentation, and theory which does not require a knowledge of the Earth's curvature; and higher geodesy which takes the Earth's curvature into account. (See (3) above.)

Geodesy can also be divided into *physical geodesy* which is concerned with the gravity field, and *geometric geodesy* which is concerned with determining positional relationships by geometric means.

Other subdivisions, such as satellite geodesy, marine geodesy, etc., refer to special data sources or to determinations in particular locations.

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PREFACE

This glossary is a revision of "Definitions of Terms Used in Geodetic and Other Surveys" (U.S. Coast and Geodetic Survey *Special Publication* 242) by Hugh C. Mitchell, published in 1948 by the U.S. Government Printing Office. Since Mitchell's book appeared, the standards, instruments, theory, and procedures of that time have been markedly changed, complemented, reduced in importance, or completely replaced by new ones. In addition, the interaction of geodesy with other disciplines has greatly increased, which demands that these relationships be covered also.

Examples of the considerable changes since 1948 can be found in almost every single page of this glossary. Invar tapes have been mostly replaced by electronic devices which employ light, infrared, or radio waves. Photogrammetry has become an important method of acquiring geodetic information. Observations on artificial satellites have become a dominant source for information on both geometric positioning and the determination of the gravity field. The computational aspects of geodesy have been just as heavily affected. Adjustment by solving for angles and distances has been superseded by solving for coordinates. Forms that depended on tables or mechanical calculators have disappeared in this age of electronic computers. The geodetic datums of 40 years ago are of interest today mainly to historians.

Such a variety of changes and additions has swelled the number of definitions from 800 to almost 5,000. Even this sixfold increase will omit many terms which should be rightfully included, but are missing because it was well-nigh impossible to keep up with the rapid innovation in geodetic theory and practice. For example, the revolution in geodetic positioning due to the implementation of the Global Positioning System (GPS) is barely touched on here; the enrichment to the geodetic vocabulary entailed by GPS will have to be documented in a future edition. The expansion in size of this glossary covers only a small part of the material available and considered. Selections had to be made, and the judgments reflect the inevitable biases of the compilers. In addition, users are bound to discover terms which are inexplicably missing. The reason for this is simple: human imperfection. Correspondence noting errors, omissions, or containing suggestions are welcomed in anticipation of a future set of addenda and corrigenda.

ACKNOWLEDGMENTS

The principal debt is, of course, owed to Hugh C. Mitchell and his associates, the compilers of the original version of this glossary. The size of this debt is evident from the large number of terms taken with little or no change from the book. It is worth pointing out that practically all other glossaries recently compiled in the United States containing geodetic terms have drawn a similarly sizable amount of definitions directly from Mitchell.

We have not hesitated to capitalize on the excellent material found in the Department of Defense *Glossary of Mapping, Charting, and Geodetic Terms* (1981), Bureau of Land Management *Glossary of BLM Surveying and Mapping Terms* (1978), American Society of Civil Engineers *Definitions of Surveying and Associated Terms* (1972), National Ocean Service *Tide and Current Glossary* (1984), and American Society of Photogrammetry *Manual of Photogrammetry* (1980). These, of course, do not begin to exhaust our numerous sources, ranging from general dictionaries, to textbooks, to survey and research articles. The References section is primarily meant to cover those explicitly cited in the text; it would not be practical to acknowledge all implicit obligations.

The major part of the compilation was carried out by Soren Henriksen during the period 1977-1983. Bernard Chovitz was responsible for the final version. Eleanor Andree served as general editor, assisted by Paul Lehr. Marie Skasko performed the laborious task of transcribing the manuscript into computer-readable form. Finally, Rear Admiral John Bossler provided the original conception, and followed through with the encouragement and support needed to see the effort reach fruition.

HOW TO USE THIS GLOSSARY

Organization

Terms consisting of a single word are entered in alphabetical order. Terms consisting of a single noun with modifiers are, for the most part, entered alphabetically according to the noun first, then according to the modifiers in their natural order. This rule is occasionally broken if a modifier is deemed to be the dominant component of the term. If the situation is doubtful, a cross-reference is added.

For example:

aberration
aberration, annual
...
aerotriangulation, direct radial
aerotriangulation, graphic radial
aerotriangulation, radial

Terms consisting of two or more nouns are entered alphabetically according to the first one, unless a later one is clearly more dominant.

For example:

gravity anomaly
...
gravity anomaly, Bouguer
...
gravity anomaly, modified Bouguer

Again, if the situation is doubtful, cross-references are given.

Definitions

The entry for a term consists of the definition proper and of amplifying descriptive material. These two parts are separated by the definition being set between the symbols #...#. Many terms have more than one definition. These are distinguished by a numerical order: (1), (2), (3), etc. Usually the most common usage appears first.

Cross-references

An italicized term in an entry indicates a cross-reference to another entry in the glossary. That entry should be accessed according to the rules given under **Organization**. For example, the first entry for **grid, transverse Mercator** is: #A *rectangular grid* placed on maps drawn on the *transverse Mercator map projection* #. The cross-referenced terms should be looked up under **grid, rectangular** and **map projection, transverse Mercator**.

Special Notation

vector: $\vec{v}$

absolute value: $|v|$

The style of National Bureau of Standards *Special Publication* 330 (1981) is followed for designating units, esp., m for meter and s for second of time.

A

abac (1) #Another name for *nomogram,* from the French "abaque".#
(2) #A *nomogram* used in aerial navigation.#
ABC survey See *survey, Airborne Control.*
aberration (1) (astronomy) #The deviation of the apparent (observed) direction of a light source from its true direction (the direction of a line from observer to source at the instant of observation) caused by the *velocity* of light from the source and the velocity of the observer relative to the source.#

Aberration does not occur if source and observer are moving directly towards or away from each other. Such motion affects the *frequency* but not the direction of the light received. See also *Doppler shift.*

In astronomy and geodesy, aberration can usually be separated into two parts: that which results from the motion of the observer alone and that which results from the motion of the source alone. That part attributable to the motion of the observer is given by

$$\sin(\theta - \theta_o) = (|\vec{v}_o|/|\vec{c}|) \sin\theta_o$$

where θ is the true direction to the light source, θ_o is the observed direction, $\vec{v}_o$ is the velocity of the observer, and $\vec{c}$ is the velocity of light. The directions are measured from the vector $\vec{v}_o$. Only two kinds of motion of geodetic importance affect $\vec{v}_o$: the rotation of the Earth which causes *diurnal aberration*, and the revolution of the Earth, which causes *annual aberration.*

The part of the aberration attributable to motion of the source alone is known as *planetary aberration.*

(2) (optical system) #Any failure of an *optical system* to image a point in *object space* as a point in *image space* or to preserve a uniform scale over the image.# An aberration therefore causes either a blurring or a distortion of the image.

Seven basic varieties of optical aberration are recognized. Five kinds (called *Seidel aberrations*) affect monochromatic light: *spherical aberration, coma, astigmatism,* curvature of field, and *distortion.* Two kinds (called *chromatic aberrations*) affect polychromatic light: longitudinal (axial) and transverse (off-axis or lateral) aberration. The first three aberrations cause points to appear as blurs. In the next two, points are resolved as points, but the object point and its matching image point do not lie on a straight line through the center of perspective. The two chromatic aberrations cause an object seen in white light to become a set of blurred, multicolored images.
aberration, annual #The apparent change in direction of stars, planets, and other celestial bodies, caused principally by the changing direction in which the Earth is moving, in its revolution about the Sun, with respect to the line connecting the Earth to the celestial object.#

During the course of a year, a star on the *ecliptic* appears to move from one end of a straight line and back again; the length of the line is twice the constant of aberration. (See *aberration, constant of.*) A star at the pole of the ecliptic appears to move in a circle whose diameter is twice the constant of aberration. Stars between the ecliptic and the pole appear to move in ellipses of major diameter twice the constant of aberration and with minor axes increasing with angular distance from the ecliptic. The ellipticity of the Earth's orbit causes the apparent paths of stars not in the ecliptic to vary slightly from the elliptical. Because the Earth revolves also about the common center of gravity of the Earth and the Moon, a small component (0.″01) of aberration with monthly periodicity is induced.
aberration, astigmatic See *astigmatism.*
aberration, chromatic #The separation, by an optical system, of a single ray of polychromatic light in *object space* into a number of monochromatic rays in *image space*, that do not refocus to a single point.#

In the absence of other kinds of aberration, chromatic aberration causes the separation of a white point in object space into a sequence of overlapping monochromatic points in image space, with the violets closest to the lens and the reds farthest from the lens. The two kinds of chromatic aberration are: longitudinal and transverse. Longitudinal chromatic aberration produces a sequence of overlapping differently colored points parallel to the optical axis; transverse chromatic aberration produces a similar sequence of points along a line across (transverse to) the axis.
aberration, comatic See *coma.*
aberration, constant of #The maximum theoretical value κ of the *annual aberration.* #

It is given by the formula

$$\kappa = 2\pi\, a/[c\, T\,(1 - e^2)^{\frac{1}{2}}]$$

in which a is the mean distance of the Earth from the Sun, c is the speed of light, T the length of the sidereal year, and e is the eccentricity of the orbit.

For the epoch 2000 A.D., κ has the value 20.″495 52 (Seidelmann 1977).
aberration, constant of diurnal #The quantity k given by

$$k = (2\pi\, R \cos\phi')/cT$$

where R is the radius of the Earth at the observer's geocentric latitude ϕ', T is the length of the sidereal day, and c is the speed of light.#

Because k is a function of ϕ', the term "constant" is not well taken. Another definition of k omits the factor cos ϕ' (See Woolard and Clemence 1966, p. 129), yielding k = 0.″32.
aberration, differential #The difference in apparent directions of moving sources of light having the same true direction.#

Differential aberration results when the angular velocities of the sources, as seen by the observer, are different, and is a form of *planetary aberration*; also called parallactic aberration. Photographs of artificial satellites against a stellar background show differential aberration.

aberration, distortional See *distortion.*

aberration, diurnal #The apparent change in direction to a star or other celestial object caused by the combination of the velocity of light and the velocity of the observer on the rotating Earth.#

Diurnal aberration is taken into account in first-order determinations of astronomical azimuth and longitude; it is not considered in determinations of astronomical latitude because an observer has practically no latitudinal motion.

aberration, planetary #The apparent change in direction of a light source, such as a planet or other astronomical body, caused by the movement of the source while the light travels to the observer.#

Stars do not show planetary aberration because they are so far away that light emitted at a particular time reaches the observer before the star has moved an appreciable angular distance with respect to the Earth. Planets and other bodies within the solar system may, however, move through an appreciable angle during the time the light is traveling to the observer. When the body is an artificial satellite of the Earth, the aberration is called *differential aberration* by geodesists.

aberration, Seidel #Any one of five different aberrations that can prevent an optical system from imaging a point or straight line in *object space* into a point or straight line in *image space*.#

See *aberration* (2) for a list of Seidel aberrations.

aberration, spherical #The focusing of rays emanating from a point source on the optical axis closer to the focal plane if they enter the optical system close to the optical axis than rays from the same source which enter the system far from the optical axis.#

The envelope of the converging rays is called the "caustic" of the system. The amount of spherical aberration varies with the location of the object point and, for any particular point, is approximately proportional to the square of the distance of the outermost rays from the optical axis.

Abney level See *level, hand.*

absolute The adjective "absolute" as used in science and in geodesy in particular has several meanings. Examples are given below.

(1) #Defined in terms of *standards* and of measurements using those standards, without reference to any theory about the nature of the quantity measured.#

For example, an absolute *coordinate system* is one whose position and scales are specified with respect to real, identifiable points and distances and directions with respect to these points. The points and the distances and directions are the standards by which the coordinate system is defined.

(2) #Defined in terms of naturally occurring things or phenomena.#

For example, an absolute coordinate system in this sense could be one using the Earth's axis of rotation and the direction of gravity to establish directions, and the Earth's gravity potential to establish vertical scales.

(3) #Measurable (or measured) directly in terms of length, mass, and time.#

For example, measurement of the acceleration of gravity by measuring the acceleration of a falling object would be an absolute measurement, while measurement of the relative extension of a weighted spring at various places would be a relative measurement.

(4) #Defined with respect to some natural base or unit.#

For example, the "absolute zero" of temperature is the lowest (theoretically) attainable temperature.

absolute scale (of temperature) See *temperature scale, absolute.*

absolute zero #The quantity −273.16°C on the Celsius (formerly centigrade) temperature scale.#

By definition, the triple-point of water is at +273.16K on the Kelvin (absolute) temperature scale. Absolute zero is the theoretical condition of complete absence of heat; all molecular motion ceases.

abstract (field survey) #A list of values of a certain quantity made for a survey, derived directly from measurements of that quantity and recorded in the field book.#

Specifically, one of the following lists. (a) In triangulation, a list of angles or (most commonly) directions, of differences of elevation along a base line, or of zenith angles. The measurements may be copied directly into the abstract from the field book or may be changed slightly; this is done, for example, in the case of an abstract of directions, in which a constant value is added to the measured value to make a particular direction equal to zero. (b) In leveling, a list of measured differences in elevation, with corresponding distances and other pertinent information.

abstract, dead-reckoning #A list of all courses and distances made good, together with all data to be used in plotting and adjusting the *dead-reckoning* line.#

abstract of title #A complete summary of all information on public record relating to ownership (title) of a piece of land.#

An abstract of title customarily cites the surveys delimiting the land, shows plats made from the surveys, and lists changes of ownership, mortgages, liens, etc.; often referred to simply as "abstract". The common practice of referring to the abstract of title as the title should be discontinued because, legally, they are entirely different things.

abuttal #The boundary of land described in terms of the other pieces of land, highways, etc., adjoining and bounding that land.#

For example, "abutted on the west by lot number 36." This term has also been used to denote the boundaries on the ends as distinguished from those on the sides, as "buttings and sidings." Also called buttal or butting.

acceleration #The rate, $\vec{a}$, of change of velocity,

$$\vec{a} = d\vec{v}/dt$$

where $\vec{v}$ is the vector of *velocity*, and t the time.#

accelerometer #A device for measuring acceleration.#

A common design of such a device is a pendulum suspended from a pivot fixed to an accelerating body. As the body accelerates, the pendulum is deflected through an angle which is a function of the acceleration. Another common design embodies a mass held in the equilibrium position by springs or other elastic members; acceleration is then determined from the distortion of the elastic members. Masses resting on strain gauges have also been used as accelerometers. A particularly sensitive accelerometer embodies a mass suspended by electrostatic or electromagnetic forces; the acceleration is measured by the amount of force that must be used to keep the mass in a fixed position. An accelerometer that detects differential accelerations by measuring changes in capacitance has been used in satellites. One conducting sphere is centered within another and the pair are placed in free-fall. The relative motions of the inner and outer spheres indicate the presence of nongravitational forces on the outer sphere—principally air-drag or radiational pressure. The force used by the balancing system to keep the inner sphere centered is measured to provide an indication of the acceleration.

accessory, corner See *corner accessory*.

accessory to corner See *corner accessory*.

accommodation (1) #The ability of the eye to see sharp images of objects at different distances.#

(2) #The ability of the eyes to bring two separate images into superposition.#

accretion #The gradual accumulation of land by natural causes, as out of the sea or a river.#

Accretion occurs principally by actions of water of which there are two kinds: the deposition of solids and the receding of the edge of the water. The first kind is called *alluvion* and its result, *alluvium*; the second kind is called *reliction* or *dereliction*.

Note that the term "accretion" applies only to the accumulation of land; the accumulation of solid matter under water is referred to as *batture*, as is the result of such accumulation.

accuracy (1) #Closeness of an estimated (e.g., measured or computed) value to a standard or accepted value of a particular quantity.#

Accuracy is commonly referred to as "high" or "low" depending on the size of the differences between the estimated and the standard values.

(2) #The square root of the average value of the sum of the squares of the differences between the values in a set and the corresponding values that have been accepted as correct or standard.#

(3) #The reciprocal of the quantity defined in (2).#

Accuracy cannot be calculated solely from values based on measurements. A standard value or set of standard values must be available for comparison somewhere in the chain of calculations. The standard of reference may be: (a) an exact value, such as the sum of the three angles of a plane triangle being exactly 180°; (b) a value of a conventional unit as defined by a physical representation thereof, such as the international meter, defined by the orange line of Kr^{86}_{30}; (c) a value determined by refined methods and deemed sufficiently near the ideal or true value to be held constant, such as the adjusted elevation of a permanent bench mark or the graticule of a map projection.

(4) Applied to the numbers in a mathematical table or to the numbers produced by a digital computer, the term "accuracy" may mean #(a) the number of significant digits in the numbers, (b) the order of magnitude of the least significant digit, or (c) the number of correct places in computations made with a mathematical table.#

Applied to numbers produced by an analog computer, the term has meaning (1) above, where the "measured" quantities are the computations made by the computer and the correct values are those that would have been obtained by exact calculation.

achromat See *lens, achromatic*.

acre #A unit of area in the English system of measure, defined as 10 square chains (1 *chain* equals 4 *rods* or 66 *feet*).#

An acre is exactly equal to 43,560 square feet or 4,840 square *yards*, and is approximately equal to 4,047 square meters. There are 640 acres in a square mile.

By an ordinance of Edward I in 1303, the acre was defined as the area contained in a rectangle 40 rods long and 4 rods wide. With the rod defined as 5 1/2 ulnae (yards), as defined by the Edward I iron standard for the ulna, the acre is again 4,840 square yards.

The term "square acre" is meaningless and should not be used.

addition constant See *stadia constant*.

adjacent #Lying near or close to.#

"Adjacent" implies that two objects or parcels of land are not widely separated, although they may not actually touch, while *adjoining* implies that no third object or piece of land lies between them.

adjoining #Touching, as distinguished from being merely close to or *adjacent*.#

"Adjoining" and "abutting" are at present often used as synonyms. However, there is an old, useful distinction: two parcels adjoin if they have a common side; they abut if they have a common end. (See *abuttal*.)

adjustment (1) #The process of changing the values of a given set of quantities so that results calculated using the changed set will be better than those calculated using the original set.#

The concept "better" is vague. The most common interpretation is that the sum of the squares of differences between results obtained by measurement and results obtained by calculation shall be a minimum. With this criterion, the method of least squares is the required process.

(2) #The result of an adjustment in the above sense.# Synonymous in this sense with "results".

(3) #The process of finding, from a set of redundant observations, a set of "best" values, in some prescribed

sense, for the observed quantities or for quantities functionally related to them.#

For example, if each angle of a plane triangle is measured, it is likely that the three values will not add up exactly to the 180° required by geometry. The mathematical process of calculating three angles which do satisfy the requirement is called the adjustment. The three resulting angles are then called adjusted values.

In general, there will be N given (observed) values and N equations relating them to M (M < N) unknowns. Adjustment is the process of reducing the N equations in M unknowns to M equations in M unknowns and solving this set of equations. The M equations are sometimes called the reduced equations.

(4) #Geological changes in the Earth, under the influence of gravity, that occur because of a change in the distribution of matter on the Earth's surface.#

Such changes create a shift from static equilibrium of the Earth's masses, and displacements called adjustments occur in the crust (and probably in the mantle) to compensate for the surface changes and to maintain static equilibrium. See also *isostatic compensation.*

adjustment, block (1) #The determination of corrections to the coordinates of a set of points extending over a large area, the solution being obtained simultaneously for all the points.#

The term block adjustment is used to distinguish this process from that in which the points are arranged along strips or arcs and corrections are obtained first for coordinates of points within each strip or arc and the results for these strips or arcs are then modified so that they fit together without any inconsistency. See also *aerotriangulation adjustment, block; aerotriangulation adjustment, bundle; triangulation adjustment, Bowie method of;* and *Helmert blocking.*

(2) #The same as definition (1), except that the adjustment need not be done for all points simultaneously.#

adjustment, Bowditch See traverse adjustment, Bowditch's method for.

adjustment, Chebychev #A process of calculating a set of values so that the largest difference between any of these and the corresponding observations is smallest in absolute value.#

adjustment, free #An *adjustment* in which the number of independent constraints (*a priori* conditions among the quantities to be adjusted) is minimal, that is, just sufficient to ensure a unique solution.#

Such an adjustment is "free" of distortion that may be introduced by redundant constraints. A free adjustment produces residual and adjusted observables that are not dependent on the particular minimal constraints used and is preferred for statistical evaluation.

Also called "adjustment using minimal constraints" or "inner adjustment".

adjustment, geodetic #The *adjustment* of the values of geodetic quantities, such as lengths, angles, directions, coordinates, etc., that characterize a geodetic network.#

adjustment, horizontal #The *adjustment* of a horizontal geodetic network.#

adjustment, isostatic See *isostatic adjustment.*

adjustment, land-line See *land-line adjustment.*

adjustment, least-squares #An *adjustment* satisfying the condition that the sum of the squares of the differences between the given and changed quantities be a minimum.#

adjustment, local See *triangulation adjustment, local.*

adjustment, network See *adjustment, geodetic.*

adjustment, station See *triangulation adjustment, local.*

adjustment, strip See *aerotriangulation adjustment, strip.*

adjustment, vertical #The *adjustment* of a vertical geodetic network.#

adjustment correction (leveling) See *leveling correction, adjustment.*

adjustment of corrections See *adjustment of observations.*

adjustment of leveling See *leveling adjustment.*

adjustment of observations #The process of *adjustment* applied to observed values; the process of calculating, from observed values of quantities, values (of these quantities) that are better in some specified sense.#

Either the observed or the theoretical values may be considered the *true* values of the quantities. When the term "adjustment of observations" is used, the theoretical values are commonly considered the true values. The numbers resulting from an adjustment are called the "adjusted values", and the differences between observed and adjusted values are called the "errors in" or the "corrections to" the observed values. The above terminology is not universal, and there has been criticism directed at use of the term "adjustment of observations" on the ground that an observation (i.e., its value) is an established fact and cannot be changed or adjusted.

See also *traverse adjustment, triangulation adjustment, leveling adjustment,* and *gravity adjustment.*

adjustment of traverse See *traverse adjustment.*

adjustment of triangulation See *triangulation adjustment.*

aeroleveling #Determination of the *Bz* values during orientation of the successive models on a stereoplotter using barometric measurements of the altitudes of the air stations (recorded during photography).#

Only differences in altitude are required; these are provided by the *statoscope.*

aerotriangulation #*Phototriangulation* using aerial photographs.#

Aerotriangulation is also called aerial triangulation.

aerotriangulation, analog See *phototriangulation, analog.*

aerotriangulation, analytical See *phototriangulation, analytical.*

aerotriangulation, analytical radial #Radial aerotriangulation (see *aerotriangulation, radial*) in which the unknown coordinates of ground points are determined mathematically from measured coordinates, on the image, of *radial centers* and directions to the images of the unknown points.#

aerotriangulation, cantilever #Determining the coordinates of ground points in a strip of aerial photographs when coordinates are known for ground points at only one end of the strip.#

Commonly contrasted to *bridging,* in which ground control is known at both ends of a strip.

aerotriangulation, direct radial #A *graphic radial aerotriangulation* done by tracing the directions from successive *radial centers* directly onto a transparent plotting sheet rather than by transferring the directions to *templets.*# Also called direct radial plot.

aerotriangulation, graphic radial #A *radial aerotriangulation* done by other than analytical means.#

Graphic radial aerotriangulation is usually done directly, incorporating the ground control plotted on a map, map graticule, or map grid, but may first be done independently of such control and later adjusted to it as a unit. In the latter case, the scale and azimuth of the resulting network are not known until the network is adjusted to the ground control.

A graphic radial aerotriangulation may be made by several methods: *slotted-templet, spider-templet,* and *hand-templet.*

aerotriangulation, radial #*Aerotriangulation* in which horizontal control extension is accomplished by a combination of *resection* and *intersection* using directions of images from the *radial centers* of overlapping photographs.#

Radial aerotriangulation can be done graphically or analytically, but it is assumed to be graphical unless otherwise specified.

A radial aerotriangulation is also termed a "radial plot" or a "minor control plot" or, inappropriately, "radial triangulation". The radial center for near-vertical photographs may be the *principal point,* the *nadir,* or the *isocenter.* A radial aerotriangulation is assumed to be made with the principal points as radial centers unless the modifying term designates otherwise, or unless the context states that a radial center other than the principal point was used.

aerotriangulation, stereotemplet #A form of *graphic radial aerotriangulation* using *stereotemplets* prepared from stereoscopic models.#

The method permits doing an aerotriangulation for a whole area at once and is not restricted to aerotriangulation along strips of photography.

aerotriangulation, strip radial #A *direct radial aerotriangulation* in which the photographs are plotted in flight strips without reference to ground control and the strips are later adjusted to each other and to the ground control.#

aerotriangulation, three-point resection method of radial #A method of computing the horizontal coordinates of the ground points corresponding to the *principal points* of overlapping aerial photographs by resecting on three horizontal control points appearing in the overlap.#

aerotriangulation adjustment See *phototriangulation adjustment.*

aerotriangulation adjustment, block (1) #An *aerotriangulation adjustment* in which the ground points whose coordinates are to be determined are not necessarily imaged on a single strip of photographs but mutually consistent corrections are determined without regard to the possible occurrence of the photographs in strips.#

The photographs, when assembled, generally form a rectangular (block-like) array.

(2) #The same as (1), except that the corrections are determined simultaneously for all the photographs.#

Also called bundle aerotriangulation adjustment.

(3) #The same as (1), except that the photographs occur in strips and the coordinates of points imaged in each strip are determined first for each strip and then adjustments are made between coordinates of points in different strips.#

aerotriangulation adjustment, bundle (1) #An *aerotriangulation adjustment* based on the principle of collinearity, i.e, the geometry underlying this adjustment is that of bundles of rays passing through *perspective centers* and joining ground points to *image points*.#

(2) See *aerotriangulation adjustment, block* (2).

aerotriangulation adjustment, Bz curve method of #A method of orienting a strip of photographs by using the *Bz curve* to find the difference between the true photographic *nadir* point and that indicated by a *multiplex* type of stereoscopic plotting instrument.#

The strip can also be leveled by this method if the aircraft's altimeter altitude is used.

aerotriangulation adjustment, individual-model #An *aerotriangulation adjustment* in which the corrections to coordinates of ground points are determined separately for each pair of overlapping photographs and the inconsistencies between coordinates from different pairs are removed in a second or third series of computations.#

aerotriangulation adjustment, strip #An *aerotriangulation adjustment* in which the photographs are arranged in strips and the corrections are determined simultaneously only to the coordinates of ground points appearing on each strip; a second set of computations is then made to minimize the disagreements between coordinates obtained for points common to two or more strips.#

age of the Moon #The time elapsed since the preceding new moon.# It is usually expressed in days.

air base (1) #The line joining two *air stations* from which overlapping photographs have been taken.#

(2) #The length of the line in (1) above.#

(3) #The distance, in a stereoscopic model, between adjacent *perspective centers* as reconstructed in the stereoscopic plotting instrument.# Also called model base or base. The analog, in the model, of the line or distance between adjacent locations of the camera.

Airborne Control system See *survey, Airborne Control.*

Airborne Profile Recorder #A system that constantly measures and records the altitude of an aircraft by combining the outputs of a precise *radar altimeter* and a very sensitive *barometric altimeter*. At the same time, the point from which the altitude was measured is determined by means of a camera synchronized with the pulses from the altimeter.#

Also called APR, TPR, and Terrain Profile Recorder.

air station #The point occupied by the *perspective center* of an aerial camera at the instant a photograph is taken.#

Airy point #One of the two points on which a bar of standard length rests when in use; these points are equidistant from the ends of the bar and separated by $1/\sqrt{3}$ the length of the bar.#

Such a suspension produces least deformation of the bar by its own weight.

Airy's hypothesis See *isostasy.*

Airy's theory See *isostasy.*

albedo #The ratio of the total amount of radiation (power) reflected or scattered by a body to the total amount of radiation incident on the body.#

In practice, albedo is measured and calculated only for the observable portion of a body. For example, the albedo of the Moon is calculated for the visible face only, although this is not stated when giving the Moon's albedo. The albedo of the Moon is 0.07, the albedo of the Earth is 0.39, the albedo of Jupiter is 0.51.

algorithm #A set of instructions for solving certain types of problems, particularly calculations.#

Eratosthenes' algorithm for finding all the primes less than a given number is an example. Most instructions (programs) for digital computers are algorithms.

aliasing (1) #The compensation, by changes in amplitude of terms in a finite Fourier series, for frequencies present in the data but not represented in the series.#

(2) #More generally, the differences between the values of the constants in a mathematical representation of data and the values the constants would have if the representation were improved by adding more terms.#

alidade #The part of a surveying instrument which consists of a sighting device, with index, and accessories for reading or recording data.#

The alidade of a theodolite or surveyor's transit is the upper part of the instrument; it includes the telescope, the micrometer microscopes or verniers, and accessories, all mounted on what is called the "upper motion" of the instrument. It is used in observing a direction or angle on a graduated circle which is mounted on the "lower motion".

The alidade used in topographic surveying consists of a straightedge carrying a telescope or other sighting device, and used in recording a direction on the *plane table* sheet.

The movable arm of a *sextant* is an alidade.

alidade, eccentricity of See *eccentricity of alidade.*

alidade, peepsight #An *alidade* consisting of a peepsight mounted on a straightedge so that the edge of the straightedge is parallel to the vertical plane in which the line of sight rotates.#

alidade, pendulum #A *telescopic alidade* containing a pendulum instead of a level for establishing the direction of the horizontal line of reference for vertical angles.#

alidade, self-indexing #An *alidade* containing a damped *pendulum* that automatically brings the index mark of the vertical arc to the correct reading on the scale even if the base of the alidade is not quite level.#

alidade, telescopic #An instrument composed of a telescope mounted on a straightedge ruler, and used with a *plane table* in topographic surveying.#

Also called a telescope alidade.

alignment (alinement) (1) #The placing of points along a straight line or in a common vertical plane.#

(2) #The location of points with reference to a straight line or to a system of straight lines.#

The use of the term in surveying should be limited to operations associated with straight lines.

(3) #In astronomic geodesy, the placement of the optical axes of a telescope in proper relation to the index marks on the horizontal and vertical, or the right ascension and declination, circles.# It should not be confused with *collimation,* which is the bringing of the optical elements of a telescope into proper relation with each other.

alignment, curve of See *curve of alignment.*

alignment correction See *taped length, alignment correction to.*

alignment error #The angle between the actual line of sight of a telescope and the direction in which the horizontal or vertical circles on the telescope or on an auxiliary telescope indicate that the line of sight should lie.#

alluvion (1) #The formation of land from the bed of a river or body of water by the gradual, natural accumulation of matter on the bed or by the gradual, natural recession of the water.#

It is differentiated from *batture* in that the latter occurs beneath the water surface and does not form land.

(2) #The land formed by the gradual, natural accumulation of matter on the bed of a river or by the gradual, natural recession of the water.#

alluvium #The solid material (sand, silt, gravel and other solids) deposited by running water.#

This material may accumulate to form land, the process (and sometimes the result) being referred to as *alluvion,* or it may remain beneath the surface of the water to raise the level of the bed (the result being referred to as *batture).*

almanac, air #An *astronomical almanac* prepared particularly for the use of aerial navigators.#

almanac, astronomical #An annual publication containing, for each day or other suitable fraction of the year, information on the locations of celestial bodies, together with the times and circumstances of various astronomical events such as sunset and sunrise, of particular use for navigation.#

In 1980 the titles, *The American Ephemeris and Nautical Almanac,* prepared by the U.S. Naval Observatory, and *The Astronomical Ephemeris,* published by H.M. Nautical Almanac Office, were changed to *The Astronomical Almanac.*

almanac, nautical #An *astronomical almanac* prepared particularly for use on ocean-going ships.#

almucantar #Any small circle on the celestial sphere parallel to the horizon.#

Also called parallel of altitude and circle of equal altitude.

altazimuth (adjective) #Rotatable in altitude and azimuth.#

Most geodetic transits, theodolites, and satellite-tracking instruments are usually altazimuth mounted.

altazimuth instrument #An instrument on an *altazimuth mounting* equipped with both horizontal and vertical graduated circles, for the simultaneous observation of horizontal and vertical directions or angles.#

The altazimuth instrument derives its name from the terms *altitude* and *azimuth*. Many theodolites and engineer's and surveyor's transits are altazimuth instruments.

altazimuth mounting See *mounting, altazimuth*.

altimeter #An instrument that determines its distance above a particular surface.#

This distance is usually referred to as the *altitude* of the instrument. There are two common types of altimeter: the *barometric altimeter*, which determines altitude above a surface of constant atmospheric pressure, and the *radar* (or *laser) altimeter*, which determines altitude above the physical surface of the Earth or other celestial body.

altimeter, barometric #An *aneroid barometer* whose scale is graduated in feet, yards, or meters as well as (or instead of) in units of atmospheric pressure.#

It indicates the distance of the barometer above a previously selected surface of constant pressure. The instrument measures air pressure and its scale is graduated to show altitude as a function of pressure. A barometric altimeter is calibrated by adjusting the instrument to read the correct elevation at a point of known elevation. Altitudes are then measured with respect to the surface of current constant pressure through this point.

altimeter, laser #An instrument that determines altitude by measuring the length of time needed for a pulse of coherent light to travel from the instrument to the surface and back, and multiplies half this time by the speed of light to get the straight-line distance to the surface.#

The pulses are usually sent out in a narrow beam that may not illuminate the surface directly below the instrument. The beam's direction must therefore be known, or controlled.

altimeter, lidar See *altimeter, laser*, and *lidar*.

altimeter, radar #An *altimeter* which emits pulses at radio frequencies, measures the time of transit to-and-from the surface below and converts this to a one-way distance by multiplying the time of transit by half the speed of radio waves in the atmosphere.#

altimeter, surveying #A *barometric altimeter* used to determine approximate differences of altitude or elevation between points.#

altimetry #Determining distances above the physical surface of the Earth or other celestial body, or above a level of specified (reference) air pressure.#

The usual instruments are *radar altimeters* or *barometric altimeters*. However, an *aneroid barometer* that indicates air pressure only may be used, the pressures measured, and the results converted to altitudes by calculation. See also *hypsometry*. Altimetry differs from hypsometry in that the latter refers specifically to determining surface elevations; i.e., distances of a physical surface above the geoid.

altimetry, barometric #A method of determining differences of altitude from differences of atmospheric pressure observed with a barometer.#

By the application of certain corrections and the use of what is sometimes called the hypsometric equation, a difference of atmospheric pressure at two places is transformed into a difference of elevations of those places. If the elevation of one station above a reference surface (such as the geoid) is known, the approximate altitudes of other stations connected with it by barometric altimetry can be computed. By using barometers of special design, and including several stations of known altitude in a series of occupied stations, the accuracy of the altitudes determined for the new stations is increased. Corrections are applied for temperature, latitude, index of barometer, closure of circuit, diurnal variation in atmospheric pressure, etc.

altimetry, fly-by method of #A method of determining approximate altitudes in regions where extremely rugged terrain exists. The method is identical to the *two-base method of barometric altimetry*, except that the roving barometers are carried by air and read in the aircraft as it passes on a level with the topographic feature whose altitude is to be determined.#

altimetry, leap-frog method of barometric #A method for quickly obtaining altitudes of points along a route between two points of known altitude by using four barometric altimeters in pairs.#

One pair of altimeters remains at the starting point while the other pair is advanced to the first point at which altitude is to be determined. At this point, the altimeters and weather instruments are read and the values are recorded. The pair at the starting point is now moved to the second point at which the altitude is to be determined, and the foregoing procedure is repeated. The pairs are advanced alternately, one past the other, until the last point of known altitude (which may be the starting point) is reached.

altimetry, radar (1) #Determining the distance of a *radar altimeter* above the physical surface of the Earth.#

The radar altimeter is usually carried in an aircraft, but has also been used in spacecraft and artificial satellites. Altitudes obtained from artificial satellites are usually converted to the *geodetic heights* of the physical surface, most commonly over water.

(2) #Determining *geodetic heights* of points on the Earth's surface using data obtained from altimeters on aircraft or artificial satellities.#

This method requires knowledge of successive locations of the altimeter with respect to the *reference ellipsoid*.

altimetry, satellite #Determining the distance of a satellite above the surface of the Earth or other celestial body by using a *radar* or *laser altimeter* in the satellite.#

altimetry, single-base method of barometric #A method of *barometric altimetry* using two barometers. One, designated the "base barometer", is left at a central point of known altitude and the other, called the "roving barometer", is moved from point to point of unknown altitude.#

At each point occupied by the roving barometer, the pressure, weather conditions, and time of observation are recorded; the same quantities are measured and recorded once every five minutes at the central (base) point. Data are later reduced to altitudes.

altimetry, thermometric #Determining *altitudes* by measuring the temperatures at which water boils at points of unknown altitude.#

The temperature at which water boils at any point on the Earth depends on the atmospheric pressure at that point, which in turn depends in part on the altitude of the point. Factors other than altitude also affect atmospheric pressure, and factors other than atmospheric pressure affect the boiling point. Hence, thermometric altimetry is less precise than barometric altimetry. See *hypsometer*.

altimetry, two-base method of barometric #A method of *altimetry* using three barometers, two of which are placed at separate points of known altitude chosen so that the altitudes of all points occupied by the third barometer lie between those altitudes.#

The barometers and weather instruments at the two points of known altitude are read and recorded every 5 minutes. The third barometer and associated weather instruments are read as each point is occupied. Data for these points are later reduced to altitudes.

altitude (1) #The *distance* of a location above a reference surface.#

The most usual reference surface is sea level.

(2) #The *distance* of a location above the physical surface of the Earth.#

"Altitude" is a generic term that defies exact technical definition. It is evident that distance must be determined along some suitable line. "Suitable" connotes a line whose direction closely approximates a perpendicular to the surface and passes through the location in question. See also *elevation, height,* and *altitude, barometric*.

(3) See *altitude, angular*

altitude, absolute See *altitude (2)*.

altitude, angular (1) #The vertical angle between the plane of the horizontal (at the point of observation) and the line connecting the point of observation with the observed (or defined) object or point.#

The angular altitude is the complement of the *zenith angle*; it is also known as the altitude, the elevation, or the angular elevation.

In surveying, the angular altitude is positive if the object is above the plane of the horizon and negative if below it. A positive angular altitude is also called the angle of elevation; a negative angular altitude is then called an angle of depression.

altitude, apparent (astronomy) #The observed *angular altitude* corrected for instrumental errors, personal errors, and errors in the surface from which the angle is measured, but not for refraction, parallax, or semidiameter.#

Also called rectified altitude.

altitude, barometric (1) #The distance between two surfaces of constant atmospheric pressure, one of which is the reference surface.#

The distance between two such isobaric surfaces is not constant in either space or time. This kind of altitude therefore depends on the theory or assumptions used for locating the surfaces as well as on the data themselves.

(2) #The difference in pressure between two surfaces of constant atmospheric pressure, with the lower surface taken as referent.#

altitude, circle of equal See *almucantar*.

altitude, ex-meridian #The *angular altitude* of a celestial body near but not on the celestial meridian.#

A correction is applied to the ex-meridian altitude to obtain the meridian altitude.

altitude, geopotential *#Dynamic height.#* This term is employed in the *U.S. Standard Atmosphere Tables*.

altitude, meridian #The *angular altitude* of a celestial body measured on the meridian of the observer.#

altitude, parallel of See *almucantar*

altitude, rectified See *altitude, apparent*.

ambit #A boundary line thought of as enclosing and going around a place.#

ambitus #A space at least 2.5 feet in width, between neighboring buildings, left for the convenience of going between them.#

amphidromic point #A point at which the variation of the tides is zero and from which the *cotidal lines* radiate, progressing through all phases of the tidal cycle.#

Also known as a nodal point.

amphidromic region #A region surrounding an *amphidromic point.* #

amphidromic system #The set of *cotidal lines* in an *amphidromic region.* #

amphidromic system, degenerate #A system of *cotidal lines* whose *amphidromic point* appears to be located on land rather than on the open ocean.#

anaglyph #A composite picture made by superposing one picture of a stereoscopic pair in one color on the other picture in a complementary color.#

The colors chosen are generally red and blue-green. When viewed through spectacles with a red filter as one lens and a blue-green filter as the other lens, the anaglyph provides a three-dimensional effect. Anaglyphs are used in photogrammetric plotting instruments.

(2) #A pair of stereoscopic pictures side by side, one of which is printed in one color and the other in the complementary color.#

analemma #A figure-eight shaped diagram showing the *declination* of the Sun throughout the year and also the *equation of time*.#

It may be shown on a plane or curved surface, such as on an *analemmatic sundial,* but is most commonly shown near the Equator on a terrestrial globe.

anallactic constant See *stadia constant (1)*.

anallatic #A variant spelling of *anallactic.* #

angle (1) #In general, a geometric figure formed by (a) a pair of intersecting, straight lines terminated at the point of intersection (the two lines are called sides; the point of intersection is called the vertex); (b) a pair of intersecting planes terminated at the line of intersection (called the axis); or (c) the surface generated by moving a straight half-line about its end point (called the apex), the line returning upon itself once and only once.#

The figure defined by (a) is a plane angle; the figure defined by (b) is a dihedral angle; the figure defined by (c) is a solid angle or cone; if the surfaces generated by the straight half-line of (c) are planes, it is a polyhedral angle.

The angle between two intersecting curves is the plane angle between the tangents to the curves at the point of intersection.

The size, or measure, of an angle is the rate of separation of the lines or surfaces forming the angle. The following methods are used to obtain a measure of each of the three kinds of angle.

(a) The size of a plane angle is determined by drawing a circle of arbitrary radius about the point of intersection. The ratio, times a specified constant, of the length of arc between the two lines to the entire circumference of the circle is the size of the angle.

If the constant is 360°, the integral part of the size is in units of degrees. The fractional part is multiplied by 60 and the resulting integral part is in units of minutes. The fractional part of the second value is multiplied by 60 to transform that part in seconds. The scheme of degrees, minutes, and seconds denoted by ° ′ ″ is called the sexagesimal system and is said to be in *arc* measure. If the constant is 400, the unit of size is the centesimal degree, grad, or gon. If the constant is 2π, the unit is the radian. If the constant is 24, the integral part of the size is in units of hours, and the fractional part is broken down into minutes and seconds similar to the sexagesimal system. This system is known as the astronomical or time system, and is 15 times as large as the corresponding unit in the sexagesimal system. It is denoted by h m s.

(b) The size of a dihedral angle is the size of the plane angle formed by a third plane perpendicular to the line of intersection (axis) of the two original half-planes.

(c) The size of a solid angle (cone) is determined by drawing a sphere about the fixed point (apex). The ratio, times a specified constant, of the area inclosed by the solid angle to the area of the entire sphere is the size of the solid angle. The constant usually employed for solid angles is 4π; the unit is the steradian. The unit *square degree* is also used in connection with other constants.

(2) (astronomy) #An angle is classified as *topocentric* if its vertex or apex is at the observer on the surface of the Earth (or other planetary body), *geocentric* if its vertex or apex is at the center of the Earth (or a representative ellipsoid), *heliocentric* if its vertex or apex is at the center of the Sun, and *barycentric* if the vertex or apex is at the center of the mass of the Solar System (or some subset thereof).#

Astronomical angles are expressed in the same units as angles in general. Where, however, the rotation of the Earth determines the angle, the size of the angle is usually expressed in units of time (hours, minutes and seconds) rather than in units of arc (degrees, minutes and seconds).

(3) (geodesy) #Angles in geodesy are usually classified according to the way they are measured. Those measured in a horizontal or nearly horizontal plane are called horizontal angles; those measured in a vertical or nearly vertical plane are called vertical angles.# In the United States of America, the size of an angle is generally given in degrees, minutes, and seconds of arc. In other countries, particularly in Europe, sizes are often given in grads, centigrads, and centicentigrads.

(4) (photogrammetry) Photogrammetric practice generally follows that of geodesy in its use of angles and angular measure. However, certain angles that occur frequently in aerial photogrammetry are given special names; the most common are: *#tilt* (or *pitch*), *roll*, and *swing* (or *yaw*).#

angle, adjusted #An *adjusted value* of an angle.#

An adjusted angle may be derived either from an *observed angle* or a *concluded angle*.

angle, azimuth (1) (astronomy) #The angle less than 180° between the plane of the *celestial meridian* and the *vertical plane* containing the observed object, reckoned from the direction of the elevated pole.#

It is the *spherical angle* at the zenith in the *astronomical triangle* with vertices: pole, zenith, and star.

(2) (geodesy) #An *angle*, in *triangulation* or in a *traverse*, through which the computation of *azimuth* is carried.#

In a simple traverse, every angle may be an azimuth angle. Sometimes, in a traverse, to avoid carrying azimuths over very short lines, supplementary observations are made over comparatively long lines, the angles between these lines forming azimuth angles.

In triangulation, certain angles, because of their size and position in the figure, are selected for use as azimuth angles and enter into the formation of the condition equation (azimuth equation) governing azimuths.

(3) #Synonymous with *azimuth*.# Not to be confused with *azimuth angle* as used in triangulation and traverse. Use of *azimuth* is preferable to azimuth angle in order to avoid confusion with (2).

angle, Cardan #One of a sequence of three angles (rotations) specifying the orientation of one (three-dimensional) coordinate system with respect to another, such that the successive rotations bringing them into coincidence are about three different axes.#

Let the system whose axes are x, y, z be rotated into the system with axes X, Y, Z. An example of a sequence of Cardan angles is given by a rotation about x yielding a coordinate system with axes x, y', z'; then a rotation about y' yielding x', y', Z; finally a rotation about Z yielding X, Y, Z. Five other sequences are possible satisfying the condition that the axes of rotation (i, j, k) are all distinct. This is in contrast to the *Euler angles* where the condition is $i = k \neq j$. Cardan angles are more practical for very small (differential) rotations than Euler angles. The photogrammetric rotations—*roll, pitch,* and *yaw*—are an example of a sequence of Cardan angles.

angle, centesimal #An angle expressed in units that are related to the degree by 100 grads = 90°: a centesimal minute is 1/100 of a grad, and a centesimal second is 1/100 of a centesimal minute.#

See also *gon* and *grad.*

angle, concluded #An *interior angle* between adjacent sides of a closed figure, obtained by subtracting the sum of all the other (computed or observed) interior angles of the figure from the theoretical value of the sum of all the interior angles.#

The concluded angle is most frequently met within *triangulation*, where it is obtained by subtracting the sum of two known angles of a triangle from 180° plus the spherical excess of the triangle.

angle, deflection #A *horizontal angle* measured from the prolongation of the preceding line, right or left to the following line.#

Only directed polygons, such as *traverses,* have deflection angles.

angle, dihedral See *angle (1).*

angle, dip #The vertical angle, at the point of observation, between the *geometric horizon* and a line of sight to the *apparent horizon*.#

angle, distance #An angle in a triangle opposite a side used as a base in the solution of the triangle or a side whose length is to be computed.#

In a chain of single triangles, as the computation proceeds through the chain, two sides are used in each triangle: a known side and a side to be determined. The angles opposite these sides are the distance angles.

angle, double zenith #An angle obtained by pointing the telescope of a transit at an object, reading the angle on the vertical circle, then reversing the instrument to put the vertical circle on the other side of the observer, redirecting the telescope at the object, and reading the new angle on the vertical circle. The difference of the two readings is the double-zenith angle and is twice the *zenith angle*.#

In trigonometric leveling and in astronomy, double-zenith angles are used because they are nearly free from effects of the inclination of the vertical axis of the instrument.

angle, Euler (Eulerian) #One of a sequence of three angles (rotations) specifying the orientation of one (three-dimensional) coordinate system with respect to another, in which the first and third rotations are about the same axis, and the second is about a different axis.#

Let the system whose axes are x, y, z be rotated into the system with axis X, Y, Z. An example of a sequence of Euler angles is given by a rotation about z yielding x', y', z; then a rotation about x' yielding x', y'', Z (finally a rotation about Z, yielding X, Y, Z). Five other sequences are possible satisfying the condition $i = k \neq j$ for the axes of rotation (i, j, k). This is in contrast to the *Cardan angles* where the condition is that i, j, k are all distinct. The example can be called the $z\,x\,z$ sequence. This and the $z\,y\,z$ sequence are the most common instances of Euler angles.

angle, exterior #The angle between any side of a polygon and the adjacent side extended.#

"Exterior angle" is also used to designate the outside angles formed by a line intersecting two parallel lines.

angle, horizontal #An angle between two directed lines in a horizontal plane. Equivalently, the dihedral angle between two planes intersecting in a vertical line.#

Angles measured on the horizontal circle of a theodolite are horizontal angles if the *standing axis* of the theodolite is vertical and the horizontal circle is perpendicular to the standing axis.

angle, hour See *hour angle* and *angle, plane.*

angle, interior #An angle between adjacent sides of a closed figure, measured on the inside of the closed figure.#

angle, interlocking #The angle between the optical axes of any two rigidly connected cameras.#

Also, the angle between the optical axes of a vertical and an oblique camera, or the dihedral angle between the planes of a vertical and an oblique photograph.

angle, map See *meridians, convergence of.*

angle, mapping See *meridians, convergence of.*

angle, observed #An angle obtained by direct instrumental observation.#

A measured angle which has been corrected for local conditions only at the point of observation is considered an observed angle.

angle, parallactic #The angle, on the celestial sphere, between a *great arc* from a celestial body to the pole and a great arc from the celestial body to the observer's zenith.#

"Parallactic angle" should not be confused with or used for "parallax".

angle, plane See *angle* (1).

angle, polyhedral See *angle* (1).

angle, position #The angle, measured eastward on the celestial sphere, from a line joining a specified point and the north celestial pole to a line joining the specified point and the point whose position angle is wanted.#

For example, the position angle of one star in a binary system is measured by placing the origin of a polar micrometer on the center of the other star and rotating the movable hairline from an initial direction through the north celestial pole to a final direction through the first star.

angle, repetition of #A method of measuring angles in which the telescope is pointed at the initial point and the direction is read. The telescope is next aimed at the second point, the horizontal circle is clamped to the telescope, and telescope and circle are swung around together to point back at the initial point. The horizontal circle is then unclamped, the telescope pointed again at the second point, and this process repeated the desired number of times.#

The final reading on the circle is the sum of the individual measurements. The average is obtained by dividing this sum by the number of measurements.

angle, solid See *angle* (1).

angle, spherical #An angle between *great circles* on a sphere.#

A spherical angle is measured by (a) the dihedral angle between the planes of great circles, (b) the plane angle between tangents to great circles at their intersection, or (c) the arc intercepted by these great circles on the great circle 90° from the point of intersection.

angle, spheroidal #An angle between two curves on a *spheroid*.# By definition, its size is that of the angle between the tangents to the two curves at the point of intersection.

angle, vertical #An angle between two directed lines in a vertical plane.#

In surveying, one of the sides of a vertical angle is usually either (a) a horizontal line in the vertical plane (the angle is then called the *angle of elevation* or *depression*), or (b) a vertical line (the angle is then called a *zenith angle*).

angle, zenith #The angle measured positively from the observer's zenith to the object observed.# Also called zenith distance.

angle of aberration See *aberration (2).*

angle of coverage See *angle of view.*

angle of depression See *angular altitude.*

angle of elevation See *angular altitude.*

angle of view (1) #The angle, at the rear *nodal point* of an optical system, between the two rays to two points that determine a characteristic dimension of the image formed by the optical system.#

Also called *field of view,* or angle of coverage. Characteristic dimensions are the length of a side or the length of the diagonal of a square image, or the length of the longer or shorter side of a rectangular image, etc.

(2) (photogrammetry) #Twice the angle whose tangent is half the length of the diagonal of the image, divided by the *calibrated focal length.* #

angle to the right #The angle, measured clockwise, from the preceding *leg* of a *traverse* to the following leg.#

Ångstrom (Å) #10^{-10} meter.#

Invented for designating wavelengths of radiation in the optical and shorter-wavelength parts of the spectrum. The optical part of the spectrum lies approximately between 4,000 and 7,500 Ångstroms. The Ångstrom is not an accepted part of *SI,* but is still used in books and papers on spectroscopy. Current unit used in *SI* for visible light is the nanometer (nm), or 10^{-9} meter.

angular momentum #The product of the *moment of inertia* of a body by its *angular velocity.* #

angulation, vertical #The process of obtaining differences of elevation by means of observed vertical angles, combined with lengths of lines.#

In geodesy, vertical angulation is called *trigonometric leveling.*

anomaly #In general, any quantity whose values differ from those expected or predicted by simple theory.#

The following usages are examples.

(a) (astronomy) *True anomaly; mean anomaly; eccentric anomaly.*

These quantities are angles which pertain to elliptic orbits. The term "anomaly" was applied because ancient astronomers expected orbits to be circular.

(b) (geodesy) *Gravity anomaly.*

(c) (geophysics) *Magnetic anomaly.*

(d) (oceanography) #The difference between some particular characteristic of seawater and the corresponding characteristic either of seawater under standard conditions or of a standard sample of seawater.#

anomaly, deflection See *deflection anomaly.*

anomaly, eccentric #The angle from the *line of apsides* of an elliptical orbit to a radius vector drawn from the center of the ellipse to a point Q on the circle having the line of apsides as its diameter, such that Q is on the perpendicular from the line of apsides through the center of mass of the orbiting body.#

The eccentric anomaly is related to the *mean anomaly* by *Kepler's equation.*

anomaly, gravity See *gravity anomaly.*

anomaly, isostatic See *gravity anomaly, isostatic.*

anomaly, magnetic See *magnetic anomaly.*

anomaly, mean #The *angle* from the *line of apsides* of an elliptical orbit to the radius vector from the attracting focus to a hypothetical point moving with angular velocity equal to the average angular velocity of the actual orbiting body.#

The mean anomaly is related to the *eccentric anomaly* by *Kepler's equation.*

anomaly, true #The angle from the *line of apsides* of an elliptical orbit to the radius vector from the attracting focus to the center of mass of the orbiting body.#

Antarctic Circle #The parallel of latitude, in the Southern Hemisphere, at which the latitude is equal to the complement of the declination of the *winter solstice.* #

Because the obliquity of the ecliptic is steadily changing, the winter solstice is not fixed in declination; thus, the Antarctic Circle, as defined above, is not a line of fixed position. On a map, the Antarctic Circle is customarily at latitude 66°33′S. This is the complement of 23°27′S used for the latitude of the *Tropic of Capricorn.*

antenna, reference #The antenna, in a set of antennas engaged in *radio interferometry*, used as a referent in establishing an epoch for the time of arrival of signals.#

The term is used in particular in *very long baseline interferometry* with a pair of antennas.

anticyclonic #Fluid flow in the atmosphere or oceans with a clockwise rotation about the local vertical in the Northern Hemisphere and a counterclockwise rotation in the Southern Hemisphere.# See *cyclonic.*

aperture (1) #Any material part of an optical system specifically intended and designed to allow some light to pass through and to stop the rest of the light. Equivalent, in this sense, to *stop.* #

(2) #In particular, the part (element) which determines

the amount of light (power) reaching the detector. Also called the *aperture stop*.#

(3) #A measure of the light-gathering power of an optical system.#

In simple refracting optical systems, the aperture is approximately the diameter of the front (objective) lens. More exactly, it is the diameter of the aperture stop that determines the angular size of the axial cone of rays from the object. In reflecting optical systems, the diameter of the primary mirror is usually considered the aperture. If the mirror is small, the square root of the unobscured area of the primary mirror is often used. In catadioptric systems, the diameter of either the primary mirror or the lens may be used. Note that aperture is not the same as *numerical aperture*.

aperture, numerical #The product of the index of refraction of the medium in *image space* and the sine of the half-angle of the cone of illumination there.#

In microscope optics, the definition above is used with "object space" substituted for "image space".

aperture, relative #The ratio of the effective focal length of an optical system to the diameter of the *entrance pupil*.#

Also called "f-number" or "f-stop". When objects other than point sources, such as stars, are viewed or photographed, the illumination in the image is determined by the relative aperture, rather than by the aperture alone. The diameter of the entrance pupil limits the power arriving at an element of the image, while the focal length determines the area over which this power is spread.

aperture stop See *stop, aperture.*

aphelion #The point, in the orbit of a planet or a comet, most remote from the Sun.#

apo #A prefix meaning farthest from (the attracting body).# E.g.; apogee, the point, in the elliptical orbit of a satellite of the Earth, at which the satellite is farthest from the Earth. Note: aphelion, not "apohelion", is used.

apoapsis #The point, in the orbit of a satellite at which the satellite is closest to its *primary*.#

apocenter #The point in the orbit of one component of a binary system at which that component is closest to the center of mass of that system.#

Note the distinction between *apoapsis* and apocenter.

apogee #The point, in the elliptical orbit of a satellite of the Earth, at which the satellite is farthest from the Earth's center of mass.# See *apsis.*

aposphere #A surface of rotation whose meridional section is defined by the the equation: $r = a \operatorname{sech}[b(\tau + c)]$, where a, b, and c are constants, τ is the *isometric latitude,* and r is the perpendicular distance from the axis of rotation to the surface.#

The constants are chosen so that the aposphere touches the ellipsoid with which it has a common axis of rotation along some parallel that passes through the center of the area for which the transformation is required.

apparent place See *place, apparent.*

appearance ratio See *hyperstereoscopy.*

Appleton layer #An atmospheric layer characterized by high ion density: the F layer of the ionosphere.#

It occurs in the general region between 150 and 300 km.

approach zone #All the air space lying within the boundaries and above the floor of the *approach-zone district* at an airport.#

approach-zone district #All of the region outward from the end of a runway in which the heights of structures or other hazards to aircraft are restricted.#

The slope and dimensions of the approach-zone district are usually fixed by zoning commissions. The surface defining maximum heights is the "floor" of the district.

approximation (1) #A value close to, but not exactly, the correct value for a quantity.#

(2) #The process of obtaining approximations (1).#

Two different methods are used: direct, in which an approximation is calculated only once; and successive, in which a value, called the first approximation, is calculated and then used in repetitions of the calculation to get values called "second approximation", "third approximation", etc., each of which is closer and closer to the correct value. This process is repeated until either a satisfactory value is obtained or no change in value results. This method is also known as the "iterative process of approximation".

apse See *apsis.*

apse, line of See *apsis.*

apsides, line of See *apsis.*

apsis (pl. apsides) (1) #A point, on a curve, at which the radius vector is a maximum or a minimum.#

(2) #Either of the two points in an orbit at which the distance of the body from the center of attraction is an extremum.#

Also called "apse". For an elliptical orbit, these two points lie on the major axis of the ellipse and the center of attraction lies on a focus of the ellipse. The point closest to that focus is called "periapsis" and that farthest is called "apoapsis". The line joining the two points is the line of apsides or line of apse. The Earth, as a satellite of the Sun, passes closest to the Sun at perihelion, farthest from the Sun at aphelion. Correspondingly, a satellite of the Earth passes through perigee and apogee.

arc (1) (mathematics) #A portion of a mathematically defined curve.# A circular arc is part of a circle; an elliptical arc, part of an ellipse; etc. A Jordan arc, also called a simple arc or simple curve, is a one-to-one continuous map of a straight line.

(2) (triangulation) See *triangulation* and *arc of triangulation.*

(3) A curved piece of metal graduated to indicate angles. See, e.g., *Beaman arc; quadrant.*

arc, Beaman See *Beaman arc.*

arc, great #An arc of a *great circle.*#

arc, Jordan See *arc.*

arc measurement #A method for the determination of the size and figure of the Earth by the measurement of lengths of arcs of triangulation and the astronomic coordinates of the ends of the arc.#

Also called grade measurement (from the German "Gradmessung", i.e., degree [of arc] measurement). It is customary to differentiate between meridional and latitudinal arc measurements.

arc of triangulation #A chain of single, connected figures (triangles, quadrilaterals, etc.) which follows, approximately, an arc on the reference ellipsoid.#

The best known arcs of triangulation follow meridians or parallels, but some, such as the Eastern Oblique Arc in the United States of America, which runs from Maine to Louisiana, do not.

arc-second #One-sixtieth of a minute of arc.# 1/3600 of a degree. More properly, "second of arc".

Also written as "arcsecond" or "arc second".

Arctic Circle #The parallel of latitude, in the Northern Hemisphere, at which the latitude is equal to the complement of the declination of the *summer solstice*.#

Because the obliquity of the ecliptic is steadily changing, the summer solstice is not fixed in declination; thus the Arctic Circle, as defined above, is not a line of fixed position. On a map, the Arctic Circle is customarily shown at latitude 66°33′N. This is the complement of 23°27′N used for the latitude of the *Tropic of Cancer*.

area (1) #The extent of a surface, or an appropriately defined portion of a surface.#

(2) #A numerical measure of (1) expressed in units of length squared.#

For example: the area of a sphere is 4 π times the length squared of the radius of the sphere. The area of the portion of a sphere within a small circle drawn on the sphere is

$$2\pi r\,[r - (r^2 - s^2)^{\frac{1}{2}}]$$

where r is the radius of the sphere and s the radius of the small circle.

The two units of area in almost universal use today are the square meter and the *hectare*.

Corresponding units in the English system, still used in the United States of America, are the square foot and the *acre*.

area, effective #For any aerial photograph that is one of a series in a flight strip, the central part of the photograph delimited by the bisectors of overlaps with adjacent photographs.#

On a vertical photograph, all images within the effective area have less displacement than their conjugate images on adjacent photographs.

argument (1) (astronomy) #Synonym for angle.# See *argument of latitude; argument of perigee*.

(2) (mathematics) #An independent variable.#

It is also used for the discrete values indexing rows or columns in tables of functions.

(3) (tides) #The angular variable in the representation of tidal variation by Fourier series.#

argument, equilibrium #The theoretical phase of a constituent of the *equilibrium tide*.#

It is usually represented as the sum of two angles V and u, in which V is uniformly and rapidly changing and involves multiples of the hour angle of the mean Sun, mean longitudes of the Sun and Moon, and mean longitude of the lunar or solar perigee; and u is slowly changing and depends on the longitude of the ascending node of the Moon's orbit.

argument, Greenwich #The (tidal) *equilibrium argument* computed for the Greenwich meridian.#

argument of latitude #The angle, at the center of attraction, from the *ascending node* to the orbiting object measured in the direction of motion of the orbiting body.#

The sum of the *argument of perigee* and the *true anomaly*.

argument number See *Doodson number*.

argument of perigee #The angle, at the center of attraction, from the *ascending node* to *perigee*, measured in the direction of motion of the orbiting body.#

Aries, First Point of See *First Point of Aries*.

arpent (1) #A unit of area approximately 0.85 acre.#

It originated in France and was used in surveys of land, now part of the United States of America, granted by the French crown. The size of the arpent depends on its origin and local custom. For surveys in Arkansas and Missouri, the value 0.8507 acre has been used. For surveys in Louisiana, Mississippi, Alabama, and northwestern Florida, the value 0.84725 acre has been used.

(2) #A unit of distance equal to the square root of an arpent as defined in (1).#

Its values corresponding to those given in (1) for area are
1 arpent = 192.500 feet or 58.674 m, and
1 arpent = 191.995 feet or 58.5198 m.

In Canada, the arpent is exactly 180 French feet. (See *toise*.)

arpentator See *surveyor, land*.

arrow, surveying See *pin, taping*.

ascending node See *node, ascending*.

ascension See *right ascension* and *oblique ascension*.

assumption, principal-point See *principal-point assumption*.

A-station (1) #A *subsidiary station* established between *principal stations* of a *traverse*, for convenience in measuring the distance between the principal stations.#

A-stations are established along a curved route, as along a curved section of a railroad, where the measured lengths must be carried through a series of short, straight lines, even though azimuth control may be carried through widely spaced stations. The A-stations form a loop with the (main) line connecting the principal stations, the distance between which is obtained by projecting the measured lengths of the short lines onto the main line. See *equation, perpendicular*. A-stations are so-called because, in a given series, they are designated by the name of a principal station followed by the letters A, B, C, etc., in order of distance from that station. They are sometimes called "A, B, C stations".

(2) See *B-station*.

asthenosphere (1) #A region of the solid Earth, composed of the lower portion of the crust and the plastic upper portion of the mantle, that allows continental drift.#

Conjectures as to the depth and thickness of the asthenosphere vary greatly.

(2) #A region, in the upper mantle, characterized by low velocity and and high attenuation of seismic waves.#

astigmatism #The difference in focus between two fans of rays coming from common point in *object space*; one fan passes through a line perpendicular to the optical axis at the front *nodal point*; the other passes through a line perpendicular to the first line at the nodal point.#

Astigmatism is one of the five *Seidel aberrations*. It is zero if the point source is on the optical axis (in symmetrical optical systems) and increases with the distance of the source from the optical axis. A single, off-axis point source is astigmatically imaged as two short, mutually perpendicular lines at different distances from the lens.

astigmatizer #A lens which introduces *astigmatism* into an optical system.#

An astigmatizer is mounted so it can be moved into or out of the optical path at will. In a sextant, an astigmatizer may be used to elongate the image of a celestial body into a horizontal line.

astre fictif #A fictitious star assumed to move along the celestial Equator at a uniform rate corresponding to the frequency of one of the several harmonic constituents of the tide-producing force.#

Each astre fictif crosses the meridian at a time corresponding to the maximum of the constituent it represents.

astrodynamics See *mechanics, celestial.*

astrogeodetic #An adjective indicating that the combined methods or data of astronomy and geodesy apply.#

For example, astrogeodetic leveling or astrogeodetic coordinates.

astrograph (1) (astronomy) See *telescope, astrographic.*

(2) (navigation) #A device used for optically projecting a set of curves showing stellar or solar *angular altitudes* onto a chart or plotting sheet; the curves vary with time so they will remain in the correct position on the chart or plotting sheet.#

astrolabe #An instrument for measuring *angular altitudes* of celestial objects.# See *astrolabe, pendulum; astrolabe, planispheric; astrolabe, prismatic;* etc.

The term, derived from Greek words meaning "to take a star", has been used to designate a great variety of instruments; the three referred to above are of especial interest to surveyors and mapmakers.

astrolabe, Danjon #An *astrolabe* designed by A. Danjon and based on the double-image astrolabe of Claude and Driencourt, but with a side-by-side relationship of the images and with a motor-driven prism.#

The Claude and Driencourt astrolabe splits light from an incoming star at about 30° zenith distance to give two images in the focal plane. As the star approaches 30° zenith distance, the two images approach each other along diagonal lines intersecting on the optical axis, and coincide when the zenith distance is exactly 30°. In the Danjon astrolabe, a double *Wollaston prism* is introduced at the focus. This, together with some screens, produces two images side by side if the prism is placed at the proper distance on the optical axis from the focal plane. This side-by-side relationship is maintained by a motor that moves the prism uniformly along the optical axis, so the zenith distance over a short interval on either side of 30° is measured by the displacement of the prism. The observer merely needs to make small corrections to the displacement from time to time.

astrolabe, pendulum #An *astrolabe* whose distinctive feature is a mirror suspended on top of a pendulum to form the artificial horizon; its telescope is placed so that observations are made at a constant *angular altitude*.#

One form of this instrument consists of a V-shaped casting carrying the objective and eyepiece lenses at the ends of the arms. The mirror, which rests on top of the pendulum and forms the level surface (artificial horizon), is located at the intersection of the V. The pendulum is suspended so that it is free to swing in either of two planes at right angles to each other, such as the north-south and the east-west planes. The pendulum is highly damped so that the mirror comes to rest quickly and remains steady under normal observing conditions.

astrolabe, planispheric #An *astrolabe* of ancient origin, consisting of a full graduated circle with a centrally mounted *alidade*, and accessory adjustable plates on which are engraved *graticules* of the stereographic projection of the heavens and of the sphere for local latitudes.# See *map projection, stereographic*.

The instrument is held suspended in a vertical plane, and the *angular altitude* of a star is observed with the alidade. The projection-bearing plates are adjusted so that, in essence, graphical solutions of astronomical problems are obtained.

astrolabe, prismatic #An *astrolabe*, consisting of a telescope with a prism and artificial horizon attached at its objective end, used for determining astronomic positions.#

In its usual form, this instrument consists of a horizontal telescope which contains a 60° prism; the face of the prism nearest the objective is perpendicular to the *line of collimation* of the telescope; and a small mercurial horizon is attached to the instrument beneath the prism. In observing, two images of an observed star are seen, one reflected directly into the telescope by the lower face of the prism, the other reflected first by the mercurial horizon, then by the upper face of the prism into the telescope. The two images of the star move in opposite directions either toward or away from coincidence. At the instant of coincidence, the star is at the apparent *angular altitude* of the prism angle. Prismatic astrolabes may be made with the angle between the lower face of the prism and the mercurial horizon inclined at other than 60°.

See also *astrolabe, Danjon.*

astrometry See *astronomy, positional*. The term is sometimes restricted to mean the positional astronomy of stars.

astronomical constant #One of a set of constants of an astronomical nature that are needed for the calculation of *ephemerides*.#

The set is sometimes referred to as a "system of astronomical constants".

Not all astronomical constants are geodetically significant. Those of particular importance and the values adopted for them in 1976 by the International Astronomical Union are listed below. (The values are not necessarily the same as the values adopted or recommended by the International Association of Geodesy for the same constants.) For constants and values used before 1976, consult the national ephemerides in use before that time.

k	Gaussian gravitational constant	$0.017\,202\,098\,95\ L^{\frac{3}{2}}\ M^{-\frac{1}{2}}\ T^{-1}$
	(where the dimensions L, M, and T stand for astronomical unit, mass of the Sun, and ephemeris day, respectively)	
c	speed of light in vacuo	299,792.458 km s^{-1}
a_e	equatorial radius of Earth	6,378,140 m
G	constant of gravitation	$6.672 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$
GM_e	geocentric gravitational constant	$3.986\,005 \times 10^{14}\ m^3\ s^{-2}$
J_2	dynamical form-factor for Earth	0.001 082 63
μ	mass of Moon/mass of Earth	0.012 300 02
p	general precession in longitude per Julian century, at epoch 2000	5 029.″096 6
N	constant of nutation at epoch 2000	9.″210 9
ϵ	obliquity of the ecliptic at epoch 2000	23° 26.″21.″448
$\pi_{\odot}$	solar parallax	8.″794 148
κ	constant of aberration at epoch 2000	20.″495 52
A	length of astronomical unit	$1.495\,978\,70 \times 10^{11}$ m

See Seidelman (1977) for further details about the above values.

astronomical unit #A conventional unit of distance in astronomy roughly equal to the semimajor axis of the Earth's orbit.# Abbreviated as "a.u".

It is determined from Kepler's third law:

$$(a.u.)^3 = k^2T^2M_s(1 + m)/4\pi^2$$

where T = the period of revolution in ephemeris days,
M_s = the mass of the Sun, taken as the unit of mass.
m = the ratio of the mass of the Earth to the mass of the Sun
k = the Gaussian gravitational constant, 0.017 202 098 95.

Initially, Gauss applied m, T, and the mean distance of the Earth to the Sun, r, to determine k. Although better values of r, m, and T are now available, k has been employed in so many computations and tables that it was found easier to use the above equation for defining the astronomical unit than for defining k. The distance in kilometers equivalent to the astronomical unit is 149,597,870 km, as calculated from the constants adopted by the International Astronomical Union in 1976.

astronomic-direction method of azimuth determination See *azimuth determination by the astronomic-direction method.*

astronomy #The science dealing with bodies and phenomena occurring in regions outside the Earth's atmosphere, and with meteors and cosmic rays within the Earth's atmosphere.#

Astronomy can be divided into (a) *positional astronomy*, which deals with the locations and motions of celestial bodies, and (b) astrophysics, which deals with intrinsic physical characteristics of the bodies, such as radiation, temperature, constitution, evolution, etc.

Some astronomers call "positional astronomy" simply "astronomy" and limit use of the term "positional astronomy" to describing only the positions and kinematics (but not the dynamics) of celestial bodies.

Astronomy is also divided into disciplines according to the wavelengths of the radiation by which the bodies are observed. Astronomy is related to geodesy principally through the use of observations of the Sun, Moon, stars, and, recently, quasars for determining locations on the Earth's surface and for determining the rotation of the Earth.

astronomy, geodetic #The determination of longitudes, latitudes, and azimuths by observations of the directions of stars, planets, the Moon, or other celestial bodies.#

Coordinates so determined are called *astronomic coordinates* or astrogeodetic coordinates.

astronomy, positional #The part of astronomy dealing with the locations and motions of celestial bodies such as planets, comets, stars, and groups of stars.#

Often referred to simply as "astronomy". Astrometry is sometimes used as a synonym for positional astronomy but is more often considered to deal only with the locations and kinematics of celestial bodies, and in particular with the locations and kinematics of stars. *Celestial mechanics* deals with the dynamics of changes in location of celestial bodies and is generally considered as being purely theoretical. Statistical astronomy deals with statistical descriptions of location and changes of location and hence deals less with locations and motions of individual bodies but rather with the locations and motions of aggregates of bodies.

astronomy, radar See *astronomy, radio.*

astronomy, radio #The branch of astronomy in which observations are made by using radio wavelengths, i.e., wavelengths longer than 300 micrometers.#

Sometimes taken to apply only to astronomy involving radio waves originating at the object observed. In contrast, astronomy involving radio waves generated at an observatory and reflected or scattered by the astronomical object is then called "radar" astronomy. Properly, radio astronomy includes both kinds. Radar astronomy currently is limited to observation of bodies within the Solar System.

asymmetry of object #A lack of symmetry in the appearance of an object as seen from a particular point of observation and caused by an actual asymmetry in the object or its aspect.#

Asymmetry of object causes an object to change appearance when observed from different locations and can result in different points on the object being sighted at from different points of observation. A square or rectangular pole may face the observer in such a way that a line bisecting the angle made by lines of sight tangent to the edges of the pole does not pass through the center of the pole. If a square cupola or tower is sighted on, resulting errors may be quite large. The errors caused by observing on such objects are of the same character as those caused by observing an *eccentric signal.*

Asymmetry of object differs from *phase* (surveying) in that the former is caused by an actual asymmetry of the geometry of the object as viewed; the latter is caused by asymmetric illumination of the object.

atmosphere (1) #The envelope of gas surrounding a planet or other celestial body.#

(2) #The envelope of gas (air) surrounding the Earth.#

The Earth's atmosphere is generally divided into a sequence of layers having different properties, the kind of division depending upon its purpose. Meteorologists divide the atmosphere into: the *troposphere,* extending from the surface of the Earth to about 11 km; the *stratosphere,* extending from there to about 50 km; the mesosphere, continuing from the top of the stratosphere to about 80 km; and the thermosphere, extending from there up to about 500 km. The outermost region, where molecules easily escape from the Earth's attraction, is called the exosphere and may or may not be considered part of the atmosphere. Geodesists and radio engineers consider the atmosphere to be divided into troposphere and stratosphere, as above, but place the *ionosphere* next. The ionosphere continues from the top of the stratosphere to 300 or 400 km and is characterized by the presence of enough ions and electrons to detectably affect radio waves.

atmosphere, ambient #The air in the immediate vicinity of a survey instrument or surveying station.#

The temperature and pressure of the ambient atmosphere are referred to as the *ambient temperature* and the ambient pressure, respectively.

atmosphere, refractive index of #The ratio of wavelength of radiation of given type in the atmosphere to the corresponding wavelength in vacuum.# Formulas for the refractive index of the atmosphere for unmodulated monochromatic light, modulated light, and for microwaves were adopted at the 12th General Assembly of the International Union of Geodesy and Geophysics in 1963. (See *Bulletin Géodésique,* No. 70, 1963, p. 390, or Bomford 1980: pp. 44-47.)

atmosphere, standard #A hypothetical vertical distribution of atmospheric temperature, pressure, and density (and sometimes height) which is generally accepted as satisfactorily representing actual conditions in the atmosphere.#

The standard atmospheres of most geodetic importance are (a) the ICAO (International Civil Aviation Organization) Standard Atmosphere (1964), (b) the ISO (International Standards Organization) Standard Atmosphere (1973), and (c) The U.S. Standard Atmosphere (1976).

Atmosphere (c) agrees with the ICAO Standard Atmosphere (1964) up to 32 km and with the ISO Standard Atmosphere (1973) up to 50 km. Above 50 km and up to 1000 km, atmosphere (c) is based on data from rockets and artificial satellites. Also of geodetic importance is (d) Table 51, Geopotential Meters to Geometric Meters, *Smithsonian Meteorological Tables* (6th edition, 1958).

attachment, solar See *solar attachment.*

attitude #The position of a body defined by the angles between the axes of the coordinate system of the body and the axes of an external coordinate system.#

In particular, in photogrammetry, the *orientation* of a camera, or of the photograph taken with that camera, with respect to some external reference system. Usually expressed as *tilt, swing,* and *azimuth,* or as *roll, pitch,* and *yaw.*

augmentation #The difference between the apparent *topocentric* angular diameter of a celestial body and its *geocentric* angular diameter.#

augmenting factor #A factor used in connection with the harmonic analysis of tides or tidal currents to allow for the fact that the tabulated hourly heights or speeds used in the summation for any constituent other than a solar one do not in general occur on the exact constituent hours to which they are assigned, but may differ from the assigned times by as much as a half-hour.#

autocollimator #A *telescope* containing illuminated cross hairs placed so that they are imaged by the objective lens system at infinity.#

When a reflecting plane is placed approximately perpendicular to the optical axis of the telescope, the cross hairs and their reflected image can be viewed simultaneously through the ocular of the telescope. The image will be displaced by twice the angle between the optical axis and the perpendicular to the reflecting surface.

autocovariance See *covariance function.*

automecoic (adjective) #True scale.#

avulsion (1) #The breaking of a stream through its banks in a sudden and unexpected manner in such a way as to form another channel.#

The term is of legal significance when the avulsion results in cutting off a large amount of land from one owner and adding it to another's land.

(2) #The rapid erosion of a shore by waves during a storm.# The legal status of this definition is uncertain, some courts assign only definition (1), above to it.

axis (1) #Any line along which measurements are made in determining the coordinates of a point, or any line from which angles are measured for the same purpose.#

An axis usually serves as a line of reference such that one of the coordinates of a point lying on the axis is zero.

(2) #A line with respect to which a geometric figure is symmetrical.#

(3) #Any line about which a body rotates or revolves.# In geodetic and astronomic instruments, the line usually coincides with the axis (sense 2 above) of a cylindrical rod or tube carried in a bearing, so the term "axis" is also applied to this cylinder.

(4) #A line connecting two distinguished points.# E.g., the magnetic poles of the Earth are joined by the magnetic axis.

axis, collimation See *collimation axis.*

axis, fiducial #The *line* joining two opposite *fiducial marks* on a photograph.#

axis, horizontal #The *axis* about which the telescope or alidade of an instrument rotates when moved vertically.#

For an instrument in perfect adjustment, the horizontal axis is perpendicular to the vertical axis of the instrument and to the collimation axis of the telescope. It should coincide with the line through the centers of the pivots that support the telescope. For an instrument in perfect adjustment and properly leveled, this axis is horizontal with respect to the surface and when the telescope is rotated around it, the collimation axis will define a vertical plane. Deviations from proper instrumental adjustment are measured with a *striding level* or a *hanging level*.

axis, optical #The ray path through the focal points of an optical system that has the shortest geometric length. Equivalently, the ray path from object space to image space with the least angular deviation along the path.#

Applied to lens systems that contain only spherical surfaces, the definition becomes "a line connecting the centers of curvature of all the surfaces in a lens system".

axis, principal (1) #One of the three (two) perpendicular axes through the center of an ellipsoid (ellipse) having, among them, the shortest length and the longest lengths of all axes of the figure.#

(2) See *inertia, moment of.*

(3) See *lens, principal axis of.*

axis, standing See *axis, vertical.*

axis, vertical #The line about which the telescope or *alidade* of an instrument rotates when moved horizontally.

For an instrument in perfect adjustment and properly leveled, this axis occupies a vertical position, passes through the center of the horizontal circle, and is perpendicular to its plane.

axis of collimation #A synonym for *line of collimation*.# Since this term can be confused with the term *collimation axis*, it is best to avoid its use altogether.

axis of homology #The intersection of the plane of a photograph with the horizontal plane of reference at the ground or with the plane of a horizontal map.#

Corresponding lines in the photograph plane and the map plane intersect on the axis of homology. Also called axis of perspective, map parallel, or perspective axis.

axis of tilt #A line through the *perspective center* of a photograph and perpendicular to the *principal plane* of a photograph.#

azimuth #A horizontal angle reckoned clockwise from the meridian.#

In the basic control surveys of the United States of America and in those of many other countries, azimuths are currently reckoned clockwise from south. In military control surveys of most countries, including the U.S.A., azimuths are reckoned clockwise from north. In 1986, when the U.S. National Geodetic Survey begins publishing geodetic data on the North American Datum of 1983 (NAD 83), the measurement of azimuths will be referenced from the north for basic control surveys in the U.S.A.

azimuth, astronomic #At the point of observation, the angle measured from the vertical plane through the celestial pole to the vertical plane through the observed object.#

The astronomic azimuth is established directly from observations on a celestial body and is measured in the plane of the horizon. It differs in value from the *geodetic azimuth* because of the *deflection of the vertical* which can be as much as a minute of arc, or more, in extreme cases.

Astronomic azimuths may also be reckoned clockwise from north. In navigation, they are sometimes reckoned either clockwise or counterclockwise through 180°, from the south in the Southern Hemisphere, and from the north in the Northern Hemisphere. In recording an astronomic azimuth it is essential that both the initial direction and the direction of reckoning be indicated.

azimuth, back See *azimuth, geodetic.*

azimuth, forward See *azimuth, geodetic.*

azimuth, geodetic #The angle at a point A between the tangent to the *meridian* at A and the tangent to the *geodesic* from A to the point B whose geodetic azimuth is wanted.#

Until 1986 the U.S. National Geodetic Survey had considered a geodetic azimuth to be positive clockwise starting from south. See *azimuth*. The azimuth is called the "forward azimuth" for the line AB. The angle at B between the tangents to the meridian and to the geodesic is called the "back azimuth" or "reverse azimuth" for the line AB. Because of the *convergence of the meridians*, the forward and back azimuths of a line do not differ by exactly 180°, except where the two end points have the same geodetic longitude or where the geodetic latitudes of both points are 0°.

azimuth, grid #The angle in the plane of projection between a straight line and the central meridian of a plane-rectangular coordinate system.#

In the State plane coordinate systems established by the former U.S. Coast and Geodetic Survey, grid azimuths are reckoned from south (0°) clockwise through 360°. While essentially a map related quantity, a grid azimuth may, by a mathematical process, be transformed into a survey or ground related quantity. See *gisement* and *grid, convergence*.

azimuth, Laplace #A *geodetic azimuth* derived from an astronomic azimuth by means of the *Laplace equation* (qv).#

azimuth, magnetic #At the point of observation, the angle between the vertical plane through the observed object and the vertical plane in which a freely suspended symmetrically magnetized needle, influenced by no transient artificial magnetic disturbance, will come to rest.#

Magnetic azimuth is generally reckoned from magnetic north (0°) clockwise through 360°. Such an azimuth should be marked as magnetic, and its date of establishment given.

azimuth, normal section #The angle at a point between the meridian plane through that point and the *normal section* which passes through that point and another point.#

azimuth, reverse See *azimuth, geodetic*.

azimuth angle See *angle, azimuth*.

azimuth determination #The determination of *astronomic azimuth*.# Although the term properly should include the determination of *geodetic azimuths*, it is not used with that meaning.

azimuth determination by the astronomic-direction method #The determination of the *astronomic azimuth* of a line by measuring, with a direction-theodolite, the horizontal angle between a selected star and a suitable mark, and applying that angle to the azimuth of the star computed for the epoch of the observation.#

In the horizontal control surveys of continental United States, azimuth determination by the astronomic-direction method is preferred over other methods. A circumpolar star is observed at any hour angle, the mark being a signal light on a main-scheme station or at a station (called an azimuth mark) established for the purpose. A correction for inclination of the horizontal axis, depending upon the *angular altitudes* of the star and of the mark, is applied to the observed angle, and corrections for curvature of the apparent path of the star, for *variation of the pole*, and for *diurnal aberration* are also used in the computation.

azimuth determination by the hour-angle of Polaris #Determination of *azimuth by the astronomic-direction method* or by the *micrometer method*, using Polaris as the observed star.#

azimuth determination by the hour-angles of crossings of the almucantar #A method of determining *astronomic azimuth* by measuring the angle between the azimuth mark and the vertical plane through the point at which a star, whose *angular altitude* is the same as the latitude of the observer, crosses the *almucantar*. The time of crossing is observed and the azimuth of the point of crossing is calculated.#

azimuth determination by the method of equal altitudes #The determination of azimuth by measuring horizontal angles from a star to the desired direction at two different times—when the star first reaches a specified *angular altitude* and when the same star next reaches that same angular altitude. The average of the two angles is the azimuth of the direction.#

In determining azimuths in the Northern Hemisphere, the direction should be generally south of the observer, while if the point is in the Southern Hemisphere, the direction should be generally north of the observer. If the Sun is used, a correction must be made for the change in declination of the Sun between the morning and afternoon observations. It is also important to remember to make all observations on the same limb. Except in the case of the Sun, a knowledge of the star's coordinates or the time is not necessary.

azimuth determination by the micrometer method #The determination of the *astronomic azimuth* of a line by measuring indirectly, with an ocular micrometer attached to a theodolite or transit, a horizontal angle mark (light) located on the ground close to the vertical plane which passes through the star, and applying that angle to the azimuth of the star computed for the epoch of the observation.#

At elongation, the apparent motion in azimuth of a close circumpolar star, such as Polaris, is very small for an appreciable period of time, so a series of observations can be made by the micrometer method without reorienting the instrument. A correction for inclination of the horizontal axis, depending on the altitudes of the star and of the mark, is applied to the observed angle, and corrections for curvature of the apparent path of the star, for *variation of the pole* and for *diurnal aberration* are also used in the computations.

azimuth determination by the method of repetitions #The determination of the *astronomic azimuth* of a line by accumulating on the horizontal circle of a repeating theodolite the sum of a series of measures of the horizontal angle between a selected star and a suitable mark, and then applying the average of such measures to the azimuth of the star computed for the mean epoch of the observations.#

This method is very precise and accurate theoretically, but in practice is not as satisfactory as the *astronomic direction method of azimuth determination*.

A correction for inclination of the horizontal axis, depending on the altitudes of the star and of the mark, is applied to the observed angle, and corrections for curvature of the apparent path of the star, *variation of the pole*, and for *diurnal aberration* are also used in the computations.

azimuth determination using the rate of change of zenith distance #A variant of the *astronomic-direction method of determining astronomic azimuth*, in which the azimuth of the star is calculated from the rate of change of *zenith distance* with time.#

azimuth error (1) #The angle from the meridian through a *meridian telescope* to a plane perpendicular to the telescope's horizontal axis.#

(2) #The angle defined similarly for any telescope with an *alt-azimuth mounting* when the horizontal axis should be perpendicular to the meridian.#

(3) #For any instrument for which a nearly vertical plane can be defined, the difference between the azimuth of that plane and the azimuth in which it is supposed to lie.#

This definition is often used for the calibration of *radio telescopes*.

azimuth line #A *radial* from the *principal point, isocenter,* or *nadir* of a photograph, representing the direction to a similar point of an adjacent photograph in the same flight line.#

The line is used extensively in *radial triangulation*.

azimuth mark #A geodetic *monument* carrying a mark whose azimuth from a given point is known either by measurement or by definition.#

azimuth mark, astronomic #A signal lamp or a target whose *astronomic azimuth* from a survey station is determined by direct observations on a celestial body.#

The mark may be a lamp or illuminated target placed especially for the purpose or may be a signal lamp at another survey station.

azimuth mark, geodetic #A marked point established in connection with a triangulation (or traverse) station to provide a starting azimuth for *dependent surveys*.#

The geodetic azimuth to the azimuth mark is determined instrumentally. Historically, azimuth marks consisting of bronze tablets set in concrete or stone have been established in connection with the basic horizontal control surveys of the United States. These marks are usually located so they can be easily used, without special construction to elevate either instrument or target. At a station having an established azimuth mark, both the *geodetic azimuth* and the *grid azimuth* of the mark on the State plane coordinate system are computed and published.

azimuth mark, Laplace #A mark whose *astronomic azimuth* from a *Laplace station* is known.#

B

backshore (1) #The land zone lying between mean (ordinary) high water and the landward line marked by a change in material or physiographic form, or the line where permanent vegetation begins.#

(2) #The part of a beach that is usually dry; the part reached only by the highest tides and waves.#

backsight (1) #A *sight* to a previously established point of a survey, or the reading or measurement obtained by that sight.#

(2) (leveling) #In leveling from an initial point to a final point through a sequence of intermediate points, a sight to (or the reading on) a leveling rod held on a preceding point.#

The sight to, or reading on, a leveling rod on the succeeding point is called the foresight.

In leveling, a backsight is sometimes called a plus sight, because its value is added to the elevation of the point on which the leveling rod is placed to obtain the elevation of the leveling instrument. But if the sight is to a mark on a wall or in the roof of a mine tunnel, with the instrument at a lower elevation than the mark, the backsight will be subtracted from the known elevation to obtain the height of the instrument. The term backsight is preferred over plus sight.

Neither of these definitions requires that the point or leveling rod to which the sight is made be at a point whose coordinates have been defined or determined previously. If the sequence consists of only two points, it does not matter which is called the backsight and which the foresight.

balance (gravimetry) See *torsion balance.*

balancing a survey #Changing, by using some reasonable hypothesis of how the errors of a specific survey behave, the measured values of lengths and angles in a traverse to eliminate the *misclosure*.#

The term is equivalent to *traverse adjustment*, which is sometimes restricted to mean only traverse adjusted by least squares.

balancing a survey, Bowditch's method for See *traverse adjustment, Bowditch's method for.*

balancing a survey, compass rule for See *traverse adjustment, compass rule for.*

balancing a survey, Crandall's rule for See *traverse adjustment, Crandall's rule for.*

balancing a survey, transit rule for See *traverse adjustment, transit rule for.*

Bamberg transit See *transit, broken-telescope.*

band, frequency See *frequency band.*

bank (1) #The rising ground bordering a sea, lake, or river.#

(2) (surveying) #The continuous margin along a stream where all vegetation characteristic of dry land ceases.#

The right and left banks of a stream are, respectively, to the right and to the left as one faces downstream.

bar #A unit of pressure of 10^6 *dynes* per square centimeter.#

In SI units, 10^5 newtons per square meter (10^5N m^{-2}) or 10^5 pascals (10^5Pa). The pressure exerted by one standard atmosphere is 1.01325 bars. The pressure exerted by a column of water 1 meter deep is approximately 1 decibar.

Barlow rod See *leveling rod, Barlow.*

barometer #An instrument for measuring atmospheric pressure.#

There are two general types of barometers: those in which atmospheric pressure is balanced by the weight of a column of liquid (usually mercury); and those in which atmospheric pressure is balanced by some elastic device. The latter are called *aneroid* (without liquid) *barometers*. See also *hypsometer.*

barometer, aneroid #A *barometer* which balances the atmospheric pressure against a mechanically elastic device.#

The usual form of aneroid barometer is a thin box of corrugated metal, almost exhausted of air. When the atmospheric pressure increases, the box contracts; when the pressure lessens, the box expands. These movements are amplified by mechanical linkages and communicated to an index hand which registers on a graduated dial. The graduations on the dial usually show the atmospheric pressure in terms of height of a corresponding column of mercury. The aneroid barometer may be equipped with an auxiliary dial, graduated to show elevations in feet or meters.

barometer, cistern #A *mercury barometer* in which a column of mercury is enclosed in a vertical glass tube, the upper end of which is sealed and exhausted of air, and the lower end placed in a cistern or reservoir of mercury which is exposed to atmospheric pressure.#

The atmospheric pressure on the free surface of the mercury in the cistern determines the height of the column of mercury in the vertical tube. This height is measured, and the pressure is reported as so many inches, centimeters or millimeters of mercury, or other units. Also called Fortin barometer.

barometer, Fortin See *barometer, cistern.*

barometer, mercury #A *barometer* in which atmospheric pressure is balanced against the weight of a column of mercury.#

There are two types of mercury barometers, differing in the form of apparatus used, but not in the underlying principle. See *barometer, cistern* and *barometer, siphon.*

barometer, siphon #A *mercury barometer* consisting of a column of mercury in a U-shaped glass tube with one vertical branch about one-fourth the length of the other. The end of the longer branch is closed and the air in it is displaced by the mercury, but the shorter branch is left open and so the mercury is subjected to atmospheric pressure.#

The difference of the height of the mercury in the two branches is a measure of the atmospheric pressure.

barometric formula See *altimetry, barometric.*

barycenter #The center of mass of an object or collection of objects.#

For example, the barycenter of the Earth and Moon lies on the line connecting the centers of mass of each and is about 1700 km inside the Earth's surface.

barye #A pressure of 1 dyne per square centimeter.#

This is equivalent to 0.1 newton per square meter, or one-millionth of a bar.

base (1) triangulation, #a synonym for *base line*.#

The term "base" is common in British practice, "base line" or "baseline" in American.

(2) #An important point in a survey.# In particular, a point used as origin or having associated with it a value to which measurements elsewhere in the survey are referred.

base, air See *air base.*

base, gravimetric See *base, gravity.*

base, gravity #A point at which gravity has been measured with sufficient accuracy for use in calibrating gravimeters or as a reference in gravimetric surveys.#

base, inertial See *mounting, inertial.*

base, model #The line, or the length of the line, at the scale of the *stereoscopic model*, joining the perspective centers as reproduced by the stereoscopic instrument.#

base, photo #The *air base* or its length as represented on a photograph or pair of photographs.#

base-altitude ratio See *base-height ratio.*

base apparatus See *base line apparatus.*

base-height ratio #The ratio of the length of an *air base* to the average altitude at which a *stereoscopic pair* of photographs was taken.#

This ratio is also referred to as the K-factor, base-altitude ratio, or B/H.

base length, photographic #The distance, on a photograph, between the *principal point* of that photograph and the point corresponding to the principal point on another (overlapping) photograph.#

The principal point on each photograph coincides with the image of a different corresponding point in object space. Each of these points in object space is imaged into a point, called the conjugate image or conjugate point on the other photograph. Each photograph therefore has a base line (see *base line, photographic*) corresponding to the base line on the other, but usually of different length. Also called a photobase.

base line (1) (geodesy) #A surveyed line established with more than usual care to which surveys are referred for coordination and correlation.#

The variant spelling "baseline" is preferred only when employed as an adjective in Very Long Baseline Interferometry (VLBI).

Base lines are established for specific purposes; the more important ones are defined below.

(2) (triangulation) #The side of one of a series of connected triangles, the length of which is measured to a prescribed standard of accuracy and from which the lengths of the sides of the other triangles are obtained by computation.#

Base lines in triangulation are classified according to the character of the work they are intended to control; the instruments and methods used in their measurement assure that the prescribed standards of accuracy are met. See Federal Geodetic Control Committee (1984).

(3) (construction) #The *center line* of location of a railway or highway. A reference line for the construction of a bridge or other structure. Often called the base line of location.#

(4) #A line extending east and west along the astronomic parallel passing through the initial point, along which standard township, section, and quarter-section corners are established.#

Such a base line serves as the starting line for the survey of the meridoinal township boundaries and section lines. Auxiliary governing lines, known as standard parallels or correction lines, are established along the astronomic parallel, usually at intervals of 24 miles north or south of the base line. In some very early surveys, the base line is referred to as the basis parallel.

(5) (international law of the sea) #The line from which the outer limits of the territorial sea and other offshore zones are measured; the dividing line between inland waters and the territorial sea.#

(6) (radio-navigation) #The line joining a pair of transmitters in a radio-navigation system.#

base line, calibration #A line on which markers are placed at intervals so accurately measured that they can be used for calibrating distance-measuring instruments or equipment.#

The characteristics of a calibration base line depend on the kind of distance-measuring instrument (or equipment) to be calibrated. Lines on which surveyor's tapes are to be calibrated are commonly short and may be paved between markers. In the U.S.A., lines on which electronic distance-measuring instruments are to be calibrated have the markers placed typically at distances of 150 meters, between 400 and 430 meters, and between 1000 and 1400 meters from the marker indicating the starting point (zero distance). Most calibration base lines are built specifically for calibrating distance-measuring instruments and are not part of a geodetic network.

base line, photographic #The line on a photograph joining the *principal point* on that photograph to the point corresponding to the principal point on another (overlapping) photograph.#

base line apparatus #Any apparatus designed for the accurate and precise measurement of the length of a base line in triangulation, or the length of a line in a first- or second-order traverse.#

The various kinds of base line apparatus include the following general types:

(1) Apparatus having a length unit composed of simple bars or tubes of wood, metal, or other material, constructed for determining alignment, contact, and temperature. The earliest bars used in geodetic work were of wood. The most effective apparatus of this type was the iced-bar.

(2) Apparatus consisting of bars or tubes or different

metals having unequal coefficients of thermal expansion, so arranged that (a) the temperature effects on the lengths of the component parts are largely neutralized and the effective length of the apparatus remains almost constant, or (b) the component parts form a metallic thermometer, by means of which the temperature of the apparatus is obtained and its effect on the length of the apparatus determined.

(3) Apparatus consisting of tapes or wires of metal, usually steel or a nickel-steel alloy. Steel tapes have a large coefficient of thermal expansion. Thus they have been replaced almost entirely by tapes of nickel-steel (invar) which have a small coefficient of thermal expansion and so give good results through a wide range of temperature.

The base line apparatus covered in (1), (2), (3) are, except for invar tapes, mainly of historical interest. Specific types—Bache-Wurdeman, compensating, contact, contact-slide, duplex, Hassler, iced-bar, optical, Repsold, Schott, Woodward—are described in Mitchell (1948).

(4) Apparatus consisting of a source of light, a collimator, a set of reflectors, and a receiver in which the phase of the received light is compared by interference with the phase of the transmitted light.

(5) Apparatus consisting of a source of light or infrared radiation, a modulator (at radio frequencies) of the radiation, a collimator, a set of reflectors, and a receiver in which the phase of the modulation on the returned radiation is compared with the phase of modulation on the transmitted radiation.

(6) The radio analog of (5), in which transponders may be substituted for reflectors.

base line apparatus, Jäderin #A base line apparatus consisting of an invar wire 24 m long and 1.6 to 1.7 mm in diameter, with a short, graduated, invar bar at each end; two special supports at each end for the wire; and precisely positionable reference marks with respect to which the distances are measured.#

The original apparatus (1880) consisted of steel wires; a later version added a brass wire parallel to the steel wire, to permit determination of the effects of temperature on the measurements. See also *wires, Jäderin.*

base line apparatus, Väisälä #A base line apparatus utilizing a collimated beam of light split into two parts. One part travels from a base mirror M_1 at one end of the base line to a mirror M_3 at the end of a segment of the base line and thence back to the observer at a telescope. The second part goes from mirror M_1 to a reference mirror M_2 and goes back to the telescope and observer after reflection between M_1 and M_2 a sufficient number of times that the total distance traveled is nearly equal to the total distance from M_1 to M_3 and back. These two parts, on being united in the telescope, interfere to form a fringe pattern of light and dark lines; the distance between fringes depends upon the amount (in fractions of a wavelength) by which the distance traveled by one part exceeds the distance traveled by the other part. Since white light is used for the source, the fringes are colored and disappear altogether if the two parts differ by more than a few wavelengths (or if they are exactly the same). If the distance between M_1 and M_2 is known exactly, the distance between M_1 and M_3 is then also known exactly.#

Refractive anomalies in the atmosphere limit the measurable distance between mirrors to between 500 and 1000 meters. Under good conditions, an accuracy of a few tens of micrometers can be obtained. See Honkasalo (1960) for details. Also called a Väisälä light-interference comparator.

base line reduction to sea level #Conversion of the measured length of a base line to the length of a line that is the vertical projection of the base line onto a surface defined by reference to mean sea level.#

The defined surface is usually equipotential or an approximation thereto; it may be the geoid. See also *base line reduction to the geoid.*

base line reduction to the geoid #Conversion of the measured length of a base line to the length of a line that is the vertical projection of the base line onto the geoid.#

The quantity $\Delta L = LH/(R + H)$ gives the reduction in measured length L, where H is the average elevation of the base line above the geoid and R is the radius of curvature of the geoid at the midpoint of the base line, to sufficient accuracy for most purposes.

base line reduction to the spheroid (reference ellipsoid) #Conversion of the measured length of a base line to the length of the line that is the orthogonal projection of the base line onto the reference ellipsoid.#

The measured length is first converted, after corrections for calibration of the tape, refraction, etc., to the length of the chord joining the two points between which the base line extends. This length is next converted to the length of the chord joining corresponding points on the ellipsoid, and then to the length of the arc on the ellipsoid.

base map See *map, base.*

base sheet See *sheet, base.*

base tape See *tape, base.*

base terminal #One of the two ends of a base line.#

bathymeter #An instrument used for determining depths of the oceans or other deep bodies of water.#

bathymetry #The measurement and study of water depths.#

batture (1) #The gradual raising of the bed of a river or body of water by the accumulation of solid matter such as silt, soil, gravel.#

(2) #The portion of the bed of a river or body of water which has been raised by the gradual accumulation of solid matter.#

When accumulated matter has reached the point where it extends above the surface of the water and is therefore no longer part of the bed, it is still sometimes referred to as batture. However, the terms *alluvion* (for the process) and *alluvium* (for the land) are more specific and are preferred.

bay (1) #In general, an unmistakable and pronounced indentation of a coast.#

According to the Geneva Convention of 1958, a bay is "a well-marked indentation whose penetration is in such proportion to the width of its mouth as to contain landlocked waters and constitute more than a mere indentation of the coast. An indentation should not be regarded as a bay, however, unless its area is as large as, or larger than, that of a semi-circle whose diameter is a line drawn across the mouth (i.e., from headland to headland, or from extremity to extremity) of that indentation." For the purpose of measurement, the area of an indentation is determined between the low-water mark around the shore of the indentation and a line joining the low-water marks at its natural entrance points.

(2) #The body of water contained within a bay as defined in (1) above.#

beach #The zone of unconsolidated material that extends landward from the low-water line to the place where there is marked change in material or topography, or to the line of permanent vegetation (usually the effective limit of storm waves).

beach berm #A nearly horizontal portion of the beach, formed by the material left by the waves.#

Some beaches have no berm, while others may have several.

beach face See *foreshore.*

beach ridge #A continuous mound of material, landward of a beach, that has been heaped up by the action of waves carrying material of the beach farther inland.#

beach scarp #An almost vertical slope along a beach, caused by wave erosion.#

The height of a scarp may vary from a few centimeters to a meter or more, depending on the kind of wave action and beach material.

Beaman arc #A specially graduated arc fitted to the vertical circle of a *transit* or *plane-table alidade* for the easy reduction of *stadia rod* observations.#

Also called a stadia circle.

beacon #Any artificial device that makes itself and its location known through the emission of light, infrared, or radio waves, either continuously or according to a schedule.#

This distinguishes the beacon from a transponder, which is turned on or off by the observer. The lamp in a lighthouse, and the transmitter in a TRANSIT satellite, are examples of beacons used for navigation.

bearing (1) In general, #the horizontal angle between a line from the observer to a given point, and a line from the observer along a specified direction (such as north).# Various conventions can apply. For example, the bearing can be determined both clockwise or counterclockwise from the specified direction, so that the bearing does not exceed 180°.

(2) #The horizontal angle that a line makes with the meridian of reference adjacent to the quadrant in which the line lies.#

Bearings are classified, according to the reference meridian used, as true bearings, magnetic bearings, or grid bearings.

A bearing is identified by naming the end of the meridian (north or south) from which it is reckoned and the direction (east or west) of that reckoning. Thus, a line in the northeast quadrant making an angle of 50° with the meridian will have a bearing of N. 50° E. In most survey work it is preferable to use *azimuths* rather than bearings.

bearing, back #The *bearing* as measured at the end of a line opposite the end at which the observer is stationed.#

Back bearings on all lines other than north-south ones differ from the bearings at the observer's station by the amount of the convergence of the meridians between the points.

bearing, compass #The horizontal angle from north, as indicated by a magnetic compass, east or west to the object being sighted, whichever gives the smaller angle.#

The compass bearing is not corrected for *deviation* as is the *magnetic bearing.*

bearing, great-circle #The initial direction of a great circle through two terrestrial points, expressed as angular distance from a reference direction.#

It is usually measured clockwise from the reference direction (at 0°) to 360°.

bearing, grid #The angle from a north-south line of the grid on a map to a line drawn on the map.#

bearing, magnetic (1) (navigation) #The *bearing* with respect to magnetic north i.e., the compass bearing corrected for *deviation*.#

(2) (surveying) #The bearing with respect to magnetic north or south and stated as east or west of the magnetic meridian.# For example, N 15° E, S 23° W, etc.

bearing, Mercator #The *bearing*, with respect to the *graticule,* of a straight line on a *Mercator* chart.#

bearing, true #The horizontal angle between the *meridian line* and a line on the Earth, the direction of the north point of the meridian being determined by astronomical observations.#

Also called astronomic bearing.

bearing object #A *corner accessory* that can be readily identified by its distance and direction from the *corner* being recorded.#

bearing tree #A tree used as a *corner accessory*.#

Bearing trees are identified by prescribed marks cut into their trunks and the species and sizes of the trees are recorded.

bed, stream #The region within the high-water lines of a stream or river.#

This region is kept practically bare of vegetation by the wash of the waters of the stream.

bedrock (1) #A hard layer of rock covered by soil, sediment, etc., extending more or less continuously over a large region.#

It is distinguished from silt, clay, etc., by being hard, and from sand, pebbles, and boulders by being continuous. Cleared of its covering, it is called exposed bedrock.

(2) #A stratum of rock in the Earth's crust formed in an approximately horizontal position.#

bematrist #A *surveyor* who measures distances by pacing them off.# This term is obsolete.

bench mark #A relatively permanent, natural or artificial, material object bearing a marked point whose elevation above or below an adopted surface *(datum)* is known. Sometimes written "benchmark".

Usually designated a BM, such a mark is sometimes further qualified as a *permanent bench mark* to distinguish it from a *temporary bench mark.*

bench mark, first-order #A *bench mark* connected to the surface of reference by continuous first-order leveling.#

bench mark, junction #A *bench mark* selected as the common meeting point for lines of levels or links of levels.#

bench mark, permanent #A *bench mark* as nearly permanent in character as is practicable.#

Usually identified simply as a bench mark or BM. A permanent bench mark is intended to maintain its elevation, with reference to an adopted surface, without change over a long period of time. Concrete or stone posts with suitable marks in their tops, such as inscribed disks, are used. A permanent bench mark is set either in firm ground sufficiently deep to be free of the action of frost or, preferably, in outcropping or buried rock. In general, the location chosen is one where disturbing influences are believed to be negligible.

bench mark, second-order #A *bench mark* connected to the surface of reference by continuous second-order leveling or by a continuous combination of first- and second-order leveling.#

bench mark, temporary #A *bench mark* established to hold, temporarily, the end of a completed section of a line of levels and to serve as a starting point from which the next section is run.#

Spikes and screws in poles, bolts on bridges, and chiselled marks on masonry have been used as temporary bench marks; some last for years. Also called a supplementary bench mark.

bench mark, tidal #A *bench mark* whose elevation has been determined with respect to mean sea level at a nearby tide gauge; the tidal bench mark is used as reference for that tide gauge.#

National geodetic organizations follow either of two different policies with respect to the use of tidal bench marks: (a) The elevation of a tidal bench mark, once determined, is kept fixed. Changes in mean sea level at the tide gauge will then not affect elevations of points in the leveling network connected to the tide gauge. (b) The elevation of the tidal bench mark is redetermined at intervals. Elevations of points in the leveling network then change with the position of mean sea level on the tide gauge.

A tidal bench mark may be included in a geodetic line of levels.

bench mark, tide-gauge #A tidal bench mark.#

Besselian elements #A set of parameters introduced by Bessel for predicting the progress of occultations and eclipses of the Sun.#

See *Nautical Almanac Offices* (1961: pp. 216-222; pp. 281-285) for a detailed description.

Bessel's formula #The formula

$$\tau = m + n \tan \delta + c^* \sec \delta$$

for the correction τ to the observed sidereal time of passage of a star through the meridian, where δ is the declination of the star, and m and n are given by

$$\tan m = \sin \phi' \tan a + \cos \phi' \sec a \tan b$$

$$\sin n = \sin \phi' \sin b - \cos \phi' \cos b \sin a$$

and a, b, c^* and ϕ' are the *azimuth error*, *level error*, *collimation error* and the *astronomic latitude* of the instrument, respectively.#

These equations apply to transit at upper *culmination.* They apply to lower culmination if $(180° - \delta)$ is substituted for δ.

In practice, a, b, and c^* are usually not measured. Instead, observations are made on stars for which the times of transit are known, and m, n, and c^* are determined by least squares from the observations.

b-factor (astronomic geodesy) See *level factor.*

Bilby tower See *tower, Bilby.*

blaze #A mark made upon a tree trunk at about breast height by cutting out a piece of bark.# The cut leaves a flat scar, or blaze, on the tree surface.

block (land surveying) (1) #A *square,* or a portion of a city or town inclosed by streets but not containing any streets.#

(2) #A subdivision of a town site.#

block adjustment of aerotriangulation See *aerotriangulation adjustment, block.*

blunder (1) #A mistake or error caused by mental confusion, carelessness, or ignorance.#

Examples of blunders are reading a horizontal circle wrong by a whole degree, neglecting to record a whole tape length in a traverse, and reversing the numerals in recording an observation. Another example is a number recorded as the result of observing on the wrong target or from the wrong control point.

(2) #A large blunder, in the sense given above.#

A small error, by this definition, is not a blunder.

(3) #An error, made by a machine, of the same nature as that defined in (1).#

For example, an error caused by a defective mechanical or electronic device would be such a blunder.

body, celestial See *celestial body.*

Borda scale #A metallic *thermometer* composed of two metals with different coefficients of thermal expansion.#

The Borda scale was devised by the French scientist, Jean Charles Borda (1733-1799), who placed a strip of copper on a strip of platinum, fastened the two together at one end, and by measuring the relative movement of their free ends, determined their temperature.

borderland, continental #An oceanic region adjacent to a continent, usually occupied by or bordering a *continental shelf* with depths much greater than those typical of the region over a continental shelf.#

Boston rod See *leveling rod, Boston.*

Bouguer anomaly See *gravity anomaly, Bouguer.*

Bouger correction See *gravity correction, Bouguer.*

Bouguer cylinder #A fictitious vertical cylinder whose upper surface passes through a point P on the Earth's surface (but above mean sea level), whose axis passes through P and is perpendicular to the terrestrial ellipsoid, and whose height is equal to the height of P above the ellipsoid.#

The radius is arbitrary but is usually between 40 and 100 km. The cylinder is assumed to be filled with matter, usually with a density of 2.67 g cm^{-3}.

Bouguer plate #An imaginary, cylindrical plate, of infinite radius and of thickness equal to the elevation of a particular gravity station, placed with its upper surface horizontal at the gravity station.#

The attraction of the Bouguer plate at the gravity station is roughly equal to the attraction there of all matter between sea level and the elevation of the gravity station. The gravitational attraction attributable to the plate is $2 \pi G \rho H$, where G is the gravitational constant, ρ is the average density of the matter in the plate, and H is the thickness of the plate. This becomes $0.112\,H$ mgal with H in meters, and $\rho = 2.67$ g cm^{-3}. The attraction corrects (approximately) for the error made in the free-air anomaly computation; which ignores the mass between the point and the geoid.

Bouguer reduction See *gravity reduction* and *gravity reduction, Bouguer.*

boundary (mathematics) #An (N-1)-dimensional region separating two N-dimensional regions.# If N is 3, the boundary is a surface separating two regions of space. If N is 2, it is equivalent to a *boundary line.*

boundary, gradient #A line located midway between the lower level of the flowing water (of a stream) that just reaches the cutbank and the higher level that approaches but does not overtop the cutbank.#

This kind of boundary was created by judicial action in the settlement of the boundary between Oklahoma and Texas. Also called flowage line.

boundary, land #A line of demarcation between adjoining politically or legally distinct areas of land.#

The adjoining land parcels may be currently owned by the same or different parties, but at some time in their history have had separate legal descriptions. A land boundary may be marked on the ground by material monuments placed primarily for the purpose; by fences, hedges, ditches, roads, and other service structures along the line; or may be specified by astronomically described points and lines, or by coordinates on a survey system whose positions are referenced material monuments established without reference to the *boundary line*. Other methods are also in use.

Although the land boundary is defined as a line and is determined as such by a surveyor, it is usually considered legally to be a surface that extends vertically upwards and downwards through that line.

boundary, sea #A line of demarcation between adjoining areas at sea.#

The boundary may be at the surface or at the bottom of the sea.

boundary line #A line separating two areas.#

In specific cases, the word "boundary" is often omitted, as in State line; or the word line is omitted, as in International boundary, county boundary, etc. The term boundary line is used to specify boundaries between political territories, as in State boundary line between two States. A boundary line between privately owned parcels of land is, by preference, called a property line, or if a line of the U.S. public-land surveys, is given the designation generally used in that survey system, such as section line, township line, etc.

boundary monument #A material object placed on or near a *boundary line* to preserve and identify the ground location of the boundary line.#

Where it is impracticable to establish a monument on or very close to a boundary line, the position of the boundary line on the ground is preserved by means of *reference marks*. The term *monument* is sometimes used to include both the mark on the boundary line and the reference mark.

boundary precedence #The ranking of boundaries of civil units to indicate which boundary should be shown when two or more boundaries overlap on a map.#

For example, where a national boundary coincides with a state boundary, only the national boundary is shown on the map. In general, the boundary of one political unit takes precedence over the boundary of a lower-ranking political unit and is preceded by the boundary of a higher-ranking political unit.

boundary survey #A survey made to establish or to reestablish a *boundary line* on the ground, or to obtain data for constructing a map or plat showing a boundary line.#

The term "boundary survey" is usually restricted to surveys of boundary lines between political territories. For the survey of a boundary line between privately owned parcels of land, the term "*land survey*" is preferred; for official surveys of the public lands of the United States, the term "*cadastral survey*" is used.

boundary-value problem #Any problem in which a partial differential equation is to be solved for the dependent function, with the values of the function or its derivatives given on the boundary of the region over which the function is to be determined.#

boundary-value problem of physical geodesy #The problem of determining the shape of the Earth's surface, given values of gravity or gravity potential on that surface.#

In the classical problem, the surface is the geoid, and the basic solution is *Stokes' formula*. In the modern formulation, the surface is the physical surface of the Earth, and the basic solution is due to Molodensky. See Heiskanen and Moritz (1967: pp. 287–294).

boundary vista #A lane cleared along a *boundary line* passing through a wooded area.#

A boundary vista is used for the ready identification of a boundary line, and as an aid to civil administration relating thereto.

Bowditch adjustment See *traverse adjustment, Bowditch's method for.*

Bowditch hypothesis See *traverse adjustment, Bowditch's method for.*

Bowie correction (effect) See *indirect effect.*

Bowie method See *triangulation adjustment.*

bridging (1) #The extension and adjustment of a photogrammetric survey between regions with ground control.#

The process contrasts with cantilevering *(cantilever extension)* which proceeds from a region with ground control into a region without ground control.

(2) #The production of maps by using stereoscopic plotting instruments.#

Also called stereocompilation.

broken grade See *grade, broken.*

Browne's correction #A correction, $-g\ \theta^2/2$ subtracted from the value g of gravity measured by a horizontally accelerated *gravimeter* to obtain the value of gravity that would have been measured by a stationary gravimeter; θ is the angle through which the axis of the gravimeter is deflected from the vertical.#

Brown gravity apparatus See *pendulum apparatus, Brown.*

Brown pendulum See *pendulum apparatus, Brown.*

Bruns' equation #The equation,

$$\partial g/\partial n = 4\pi G\bar{\rho}(H) - 2g/R - 2\omega^2$$

which relates the vertical gradient of gravity, $\partial g/\partial n$, to the mean curvature, R of the level surface at elevation H. In the equation, G is the *gravitational constant*, $\bar{\rho}\ (H)$ the average density of matter at elevation H, and ω the rate of rotation of the Earth.#

Also called Bruns' theorem.

Bruns' formula #The formula $N = T/\gamma$ which relates the *disturbing potential* T and *normal gravity* γ at a point on the *geoid* to the *geoidal height* N of that point.#

Bruns' term See *indirect effect.*

Bruns' theorem See *Bruns' equation.*

B-station (navigation by Loran) #The transmitting station of a pair, the signal from which always occurs more than half a repetition period after the immediately succeeding signal and less than half a repetition period before the immediately preceding signal from the other, or A-station of the pair.#

bubble tube See *level.*

buck (geodesy) #A support for a surveyer's tape.#

Bullard method (of isostatic reduction of gravity) See *gravity reduction, Hayford-Bullard method of.*

Bullard's term See *gravity reduction, Hayford-Bullard method of.*

Bureau International de l'Heure (BIH) The organization responsible, by international agreement, for coordinating the measurements of time by national observatories and for providing an internationally acceptable and common time. It is also responsible for maintaining the international *atomic second*. As part of its function, it calculates the position of the Earth's axis of rotation and changes in the Earth's rate of rotation.

buttal See *abuttal.*

butting See *abuttal.*

Bx #The x-component of the representation in a photogrammetric model of the *air base* - the line joining two camera stations.#

By #The y-component of the representation in a photogrammetric model of the *air base*.#

Bz #The z-component of the representation in a photogrammetric model of the *air base*.#

Bz curve #A graphical representation of the vertical errors in the *aerotriangulation* of a strip of photographs.#

The x-coordinates of the vertical control points, referred to the initial nadir point as origin, are plotted along the abscissa, and the differences between the known elevations of the control points and their elevations as determined by aerotriangulation are plotted along the ordinate. The *Bz* curve is a smooth curve drawn through the plotted points. The elevation of any pass point in the strip is adjusted by the amount of the ordinate of the *Bz* curve for the corresponding x-coordinate of the point.

C

c #The conventional symbol for the speed of electromagnetic radiation in a vacuum (299,792,458 m/s) (Seidelmann 1977).#

C (1) #A notation for *collimation correction factor*. #
(2) #A notation for *collimation factor (2)*. #
Rappleye (1948) and Mitchell (1948) use C to express (1), a correction in terms of *stadia intervals*. Schomaker and Berry (1982) use C to express (2), a correction in terms of *imbalances* of sighting distances. When modern instruments and rods are employed, the latter method is generally used. Often referred to as C-factor.

cadastre #An official register of the location, quantity, value, and ownership of real estate, compiled to serve as a basis for taxation.#
Also spelled cadaster.

cadastre, coordinate #A *cadastre* specifying the boundaries of a region by the coordinates of points on those boundaries.#

cadastre, metes and bounds See *cadastre, numerical.*

cadastre, multipurpose #An extension of the cadastral concept to include geodetic control, topographic base maps, land information overlays keyed to the base maps, and real estate files linked to the overlays, all of which serve to supply information for juridical, fiscal, environmental, and statistical purposes.#
It is designed to support continuous, readily available, and comprehensive land-related information at the parcel level, and it provides a common framework for a *land information system.*

cadastre, numerical #A *cadastre* specifying the boundaries of a region numerically.#
In particular, a cadastre specifying the boundaries from their lengths and directions, and from their locations with respect to certain identified, physical monuments or marks. In this sense it is a cadastre made in terms of *metes and bounds,* and so may be called a metes and bounds cadastre.

cairn #A mound of rocks, stones, or masonry constructed to mark a surveyed point or a point of importance to a survey.#
Usually conical or pyramidal. See *monument.*

calendar #A system of reckoning time over extended intervals by combining *days* into various periods adapted to purposes of civil life, to fixing religious observances, or to meeting scientific needs (Nautical Almanac Offices 1961).#
The two calendars of particular importance astronomically are the Julian and the Gregorian. The change from the *Julian calendar* to the *Gregorian calendar* was made by omitting ten days from the calendar in 1582; the day after October 4, 1582 was designated October 15, 1582. The Gregorian calendar was adopted in 1582 by all countries with Roman Catholicism as the state religion. Great Britain and the American colonies adopted the Gregorian calendar on September 3 (14) 1752. The U.S.S.R. adopted the Gregorian calendar for civil purposes on February 1 (14), 1918.

calendar, Gregorian #A *calendar* in which years with numbers not divisible by 4, or divisible by 100 but not by 400, contain 365 mean solar days, while those years with numbers divisible by 400 or by 4 but not by 100, contain 366 mean solar days.#
In this calendar only 97 years out of every 400 contain 366 mean solar days. The average length of a year in the Gregorian calendar is exactly 365.2425 mean solar days, which is about 26 seconds longer than the *tropical year.*

calendar, Julian #A *calendar* in which those years with numbers not divisible by 4 contain 365 mean solar days, while those years with numbers divisible by 4 contain 366 mean solar days.#
The average length of a year in the Julian calendar is 365.25 mean solar days, which is about 674 seconds longer than the *tropical year.*

calendar, proleptic #The extension of a calendar to a time before its actual usage.#
For example, the year 1 B.C. is a leap year in the Gregorian proleptic calendar.

calibration (1) #Determining the systematic errors in a measuring device by comparing its measurements with the markings or measurements of a device which is considered correct.#
Frequently used instruments are usually calibrated with a measuring device (a *working standard*) which has itself been calibrated. Working standards are calibrated by comparison with another calibrated set called *laboratory standards*, and these in turn are calibrated by comparison with the *primary standard.*
(2) #The determination, in terms of an adopted unit and by mechanical interpolation based on values obtained by *standardization,* of the values of supplementary marks on a measuring device.#
An example is the determination of the values of the divisions of a circle as proportional parts of a circumference. When the length of a tape has been determined by standardization, the value of its intermediate marks may be determined by calibration, the assumption being that the tape has been divided into parts which are directly proportional to its length. See *standardization.*

call (land surveying) #A clause, phrase, or statement in a description of property that identifies a particular characteristic of the boundary of the property.#
For instance, a call for a *monument* identifies a monument on the boundary; a call for a survey identifies a prior survey that was made of the property, etc.

call, passing #A *call* for a topographic or cultural feature along a surveyed line.#

Callippic cycle See *cycle, Callippic.*

calotte #A small region on an ellipsoid of revolution bounded by a small circle.#

camera #Any instrument for converting electromagnetic radiation from a source into an image of that source.#

The two most common kinds of camera are the photographic camera, which records the image directly on a radiation-sensitive emulsion, and the television camera, which focuses the image onto a surface whose electrical properties vary with the intensity of radiation striking it. The television-camera image is converted into a set of electrical impulses that can be recorded on magnetic tape or transmitted by radio to remote receivers.

At present, only the photographic camera is used in geodesy because other types of camera do not have sufficient metric fidelity and stability.

A camera consists of four, usually distinct and separable, subassemblies: the lens assembly, consisting of the lens system and the lens cone which keeps the lens system in place; the shutter mechanism, which determines the amount of light admitted to the camera for each picture taken; the magazine, which stores, moves, and positions the light-sensitive material (film or plates); and the body, which holds the other subassemblies in place and keeps out all light except that admitted through the lens system.

The infrared, ultraviolet, and X-ray portions of the spectrum can be recorded by photographic or television cameras.

camera, aerial #A camera especially designed for photographing the Earth's surface from above the ground; usually carried in aircraft and Earth-orbiting satellites.

camera, axis of #An imaginary line through the optical center of the lens system and perpendicular to the focal plane of the camera.#

camera, ballistic (1) #A camera used for photographing rockets or missiles which produces photographs of sufficient metric fidelity to permit determination of the object's trajectory.#

A ballistic camera may be either fixed or tracking. A photograph made by a fixed ballistic camera shows the missile as a thin streak interrupted by spacings caused by closing and opening the camera shutter. A photograph made by a tracking camera shows the object as a dot; the trajectory is determined by use of the recorded directions in which the camera is pointed during tracking.

(2) #Any camera used in ballistics.#

camera, calibration of #Determination of the following quantities: (a) the calibrated focal length, (b) the location of the principal point with respect to the fiducial marks, (c) the location of the point of symmetry, (d) the distortion effective in the focal plane of the camera and referred to the particular calibrated focal length, (e) the resolution of the lens system, (f) the degree of flatness of the focal plane, and (g) the opening and closing cycle of the shutter as a function of time. Also sometimes included under "calibration" is determining the locations of fiducial marks and intersections in a *reseau.* #

camera, continuous-strip #A camera in which the film moves continuously past a slit in the focal plane so the photograph produced is a continuous strip rather than a single frame or series of frames.#

In particular, an aerial camera in which the film moves at a rate proportional to the speed of the aircraft to produce one continuous photograph of the terrain. Also called a Sonne camera.

camera, dual-rate Moon #A camera invented by William Markowitz for photographing the Moon against a stellar background. The camera is attached to a telescope with equatorial mounting. The telescope moves at the sidereal rate in right ascension, so that it and the camera track the stars around the Moon. A transparent, plane-parallel plate of glass placed in the path of the rays forming the lunar image is rotated slowly about an axis perpendicular to the apparent path of the Moon's image on the photographic plate and at a rate that just compensates for the apparent motion of the Moon relative to the stars during the time needed to photograph the stars.#

The image of the Moon is thus kept stationary on the photographic plate. The first application of the camera was to determine the Moon's orbit more precisely as an adjunct to determining time. It was later used to determine the coordinates of observing stations. A detailed description is given in Markowitz (1960).

camera, frame #A camera in which the entire picture is taken through a lens system that is fixed relative to the focal plane.#

Compare with *camera, panoramic,* or *camera, continuous-strip.*

camera, mapping #A camera designed specifically for taking photographs to be used in mapping.#

The mapping camera is equipped with mechanisms to maintain and indicate the *interior orientation* of the photographs with sufficient accuracy for mapping purposes. Also called surveying camera.

camera, metric #A camera designed particularly for *photogrammetry,* constructed so that the image is distorted geometrically as little as possible and the camera characteristics do not change from photograph to photograph.#

camera, panoramic #A camera designed to take a partial or a complete panoramic photograph of the terrain.#

In some designs, a lens system that revolves perpendicularly about the optical axis is used; in others, the camera itself is turned by clockwork to obtain a panoramic field of view. Compare with *camera, frame.*

camera, pinhole #A camera whose optical system consists solely of a small hole through which the light is admitted.#

A pinhole camera has extremely high geometric fidelity but its resolution is limited by diffraction. Pinhole cameras have been used for architectural photogrammetry and for other purposes where very high accuracy is important. The camera has one disadvantage that limits its usefulness drastically: the very small aperture needed to keep geometric fidelity also cuts down the amount of light admitted so that only very bright objects can be photographed, or the exposure time must be very long, with both camera and object held immovable.

camera, Sonne See *camera, continuous-strip.*

camera, split #An assembly of two cameras pointed at a fixed angle with respect to each other so that their fields of view overlap.#

camera, stereometric #A combination of two cameras mounted at opposite ends of a short, rigid bar with their optical axes parallel.#

A stereometric camera is used in terrestrial photogrammetry for taking stereoscopic pairs of photographs.

camera, strip See *camera, continuous-strip.*

camera, surveying See *camera, mapping.*

camera, terrestrial #A camera designed for taking photographs at the Earth's surface.#

Ballistic cameras or cameras used for photographing aircraft or extraterrestrial (celestial) bodies are not considered terrestrial cameras.

camera, tracking #A camera placed on a mounting that permits pointing it continuously at a moving object such as a rocket, satellite, or even a horse; the camera incorporates an optical or other tracking system to ensure that the pointing is correct.#

Small tracking cameras may be pointed in the proper direction by the operator, who looks through an auxiliary optical system at the object being tracked. Many of the larger tracking cameras are kept pointed automatically by optical photocells or by radar.

camera, zenith #A portable camera for determining an astronomic position by taking a photograph of the sky immediately around the zenith.#

The zenith camera has a small field of view; it is equipped with leveling screws and a very sensitive level so that the optical axis can be set precisely in the vertical. The time of each observation is recorded to provide the information needed for computing the astronomic latitude and longitude. A zenith camera is distinguished from a photographic zenith telescope (PZT) by its short focal length. The zenith camera has a focal length of less than 1 meter; that of the PZT is several meters.

camera calibration See *camera, calibration of.*

camera system #A camera and all the equipment used with it for taking pictures.#

A camera system consists, typically, of the camera itself, perhaps a range-finder, an exposure meter, a timing device or intervalometer for controlling the shutter mechanism of the camera, a vacuum pump if the camera holds the film in place by vacuum, and a source of electrical power for the rest of the system. Items other than the camera itself are called accessories.

cantilever extension #The extension and adjustment of a photogrammetric survey from a region containing ground control into a region without ground control.#

Cantilever extension differs from *bridging*, in which control is available at both ends of the photogrammetric survey. Also called cantilever method and cantilevering.

cardinal (surveying) Synonym for *direction, cardinal.*

cartography (1) #The science and art of making maps.#

It is customary to distinguish between maps in general and maps used for navigation; the latter are generally called *charts*. Cartography, however, embraces the making of all kinds of maps.

(2) #The process of making maps.#

The process is generally considered to include all steps from conception to finished product. The usual steps are: (a) establishing the coordinate system for the map; (b) plotting the data from surveys or other sources (including other maps), (c) filling in where data are insufficient and generalizing where data are too plentiful, (d) comparing the resulting "manuscript" form of the map with new data (field checking), (e) making plates or other reproducible forms of the map, and (f) printing copies of the map.

cartouche #A panel on a map, often with decoration, inclosing the title or other legends, the scale, and so on.#

catalog (astronomy) #A compilation of locations of celestial objects such as stars, galaxies, and radio sources, whose directions are relatively fixed.#

The analogous compilation for rapidly moving objects such as the Moon, planets, and comets is termed an *ephemeris* or an almanac. See, in particular, *star catalog.*

catenary #The curve whose equation is

$$y = h_o \cosh (x/h_o),$$

where h_o is the height of the lowest point of the curve above the x-axis.#

A homogeneous, perfectly flexible, inelastic cable, tape, or wire, when allowed to hang freely from two fixed points, follows a catenary curve.

catenary correction See *taped length, sag correction to.*

C-band See *radio waves, classification of.*

celestial body #Any material object which is observable over a reasonable period of time on the celestial sphere.#

Specifically, the Sun, Moon, planets, and asteroids and their satellites, and comets of the Solar System; stars; clouds of gas in interplanetary, interstellar or intergalactic space; nebulae; and galaxies. Meteors and meteorites are not celestial bodies; neither are the individual atoms, molecules, and particles dispersed through space. Artificial satellites and spacecraft in stable orbits are considered celestial bodies.

celestial mechanics See *mechanics, celestial.*

celestial sphere See *sphere, celestial*

Celsius scale See *temperature scale, Celsius.*

center (1) (of instrument) #The point on the vertical axis of rotation of an instrument which is at the same elevation as the *collimation axis* when that axis is in a horizontal position.#

In a transit or theodolite, it is close to or at the intersection of the horizontal and vertical axes of the instrument.

(2) (of photograph) See *photograph, center of.*

(3) (of transit or level) #The spindle or spindles that are in a vertical position when the instrument is in use, and about which the instrument, or part of the instrument, rotates.#

The engineer's transit (repeating theodolite) has two such centers: an inner center to which the *alidade* is attached, and an outer center to which the horizontal circle is attached. It is hollow and rotates on the inner center. The rotation of the alidade is spoken of as the upper motion, and the rotation of the horizontal circle as the lower motion of the instrument.

center, anallactic #A point, in a telescope, which (a) is the image of a point on the optical axis in object space and (b) lies on the axis of rotation of the telescope.#

center, geographic The geographic center of an area on the Earth has been defined as #the point on which the area would balance if it were a plate of uniform thickness.# In other words, it is the center of gravity of that plate. The geographic center of continental United States (exclusive of Alaska) is in the eastern part of Smith County, Kansas, at latitude 30° 50′ North, longitude 98° 35′ West. The geographic centers of the various States are given in *U.S. Geological Survey Bulletin* 817, "Boundaries, Areas, Geographic Centers, and Altitudes of the United States and the Several States".

center, optical #The point, on the optical axis of an optical system, that is midway between the front and rear nodal points of the system.#

For a thin lens in air, the optical center, front and rear nodal points, and first and second principal points are all one and the same point. An oblique ray, even if it passes through the optical center, still undergoes a longitudinal displacement which is directly proportional to the thickness of the lens.

center, perspective (1) #The given point, in a perspective projection, from which straight lines are drawn through points on one surface to determine, by intersection, points on a second surface.#

(2) #The point of intersection of lines drawn between corresponding points in *object space* and *image space*.#

No such point exists for any real optical system, but it is usually convenient to describe the performance of an optical system in terms of the differences between the actual image and the hypothetical image created by a hypothetical perspective center.

(3) #One of the two points, in a camera or projector, such that a ray coming to it from object space emerges from the other point in image space in the same direction. The two points may coincide.

center, photograph See *photograph, center of.*

center, radial #The point on a photograph from which lines (radials) are drawn or distances measured to other points on the photograph.#

The radial center is either the *principal point,* the *nadir,* the *isocenter,* or an easily identifiable point (the substitute center) close to one of these (Slama 1980).

center, reduction to #The corrections, or the process of computing the corrections, which must be applied to a *direction* observed at an *eccentric station* or to an *eccentric signal,* to reduce it to what it would be if there were no such *eccentricity.* #

Computation of the reduction to center is similar for the two cases; the same form can be used for the correction to a direction observed at an eccentric station as for a direction to an eccentric signal.

The formula for the correction δ, in radians, is

$$\delta = (d \sin E)/s.$$

In this formula, d is the distance from the central station to the eccentric station, s the distance from the central station to the target, and E the angle at the eccentric station from central station to the target.

center, substitute #A point on a photograph which, because of its easy identifiability, is used as a *radial center* instead of the *principal point,* the *nadir* point, or the *isocenter.* #

centering, double #A method of elongating a line from a fixed point.#

The transit and a forward target are set up approximately on the line to be elongated, and a backsight is taken with the telescope in the direct (normal) position. The telescope is then inverted and a foresight is taken, and the point where the vertical cross hair intersects the target is marked on the target. The telescope is then rotated 180° horizontally and, still in the inverted position, a backsight is taken. The telescope is then restored to its direct position, another foresight is taken, and the new point of intersection of the vertical cross hair with the target is again marked. The elongated line passes through a point midway between the two marked points.

centering device #A part of, or an attachment to, the leveling base (tribrach) that permits the instrument mounted on it to be moved a short distance in each of two orthogonal directions.#

The *standing axis* of a surveying instrument can thus be positioned above a mark on the ground without moving the tripod or putting the standing axis out of the vertical.

center line #The line connecting opposite *quarter-section corners,* or opposite *sixteenth-section corners.* # *See section, quarter* and *section, quarter quarter.*

center of figure #The point whose coordinates are the average values of the coordinates of all points of the figure.# This definition assumes that the coordinate system in which the figure is expressed is Cartesian.

It is the geometric analog of the *center of mass* of a body and coincides with that center if the density of the line or surface is not a function of location. Also called the *centroid.*

center of gravity #The point whose Cartesian coordinates are the average values of the weighted Cartesian coordinates of all points of the figure, the weight at each point being the product of the density and the acceleration of gravity at that point.#

If the acceleration of gravity at all points of the figure is taken to be the same, which is a reasonable approximation for small bodies on the Earth's surface, then the center of gravity coincides with the *center of mass.*

center of mass #The point whose Cartesian coordinates are the average values of the weighted Cartesian coordinates of all points of the figure, the weight at each point being the density at that point.# Compare with *center of figure* and *center of mass.*

center of perspective #A point through which lines are drawn from points on a surface S to points on a surface S' to establish a correspondence between the points on S and S' joined by the lines.#

In the theory of map projections, S is a curved surface and S' is a plane or *developable surface.*

centigrade scale See *temperature scale, Celsius.*

centrifugal force #The force with which a body moving under constraint along a curved path reacts to the constraint.#

Centrifugal force acts in a direction away from the center of curvature of the path of the moving body. As a force caused by the rotation of the Earth on its axis, centrifugal force is opposed to gravitation, and combines with it to form gravity. The centrifugal force $\vec{F}$ exerted by a body of mass M traveling along a curve with radius of curvature R and with linear velocity $\vec{v}$ or angular velocity $\vec{\omega}$ is $\vec{F} = M \vec{v}^2/R$, or, since $\vec{v} = \vec{\omega} R$, $\vec{F} = M \vec{\omega}^2 R$.

centroid See *center of figure.*

C-factor (1) (leveling) See *collimation correction factor.*

(2) (photogrammetry) #The ratio of the altitude of a camera above the ground to the smallest contour interval that can be accurately plotted by using the photography and a particular photogrammetric plotting instrument.#

The optical axis of the camera is assumed to be vertical and the height constant. The C-factor will vary with the camera system and with the stereoscopic plotting instrument used. It is also called the altitude-contour ratio.

c.g.s. system of units #The system of units for physical measurement in which the fundamental units of length, mass, and time are the centimeter, the gram, and the mean solar second.#

While the c.g.s. system is particularly useful for expressing quantities of the size encountered in a physical laboratory, its units are too small for conveniently expressing quantities measured in ordinary work. It has therefore been replaced, by international agreement, by the SI (Le Systéme International d'Unitès) in which the meter, the kilogram, and the second are used as fundamental units of length, mass, and time.

chain (1) #The unit of length prescribed by law for the survey of the public lands of the United States; it is equal to 66 feet or 100 *links.* # One acre equals 10 square chains.

The chain derives its name from the *Gunter's chain*, which had the form of a series of links connected together by rings.

(2) #A Gunter's chain or similar measuring device.#

chain, Gunter's #A measuring device once used in land surveying. It is composed of 100 metal links fastened together with rings; the total length of the chain is 66 feet.#

This chain was invented by an English astronomer, Edmund Gunter, about 1620. It is the basis for the *chain* and the *link,* the legal units of length used in the survey of the public lands of the United States. The chain in its original form has been replaced by metallic tapes or ribbons graduated in links and chains. The new forms are still called chains.

chaining #Measuring distances on the ground with a graduated tape or with a *chain.* #

While the chain has been superseded by the tape for most surveys, the term chaining has continued in use, especially where reference is to surveys of the public lands of the United States. For the corresponding operation in other surveys, the term *taping* is preferred.

chaining, slope #Measuring distance along a slope with a graduated tape held as nearly parallel to the ground as possible.#

The measured distance is reduced to horizontal distance by calculation, using the slope of the tape or the difference in elevation at the ends of the tape.

chainman #The person who marks the tape ends in measuring distance with a graduated tape.#

Chandlerian motion #A nearly periodic variation in the astronomic latitudes of points on the Earth's surface. The period has a duration of about 1.2 years and an amplitude of about 0."3 (10 meters).#

This is nearly the same thing as the motion of the instantaneous axis of rotation of the Earth about the Earth's average axis of figure (axis of greatest moment of inertia) but not quite the same because (a) the Earth's crust moves with respect to the mantle and core, and (b) the method of measurement used does not refer to the instantaneous axis of rotation.

channel, main #The deepest and most navigable channel of a navigable stream that existed at the time it was surveyed as a boundary between states or nations.#

chart #A *map* designed for use in navigation.#

The term chart is used primarily for maps developed for nautical or aeronautical navigation, and for maps of the heavens. The term, however, is sometimes used to describe other, special-purpose maps.

chart, aeronautical #A chart designed specifically for use in aircraft navigation.#

An aeronautical chart shows airports, aids, hazards to navigation, and some of the natural features and man-made objects shown on general maps.

chart, alignment See *nomogram.*

chart, bathymetric #A *topographic map* of the bed of the ocean or other body of water.#

Bathymetric charts usually indicate depths by contour lines, with tinted areas between contours. Bathymetric charts are designed especially for geophysical (oceanographic) studies, but are also useful for ship navigation.

chart, fair See *sheet, smooth.*

chart, great-circle #A *chart* on the *gnomonic map projection.* # Hence, a chart on which great circles appear as straight lines.

chart, isogonic #A chart on which lines of constant deviation between geographic north and magnetic north (isogons) are drawn.#

chart, magnetic #A *special-purpose map* showing the distribution of one of the *geomagnetic elements*, or the distribution in secular change of one of these elements.#
An example is a chart showing local deviations of magnetic north from geographic north.

chart, Marsden #A global chart divided into quadrangles (Marsden squares), each extending 10° in latitude and 10° in longitude, which may be subdivided further into quarters or into 1° quadrangles.#
The Marsden chart commonly has a number entered into each subdivision. The numbers indicate some average characteristic of the ocean or atmosphere in the region covered by that subdivision. For example, a Marsden chart of sea-state can show, in each quadrangle, the average, or other characteristic, height of the waves in the corresponding region.

chart, Mercator #A chart based on the *Mercator map projection.*#

chart, nautical #A chart designed for use in navigating on or under water.#
A nautical chart contains information on aids and hazards to navigation, critical depths of the water, etc.

chart, Ney's #A chart designed for use in polar regions based on a modification of the *Lambert conformal map projection* in which the parallels are expanded to form complete concentric circles.#

chart, sailing #A small-scale chart used for offshore sailing between distant coastal ports.#
The sailing chart is used for plotting a craft's position out of sight of land or upon approaching the coast from the open ocean. The chart shows offshore soundings and the most important lights, outer buoys, and natural landmarks visible at considerable distances.

chart, smooth See *sheet, smooth.*

chart, World Aeronautical See *World Aeronautical Chart.*

charting #The preparation of *charts.*#

Cholesky's method #A modification of *Gauss' method* for solving a set of *normal equations*, which minimizes roundoff errors and generally proves more efficient in handling the coefficients of sparse (i.e., relatively few nonzero terms) sets.#
For details, see, e.g., Bomford (1980: pp. 671-2). Also spelled Choleski.

chord (1) #In general, a straight line between two points on a curve.#
(2) #The arc of a great circle connecting any two *corners* on a *base line, standard parallel,* or township's latitudinal boundary.#

chord, long (1) #On a simple curve, the *chord,* or the length of the chord, that extends from the point where a straight line ends and the curve begins (point of curvature) to the point where the curve ends and its straight-line extension continues (point of tangency).#
(2) #On a curve composed of two circular arcs, the *chord* that extends from the point where the two arcs meet either to where the first arc is met by the straight line leading into it or to where the second arc ends and its straight-line extension continues.#
In descriptions of a circular land boundary, the length and bearing of the long chord are important features.

chord, nominal #*Degree of curve* for chords less than 100 feet long.#

chronograph #An instrument for producing a graphical record of time.#
In use, a chronograph produces a double record. The first is made by the associated clock and forms a continuous time scale with significant marks indicating periodic beats of the timekeeper. The second is made by some external agency, human or mechanical, and records the occurrence of an event or a series of events. The times, as shown by the clock, of such occurrences are read from the record made by the chronograph. In observations for time and longitude, the clock's times of stellar observations are recorded on the chronograph either manually by pressing a key at the instant a star is bisected by a line of the reticle of the telescope used in the observing, or automatically, by keeping a star bisected by a movable wire as it travels across the field of view. See *micrometer, transit*. In determining longitudes, the chronograph also records the time signals received from the station of known longitude which is used as a base.

chronometer #A portable clock capable of showing time with high precision and accuracy.#
Chronometers are used in scientific and engineering work (astronomy, navigation, geophysics, etc.) where accuracy and precision in the timing of observations are demanded.

chronometer, break-circuit #A *chronometer* equipped with a device that automatically breaks an electric circuit to indicate a specific time or interval of time.#

chronometer, hack #A *chronometer* used visually for meeting a schedule of observations, making routine settings of instruments, etc., but not usually as an accurate source of actual or recorded time.#

cine-theodolite #A *theodolite* that takes pictures of moving objects through its telescope and simultaneously photographs the readings on the vertical and horizontal circles of the theodolite.#
The object is kept in the camera field of view by one or two operators tracking the object through a (usually separate) telescope. It has been used principally in *flare triangulation* and ballistics.
Some later versions have the horizontal and vertical axes of the theodolite connected to optical or electrical recording devices whose output is recorded, together with time, on magnetic tape.

circle (1) #The locus of all points, in a plane, equidistant from a single point (the center).#
(2) #A telescope having motion only about a horizontal axis.# E.g., a meridian circle is a telescope having movement only in the meridian.

(3) #A circular disk or ring whose perimeter is graduated in angular units.# See *circle, horizontal* and *circle, vertical.*

Many instruments do not require a full 360° circle and use only a sector of a circle. These sectors, and often the instruments containing them, are then called quadrants, sextants, or octants, i.e., quarters, sixths, or eighths of circles.

circle, equatorial #The circle on an ellipsoid of revolution in which a plane through the center of the ellipsoid and perpendicular to the axis of rotation of the ellipsoid intersects the surface.#

If the ellipsoid is a sphere, a particular diameter of the sphere can be specified as the axis of rotation.

circle, finder #A small *vertical circle* with coarse graduations and an auxiliary spirit level of low sensitivity, attached to an astronomical telescope of the type used in geodetic astronomy in a plane perpendicular to the horizontal axis of the telescope, and used in placing the telescope in approximate position for observing.#

Using the angular elevation computed for the proposed time of observation, the telescope is pointed in the direction of the object to be observed. When that object comes into the field of view, the finder circle has served its purpose, and subsequent observations are made with more precise apparatus. Also called a setting circle.

circle, great #The circle formed by the intersection of a sphere with a plane that passes through the center of the sphere.#

The shortest distance between any two points on a sphere is along the arc of a great circle connecting the two points. Great circles on the celestial sphere with particular designations are the Equator, the ecliptic, meridians, hour circles, prime verticals, colures, and horizons. The shortest distance on an ellipsoid of revolution is a geodesic, which is not a plane curve except for the Equator (a circle) and the meridians (ellipses). In cartography, the gnomonic map projection is the only one that transforms all great circles into straight lines. Also called an *orthodrome.*

circle, horizontal #A ring with its perimeter graduated in angular measure and placed perpendicular to a vertical axis of rotation passing through its center.#

Horizontal circles of theodolites were formerly made of metal and the graduations read through two microscopes placed 180° apart. In modern theodolites, the horizontal circle is made of glass and is read through a single microscope which, by a prismatic train, lets the observer see the two opposite sides of the circle simultaneously.

circle, hour #A *great circle* on the celestial sphere that contains the north and south celestial poles.#

circle, setting See *circle, finder.*

circle, small #The intersection of a sphere with a plane not passing through the center of the sphere.# Parallels of latitude are small circles.

circle, stadia See *Beaman arc.*

circle, vertical (1) #A circle with one of its diameters vertical.#

(2) #Any *great circle* of the celestial sphere passing through the zenith (and nadir).# It is the line of intersection of a vertical plane with the celestial sphere.

(3) #A graduated circle so mounted on an instrument that the plane of its graduated surface can be placed in a vertical plane.#

It may be an auxiliary attachment to a theodolite or transit, or it may be the major feature of an instrument intended primarily for use in measuring vertical angles in astronomical and geodetic work.

(4) #A ring with its perimeter graduated in angular measure and placed perpendicularly to a horizontal axis of rotation passing through its center.#

(5) #An instrument used in astronomy for measuring *zenith distances.*# See (3) above and *angle, zenith.*

circle left, vertical See *vertical-circle left.*

circle of confusion #The image of a distant point, formed as a circular spot in a focal plane by an optical system.#

A distant, point-like object (e.g., a star) is imaged in the focal plane of an optical system as an approximately circular spot of finite size for one or more of the following reasons: (a) the focal plane is not at the point of sharpest focus; (b) certain aberrations are present; (c) diffraction is caused by the optical system; (d) the photographic emulsion is grainy; or (e) the lens is of poor quality.

circle of equal altitude See *almucantar.*

circle of least confusion #The image of a point source which has the smallest maximum diameter.#

The smallest *circle of confusion* (as measured by the maximum diameter of the image). The plane on which the circle of least confusion lies is often taken as the *focal plane.*

circle of perpetual apparition #The circle of the *celestial sphere,* centered on the polar axis and a polar distance from the elevated pole approximately equal to the latitude of the observer, within which celestial bodies do not appear to set.

Compare with *circle of perpetual occultation.* See also *star, circumpolar.*

circle of perpetual occultation #The circle of the *celestial sphere,* centered on the polar axis and at a polar distance from the depressed pole approximately equal to the latitude of the observer, within which celestial bodies do not appear to rise at the observer's latitude.#

Compare with *circle of perpetual apparition.*

circle of position #A *small circle* on a sphere representing the Earth at every point of which, at the instant of observation, the observed celestial body (Sun, star, planet) has the same angular elevation and therefore the same *zenith distance.*#

At the instant of observation, the center (on the sphere) of the circle of position is the point which has the same longitude and latitude as the celestial body. The radius (on the celestial sphere) of the circle is the observed zenith angle of the body. The observer is therefore somewhere on that circle. A second observation on the same object at a different time or on a different object at the same time will determine a second and different circle of position, and, if the observer has not moved, it will be at an intersection of these circles. If the observer has moved, as may occur when observations are made from a moving ship, allowance is made for the direction and amount of the movement, and a position is obtained for either point of observation. In navigation, a short portion of a circle of position is plotted as a straight line and is called a *Sumner line* or *line of position*.

circle of uncertainty #A circle whose radius is the *probable error* of the location of its center.#

circle right, vertical See *vertical-circle, right*.

circuit (leveling) #A continuous *line of levels*, a series of lines of levels, or a combination of lines or parts of lines of levels that, together with a continuous series of measured differences of elevation, forms a loop back to the starting point.#

circuit misclosure (leveling) #The amount by which the algebraic sum of the measured differences of elevation around a *circuit* fails to equal zero. See also *misclosure*.

circumferentor #A *surveyor's compass* that has an attached radial arm with a vertical, slotted strip at each end.#

The surveyor sights an object through the two slots and then, by raising his eye slightly, sees and reads off the direction shown on the compass.

circumpolar #Remaining above the observer's horizon during a complete rotation of the Earth.#

The term is commonly applied only to stars and other fixed objects in the sky. See also *circle of perpetual apparition*.

Clairaut's theorem (1) #An equation relating the flattening f, semimajor axis a, rotational rate ω, and values of gravity at the pole, γ_p, and at the Equator, γ_e of a *level ellipsoid*, as expressed by

$$(\gamma_p - \gamma_e)/(\gamma_e) + f = (5\ \omega^2 a)/(2\ \gamma_e).\#$$

This is the original form as given by Clairaut in 1738, and is immediately derivable from the first-order formula for *normal gravity*

$$\gamma = \gamma_e\ [1 + \{(5/2)m\ - f\}\sin^2\ \phi]$$

where $m = \omega^2\ a/\gamma_e$ and ϕ is *geodetic latitude*. The equation holds only to the first-order in f and m. More exact versions, instances of which are referred to as "extended Clairaut theorem", can be obtained by including higher-order terms in f and m, and higher powers of $\sin^2\ \phi$, or by a rigorous expression in closed form in terms of ellipsoidal coordinates. See Heiskanen and Moritz (1967: 64-79).

(2) #For every point P of a geodesic on a surface of revolution, the product of the distance, r_o, of P from the axis of revolution and the sine of the angle θ between the meridian through P and the tangent to the curve at P is a constant, i.e., $r_o \sin\theta$ = constant.#

classification (geodesy) #Placing surveys in hierarchical classes according to certain criteria, such as accuracy, application, etc.#

(1) Surveys may be classified according to the type of application, as, e.g., geodetic, mining, hydrographic, topographic, cadastral, land, engineering, and so on.

(2) Classified by method: leveling, horizontal, satellite geodesy, inertial, etc.

(3) Within each category of (1) or (2), there is usually a classification on the basis of accuracy or precision. In the case of geodetic surveys, with each class is associated a corresponding set of specifications. These specifications give the essential elements that should be present in a surveying procedure if the survey is to lie in the corresponding class.

Such a classification has two purposes: (1) it provides the user of the survey with an immediate, rough, but usually sufficient estimate of the precision of the data being used; and (2) it provides the surveying organization with an efficient way of controlling the precision of surveys. See also *control, classification of*.

clinometer #An instrument, small enough to be held in one hand, that combines a spirit level, a vertical circle, and a sighting device for coarse but rapid measurement of vertical angles.#

One type of clinometer consists of an open tube, with cross hairs at one end (for sighting), which pivots on a flat piece to which are attached a vertical circle and spirit level. The inclination of the line of sight can be read on the circle by holding the flat piece so that the bubble in the spirit level is centered at the instant of observation. By means of a prism, the bubble is kept in view as the observer looks through the observing tube and aligns the observed object with the cross hair. See also *level, hand*.

clock #Any device for indicating the time.#

Conventionally, any time-indicating device too large to be conveniently carried on the person.

clock, atomic #Any clock in which the intervals of time are determined by reference to the frequency of radiation emitted by atoms.#

Since a particular frequency of transition of electrons in cesium atoms has been designated by international agreement as defining the second, cesium clocks are the primary standards of frequency. Rubidium clocks, in which a frequency of transition of electrons in rubidium atoms is used, have better short-term stability than cesium clocks. Although it is common to refer to clocks using the frequency of rotation of ammonia molecules for the referent as atomic clocks, such clocks should be called *molecular clocks* or *masers*.

clock, crystal #A clock in which intervals of time are determined by reference to the frequency of oscillations of a crystal held between plates of a condenser in a resonant circuit.#

The "crystal" is a flat plate cut from a crystal of quartz so that the greatest stability of oscillation is obtained. The crystal is usually cut to have a resonant frequency of either 1 MHz or 5 MHz, although other frequencies that relate better to the sidereal day or the mean solar day have been used. The resonant frequency of the quartz plate is divided down to one cycle or pulse per second by electronic circuits.

clock, molecular #Any clock in which the intervals of time are referred to the frequency of rotation of molecules.#

The first clock of this kind was the ammonia clock. A more recently developed molecular clock uses methane. Molecular clocks are frequently called atomic clocks.

clock, pendulum #A clock that uses the back-and-forth motion of a swinging pendulum to regulate the indicated time.#

Energy is fed to the pendulum by a mechanical or electromagnetic device called an escapement. To a good first approximation, the period of oscillation is independent of the mass of the pendulum and depends only on the length of the pendulum and on the magnitude of the force of gravity at the location of the clock.

clock, Shortt #A *pendulum clock,* formerly much used in observatories and time-services for highest accuracy, which is distinguished by its use of a "slave pendulum" to do the mechanical work such as turning the hands of the clock, opening and closing contacts, and giving the impulses to the master pendulum, thus leaving the master pendulum free of most perturbations.#

clock, stability of #The ability of a clock to keep marking equal intervals of time.#

The increasing accuracy with which time can be measured has led to establishment of three categories of stability: drift (a steady lengthening or shortening of the interval of time over a long period); long-term stability (the root-mean-square deviation of the interval from its average value, after drift has been removed, over a long period of time, generally in excess of 10 seconds); and short-term stability which is the same as long-term stability except that the averaging interval is between 100 microseconds and 10 seconds. These limits and definitions vary somewhat because their usefulness depends on the stability of the clock being characterized. For example, the above definition of short-term stability would be useless if applied to a portable chronometer.

clock correction #The quantity added algebraically to the time shown by a clock to obtain the correct time.#

clock rate #The rate of change of a *clock correction.* #

closing the horizon See *horizon, closing the.*

closure See *misclosure.*

clothoid #A curve, also called the Cornu spiral, having the parametric representation

$$x(t) = \int_0^t \cos(\pi u^2/2)\, du$$

$$y(t) = \int_0^t \sin(\pi u^2/2)\, du .\#$$

The name "Cornu spiral" is applied to the curve as used in physics for determining the pattern of diffraction by slits or apertures. The name "clothoid" is used in surveying to refer to the curve used as a transition between two other curves on the same path, e.g. when laying out roads or tracks. Also called an Eulerian spiral.

coast #A strip of land, of indefinite width, that extends inland, perhaps as much as 1 to 5 km, from the *shore* to the first major change in type of terrain.#

coastline #The line that forms the boundary between the *coast* and the *shore* and marks the seaward limit of the permanently exposed coast.#

The U.S. National Ocean Service uses the terms "coastline" and "shoreline" as synonymous and defines them as being the line of mean high water. The U.S. Submerged Lands Act, 43 U.S.C. 1301(c), states: "The term 'coast line' means the line of mean low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters."

code (1) #A set of symbols causing a computing machine to carry out certain operations such as multiply, print, sort, start, and stop.#

(2) #Any set of symbols so related to another set of symbols that all information contained in the first set is contained in the second set.#

Codes are used principally for two purposes: to hide information from those not entitled to it, or to transform information into a form suitable for transmission or computation. The Morse code and Gray code are codes designed for transmission. Binary coded decimal and sequenced codes are designed for computation.

code, pseudo-random #Any periodic sequence of signals, in which each cycle is very long; the sequence within a cycle has statistical characteristics close to those of a random distribution.#

An alternative, but equivalent, definition is: a sequence of signals organized in sub-sequences so that signals occur with approximate randomness within the sub-sequences and in the sequence as a whole, but each individual sub-sequence carries one unit of information. A common method of generating a pseudo-random sequence containing digits x_1, x_2, ... x_n, ... x_N is to use the method of congruences:

$$x_{n+1} = a\, x_n + b \pmod{T},$$

where b and T are relatively prime integers. a and b are chosen to make the sequence as long as possible before repeating while keeping the numbers as random as possible; T is chosen to fit the base of the computer's number system and the computer's memory capacity. Pseudo-random codes have considerable use in cryptography and simulation studies, as well as in communications when a noise-like signal is wanted.

codeclination #The complement of the (astronomic) *declination*, i.e., 90° minus the declination.#

Also called the *polar distance.*

cogeoid (1) #The surface which lies below the Earth's surface a distance equal to the elevation (referred to mean sea level) of the Earth's surface as determined by leveling. The distance is measured along the vertical to the local level surface.# This kind of cogeoid is the easiest to determine and the most closely related to leveling.

(2) #An equipotential surface which is reached by repeat edly transferring all matter from above to below the geoid, thereby repeatedly lowering the geoid until no change in the position of the geoid results.# This limiting position is the cogeoid. Also called a *regularized geoid* or a *compensated geoid.*

(3) #Any surface derived from observed values of gravity by using Stokes' or a similar formula for the height of the geoid.#

For each type of anomaly (free air, isostatic, etc.) a different cogeoid is obtained. The cogeoid is not, according to most definitions, an equipotential surface nor is it defined in terms of potential. Because of the various definitions, any user of the term should define it precisely before using it.

colatitude #The complement of the latitude; 90° minus the latitude.#

Colatitude forms one side, zenith to pole, of the fundamental astronomical triangle. It is opposite the vertex representing the celestial body.

collimation (1) #The process of bringing the optical elements of an optical system into proper relation with each other.#

The process of bringing the collimated system into proper relation with the pointing mechanism is called *alignment.*

(2) #Adjusting the fiducial marks in a camera so that they locate the principal point.# Also called adjustment for collimation.

(3) #The act of making a *collimation adjustment*.#

This use of the term may lead to confusion; the process should always be identified as a collimation adjustment.

collimation, axis of See *collimation axis.*

collimation, error of #The angle between the line of collimation (line of sight) of a telescope and its collimation axis.#

Also called *collimation error,* although that term has other meanings besides the one above. See *collimation error (1).* If the *collimation adjustment* of an instrument were perfect, the *line of collimation* and the *collimation axis* would coincide, and the error of collimation would be zero. In practical work, the collimation adjustment is continued until the error is so small that it may be considered negligible. In precise work, after the collimation adjustment has been made, the remaining error is either determined by observation and applied as a correction, or is eliminated from the result by a suitable program of observing. Error of collimation is systematic, so in a series of observations it is usually treated as a constant.

collimation, line of #The line through the second nodal point of the objective of a telescope and the center of the *reticle.*#

Also called the *line of sight,* sight line, pointing line, and aiming line of the instrument.

The center of the reticle of the telescope of a transit can be defined by the intersection of cross hairs, by the midpoint of a fixed vertical wire, or by the midpoint of a micrometer wire in its average position. In a leveling instrument, the center of the reticle may be the midpoint of a fixed horizontal wire.

collimation adjustment #The process of bringing the line of collimation of a surveying instrument into close agreement with the *collimation axis.*#

Also called adjustment for collimation or, ambiguously, *collimation.*

collimation axis #The line through the second nodal point of the objective of a telescope and perpendicular to the axis of rotation of the telescope.#

collimation correction factor #The quantity

$$C = -[(H^b - H^f)_1 - (H^b - H^f)_2]/[(I^b - I^f)_1 - (I^b - I^f)_2].$$

In this formula, H is a height read on a leveling rod, I is the corresponding stadia intercept; superscripts b and f denote the backward and forward leveling rods, respectively; and subscripts 1 and 2 denote positions 1 and 2 of the leveling instrument with respect to the leveling rods. In position 1, the leveling instrument is about 10 m from the backward leveling rod and about 50 m from the forward leveling rod; in position 2, the leveling instrument has been moved forward to within 10 m of the forward leveling rod and so is about 50 m from the backward leveling rod.#

The collimation correction factor, multiplied by the ratio of *stadia intercept* to horizontal distance (or divided by the *stadia factor*) gives the tangent of the angle from the line of sight in the *leveling instrument* to the horizontal plane, and is approximately the correction needed to make the line of sight horizontal. Also called the level constant and the C-factor.

collimation correction factor, level See *collimation correction factor.*

collimation error #The angle between the actual *line of sight* in an optical instrument and the position the line of sight would have in a perfect instrument.# There are several different interpretations of this definition.

(1) #The angle between the actual line of sight and a line through the second (rear) nodal point of the objective and perpendicular to the axis of rotation.# This interpretation, commonly accepted in surveying, is applied to theodolites, meridian instruments, transits, and levels, and is synonymous with error of collimation.

(2) #The angle between the actual line of sight and the optical axis of a perfectly adjusted optical system.#

Divergence of the optical axis from perpendicularity to the axis of rotation is then called *alignment error.* This interpretation is used in astronomical optics and other fields. Collimation error in sense (1) above is then the sum of alignment error and collimation error in sense (2).

(3) The line of sight and the axis of rotation are generally skew to each other. The collimation error is therefore sometimes defined as #the angle between two planes, one through the line of sight and parallel to the axis of rotation and the other through the rear nodal point (of the objective) and the axis of rotation.# This is the projection, onto a plane perpendicular to the axis of rotation, of the angle in sense (1) above. The other component of direction between the two lines does not have a universally accepted name, although the terms "skew angle" and "skew error" have been used.

(4) By extension, in radio telescopes, #the angle between the plane perpendicular to the antenna baseline and the surface of symmetry of the central lobe.# Because the angle varies with distance from the antenna, a cone asymptotic to this surface is sometimes chosen instead. Also called squint angle.

(5) See *collimation error, level.*

collimation error, level #The angle from a horizontal plane to the line of collimation of a telescope when all leveling devices indicate that the line of collimation should be level.#

The angle is considered positive upwards. Also referred to as collimation error.

collimation factor (1) #The factor c^* or c in *Mayer's* or *Bessel's formula*.#

It is also called the *collimation error* and is equal to the angle between the optical axis of a telescope and a vertical plane through north.

(2) #The tangent of the *level collimation error*.#

The term is used in this sense by Schomaker and Berry (1981) who refer to it also as "C" or "C-factor". The relation between it and the collimation correction factor is given by

$$C_R = C_{SB}\,\beta$$

where C_R is C (collimation correction factor) as defined in Rappleye (1948), C_{SB} is the collimation factor as defined above, and β is the *stadia factor*.

collimation plane #The plane described by the *collimation axis* of a telescope of a transit when the telescope is rotated around a horizontal axis.#

collimator (1) #Any device for lining up (collimating) the optical axes of the various elements of an optical system.#

The usual collimator consists of a reticle and an arrangement of lenses for passing light through the reticle perpendicularly to the plane of the reticle, e.g., by placing the observer or a light source at the principal focus of the lens system. A source of light is often included.

The mark in a collimator may be viewed from very short distances with the same effect as if it were at an infinite distance, and therefore may be used in place of a distant mark when making any adjustment of the line of sight (line of collimation) of an instrument. In adjusting a surveying instrument, the telescope of another surveying instrument may be used as a collimator, the reticle furnishing the mark. Alternately, the telescope of a discarded instrument may be placed on a special mounting to form a permanent installation.

(2) #A lens or lens system for producing a planar wavefront of light from a spherical wavefront.#

Equivalently, it may be considered a lens system for producing parallel rays of light. Also called a collimating lens.

collimator, auto- See *autocollimator.*

collimator, vertical #A telescope so mounted that its *collimation axis* can be made to coincide with the vertical, or with the direction of the plumb line.#

The vertical collimator serves as an optical plumb line. It may be used for placing a mark on the ground directly under an instrument on a high tower or for centering an instrument on a high tower directly over a mark on the ground.

collinearity condition #The condition under which a point in object space, the corresponding point in image space, and the corresponding perspective center are collinear.#

Note the similarity to the *coplanarity condition,* which states a relationship between three lines and one plane. It has been found that photogrammetric problems formulated in terms of the collinearity condition are better suited for computation than those formulated with the coplanarity condition.

collocation (1) #A generalized theory of least squares adjustment that includes two kinds of random quantities—noise (residuals in the classical least squares, obtained from observations) and signals—related by a known covariance function.

The method combines adjustment of model parameters in the conventional least squares sense, with predicted (interpolation and extrapolation) of the signals, which may be expressed continuously or discretely. In geodetic applications, an example is the determination of the gravity field where the observations are gravity measurements, the signals are gravity anomalies, the noise is any random measuring error, and the adjusted parameters are the parameters of the normal gravity field.

A least squares collocation solution depends on assumption of knowledge of the covariance function between signals and observations. The determination of adequate models for both global and local covariance functions is an essential aspect of application of this method.

Because the gravity field is continuous in structure, and contains an unlimited number of parameters, the method of collocation can be naturally extended to infinite dimensional Hilbert space. See Moritz (1980) for details.

The name "collocation" (due to Torben Krarup) indicates that the signals attain a given set of values at given points. However, this does not hold exactly in the presence of random noise.

(2) #The exact agreement of a function with the boundary values of a boundary-value problem.#

(3) #A method of solving, approximately, a system of differential equations by expressing the solution as a sum

$$y = y_o(x) + k_1y_1(x) + \ldots + k_Ny_N(x),$$

where y_o is any function satisfying the boundary conditions.#

(4) See *colocation.*

colocation #The placement of two different geodetic instruments at the same control point.#

By extension, the placement of different instruments near but not at the same point, with all instruments connected geodetically to the control point.

colure An *hour circle* through the *equinox* or the *solstice.*

colure, equinoctial #The *hour circle* through the *equinox.* #

colure, solsticial #The *hour circle* through the *solstice.* #

coma #The aberration of an optical system which causes rays from an off-axis point in object space to be imaged in a circle rather than in a point upon passing through a given circular zone of the optical system. The circles formed by rays through different zones of the lens are of different sizes and are located at different distances from the optical axis.#

The resulting pattern, the comatic patch, looks in the focal plane like a drop of water about to break off from a dripping faucet, or like a comet with a wide tail. The tip of the comatic patch is the intersection of the principal ray with the focal plane.

comb #A notched scale placed at right angles to the movable wire of a *filar micrometer,* and designed so that one turn of the micrometer screw will move the micrometer wire across one notch of the scale.#

The central notch of the comb, in conjunction with the zero of the micrometer head, furnishes a fiducial point from which all readings are reckoned. The comb is used for keeping count of whole turns of the micrometer screw; parts of turns are read on the graduated micrometer head.

common establishment See *establishment of the port.*

comparator (1) #An instrument or apparatus for measuring a length or dimension in terms of a standard.#

In surveying, a comparator may be an instrument for comparing standards of length, for subdividing such standards, or for determining the standard length of a measuring device such as a bar, tape or wire. A field comparator or comparator base is a short line whose length has been measured both accurately and precisely; it is used to check the lengths of apparatus (tapes) used in surveying. Special types of comparators are used in astronomic and photogrammetric work, and in various other sciences and engineering.

(2) #A precise optical instrument used to determine the rectangular coordinates of a point with respect to those of another point on any plane surface, such as a photographic plate.#

comparator, blink #An instrument for comparing two photographs by viewing them alternately and rapidly.#

The two photographs are placed side by side in the comparator and viewed simultaneously through a single microscope. The photographs are adjusted until their images are superimposed as exactly as possible. The photographs are then illuminated alternately at a high rate. Any object not in the same place in both pictures appears to flicker or move back and forth. The instrument is widely used for detecting movement of stars, satellites, or other such objects. Also called a blink microscope or a flicker comparator.

comparator, flicker See *comparator, blink.*

comparator, stereoscopic #A photogrammetric instrument that permits stereoscopic viewing of two photographs and measurement of the coordinates of corresponding points, the coordinates of one point and the stereoscopic parallax of its conjugate, or just the parallax between the two points.# Often called a stereocomparator.

comparator, Väisälä See *base line apparatus, Väisälä.*

comparator, Väisälä light-interference See *base line apparatus, Väisälä.*

compass #An instrument that indicates the direction of north and the directions of other points with respect to north.#

The most common type is the *magnetic compass,* which indicates the direction of magnetic north. The *gyroscopic compass* is usually set to indicate astronomic north or, less frequently, geodetic north. The *solar compass* and the *sun compass* also indicate astronomic north, but can be used only during daylight; their use requires some knowledge of the Sun's position. See also *declination, magnetic;* and *declination arc.*

compass, Anschutz #A particular make of gyroscopic compass.#

compass, aperiodic #Literally, "a compass without a period"; that is, a compass whose indicator, after being deflected, returns by one direct movement, without oscillation, to its proper reading.# Also called a deadbeat compass.

compass, box #A combined straightedge and *magnetic compass,* suitable for use on a plane table to mark the *magnetic meridian.* #

Also called a declinatoire, or trough compass.

compass, Brunton #A small instrument combining the features of both the *sighting compass* and the *clinometer.* #

It can be held in the hand or supported upon a *Jacob's staff* or light tripod when in use for determining horizontal and vertical angles, for leveling, or for determining the magnetic bearing of a line. Also called Brunton pocket transit.

compass, Burt See *compass, solar.*

compass, deadbeat See *compass, aperiodic.*

compass, declination of See *declination, magnetic.*

compass, deviation of #The deflection of the needle of a *magnetic compass* by the magnetic fields(s) of metallic masses within the ship on which the compass is located.#

compass, Earth-inductor #A compass depending for its indications on the current generated in coils rotating in the Earth's magnetic field.#

compass, gyroscopic #(1) A compass consisting of a gyroscope suspended so that its axis of rotation points north.#

Gravitational torque and the Earth's rotation combine to cause the gyroscope's axis of rotation to precess along an ellipse if motion is unconstrained. A damping force is therefore imposed on the precessing motion, which causes the axis to move in a spiral path ending at north. At high latitudes, gyroscopic compasses become undependable.

A *magnetic compass* fixed to a mounting stabilized by gyroscopes is sometimes mistakenly referred to as a gyroscopic compass.

compass, magnetic #A device that indicates direction by means of a magnet supported at its midpoint so that the magnet aligns itself with the local magnetic field. The end of the magnet which points in the general direction of north is marked.#

compass, prismatic #A small, hand-held *magnetic compass*, equipped with peep sights and glass prism arranged so that the *magnetic bearing* or *magnetic azimuth* of a line can be read while a sight is being taken over the line.#

compass, sighting #A *magnetic compass* with a sighting device attached for determining the direction of an object from the observer.#

The sighting device usually is just a pair of upright, slitted pieces of metal placed on the rim of the compass at opposite sides of the pivot. See also *compass, prismatic.*

compass, solar #A compass for determining astronomic north, the astronomic meridian, or bearings from astronomic north, by observations on the Sun. The observer sets his latitude and the hour-angle and declination of the Sun on accurately divided circles, so when one sighting device is pointed at the Sun, another sighting device points toward astronomic north.# See also *declination arc.*

compass, sun #A navigation instrument for determining the direction of the astronomic meridian mechanically and instantaneously from an observation on the Sun.#

The sun compass differs mechanically from a *solar compass,* and is designed for use on a moving vehicle.

compass, surveyor's #A compass for determining the *magnetic azimuth* of a line of sight by means of a sighting device, a graduated horizontal circle, and a pivoted magnetic needle.#

Older versions almost universally indicate *bearings,* rather than azimuths.

The surveyor's compass used on the early land surveys in the United States contained a pair of peep sights to define the line of sight, and was usually mounted on a single leg, called a *Jacob's staff.* This instrument has been completely displaced by the surveyor's transit, and the solar transit.

compass, trough See *compass, box.*

compass, variation of See *magnetic variation.* Navigators use the term variation, land surveyors the term declination.

compass rose #A circle graduated in degrees clockwise from 0° at the reference direction to 360°, in direction *points of the compass*, in both degrees and points, or in *bearings.* #

compass rule for balancing a survey See *traverse adjustment, compass rule for.*

compensation (geology) #The process by which the Earth's crust and interior adjust themselves to maintain nearly static equilibrium in spite of the shift, by geological forces, of matter from one part of the surface to another.#

compensation, depth of #The depth to which a column of matter must extend to keep itself in hydrostatic equilibrium with surrounding matter.#

In *Pratt's hypothesis of isostasy,* the depth of compensation from the *geoid* is a constant; the density of matter in a column depends on the latitude and longitude but not the depth. In *Airy's hypothesis of isostasy*, the depth of compensation from the *geoid* varies with latitude and longitude, but the density of the column is constant. See also *isostasy* and *isostatic compensation.*

compensation, isostatic See *isostatic compensation.*

compensation plate (photogrammetry) #A glass plate having a surface ground to a predetermined shape, for insertion in the optical system of a diapositive printer or plotting instrument, to compensate for radial distortion introduced by the camera lens.#

compensator #An optical-mechanical device interposed in the *line of sight* (line of collimation) of a leveling instrument to keep the line of sight horizontal regardless of the tilt (within limits) of the rest of the instrument.#

It consists of at least one optical element (prism, mirror or train of prisms or mirrors) suspended by fine invar wire, by flexible tapes, or as the bob on a pendulum. The force of gravity keeps the component from rotating with the rest of the instrument when the instrument is rotated slightly in a vertical plane. The arrangement of rotating and nonrotating components is such that a horizontal ray entering the tilted telescope is deflected by the compensator so it passes first through the center of the reticle and then through the ocular to the observer. The compensator of most leveling instruments can compensate for about 10' of tilt in the instrument. It replaces the sensitive spirit level that required manual adjustment for tilt of the telescope. A leveling instrument equipped with a compensator is referred to as an automatic level, a compensator leveling instrument, or a self-leveling instrument.

compilation (1) #The production of a new or revised map or chart, or portions thereof, from existing maps, aerial photographs, surveys, new data and other sources.#

(2) #The production of a map or chart, or portions thereof, from aerial photographs and geodetic control data, by means of photogrammetric instruments.#

The process is called stereocompilation if stereoscopic plotting instruments are used.

compilation, primary #The depiction, on a specially prepared matte plastic sheet, of sounding data corrected to true depths.#

compilation manuscript #The original drawing or drawings on a stable base of a map or chart as compiled or constructed from various data, on which cartographic and related detail is delineated in color.#

compression (of the Earth) See *flattening.*

condensation (geodesy) #The theoretical replacement of matter between the geoid and the surface of the Earth by an equivalent layer of matter on the *geoid.* #

conformality #The property of transformation from one surface to another which insures that the angle between any two curves on one surface is preserved in magnitude and sense by the angle between the corresponding curves on the other surface.#

This property is equivalent to the condition that the coefficients of the first fundamental form on one surface be proportional to the corresponding coefficients on the other surface, with both surfaces having the same coordinate systems.

conjunction (astronomy) #The configuration taken by the Sun, the Earth, and another planet when the apparent geocentric (celestial) longitude of Sun and planet are the same.#

Conrad discontinuity See *discontinuity, Conrad.*

constant (physical sciences) (1) #Any number that is accepted by physical scientists as characterizing a measurable, calculable, or defined quantity.#

There are three kinds of constants in use: (a) Constants whose values are independent of measurement by definition. The length of the *meter,* the mass of the *kilogram,* the duration of the *second,* and intensity of the ampere are such constants. (b) Constants by definition whose values can nevertheless be determined by measurement. Examples are the velocity of light, the gravitational constant, and the charge on the electron. Since the definitions are usually based on the best measurements available at the time of definition, the defined value is usually not as close to the true value of the natural quantity as are values observed some time after initial definition. Use of the currently accepted defined value, however, ensures that results calculated by different scientists are comparable. The defined values can be changed at intervals, by international agreement, to agree better with the best values obtainable by measurement. The constants described under (a) and (b) are known as primary, or fundamental, constants. (c) Constants derived by calculation from defined constants. These are frequently used quantities which it is convenient to express in terms of the defined constants of (a) and (b) above. Also called derived constants.

For definitions and values of various constants, see the name of the object to which it applies (e.g., *solar constant*) or the science in which it is used (e.g., *astronomical constant, physical constant, geodetic constant*).

constant, Gaussian See *gravitational constant.*

constant, level See *collimation correction factor.*

constituent (tides) #A term in the Fourier series representation of the variation of tidal height with time at a particular *tide station.* #

A single constituent is usually written in the form

$$y = A\cos(at + \alpha),$$

in which y is a function of the time t and is reckoned from a specified origin. The coefficient A is called the amplitude of the constituent and is a measure of its relative importance. The angle $(at + \alpha)$ changes uniformly and its value at any time is called the phase of the constituent. The "speed" of the constituent is the rate of change in its phase and is represented by the symbol a. The quantity α is the phase of the constituent at the initial time. The period of the constituent is the time required for the phase to change through 360° and is the cycle of the astronomical condition represented by the constituent. See also *tide.*

constituent, long-period #A *constituent* having a period longer than one day.#

constituent, species of #A classification of tidal constituents according to the period of the constituent.#

The principal species are semidiurnal, diurnal, and long-period.

contact correction See *micrometer, contact correction for.*

continent #One of the land masses of the Earth identified as the continents of Africa, Antarctica, Asia, Australia, Europe, North America, and South America. Greenland is sometimes included.#

continental drift #The hypothesis that the continents of today were at one time integral parts of a single large continent (Pangea) or of a northern continent (Laurasia) separated by the Tethys Sea from a southern continent (Gonwanaland).#

Evidence provided by paleomagnetic data on seafloor spreading and movement of the magnetic pole led in the late 1960's to widespread acceptance of the hypothesis. However, in the general theory of *plate tectonics,* there is no definite correspondence between individual plates and continents, and it has been shown that most long term crustal motion occurs in the oceans. Thus the hypothesis remains controversial.

contour (1) #An imaginary line on the ground, all points of which are at the same elevation above or below a specified reference surface.#

An example of a *contour* is illustrated by the shoreline of an imaginary body of water, whose surface is at the *elevation* represented by the contour. A contour forming a closed loop around lower ground is called a depression contour.

A contour should not be confused with a *contour line,* which is a line drawn on a map.

(2) In general, a line on a surface on which a function of location on that surface remains constant.

contour, carrying See *contour line, carrying.*

contour, geoidal #A line, on the surface of the geoid, of constant elevation above the surface of the *reference ellipsoid.* #

contour, index See *contour line, index.*

contour finder #A stereoscopic instrument of simple design for tracing contour lines from stereoscopic pairs of photographs.#

It does not compensate for changes of scale resulting from differences in relief or from tilt in the optical axis of the camera.

contouring, logical #A method of drawing contour lines by spacing them proportionately between elevations established at points where the slope changes.#

This procedure, based on the assumption that the slope is uniform between such points, permits the sketching of contours of adequate accuracy from carefully located spot elevations.

contour interval (1) #The difference in elevation between two adjacent contours. See *contour (1)*. The difference of elevation represented by adjacent contour lines.# This is the most common use of the term in geodesy.

In general, (2) #The numerical difference between two adjacent contours. See *contour (2)*.#

contour interval, variable #A nonuniform contour interval.#

Variable contour intervals may occur when cartographic sources that contain different contour intervals are used or when adapting the contour interval for best showing the relief of specific types of terrain.

contour line #A line on a map representing a contour.#

contour line, carrying #A single contour line representing two or more contours.# It is used to show vertical or nearly vertical topographic features such as cliffs, cuts and fills.

contour line, index A *contour line* accentuated by a heavier line-weight to distinguish it from the contour lines on either side; usually drawn for a multiple of the basic contour interval.#

contra sole See *rotation, counter-clockwise*.

contrast (photography) (1) #The actual difference in density between the highlights and the shadows on a negative or positive.# Contrast does not refer to the magnitude of densities, but only to the difference in densities.

(2) #The rating of a photographic material corresponding to the relative density difference it is capable of reproducing.#

control (1) #A *control station*.#

(2) #The *coordinates* of a control station.#

(3) #Both (1) and (2), i.e., a control station and its coordinates.#

(4) #A collection of control stations.#

(5) #The geometric data associated with a collection of control stations, such as coordinates, distances, angles, or directions between control stations.# It is practically equivalent, in this sense, to *basic control*.

(6) #The collection of control stations and the geometric data associated with them.# It is equivalent, in this sense, to *control network*.

In general, one must determine from the context which of the above meanings is intended. See *station, control*.

control, basic In general, #the data associated with a set of control stations and used as the basis for detailed surveys.#

Basic control is not changed by the detailed surveys nor by their subsequent adjustment. Basic control may be horizontal, vertical, or both. The basic control for topographic maps of the United States consists of the data from first- and second-order triangulation and traverse and from first- and second-order leveling.

control, cadastral (1) #Control established specifically for use by a *cadastral survey*.#

(2) #Lines established and marked on the ground by survey monuments that are used as starting and closing points in surveys of the public domain of the United States.#

The fundamental cadastral control of the public-land surveys of the United States consists of base lines, *standard parallels* (correction lines), *principal meridians*, and *guide meridians*.

control, classification of Control is classified either by the kind of coordinates involved (e.g., horizontal or vertical) or by the average accuracy or precision, (e.g., first order and second order). The United States of America has, from time to time, revised the classification of its control networks. The most recent classification is given in *Standards and Specifications for Geodetic Control Networks* (Federal Geodetic Control Committee 1984). Three schemes are used. For horizontal control, the categories and the criteria defining them are:

First order	1: 100,000
Second order	
Class I	1: 50,000
Class II	1: 20,000
Third order	
Class I	1: 10,000
Class II	1: 5,000

The numerical criteria are the maximum values of the ratio of standard deviation of distances between survey points to the distances themselves.

For vertical control, the categories and the criteria defining them are:

First order	
Class I	0.5
Class II	0.7
Second order	
Class I	1.0
Class II	1.3
Third order	2.0

The numerical criteria are the maximum values of the ratio of standard deviations of elevation differences in millimeters between survey points to the square root of the horizontal distance in kilometers between those points (traced along level routes).

The numerical definitions of the classes are called *standards of accuracy*. They are supplemented by *specifications* which set forth those steps and numerical quantities in the surveying procedure considered essential to achieving the required standard of accuracy.

The 1984 classification does not provide a category for control significantly more accurate or precise than that listed as "first-order control" of the United States of America. The nationwide traverse made with geodimeters has, for that reason, been called a "high-precision traverse", although this is not an official category. Using stellar triangulation (Väisälä's method), Finland has reduced the errors in its horizontal control to the point where the control deserves a special category. This problem of classification will probably be provided for in future schemes of classification. A detailed discussion will be found in Federal Geodetic Control Committee *(1984)*.

See also *classification; specifications; standards of accuracy;* and the classification of particular kinds of survey such as *leveling, triangulation,* and *traverse.*

control, geodetic (1) A synonym for control. (2) #A set of control stations established by geodetic methods.#

The data of geodetic control consist first of the distances, directions, and angles, between control stations. These are converted to geodetic coordinates and azimuths. The latter, in turn, may be converted into other kinds of coordinates such as plane coordinates in a *State plane coordinate system*. This is the form in which they are usually used in the United States for local surveys.

control, ground #A point or set of points, the coordinates of which have been determined by survey, used for fixing the scale and position of a photogrammetrically determined network.#

Also called photogrammetric control or field control.

control, horizontal (1) #A *control station* whose horizontal coordinates have been determined.# (2) #The geometric data relating to the horizontal coordinates of a control station.#

For classification of horizontal control, and for definitions of specific categories of horizontal control, see *control, classification of.* For definitions of specific methods of obtaining horizontal control, see *triangulation; trilateration; traverse; control, photogrammetric.*

control, photogrammetric (1) #Geodetic or other control established to provide scale, location, and orientation for a photogrammetric network.#

Locations of photogrammetric control points are marked on the ground before photographing so the points can be identified in the photographs. Also called ground control.

(2) #Geodetic control established by photogrammetric methods.#

control, vertical (1) #Control points whose elevations are accurately known can be identified with physical points on the Earth, and can be used to provide elevations for other surveys.#

Elevations are referred, by definition, to the *geoid.* However, horizontal surfaces through selected points on mean sea level have been used for reference, as have non-horizontal surfaces defined by a combination of leveling surveys and points on mean sea level.

(2) #The elevations (or approximations thereto) associated with control points.#

See also *control, classification of; leveling, classification of; leveling; geoid; datum, vertical control;* and *mean sea level.*

control base #A surface upon which the graticule of a map and ground control are plotted and upon which templets have been assembled or upon which aerotriangulation has been done and the control points thus determined have been marked.#

control network *#Geodetic control* together with the measured or adjusted values of the distances, angles, directions, or heights used in determining the coordinates of the control.#

control point (1) #A point to which coordinates have been assigned; these coordinates are then used in other (dependent) surveys.#

The term is sometimes used as a synonym for *control station.* However, a control point need not be realized on the ground.

(2) #A point identified on a photograph with known coordinates that is used with others for establishing the scale and absolute orientation of the photograph.#

The term is usually modified to show the type or purpose of the point, for example, ground control point, horizontal control point, photocontrol point, picture control point, and vertical control point.

control point, secondary #A photographically identifiable point, whose location has been determined either photogrammetrically or by means of an accurate positioning or navigation system.# *Hiran* and *shiran* (positioning systems) have been used for this purpose.

control station See *station, control.*

control survey See *survey, control.*

control survey, first-order See *survey, first-order.*

control survey, second-order See *survey, second-order.*

control survey net, national See *survey network.*

Conventional International Origin #The origin of a coordinate system, derived from the following original latitudes of five observatories:

Misuzawa, Japan	N 39° 8′ 3.″602
Kitab, U.S.S.R.	N 39° 8′ 1.″850
Carloforte, Italy	N 39° 8′ 8.″941
Gaithersburg, MD	N 39° 8′ 13.″2022
Ukiah, CA	N 39° 8′ 12.″096.#

It is approximately the average position, on the Earth, of the Earth's axis of rotation during the period 1900 to 1905. It is used as the origin for the coordinates of the instantaneous pole of rotation of the Earth. In 1967, the International Union of Geodesy and Geophysics recommended that the Conventional International Origin (CIO) be used in defining the direction of a north pole for geodetic reference systems.

convergence (of meridians) See *meridian, convergence of.*

convergence, grid See *grid, convergence*, and *gisement*.
Conybeare leveling rod See *leveling rod*.
coordinate (1) #One of a set of N numbers designating the location of a point in N-dimensional space.#

Examples are: (a) A single real number is necessary and sufficient to designate the location of a point on a line (relative to other points on the line) which does not intersect itself; such a number could be the distance along the line from some starting point. (b) The only 4-dimensional space of geodetic importance is that in which three of the coordinates (x, y, z) are spatial in nature and the fourth is time (t). (c) Coordinates in 6-dimensional space are frequently used in dynamics; three of them are locational coordinates, the other three are the corresponding components of velocity. (d) The set of N numbers can be infinite (e.g., Hilbert space).

Coordinates are almost always associated with *coordinate systems*. A coordinate system provides an easy way for finding the point designated by the set of coordinates, or for assigning a set of coordinates to a point. The coordinates are said to be "in" the associated coordinate system. It is also common to speak of the associated point as being "in" that coordinate system. Properly speaking, however, the point and its location are independent of the coordinate system; only the values of the coordinates assigned to the point depend on the coordinate system.

More generally, (2) #one of a set of N numbers designating the location of a point in M space, where M may be less than N.# There are then N-M relations between the coordinates in a set of coordinates. Typical are *homogeneous coordinates* and Plücker's coordinates.

coordinate, angular #An angle used as a coordinate, i.e., an angle that, together with other coordinates, specifies the position of a point.#

Astronomers use two angular coordinates for specifying the directions to stars and similar celestial objects. These coordinates are called a "position", although the third coordinate, distance, is usually absent.

coordinate, astronomic (1) #One of a pair of numbers indicating the direction of the zenith at a point on the Earth's surface; the direction is referred to (a) a selected celestial meridian to give an angle called the astronomic longitude; and (b) the celestial Equator to give an angle called the astronomic latitude.#

At least to within the ability of present-day instruments to measure it, the direction of the zenith (the direction opposite to that of gravity) is unique at every point on the Earth's surface. Each point on the Earth's surface therefore has a unique pair of astronomic coordinates. See also *triangle, astronomical*.

(2) For a point on the Earth's surface, #one of a pair of numbers giving the direction of the zenith determined at that point on the geoid which is vertically below the point on the surface; the coordinate system, terminology and symbolism are otherwise the same as in definition (1).#

Some organizations define astronomic coordinates according to definition (2) but have on file actually the coordinates according to definition (1). Where the distance between the Earth's surface and the geoid is so great that the curvature of the vertical between the two points is significant, the user of astronomic coordinates should check the procedure used for obtaining the coordinates to determine which definition actually applies.

(3) #A coordinate in a coordinate system defined wholly or in part by reference to celestial bodies, e.g., right ascension and declination.#

coordinate, barycentric #A coordinate of a point in a *barycentric coordinate system*. #
coordinate, Cartesian #A coordinate, of a point, in a *Cartesian coordinate system*.#
coordinate, Cassini #One of a pair of coordinates in the *rectangular spherical coordinate system*.# Also called Soldner coordinate.
coordinate, curvilinear #A coordinate in a *curvilinear coordinate system*.#
coordinate, ellipsoidal (1) #A coordinate in an *ellipsoidal coordinate system (1)*.# Also called *Lamé coordinate*.

Algebraically, an ellipsoidal coordinate is defined as one of a set of three numbers ξ_i ($i = 1$ to 3) satisfying simultaneously the three terms of the following equation

$$x^2/(a^2 + \xi_i^2) + y^2/(b^2 + \xi_i^2) + z^2/(c^2 + \xi_i^2) = 1,$$

where x, y, z are rectangular Cartesian coordinates and a, b, c are constants.

(2) #A coordinate in an *ellipsoidal coordinate system (2)*. #

coordinate, equatorial spherical (1) #One of three quantities specifying: the distance of a point from the origin; the angle, at the origin, from a given plane through the origin (Equator) to the point; and the angle from a second plane through the origin, perpendicular to the Equator, to the line from origin to point.#

The three coordinates are called radial distance, latitude, and longitude, respectively. See also *coordinate, polar*.

(2) #The same as the previous definition except the complement of the first-mentioned angle is used instead.# Called colatitude.

coordinate, Gauss-Krüger #One of a pair of coordinates in the coordinate system of the *transverse Mercator map projection*. #
coordinate, geocentric (1) #One of a set of three coordinates in a *geocentric coordinate system*.#

(2) #One of a set of coordinates designating the location of a point by means of the angles made between a line from the center of the Earth to the point and the planes of the celestial Equator and of a selected initial geodetic meridian.# See *latitude, geocentric*.

coordinate, geodetic #One of a set of coordinates designating the location of a point with respect to the reference ellipsoid and with respect to the planes of the geodetic Equator and a selected geodetic meridian.# See *latitude, geodetic; longitude, geodetic;* and *coordinate system, geodetic*.

The geodetic coordinates (λ, ϕ, h) of a point are related to the rectangular Cartesian coordinates (x, y, z) of the point by the equations below. Both coordinate systems have the same origin, the z-axis lies on the axis of rotation of the ellipsoid with semimajor axis of length a and eccentricity e, and the x-axis lies in the plane of the zero meridian).

$$x = (N + h) \cos \phi \cos \lambda,$$
$$y = (N + h) \cos \phi \sin \lambda,$$
$$z = [N(1 - e^2) + h] \sin \phi,$$

where $N = a/(1 - e^2 \sin^2 \phi)^{1/2}$.

N is the length of that part of the perpendicular (the "normal") to the surface lying between the surface and the minor axis (radius of curvature in the prime vertical).

coordinate, geographic (1) #An inclusive term, used to designate either a geodetic or an astronomic coordinate.#

(2) The term may also designate #one of a pair of coordinates that specify the angular distances of a point from a meridian and from the Equator.#

coordinate, grid #A coordinate in a *grid coordinate system.* #

In particular, in geodesy, a coordinate in a *plane rectangular Cartesian coordinate system.* See *coordinate system, grid*. In this sense, it is common to think of grid coordinates as two distances which fix the position of a point on a grid: the perpendicular distance to the point from the y-axis (the abscissa or x-coordinate); and the perpendicular distance from the x-axis (the ordinate or y-coordinate).

In surveying, the nominal origin at the intersection of the axes is usually given large numerical coordinates, so the inconvenience of using negative coordinates can be avoided.

coordinate, homogeneous #In 3-space, one of a set of four coordinates w_1, w_2, w_3, w_4 assigned to each point in such a way that the Cartesian coordinates (x,y,z) of a point are given by

$$x = w_1/w_4;\ y = w_2/w_4;\ z = w_3/w_4.\#$$

Homogeneous coordinates have the advantage that all algebraic equations become homogeneous. This makes for symmetry in the theory and can provide greater ease or versatility in programming.

coordinate, horizontal (1) #One of a pair of coordinates referred to a coordinate system on a level surface, usually the geoid.#

(2) #One of a pair of coordinates referred to a coordinate system on an ellipsoid taken to represent the Earth.#

(3) #One of a pair of coordinates on a horizontal plane.#

coordinate, isometric #For a given surface, one of the coordinate pair (x,y) such that the element of length, ds, on that surface is given by

$$ds^2 = m(dx^2 + dy^2)$$

where m is a function of (x,y).#

Examples of isometric coordinates:

(a) Plane: Cartesian coordinates with m constant

(b) Sphere: (χ, λ) with $m = R^2 \cos^2 \phi$,

λ = longitude, ϕ = latitude

R = radius of sphere and

$d\chi = \sec \phi \, d\phi$

(c) Ellipsoid: *see latitude, isometric (1).*

coordinate, Lamé #See *coordinate system, ellipsoidal (1)*.

coordinate, Mercator #One of the *Cartesian coordinates* defined by a *Mercator map projection*.#

coordinate, photo #One of a pair of coordinates of a point on a photograph, given in a coordinate system lying in a plane approximating the surface of the photograph.#

A rectangular Cartesian coordinate system, established by the measuring engine (comparator) that was used for measuring the coordinates, is common. However, polar coordinates have been used in photographic astrometry, and coordinates of other kinds have been used on photographs taken by a camera with a curved focal surface.

coordinate, plane rectangular #One of a pair of coordinates in a rectangular coordinate system in the plane, i.e., in a *plane rectangular coordinate system*.#

In geodesy, plane rectangular coordinates are usually calculated from data in the form of polar coordinates, that is, the distances and directions (bearings or azimuths) of points from previously determined points, such as the computation of latitudes and departures in land surveying. The methods used are based on plane geometry and trigonometry. The location of a point on the Earth may be given by plane rectangular coordinates on a tangent plane or on a conic or cylindrical map projection.

coordinate, polar #The distance from a central point of reference or the direction from a specified line or plane of reference to the point whose coordinates are wanted.#

The point of reference is called the pole, the center, or the origin. The line connecting the center with the point is the radius vector and the angle between the fixed line or plane to which the direction is referred and the radius vector is the vectorial angle, the central angle, or the polar angle. In surveying, observations are usually put in the form of polar coordinates as a first step in computing coordinates in other coordinate systems. For example, computations of geodetic coordinates (latitudes and longitudes) are based on azimuths and distances from points of known location.

coordinate, rectangular #A coordinate in any coordinate system whose axes intersect at right angles.# Also called orthogonal coordinate.

coordinate, rectangular Cartesian See *coordinate system, rectangular Cartesian.*

coordinate, rectangular spherical #One of a pair of coordinates in a *rectangular spherical coordinate system*.#

One coordinate of a point is the distance from the origin along one of the axes to the intersection with the great circle orthogonal to that axis through the point. The other coordinate is the distance along that great circle from the intersection to the point. See also *coordinate, Soldner*.

coordinate, Soldner (1) #One of the two coordinates in a *Cassini-Soldner coordinate system*.# Also called a Cassini-Soldner coordinate.

(2) #One of the two coordinates in a *Soldner coordinate system*.# See also *map projection, Cassini-Soldner (2)*.

(3) #A coordinate in a *rectangular spherical coordinate system*.# Also called a Cassini coordinate.

coordinate, space rectangular (1) #One of a set of three coordinates in a rectangular Cartesian coordinate system in 3-dimensions.#

Equivalently, the perpendicular distance of a point from a plane through a pair of axes of the coordinate system.

(2) In photogrammetry, space rectangular coordinates are also called survey coordinates. #These are the x- and y-coordinates which define the horizontal location of a point on the ground, and the z-coordinate, which indicates the elevation of the point.#

coordinate, spherical (1) #One of a set of three coordinates in a *spherical coordinate system*.# (2) #A coordinate in a coordinate system on a sphere.#

Usually two quantities, angular, linear, or both, are given; these define the location of a point on a sphere, with respect to two designated great circles or the point's location with respect to a great circle and a point not on that circle.

The term "spherical coordinates" sometimes designates coordinates on any surface approximating a sphere. See *coordinate, geographic; coordinate, geodetic*; and *coordinate, astronomic*.

coordinate, spheroidal (1) #A coordinate in a *spheroidal coordinate system*.# (2) #A coordinate in a coordinate system on a *spheroid*.#

coordinate, State #A coordinate in a *State plane coordinate system*.#

Also called a State plane coordinate.

coordinate, State plane #One of a pair of coordinates in one of the plane rectangular coordinate systems known as the *State plane coordinate systems*.#

Each State in the United States of America has its own State plane coordinate system (or State coordinate system). When necessary, the coordinates in the coordinate system of a particular State are referred to by the name of the State, e.g., Georgia plane coordinates. State plane coordinates are used extensively for calculating and recording the results of land surveys.

coordinate, topocentric #A coordinate in a *topocentric coordinate system*.#

coordinate, vertical #The vertical distance (i.e., distance measured along a vertical; elevation) of a point above or below a surface of reference (datum).#

The vertical coordinate of a point may be positive or negative, depending on whether the point is above or below the surface of reference. This surface may be assigned a large positive elevation, so that all elevations referred to it will be positive. Instead of "elevation," the term "height" is sometimes used.

coordinates, origin of (1) #The point of intersection of the axes of a coordinate system.#

The coordinates of this point are usually assigned the value 0. However, in surveying, the origin (of a rectangular plane coordinate system) is often assigned large positive values so that negative values need not be used. These values are called *false easting* (or westing) and *false northing* (or southing). See *coordinate system, State plane*.

(2) #The point to which the coordinates are assigned zero values, regardless of its location with respect to the axes.#

(3) #The point to which coordinates of other points in the coordinate system are referred.#

coordinate system #A set of rules for specifying how *coordinates* are to be assigned to points.#

The rules usually specify an origin of coordinates, and a set (in 2-dimensional systems, e.g., a pair) of axes from which distances or angles are measured to yield coordinates. See *axis (1)*. Alternately, families of lines or surfaces can be used as referents, each member of a family being assigned a unique value which is then the coordinate of any point lying on that member.

Coordinate systems may be classified according to (a) where the origin is located (geocentric, topocentric, heliocentric, etc.); (b) the kinds of surfaces used as referents (plane, spherical, spheroidal, etc.); or (c) the orientation of the axes (horizontal, equatorial, etc.).

coordinate system, astrogeodetic #A coordinate system that has its origin at a point with known geodetic coordinates and its axes oriented like those of an *astronomic coordinate system*.#

This is equivalent to defining the system by specifying both the geodetic and astronomic coordinates of a given point in the system.

coordinate system, astronomic (1) #A coordinate system consisting of the celestial Equator and of a selected celestial meridian, or, equivalently, of one plane perpendicular to the Earth's axis of rotation and another plane parallel to that axis and passing through the vertical at a specified point. The coordinates of a point are determined by the meridional arc between the Equator and the point and by the arc of the Equator between the selected meridian and the meridian through the point.#

(2) #A coordinate system similar to that of (1) but with directions specified at points on the *geoid* and vertically below (or above) the points of the Earth's surface.#

(3) #A coordinate system similar to that of (2), but with an average position chosen for the Earth's axis of rotation.#

This coordinate system is sometimes referred to as a reduced astronomic coordinate system, and the coordinates in the system as reduced astronomic coordinates.

(4) #A coordinate system in which the locations of heavenly bodies (Sun, planets, stars, etc.) are given.#

coordinate system, barycentric #A coordinate system associated with a set of bodies, with the origin of the coordinate system at the center of mass of the set.#

coordinate system, bipolar #A coordinate system, in the plane, consisting of two points a specified distance apart and two families of numbered, concentric circles having these two points as their centers.#

The coordinates of a point are the numbers of the two circles intersecting at that point, together with a sign indicating on which side of the line between centers the point lies. Alternatively, the coordinates of a point can be considered the two distances of that point from the two given points, again with a sign indicating on which side of the line the point lies. Usually, the two centers are fixed and only the radii are variable. However, some map projections, such as the van der Grinten, are best described in a coordinate system with variable distance between centers.

coordinate system, Cartesian #A coordinate system consisting of N straight lines (1-dimensional spaces) intersecting at one common point (the origin) and determining N distinct hyperplanes ((N-1)-dimensional spaces); the n-th ($1 \leq n \leq N$) coordinate of a point is the distance, along the n-axis, from the origin to the point where that axis is intersected by the hyperplane containing that point, through the N-1 other axes.#

In three-space, the coordinate system consists of three straight lines (the axes) intersecting at a common point (the origin) and determining three planes; coordinates are assigned to a point by passing three planes through that point, each plane intersecting one axis and parallel to the other two. The distances from the origin to the points of intersection are the coordinates.

The units used for measuring distances along the axes need not be the same on all axes, and the axes need not intersect at right angles. If the axes all intersect at right angles, the coordinate system is called a rectangular Cartesian coordinate system; otherwise, it is called an oblique Cartesian coordinate system.

An alternative but equivalent definition often useful is: "a coordinate system comprising three families of planes". The planes within any one family are parallel and consecutively (but otherwise arbitrarily) numbered; the planes from separate families are not parallel, and a set of three planes from separate families intersect at a single point to which is assigned, as coordinates, the numbers of the three intersecting planes.

coordinate system, Cassini-Soldner (1) #A coordinate system, on the sphere, consisting of two great circles intersecting at right angles. One of the intersections is chosen as origin. The y-coordinate of a point is the distance from the point to the central meridian measured along a great circle, C, through the point and perpendicular to the great circle chosen as central meridian. The x-coordinate is the distance from the origin along the central meridian to its intersection with C.#

(2) #The same as (1) generalized to an ellipsoid, for which the great circles are replaced by geodesics.#

Also called the Soldner coordinate system. However, the term "Soldner coordinate system" appears to have acquired two meanings, so it is best to use the full name if any doubts may arise. The Cassini-Soldner coordinate system forms the basis for the map projection of the same name.

coordinate system, curvilinear #Any coordinate system in which at least one of the families of lines or (hyper) surfaces used as referents are curved.#

In geodesy the most important curvilinear coordinate systems are the *spherical, spheroidal, and ellipsoidal.*

coordinate system, ecliptic #A right-handed, rectangular coordinate system which has one axis perpendicular to the plane of the Earth's orbit, and another axis parallel to the line of intersection of the plane of the Earth's orbit with the plane of the *celestial Equator*.#

The system is defined only as to orientation. The origin may be anywhere in the Solar System but usually is either Sun- or Earth-centered or is barycentric. Ecliptic coordinates may be linear or angular. If they are angular, longitude is measured as the angle in the plane of the Earth's orbit counter-clockwise from the *vernal equinox,* latitude is measured from the plane of the Earth's orbit positive northwards, and distance is measured radially from the origin.

coordinate system, ellipsoidal (1) #(mathematics) A coordinate system defined by three numbered families of confocal quadric surfaces of the following types: (a) ellipsoids; (b) hyperboloids of one sheet; and (c) two-sheet hyperboloids, such that three surfaces (one from each family) intersect orthogonally at every point of the space. The coordinates of a point are the numbers of the surfaces intersecting on the point.#

See Morse and Feshbach (1963: p. 663) for a stereoscopic picture of the coordinate system.

(2) #(geodesy) A coordinate system defined by three families of surfaces as follows: (a) longitude is defined by a family of numbered planes intersecting in a common line (the polar axis); (b) latitude is defined by a family of numbered confocal hyperboloids with common axis on the polar axis; and (c) distance is defined by a family of numbered confocal ellipsoids having one of their common axes on the polar axis and their common center on the center of the family of hyperboloids.# Also called an ellipsoidal coordiante system. See Heiskanen and Moritz (1967: p. 39–40).

coordinate system, equatorial #A right-handed coordinate system in which one axis, the Z-axis, is parallel to the Earth's axis of rotation and another, the X-axis, is parallel to the line of intersection of the planes of the *celestial Equator* and the *ecliptic*.#

The X-axis points towards the *first Point of Aries* (vernal equinox) at some particular epoch and the Z-axis points to the North Celestial Pole. The Y-axis is perpendicular to the plane of the X- and Z-axes. Only the orientation of the system is fixed. If the origin is at the observer, the system is called a topocentric equatorial system; if it is at the Sun, the system is called a heliocentric equatorial system.

coordinate system, geocentric (1) #Any coordinate system with origin at a specified and defined center of the Earth, such as the center of mass or the geometric center.#

(2) #A spherical (polar) coordinate system in which the coordinates of a point are *geocentric latitude*, longitude, and distance from the origin.

coordinate system, geodetic #A coordinate system consisting of an ellipsoid, the equatorial plane of the ellipsoid, and a meridional plane through the polar axis. The coordinates of a point in this system are given by the perpendicular distance of the point from the ellipsoid, the angle between that perpendicular (the "normal") and the equatorial plane, and by the dihedral angle between the meridional plane and a plane perpendicular to the equatorial plane and containing the normal.#

coordinate system, geomagnetic #A spherical coordinate system which has its polar axis coincident with the axis of the dipole representing the Earth's magnetic field.#
The zero meridian is usually selected to pass through the astronomic or geodetic North Pole.

coordinate system, GEOREF #An alphanumeric coordinate system adopted by the U.S. Air Force for designating the latitude and longitude of a point on the Earth's surface.#
The name is derived from the name "The World Geographic Reference System".

coordinate system, grid #A coordinate system on a plane usually based on a map projection.#
The most common form is a rectangular Cartesian coordinate system. An example is the State plane coordinate system. Polar coordinate systems are also used, for example, in aviation and artillery firing. The advantage of a grid coordinate system is that plane coordinates may be substituted for geographic coordinates and the computations relating to them may be made by the simple methods of plane surveying.

coordinate system, hour-angle #An equatorial coordinate system in which the Equator and the local meridian are the reference planes. The position of the celestial body is given by its *hour angle* and *declination.* #

coordinate system, inertial #A coordinate system (framework of reference) in which Newton's Second Law of Motion is obeyed.#
Also called a Galilean system. A practically equivalent definition is that the inertial system is not rotating with respect to distant galaxies.

coordinate system, isothermal #A coordinate system with coordinates (u,v) such that, in the first fundamental form for the element ds of length of a line,

$$ds^2 = E\,du^2 + F\,du\,dv + G\,dv^2 ,$$

$E = G$ and $F = 0$.#
Also called isometric. All conformal map projections yield coordinate systems of this type.

coordinate system, local #A coordinate system that has its origin within the region being investigated and is used principally for points within that region.#

coordinate system, oblique Cartesian See *coordinate system, Cartesian.*

coordinate system, orthogonal #A coordinate system defined by families of curves or surfaces intersecting at right angles.#
Although this kind of coordinate system is sometimes referred to as a rectangular coordinate system, the latter term is more frequently used to indicate a coordinate system composed of straight lines or planes.

coordinate system, plane rectangular #A *Cartesian coordinate system* in the plane, with the axes intersecting at right angles.#

coordinate system, polar #A coordinate system in the plane, consisting of a straight line, called the base line, and a point, called the center, on that line. The coordinates of a point are (a) the distance of the point from the center and (b) the angle between the radius vector to the point and the base line.#
See also *coordinate, polar.*

coordinate system, rectangular (1) #Any coordinate system in which surfaces or lines from the separate families defining the system intersect at right angles.# More usually called an orthogonal coordinate system.
(2) #A Cartesian coordinate system in which the lines or planes intersect at right angles.# To avoid confusion, the term should not be used in this sense; *rectangular Cartesian coordinate system* should be used instead.

coordinate system, rectangular Cartesian #A coordinate system consisting of straight line axes intersecting at a common point and perpendicular to each other; the coordinates of a point are the distances from the point along a line parallel to one axis and extending to the plane containing the other axes.# This is equivalent to specifying a coordinate system that is both rectangular and Cartesian.

coordinate system, rectangular spherical (1) #A coordinate system on the sphere consisting of two mutually perpendicular families of great circles. One great circle from each family is selected as a referent, and the origin is chosen as one of the points of intersection of the referents. Each family of great circles passes through the poles of the referent from the other family.#
Called the Cassini-Soldner coordinate system if one of the families are north-south meridians. See also *coordinate, rectangular spherical.*
(2) #The same as definition (1), except that one of the families consists of small circles (except for the referent circle).#

coordinate system, right-handed #A rectangular Cartesian coordinate system in three dimensions which has the positive directions on the three axes (X-, Y-, and Z-axes) defined in the following way: if the thumb of the right hand is imagined to point in the positive direction of the Z-axis and the forefinger in the positive direction of the X-axis, then the middle finger, extended at right-angles to the thumb and forefinger, will point in the positive direction of the Y-axis.#
If the coordinate system is left-handed, the middle finger will point in the negative direction of the Y-axis.

While two oppositely oriented rectangular Cartesian coordinate systems can be defined on a plane, neither is intrinsically right-handed or left-handed. However, if the plane has a positive and a negative side by definition or by circumstance (like a sheet of paper with diagrams only on one side), a Z-axis with positive and negative directions can be considered to be present implicitly, and right-handed and left-handed coordinate systems can be defined on the plane.

coordinate system, Soldner (1) #A coordinate system, on the sphere, whose axes are two great-circles intersecting at right angles. One intersection is chosen as the origin. One coordinate of a point is the distance measured along a small circle through the point and parallel to one of the axes; the other coordinate is the distance from the origin to the intersection of the small circle with the other axis.#

It is usually postulated that one of the great circles lies in the plane of a geodetic meridian and that the other lies in the Equator.

(2) See *coordinate system, Cassini-Soldner*.

coordinate system, spherical #A coordinate system whose referents are of a primary plane (the equatorial plane), a secondary plane (the zero-meridian plane) intersecting the primary plane at right angles, and a point (the center) on the line of intersection of the two planes. The coordinates of a point are its distance from the center, the angle between its radius vector and the primary plane, and the angle between the secondary plane and a plane perpendicular to the primary plane and through the radius vector.#

The intersection of the equatorial and zero-meridian planes is a straight line, called the polar axis.

coordinate system, spheroidal See *coordinate system, ellipsoidal* (2).

coordinate system, square Cartesian #A *Cartesian coordinate system* in which the distance unit along each axis is the same and all axes intersect at right angles.#

coordinate system, State See *coordinate system, State plane.*

coordinate system, State plane #One of the plane rectangular coordinate systems, one for each State in the Union, established by the U.S. Coast and Geodetic Survey in 1933 for use in defining locations of geodetic stations in terms of plane-rectangular Cartesian coordinates.#

Also called State coordinate system.

Each State is mapped by a conformal map projection in one or more zones, over each of which is placed a rectangular grid. Zones of limited east-west extent and indefinite north-south extent are mapped by a *transverse Mercator map projection*; zones of indefinite east-west extent and limited north-south extent are mapped by the *Lambert conformal conic map projection* with two standard parallels. Zone One of Alaska is on the *oblique Mercator map projection.* The use of the projections assures that, for zones having a width of 250 km, the greatest departure from exact scale (scale error) is 1 part in 10,000. All geodetic positions determined by the National Geodetic Survey or its predecessor are transformed into plane rectangular coordinates on the proper grid, and are distributed by the Survey together with the geodetic positions.

When the new North American Datum of 1983 replaces the North American Datum of 1927, the State plane coordinate system (SPCS) will be modified in the following respects. (a) Distances and coordinates are expressed in meters. (b) The transformations from geodetic to grid coordinates are revised to yield errors less than 0.01 m for a point within the boundaries of a zone.

coordinate system, topocentric #A coordinate system having its origin at the point of observation or, by inference, on the surface of the Earth or the representing ellipsoid.#

coordinatograph #An instrument used to plot points from their plane coordinates.#

It may be an integral part of a stereoscopic plotting instrument by means of which the planar coordinates of the *floating mark* are plotted directly.

coplanarity condition #The condition, in photogrammetry, requiring that the following three lines be coplanar: the two lines from a point in object space to its images on two photographs and the one line joining the perspective centers of the two photographs.#

The coplanarity condition has been found to be less easy to adapt to numerical computation than the *collinearity condition*.

core #The portion of the Earth extending from the lower boundary of the *mantle* to the center of the Earth.# The radius of the core is about 3500 km; the core's surface is about 2900 km below the Earth's surface.

Only longitudinal (P) seismic waves will propagate through the core; transverse (S) seismic waves will not. Since liquids will propagate longitudinal but not transverse seismic waves, the core (or at least the part adjoining the mantle) is thought to be liquid. There is some seismological evidence that a region from the center of the Earth out to about 1400 km is partly or entirely solid. This portion is called the inner core.

Coriolis force #An apparent force used by an observer in a rotating coordinate system to account for the failure of a body moving in a nonrotating coordinate system to rotate with the former system.#

A body following a straight line at constant velocity in the nonrotating system appears to follow a curved path with variable velocity in the observer's rotating system. An observer in the rotating system ascribes a Coriolis force

$$-2m \vec{\omega} \times \vec{v}$$

to the motion of a body of mass m moving with velocity $\vec{v}$ in the nonrotating system; $\vec{\omega}$ is the angular-rate-of-rotation vector of the observer. Coriolis force accounts for the deflection of winds and ocean currents on the Earth to the right of the pressure gradient in the Northern Hemisphere and to the left in the Southern Hemisphere.#

corner (land surveying) (1) #A point on a land boundary at which two or more boundary lines meet.#

This is not the same as *monument,* which is the physical evidence of the corner's location on the ground.

(2) #A point on the Earth whose location is determined by surveying and marking an extremity of a boundary of a subdivision of the public lands, usually at the intersection of two or more surveyed lines.#

The term is often used incorrectly to denote the physical structure, or monument, erected to mark the corner point.

Corners are described in terms of the points they represent, e.g., township corner—a corner at the extremity of a township boundary; section corner—a corner at the extremity of the boundary of a section; and quarter-section corner—a corner at an extremity of a boundary of a *quarter section,* midpoint between or 40 chains from the controlling section corners, depending on location within the township.

corner, auxiliary meander #A *corner,* established at a suitable point on the *meander line* of a lake lying entirely within a quarter section or on the meander line of an island, falling entirely within a section, which is found to be too small to subdivide.#

A line is run connecting the monument to a regular corner on the section's boundary line.

corner, closing #A *corner* at the intersection of a surveyed boundary with a previously established boundary line.#

If, during the surveying of the public lands of the United States, the line connnecting the last section corner and the objective corner on an established township boundary departs from the astronomic meridian by more than the allowable deviation, the line being surveyed is extended in a cardinal direction to an intersection with the township boundary, where a closing corner is established and a connection is made to the previously established corner. Closing corners are established to avoid excessive deviation from a cardinal direction which might be required to connect with the object corner on that boundary. Closing corners are also established at the intersection of township, range, or section lines with the boundaries of previously surveyed and segregated tracts of land, such as private land claims, mineral claims, etc.

corner, existent #A *corner* which has a location that can be identified by verifying the evidence of the monument or its accessories, by reference to a description contained in field notes, by an acceptable supplemental survey record, by some physical evidence, or by testimony as to where the point can be located.#

Even though its physical evidence may have disappeared entirely, a corner will not be regarded as lost if its position can be recovered through the testimony of one or more witnesses who have a dependable knowledge of the original location.

corner, found #A *corner* (a) for which the original or restored monument or mark is recovered, or (b) for which the location is definitely established by one or more witness corners or reference monuments.#

corner, lost #A *corner* whose location cannot be determined beyond reasonable doubt, either from traces of the original marks or from acceptable evidence or testimony that bears upon the original location, and whose location can be restored only by reference to one or more interdependent corners.#

corner, meander #A *corner* established at the intersection of a township, range, or section line with the banks of a navigable stream or a body of water around which a *meander line* has been established.#

corner, obliterated #A *corner* where there are no remaining traces of the monument or its accessories, but whose location has been perpetuated. Also, a corner whose location may be recovered, beyond reasonable doubt, by the testimony of the interested landowners, competent surveyors, or other qualified local authorities or witnesses, or by some acceptable recorded evidence.#

A location that depends upon the use of collateral evidence for verification can be accepted only as duly supported, generally through proper relation to known corners, and agreement with the field notes on distances to natural objects, stream crossings, line trees, and off-line tree blazes, etc., or unquestionable testimony.

corner, standard #A *corner* on a standard parallel or base line.#

corner, witness (1) #A marked point established on firm ground at a measured distance and direction from a *corner* so situated that it cannot be marked permanently.#

A witness corner in land surveying corresponds to a reference mark in control surveying.

(2) #A monumented, surveyed point near a *corner,* established as a reference mark when the corner is so situated as to render its monumentation or ready use impracticable.#

A witness corner is marked in the same way as a true corner.

corner accessory #A physical object close to a *corner,* to which reference is made in describing the location of the corner.# Examples are *bearing trees,* mounds, pits, ledges, rocks, and other natural features to which distances or directions, or both, from the corner or monument are known. Corner accessories are considered part of the monument of the corner.

corner contiguity #The characteristic of having a corner but not a boundary line in common.#

correction (1) #A quantity applied to a given value in order to improve that value.#

The value may be obtained by observation (or a function thereof) or by theory. For instance, in communication theory, it is assumed that the message being sent (the signal) is correct and that the signal is distorted during transmission by added noise (errors). This results in the received message being wrong. Here it is the observation that is erroneous and must be corrected.

In gravimetric geodesy, gravity can be measured at the Earth's surface. Its value can also be predicted by a gravity formula. To compare measured values with predicted values, corrections must be added to the values given by the gravity formula. Here it is the observed value which is correct and the predicted value which must be corrected.

(2) #The difference between the theoretical value of a quantity and its observed value.#

See also under the specific name of the correction such as *leveling correction, orthometric; gravity correction.*

correction, adjustment See *leveling correction, adjustment.*

correction, dynamic #The quantity which must be added to the *orthometric elevation* of a point to obtain the *dynamic number*.#

correction, orthometric See *leveling correction, orthometric.*

correlate #A one of a set of factors, introduced as additional unknowns (called Lagrangian multipliers) and used in the *method of correlates.* #

Also called a "correlative".

correlates, method of #The method of least squares applied to a combination of observation equations and condition equations by introducing additional unknowns (*correlates*) and proceeding by solving first for the correlates and then, using this solution, solving for the original unknowns in the observation equations.#

See also *equation, correlate.*

correlation (statistics) #The extent to which one randomly varying quantity can be expressed as a function of another, or to which both quantities can be expressed as functions of a third, nonrandom quantity.#

This definition can be extended to situations involving several variables by applying it to each different pair of variables in the set. It is measured by a quantity called the correlation coefficient.

correlative See *correlate.*

correspondence (photogrammetry) #The condition that exists when corresponding images on a pair of photographs lie in the same *epipolar plane*; the absence of *y-parallax*.#

cotidal line #A line on a chart passing through all points where high water occurs at the same time.#

The lines show the interval of time (expressed either in solar or lunar hours), between the Moon's transit over a reference meridian (usually Greenwich) and the occurrence of high water for any point lying along the line.

course #In general, a line having a specific direction.#

Many variations of this basic definition are in use in different disciplines. (a) #In surveying, the term is used to designate the *bearing* (or *azimuth*) of a line, the length of a line, or both.#

(b) #The azimuth and length of a single line of traverse considered together in describing a traverse.#

(c) #In navigation, the azimuth or bearing of a line along which a ship or aircraft is to travel or does travel.#

course of a river (1) #A route along which a river flows.#

(2) #The river itself.#

covariance #The average value of the quantity

$$(x_1 - \mu_1)(x_2 - \mu_2),$$

where x_1 and x_2 are random variables with average values μ_1 and μ_2 respectively.#

If x_1 and x_2 are the same variable, the covariance is called the "variance".

covariance, lag See *covariance function.*

covariance function #The average value of the quantity

$$x(r_1) \times x(r_2)$$

where x is a randomly varying function of the variable r and r_1 and r_2 are two given values of r.#

Also called the autocovariance or lag covariance.

covariance matrix #A matrix whose element in row i and column j is the average value of

$$(x_i - \mu_i)(x_j - \mu_j)$$

where x_i and x_j are random variables with average values μ_i and μ_j respectively.#

The elements along the main diagonal are the variances of the corresponding variables; those off the main diagonal are the covariances.

crab #The condition in which the sides of an aerial photograph are not parallel or perpendicular to the direction of flight.#

This usually occurs when the aircraft's longitudinal axis does not coincide with the direction of flight; it may occur if the photographs are taken when cross-winds are strong. See also *yaw.*

crest (1) #A line, along a ridge, hill or mountain, on both sides of which the ground slopes downward toward lesser elevations.# Also called a topographic crest.

(2) #A line, along a ridge, hill or mountain, from which all points lower down on one side of the line are visible.# Also called a false crest or a military crest. The location of the military crest will depend upon the height assumed for the observer.

crest, false See *crest (2).*

crest, military See *crest (2).*

crust #The spherical, shell-like portion of the solid Earth that has considerable rigidity, a characteristic that sustains both transverse and longitudinal seismic waves, and permits a seismic wave to have velocities up to about 7.2 km/s.#

The crust extends from the surface of the Earth down to about 5 to 10 km in oceanic regions, 35 to 40 km under much of the continental regions, and perhaps 60 to 80 km under mountainous regions. The crust is separated from the mantle by a thin layer, called the *Mohorovičić discontinuity,* in which the velocity of seismic waves jumps from about 7.2 km/s to more than 8 km/s.

crustal motion #A movement of the Earth's surface, horizontally or vertically, resulting in the displacement of monuments or bench marks.#

Crustal motion can be episodic, as caused, for example, by earthquakes, or continuous, as caused, for example, by withdrawal of fluids, or by plate tectonic motion.

C-shot #A sighting made in determining the *C-factor*.# The term is considered jargon.

C-test #A method for determining *C* by making readings on leveling rods held on intervisible turning points, with one leveling rod considerably farther from the leveling instrument than the other.#

culmination (1) #The location of a heavenly body at the instant it crosses an observer's meridian above or below the horizon.#

Culmination occurs when the body transits the local meridian: upper culmination is at the branch of the meridian above the celestial pole; lower culmination at the branch below the celestial pole. As an observer approaches a pole of the Earth, culmination of the fixed stars becomes less noticeable, disappearing when the pole is reached. Culmination of bodies within the solar system may, under some conditions, be obscured by changes in declination. At one time, lunar culminations were used extensively in determining astronomic longitude.

(2) #For a heavenly body that is continually above the horizon, the location of the lowest apparent altitude.#

current (oceanography) #Generally, a horizontal movement of water in a general direction over a great distance.#

Currents may be classified as tidal or nontidal. Tidal currents are caused by the gravitational action of the Sun and the Moon on the Earth. Nontidal currents include the permanent currents of the oceans.

current, ebb #The movement of a tidal current away from shore or down a tidal river or estuary.#

current, flood #The movement of a tidal current toward the shore or up a tidal river or estuary.#

current, geostrophic See *flow, geostrophic.*

current, rotary #A tidal current that flows continually, with the direction of flow changing through all points of the compass during the tidal period.#

current ellipse #A graphic representation of a rotary current in which the velocity of the current at different hours of the tidal cycle is represented by vectors.# The cycle may be semidiurnal or diurnal.

current rose #A graphic representation of currents for specified regions.#

Arrows at cardinal and intercardinal compass-points show the directions toward which the prevailing current flows and the frequency with which this direction occurs for a given period of time. The arrows may be varied (by thickness, pattern, or length) to designate categories of current speeds.

curvature #At a given point on a surface, the rate of change of the inclination of the tangent with respect to change of arc length of a normal section curve passing through that point.#

This definition applies to a plane curve. It can be generalized to a curve in n-dimensions.

See also *curve,* and *Gaussian curvature*. Curvature, plus modifiers (e.g., normal curvature), has a number of precise meanings in differential geometry.

curvature, Gaussian #The reciprocal of the product of the *principal radii of curvature* at a point on a surface.#

curvature, radius of #The reciprocal of the *curvature*.# See also *curvature, radius of normal*.

curvature, radius of normal #The radius of the osculating circle in a *normal section* at a point on a surface.#

Among the normal sections at a point of a surface there exist two, in one of which the osculating circle has the greatest radius and in the other the least radius of all such circles. The planes containing these two normal sections are called the principal planes, and the reciprocals of the radii are called the principal curvatures of the surface at the point. The directions of these principal curvatures are called "principal directions". Half the sum of the principal curvatures is called the mean curvature of the surface at the point, while the product is called the Gaussian curvature of the surface at the point. The term, radius of curvature, usually refers to radius of normal curvature.

curvature, radius of principal #The extremal values of the *radius of curvature* at a point on a surface for all normal section curves passing through that point.#

See *curvature, radius of normal.*

curvature correction (1) (astronomy) #A correction applied to the average of a series of observations on a star or planet, to take account of the divergence of the apparent path of the star or planet from a straight line.#

(2) (geodesy) #The correction applied in some geodetic work to take into account the divergence of the surface of the Earth (or its representing ellipsoid) from a plane.#

curvature of field #The distance, parallel to the optical axis, from an off-axis image point to the axial focal plane (the plane through an on-axis image point and perpendicular to the optical axis).#

Some telescopes have pronounced curvature of field. This is particularly true of Schmidt telescopes, in which the focal surface is spherical and film must be cut in the form of a Maltese cross to lie flat on a surface.

curvature of ray-path #The curvature of the path taken by electromagnetic radiation in passing through the atmosphere.#

The curvature is not constant but varies with altitude, h. At each point of the path, the radius of curvature, R, is a function of h, the index of refraction, n, and the angle, θ, that the path makes with the horizontal. The equation for the radius of curvature is

$$R = -n \sec \theta/(dn/dh).$$

curve (1) #A continuous geometric figure which can be expressed as a function of a single variable.#

Usually, a curve is considered to have no abrupt changes of direction, or, if so, only at isolated points. Sometimes the definition is restricted to exclude the straight line.

(2) #A curved, stiff device, flat on one side and usually made of plastic or sheet metal, that is used for drawing curved lines other than circular arcs.# Also called an irregular, a French, or a Copenhagen curve.

curve, characteristic #A curve showing the relationship between exposure and resulting density in a photographic image, usually plotted as the density (D) against the logarithm of the exposure (log H) in candle-meter-seconds.

curve, clothoid See *clothoid.*

curve, Copenhagen See *curve (2).*

curve, degree of #The number of degrees of angular measure, at the center of a circle, subtended by a chord or arc 100 feet in length.#

The chord definition has been applied in railroad and early highway design. The arc definition is used in present-day highway design.

curve, easement A *transition curve.*

curve, hypsographic #A diagram showing the frequency of occurrence of groups of elevations over the entire world.#

curve, isoperimetric #A line on a map along which there is no variation from exact scale.#

curve, latitudinal #An easterly and westerly property line adjusted to the same average *bearing* from each monument to the next one in regular order, as distinguished from the long chord or great circle that would connect the initial and terminal points.#

curve, loxodromic See *rhumb line.*

curve, point of intersection of a #The point where the two tangents at the extremities of a circular arc meet.#

Also called the vertex of curve or the P.I.

curve, point of tangency of #The point of a line where a circular curve ends and a tangent begins.#

Also called point of tangent or P.T. The point of tangency and point of curvature are both points of tangency to a curve, their different designations being determined by the direction of progress along the line. The point of curvature is reached first.

curve, reverse #A curve composed of two circular arcs with a common tangent at their point of junction and lying on opposite sides of the tangent, i.e., with their centers of curvature on opposite sides of the tangent.#

curve, spiral See *spiral* and *curve, transition.*

curve, transition #A curve joining the adjacent endpoints of two other lines (usually circular arcs) in such a way that the tangents to the lines and joining curve coincide at the points of junction, and the curvature of the joining curve changes in some suitable manner.#

Transition curves commonly used are the cubic parabola, the Cornu spiral (*clothoid*) and the spiral of Archimedes. Also called easement curve or spiral curve (the latter term is properly used only for true spirals).

curve, vertex of See *curve, point of intersection of.*

curve, vertical (1) #A parabolic curve used as a *transition curve* between different grades or slopes.#

(2) A *Bz curve.*

curve fitting #Representing a set of points by a curve.#

The term is also inappropriately used to mean representing a set of points by a surface. Of the infinite number of curves that might be chosen to represent a particular set of points, one is usually selected by specifying certain characterictics, e.g., that it be of a specified degree, and that all points lie as close to it as possible.

curve of alignment #A line connecting two points on the surface of the ellipsoid and defined by the condition that at every point the azimuths of the two endpoints of the line differ by exactly 180°.#

A curve of alignment is slightly less in length than the *normal-section lines* connecting its endpoints.

cutbank #A steep bare slope formed by stream erosion.#

cycle (astronomy) #A set of events that recurs regularly; also, the time between recurrences.# See names of particular cycles such as *cycle, Callippic; cycle, Metonic;* and *Saros.*

cycle, Callippic #A period of 940 lunations, 27,759 days, or about 76 years.#

Introduced by Callippus, a Greek astronomer, about 350 B.C. as a suggested improvement to the Metonic cycle for a period in which new and full Moon would recur on the same day of the year. Taking the length of the synodical month as 29.530 59 days, 940 lunations yield 27,758.76 days, a difference of 0.24 days in 76 years.

cycle, Metonic #A period of 235 *lunations*, 6940 days (or about 19 years).#

Devised by the Athenian astronomer Meton (c. 450 B.C.) for obtaining a period in which new and full moon would recur on the same day of the year. Taking the *synodical month* as 29.530 59 days, 235 lunations yield 6939.69 days, a difference of 0.31 days in 19 years.

cycle, node #The period of about 18.61 Julian years required for the Moon's nodes to regress through a complete circuit of 360° of longitude.#

It is accompanied by a corresponding cycle of changing inclination of the Moon's orbit relative to the plane of the Earth's Equator, with resulting variations in the rise and fall of the tides and in the speeds of tidal currents.

cyclonic #Rotary motion that is counterclockwise, as viewed from above, in the Northern hemisphere and clockwise, as viewed from above, in the Southern Hemisphere.#

cylinder, cutoff #A device consisting essentially of a short, rigid bar so made and mounted that it forms a direct connection between the apparatus being tested and a permanent monument on the ground. Its length and inclination provide the means for determining the relative locations of the fiducial marks on the base tape or bar and those on the monument.#

It is used to refer a mark at the end of a surveyor's tape or bar standard to a mark on the ground.

D

daily variation See *magnetic variation, daily* and *magnetic variation, lunar daily.*

Dalby's theorem #A formula for the reverse azimuth A_{21}, from point P_2 to point P_1 on an ellipsoid, in terms of the forward azimuth A_{12} from P_1 to P_2 and the forward and back azimuths B_{12} and B_{21} of the corresponding points on a sphere having the same geographic coordinates (λ_1, ϕ_1) and (λ_2, ϕ_2).#

The formula is:

$$A_{21} = A_{12} + (B_{21} - B_{12}) - (e^4/4)(\lambda_2 - \lambda_1)(\phi_2 - \phi_1)^2 \cos^4 \phi_1 \sin \phi_1$$

where e is the eccentricity of the ellipsoid.

data #A collection of pieces of information.#

For example, geographic data refers to a list of *longitudes* and *latitudes.* The term is sometimes used to denote only values obtained by measurement or observation. Values obtained from these by calculation are then termed results. However, it is also customary to differentiate between these different kinds of information by terms such as observational data or raw data and results or calculated data.

data bank (1) #A specific collection of data, such as the material in the U.S. National Archives and Records Service.#

(2) #A place or organization containing or holding data, such as the National Archives and Records Service, or the memory of a computing machine.#

data base #Data collected for a particular project or organized for a specific purpose.#

A data base differs from a data bank in that the latter collection need not have been assembled for any particular project.

date (1) #A specified instant.#

The instant is specified by giving its time within the day and by specifying the day.

(2) #A specified day.#

The *day* may be specified by giving its ordinal number within a *month,* the name or ordinal number of the month within the *year,* and the number of the year in some *calendar.* (In civil matters, the instant is usually not considered part of the date). See *date, astronomical.*

date, astronomical #An instant designated by *year, month, day,* and fractional part of a day. The year is specified to begin at 0^h (i.e., the starting midnight) of December 31 of the previous year, this day (December 31) being then day 0 of the reckoning.#

For example, the astronomical date corresponding to December 21, 1966 at 18 hours *universal time* is 1966 December 21.75 U.T. The astronomical date, 1980 January 0.5 U.T., corresponds to 12^h on December 31, 1979. The order in which the parts of an astronomical date are given and the manner in which they are given are not standardized.

date, Besselian #The time of an event designated by giving the *Besselian year* in which it occurred and the fraction of the Besselian year that has passed since the beginning of that year.#

date, double See *dating, double.*

date, Greenwich sidereal #The whole and fractional number of sidereal days, determined by the *equinox of date,* that have elapsed at Greenwich since the beginning of the sidereal day that was in progress at *Julian Date* (J.D.) 0.0 (Noon, January 1, 4713 B.C.).#

For example, 1980 January 0.5 U.T. has the Greenwich sidereal date 2,450,931.77.

date, Julian #An instant identified by giving the *Julian day number* of the day preceding the instant and the fractional part of the day from the preceding noon (12^h) U.T. to the instant.#

date, Julian ephemeris #A Julian date calculated in days containing 86,400 ephemeris seconds.#

date, modified Julian #A date obtained by subtracting 2,400,000.5 from the Julian date.#

date line #A hypothetical line separating two neighboring time zones in which the date differs by one day.#

This term is most often used to designate the International date line.

date line, International #A particular, hypothetical line on the Earth separating neighboring regions in which the date differs by one day.#

It coincides basically with the 180° meridian, but with deviations to avoid separating contiguous or nearby inhabited areas.

Also called simply the *date line.*

dating, double Dating an event according to both the Julian and the Gregorian calendars.#

During 1752, Great Britain and her colonies officially replaced the Julian Calendar with the Gregorian calendar. To avoid confusion resulting from the change, dates according to the Julian Calendar were marked "old style" or (O.S.); those on the Gregorian Calendar, "new style" or (N.S.). See also *calendar*; *calendar, Gregorian*; and *calendar, Julian.*

datum (1) #Any quantity or set of such quantities that may serve as a referent or basis for calculation of other quantities.#

In particular, a geodetic datum, chart datum, or tidal datum. The plural form is datums.

(2) #The singular of data.# Thus, a single, isolated piece of information.

datum, absolute #A geodetic datum in which the reference ellipsoid is Earth-centered with its minor axis corresponding to the Earth's axis of rotation.#

See also *datum, geocentric geodetic.*

datum, astrogeodetic #A *geodetic datum* defined in terms of astronomic and geodetic quantities.#

datum, chart #A datum to which depths (soundings) in a hydrographic survey or on a chart are referred.#

datum, complete #A datum containing all the quantities needed for specifying the coordinate system used.#

The term datum has often been applied to a set of quantities insufficient for specifying the coordinate system. Usually in these cases certain conditions are assumed but not specified, e.g., that one axis of the coordinate system is parallel to the Earth's axis of rotation, or that the *vertical* and *normal* should coincide at some point.

datum, geocentric #A *geodetic datum* in which the Earth's center of mass is involved in specifying the coordinate system.#

The involvement may be direct, e.g., by specifying that the origin of the coordinate system be at the center of mass, or indirect, e.g., by including specifications for values of gravity or gravity potential. It is sometimes referred to as an absolute geodetic datum. Geocentric datums cannot be located by simply identifying surface points but are located by computations that take into account the Earth's gravitational field as determined from measurements on the surface or from analyses of the orbits of satellites.

datum, geocentric geodetic #A *geodetic datum* that specifies the center of the reference ellipsoid shall be located at the Earth's center of mass.#

It is customary also to specify that the semiminor axis of the ellipsoid coincides with the Earth's axis of rotation (instantaneous, average, or conventional). A rectangular coordinate system is often associated with a geocentric geodetic datum by placing the origin of that coordinate system at the center of the ellipsoid, making the Z-axis coincide with the semiminor axis of the ellipsoid, with the X-axis passing through the zero meridian, and requiring that the coordinate system be right-handed.

datum, geodetic (1) #A set of constants specifying the coordinate system used for geodetic control, i.e., for calculating coordinates of points on the Earth.#

At least eight constants are needed to form a *complete datum*: three to specify the location of the origin of the coordinate system, three to specify the orientation of the coordinate system, and two to specify the dimensions of the reference ellipsoid. Before geocentric geodetic datums became possible, it was customary to define a geodetic datum by five quantities: the latitude and longitude of an initial point, the azimuth of a line from this point, and the (two) parameters of a reference ellipsoid. In addition, specification of the components of the deflection of the vertical at the initial point, or the condition that the minor axis of the ellipsoid be parallel to the Earth's axis of rotation provided two more quantities. The datum was still not complete because the origin of the coordinate system remained free to shift in one dimension. This meaning does not conform to modern usage.

The term datum alone is often used as a synonym for geodetic datum.

(2) #The datum, as defined in (1), together with the coordinate system and the set of all points and lines whose coordinates, lengths, and directions have been determined by measurement or calculation.#

datum, horizontal control #A *geodetic datum* specifying the coordinate system in which horizontal control points are located.#

datum, hydrographic #A datum for depths (soundings), depth contours, and elevations of foreshore and offshore features.# Also called chart datum.

datum, leveling See *datum, vertical control.*

datum, local #A datum defining a coordinate system that is used only over a region of very limited extent.#

datum, low water #An approximation to *mean low water* that has been adopted as a standard tidal datum for a specific region although it may differ slightly from a later determination.#

datum, lower low water #An approximation to *mean lower low water* adopted as a tidal datum for a limited area and retained for an indefinite period.#

Used primarily for river and harbor engineering. The Columbia River lower low water datum is an example.

datum, low water springs #An approximation to *mean low water springs* used as a tidal datum in local areas.#

Such values are often retained for an extended period even though better determinations of mean low water springs may be available.

datum, mean lower low water #The average level of the lower of two successive low waters.#

Such values are frequently specified as the average during a particular part of the month or year, as, e.g., mean lower low water springs, etc.

datum, model #An imaginary surface in a stereoscopic model to which elevations are referred.#

datum, origin of #The point in a geodetic network whose coordinates are fixed by definition.#

Not necessarily the same as the origin of the coordinate system involved.

datum, photographic #A *horizontal plane* at the average elevation of the terrain shown in a photograph and on which distances measured will be approximately proportional to corresponding distances measured on the photograph.#

datum, sea level (1) #An equipotential surface passing through a specified point at mean sea level which is used as a referent for elevations.#

(2) #A surface passing through mean sea level at certain specified points to which elevations determined by leveling are referred.#

Because these points do not necessarily lie on a single equipotential surface, the surface which they and the leveling define may not be an equipotential surface. A datum of this kind defined by the U.S. Coast and Geodetic Survey in 1929 was called the Sea Level Datum of 1929. The name, but not the definition, was changed in 1976 to the National Geodetic Vertical Datum.

(3) See *datum, tidal.*

datum, tidal #A surface with a designated *elevation* from which heights or depths are reckoned, defined by a certain phase of the tide.#

A tidal datum is local, usually valid only for a restricted area about the tide gauge used in defining the datum. For permanency and convenience, a bench mark is emplaced in stable ground close to the tide gauge. The elevation of the bench mark with respect to the tidal datum is determined from the tide gauge.

When used as reference surfaces for hydrographic surveys, tidal datums have been called datum planes; however, they are not planes and so are not treated as planes but as curved level surfaces. The tidal datum in most general use in geodesy is *mean sea level.* In land surveying, where boundaries and riparian rights are involved, *mean high water* and *mean low water* are sometimes used as tidal datums.

datum, tide gauge #A *horizontal plane* defined at a particular, arbitrary distance below a tide gauge bench mark and from which tidal heights at a tide gauge are, in theory, measured.#

In the period between successive levelings to a tide gauge bench mark, the plane is established at the tide gauge by reference to the *contact mark.*

datum, vertical control (1) #A set of fundamental *elevations* to which other elevations are referred.#

(2) #The coordinate system specified by the fundamental elevations.#

datum origin See *datum, origin of.*

datum plane See *datum, tidal.*

datums Specific geodetic datums are usually given distinctive names. A name may consist of the name of the control station taken as the origin, the name of the region to which the datum applies, the name of the parallel or meridian along which the network controlled by the datum runs, etc. This is often followed by the year in which the datum was defined. Examples are North American Datum of 1927, Arc Datum, Datum Europeén 1950. The following entries define specific important geodetic datums. See Mitchell (1948) for further entries concerning older datums in North America and elsewhere.

SPECIFIC GEODETIC DATUMS

datum, Arc #An African *horizontal control datum* based on the *Cape datum,* presumably having the same origin with the same coordinates and azimuth there.#

However, the vast longitudinal and latitudinal extent of the networks has caused complex modifications to take place during the calculations, so it is difficult to say exactly what datum or datums govern the networks. There exist a series of datums called Arc datum 1950, Arc datum 1960, etc.

datum, Australian geodetic #A *geodetic datum* based on a spheroid with

semimajor axis	6,378,160 m
flattening	1/298.25

The origin is at Johnston Geodetic Station, with coordinates:

longitude	133° 12′ 30.″0771 E
latitude	25° 56′ 54.″5515 S
elevation	571.2 m above geoid
height of geoid	−6 m

No azimuth appears to be specified.# The datum was adopted in 1965.

datum, Australian height #A datum for *vertical control* in Australia, based on a defined geoidal height at Johnston Geodetic Station of −6 m.#

datum, Cape #A South African *horizontal control datum* defined by the following location and azimuth on the *Clarke spheroid of 1880*; the origin is at Boffelsfontein:

longitude	25° 30′ 44.″622 E
latitude	33° 59′ 32.″000 S
azimuth from origin to Zurrberg	
(clockwise from south)	184° 15′ 26.″311#

On extension of the triangulation on this datum northward to the arc of the 30th meridian, Cape Datum was applied to the entire network and extensions from it, but the name for the extended network was changed to *Arc Datum.*

datum, Cape Canaveral See *Survey, Cape Canaveral.*

datum, Cape Kennedy See *survey, Cape Canaveral.*

datum, European 1950 #A *horizontal control datum* defined by the following location and deflection of the vertical on the International Ellipsoid; the origin is at the control point in Helmert Tower, Potsdam:

longitude	13° 03′ 58.″9283 E
latitude	52° 22′ 51.″4456 N
deflections of the vertical	
meridian	3.″36
prime vertical	1.″78#

Horizontal control in Europe has been readjusted by several countries, and the Bomford geoid of 1963 was recommended for use in these readjustments. Geoids other than Bomford's have been used. In the original adjustment, a specific origin was not used. Also called Datum Europeén 1950.

datum, Europeén 1950 The correct designation for *European datum 1950.* The latter term is, however, the one generally used.

datum, Gulf Coast low water #The *tidal datum* used as chart datum for the coastal waters of the Gulf Coast of the United States of America and defined as *mean lower low water* when the type of tide is mixed and as *mean low water* when the tides are diurnal.#

This datum was abandoned by the National Ocean Survey in 1980 and replaced by mean lower low water for the region involved.

datum, Indian #A *geodetic datum* based on the *Everest spheroid,* with the origin at triangulation station Kalianpur:

longitude of origin*	77° 39′ 17.″57 E
latitude of origin	24° 07′ 11.″26 N
deflections of the vertical	
meridian	−0.″29*
prime vertical*	2.″89*
geoidal height	0 m.

*Deflection of the vertical in the prime vertical is defined to be zero, except for adjustment of Laplace azimuths, when it is given the value shown. Deflection of the vertical in the meridian is as shown.#

These constants are the ones used in the adjustment of 1938, and are the ones usually meant when Indian Datum is specified. However, the datum has had a long (from 1802) and complicated history, and coordinates determined before 1938 should be verified as to the actual datum used.

datum, International Great Lakes (1955) #A *vertical control datum* with zero at mean sea level at Pointe-au-Pere, Quebec, as determined from readings over the period 1941-1956.#

It is used primarily for hydraulic studies and for the definition of chart datums in the Great Lakes and connecting waterways. Elevations on this datum are based on leveling from Pointe-au-Pere to Lake Ontario and along all connecting waterways, to Lake Superior. Elevations on the lakes are derived by water level transfer, based on the assumption that the mean water level in each lake, for the months of June, July, August, and September (for the period 1941-1956) defines an equipotential surface. Elevations are stated in units of *dynamic number* as defined in Bowie and Avers (1914).

datum, Mercury 1960 #A *geodetic datum* based on the *Mercury spheroid 1960,* which is located with respect to a number of major datums of the world by a set of constants.#

It was used principally by the United States of America in computation of orbits and trajectories in relation to tracking stations - in particular, to those tracking stations in Project Mercury. It has also been used as the datum for locating omega, loran-c, and loran-a stations.

datum, Modified Mercury 1968 #A datum derived in 1968 as an improvement on the *Mercury 1960 datum*.#

A spheroid of the same flattening but with a semimajor axis of 6,378,150 m was used. The other defining constants, those relating coordinates in the datum to coordinates in other national or continental datums, were also changed.

datum, NAP See *Normaal Amsterdams Peil.*

Datum, National Geodetic Vertical (1) #The *vertical control datum* used by the National Geodetic Survey for vertical control.#

(2) In the form "National Geodetic Vertical Datum of 1929", a synonym for *Sea Level Datum of 1929.* This term was officially adopted by the National Geodetic Survey on May 17, 1976. It was a change in name only—the datum remained the same.

datum, Newlyn #A *vertical control datum* referred to mean sea level at Newlyn, England.# See also *Datum, Ordnance Newlyn Third Geodetic Leveling.*

Datum, North American #The *horizontal control datum* that is defined by the following location and azimuth on the *Clarke spheroid of 1866,* with origin at Meades Ranch:

longitude	98° 32′ 30.″506 W
latitude	39° 13′ 26.″686 N
azimuth from Meades Ranch to Waldo	75° 28′ 14.″52#

North American Datum is identical with *United States standard datum:* the latter name was changed in 1913 when its adoption by the governments of Canada and of Mexico for their control surveys gave it an international character.

Datum, North American 1927 See *Datum of 1927, North American.*

Datum, North American 1983 See *Datum of 1983, North American.*

datum, Ordnance Newlyn Third Geodetic Leveling #The *vertical control datum* used in Great Britain for the Third Geodetic Leveling. It is based on mean sea level at Newlyn, England.

datum, Pulkovo 1932 #The *geodetic datum* based on the *Bessel spheroid* and having as origin the center point of the Round Hall at Pulkovo observatory:

longitude of origin	30° 19′ 42.″09 E
latitude of origin	59° 46′ 18.″55 N
azimuth from origin to Signal "A"	317° 02′ 50.″62#

The same origin corrected for the deflection resulting from an astrogeodetic adjustment and computed on the *Krasovsky spheroid* is known as *Pulkovo datum 1942.*

datum, Pulkovo 1942 #A *geodetic datum* based on the *Krasovsky spheroid* and with the same origin at Pulkovo observatory as the *Pulkovo 1932 datum:*

longitude of origin	30° 19′ 42.″09 E
latitude of origin	59° 46′ 18.″55 N
deflections of the vertical	
meridian	0.″16
prime vertical	−1.″78#

It is officially called the "1942 Pulkovo system of Survey Coordinates".

Datum, Sea Level of 1929 #A *vertical control datum* established for vertical control in the United States by the general adjustment of 1929.#

Mean sea level was held fixed at the sites of 26 tide gauges, 21 in the U.S.A. and 5 in Canada. The datum is defined by the observed heights of mean sea level at the 26 tide gauges and by the set of elevations of all bench marks resulting from the adjustment. A total of 106,724 km of leveling was involved, constituting 246 closed circuits and 25 circuits at sea level.

The datum is not mean sea level, the geoid, or any other equipotential surface. Therefore it was renamed, in 1973, the National Geodetic Vertical Datum of 1929.

datum, South American 1969 #The *geodetic datum* based on the South American spheroid 1969

semimajor axis	6,378,160 m
flattening	1/298.25

and with origin at triangulation station Chua (Brazil):

	geodetic	astronomic
longitude	48° 06′ 04.″0639 W	48° 06′ 07.″80 W
latitude	19° 45′ 41.″6527 S	19° 44′ 41.″34 S

azimuth from origin to Uberaba

(measured clockwise from north)	91° 30′ 05.″42
geoidal height	0 m#

datum, South American Provisional (1956) #The *geodetic datum* based on the International ellipsoid and with origin at triangulation station La Canoa:

longitude of origin	63° 51′ 34.″88 W
latitude of origin	8° 34′ 17.″17 S
geoidal height	0 m#

datum, Tsingtao #A *vertical control datum* based on the bench mark at Tsingtao and assigning to that bench mark an elevation of 72.289 m above mean sea level of the Yellow Sea.#

datum, Tokyo #A *horizontal control datum* defined by the following location and azimuth on the *Bessel spheroid* of 1841; the origin is at the center of the transit circle at the old Tokyo Observatory:

longitude	139° 44′ 40.″50 E
latitude	35° 39′ 17.″51 N
azimuth from the origin to station Kano-Yama (clockwise from north).#	156° 25′ 28.″44

datum, United States Standard #The name given on March 13, 1901 to the New England datum. Adjustment of geodetic networks in the United States had been done using a datum with origin at Meades Ranch. The final, adjusted coordinates differed so little from those in the earlier, New England datum, that the latter was retained but given a change of name. This name was later changed to North American Datum.#

datum, World Geodetic System 1972 See *World Geodetic System 1972.*

datum, World Geodetic System 1983 See *World Geodetic System 1983.*

datum, Yof Astro 1967 #A *horizontal control datum* based on the *Clarke spheroid of 1880* and with origin at station Yof Astro 1967:

longitude	17° 29′ 07.″02 W
latitude	14° 44′ 41.″62 N
deflection of the vertical	0.0#

Datum of 1927, North American #The *horizontal control datum* that is defined by the following location and azimuth on the Clarke spheroid of 1866, with origin at Meades Ranch:

longitude	98° 32′ 30.″506 W
latitude	39° 13′ 26.″686 N
azimuth from Meades Ranch to Waldo	75° 28′ 09.″64

Geoidal height at Meades Ranch is assumed to be zero.#

Geodetic positions on the North American Datum of 1927 were derived from the above location and azimuth through a readjustment of the triangulation of the entire network in which Laplace azimuths were introduced, and the Bowie method was used.

Datum of 1929, National Geodetic Vertical The name, after May 10, 1973, of *Sea Level Datum of 1929.*

Datum of 1983, North American #The *horizontal control datum* for the United States, Canada, Mexico and Central America, based on a geocentric origin and the *Geodetic Reference System 1980*.#

This datum, designated as NAD 83, is the new geodetic reference system. It is scheduled for implementation in 1986 to replace the North American Datum of 1927. NAD 83 is based on the adjustment of 250,000 points including 600 satellite Doppler stations which constrain the system to a geocentric origin.

Davidson meridian instrument See *telescope, meridian.*

day (1) #The *period* during which the Earth rotates through 360°; the interval between successive passages of a fixed point on the Earth's surface through a specified plane in space.#

Since the direction of this plane is not usually fixed in inertial space, the length of the day will depend on how the direction is specified. For example, the reference plane may be required to pass through the center of the Sun, giving rise to the *apparent solar day,* or the plane may be specified to pass through the vernal equinox, giving rise to the *sidereal day.*

(2) #A period containing 86,400 *seconds* of time.#

If the second is defined by reference to a spectroscopic frequency, the length of the corresponding day is constant. The length of the day is also constant if the *ephemeris second* is used. If the second is defined by reference to current positions of heavenly bodies, the length of the day is not constant, and the definition of day may become equivalent to that given above as (1).

(3) #A period that is a specified fraction of the period of motion of some heavenly body such as the Earth, Moon, etc.#

See *day, lunar* for an example.

day, apparent solar #The *time interval* from a transit of the Sun across a given meridian to its next successive transit across the same meridian.#

Because the revolution of the Earth is not uniform, apparent solar days vary in length through the year; the maximum deviation from a *mean solar day* is not quite a half minute.

day, astronomical #A *solar day* beginning at noon.#

The astronomical day may be based on either *apparent solar time* or on *mean solar time*. It begins 12 hours later than the civil day of the same date. Before 1925, the astronomical day was used in the *American Ephemeris and Nautical Almanac*. Since the beginning of 1925 the civil day has been used instead.

day, civil #A *solar day* beginning at midnight.#

The civil day may be based either on *apparent solar time* or on *mean solar time*. It begins 12 hours earlier than the astronomical day of the same date.

day, constituent #A period of rotation (of the Earth with respect to a fictitious star) representing one of the periodic elements in the tidal forces.#

A constituent day approximates in length the lunar or solar day and corresponds to the period of a diurnal *constituent* or twice the period of a semidiurnal constituent. The term is not applicable to the long-period constituents.

day, ephemeris #A day containing 86,400 *ephemeris seconds*.#

day, lunar (1) #The *time interval* from one upper transit of the Moon through a meridian of the Earth to the next upper transit.#

Its mean value is about 24 hours 50 minutes, but it varies as much as 10 minutes from the mean.

(2) #The *time interval* between two successive transits of the Sun through a meridian of the Moon.#

day, mean solar #The *time interval* from a transit of the *mean Sun* across a given meridian to its next successive transit across the same meridian.#

The mean solar day is the average length of the apparent solar day throughout the year. See also *time, mean solar*.

day, sidereal #The *time interval* from a transit of the (true) *vernal equinox* across a given meridian to its next successive transit across the same meridian.#

The length of the sidereal day is subject to slight irregularities on account of small differences between the positions of the true equinox, which are affected by precession and nutation, and the mean equinox, which are affected by precession only. The sidereal day contains $23^h56^m04^s.091$ of *mean solar time*. See also *time, sidereal*.

day, solar #The *time interval* from the transit of either the Sun or the *mean Sun* across a given meridian to the next successive transit of the same body across the same meridian.#

See *day, apparent solar* and *day, mean solar*.

day, tidal (1) See *day, lunar* (1).

(2) #The *time interval* from *higher high water* to higher high water at a particular place.# The tidal day is about 24^h50^m long (approximately equal to the *lunar day (1)*).

daylight-saving time See *time, daylight saving*.

day number #Either a *Besselian day number* or an *independent day number*.#

day number, Besselian #A member of a set of five first-order (A, B, C, D, E) and two second-order (J, J') quantities that appear in equations for determining the apparent (true) right ascension and declination of a star as a function of time from its mean right ascension and declination at an initially given time.#

A, B, and E account for first-order corrections, and J and J' the second-order corrections due to precession and nutation; C and D account for the effect of the annual aberration. The first-order quantities are commonly listed in ephemerides for every day of the year, together with the increment of time from the nearest beginning of a *Besselian year*, which is taken as the initially given time.

Besselian day numbers and *independent day numbers* are related by simple transformations. Formulas involving the Besselian day numbers are best used for the systematic calculation of a number of star places, but for an occasional reduction the independent day numbers are more suitable. (See Explanatory Supplement, H.M. Nautical Almanac offices, 1961, pp. 150-164.)

day number, Greenwich sidereal #The integral part of the *Greenwich sidereal date*.#

day number, independent #A member of a set of six first-order quantities (f, g, G, h, H, and i) that appear in equations for determining the apparent (true) right ascension and declination of a star as a function of time from its mean right ascension and declination at an initially given time.#

f, g and G are transformations of Besselian day numbers. A, B and E, and h, H, and i are transformation of Besselian day numbers C and D. Independent day numbers are usually listed together with Besselian day numbers in ephemerides

See *day number, Besselian*.

day number, Julian #An integral number of days reckoned from Greenwich mean noon (1200 UT) on January 1, 4713 B.C.#

Julian day number 2,415,020 corresponds to 12^h on January 0, 1900. The Julian day number for 1950.0 (Besselian year) is 2,433, 282.423.

day number, Julian ephemeris #A Julian day number in which the days are 86,400 ephemeris seconds long.#

day number, modified Julian #A Julian day number from which 2,400, 000.5 has been subtracted.#

dead reckoning #The calculation of the location of a moving craft from its known or assumed initial position and from estimates or measurements of the vessel's velocity and drift without consideration of additional observations.#

decentration #Failure of the optical center of one element of an optical system to lie on the optical axis of a preceding or succeeding element.#

Decentration causes distortion, particularly tangential distortion, similar to that caused by introducing a thin wedge into a perfectly centered optical system. Thus the effect of decentration is sometimes called the "wedge effect".

declination (1) (astronomy) #The angle at the center of the celestial sphere between the plane of the celestial Equator and a line from the center to a point on the celestial sphere.#

Declination is measured by the arc of the hour circle between the point in question and the Equator; it is positive when the point is north of the Equator, and negative when south of it. Declination corresponds to latitude on the Earth, and together with right ascension it is part of a pair of coordinates that define the position of a point on the celestial sphere.

(2) (geomagnetism) See *declination, magnetic.*

declination, grid See *gisement,* and *convergence, grid.*

declination, magnetic #The angular direction, east or west from the north branch of the celestial meridian, of magnetic north as determined by the positive pole of a freely suspended magnetic needle that is not subject to any transient, artificial disturbance.#

In nautical and aeronautical navigation the term variation is used instead of declination, and the angle is called variation of the compass or magnetic variation. Except for usage in navigation, magnetic declination is not synonymous with magnetic variation, which refers to regular or irregular change with time of the magnetic declination, dip, or intensity.

declination, parallel of #A small circle on the celestial sphere, parallel to the celestial Equator.#

declination arc (1) #A graduated arc on a surveyor's solar compass or on the solar attachment of an engineer's transit, on which the declination of the Sun (corrected for refraction) is marked.#

(2) #A graduated arc, attached to the alidade of a surveyor's compass or transit, on which the magnetic declination is marked.#

A reading of the needle will give a bearing corrected for that declination.

declinatoire See *compass, box.*

declinometer #A magnetic compass similar to a surveyor's compass, but arranged so that the line of sight can be rotated to conform with the needle or to any desired setting on the horizontal circle.#

Used for determining the magnetic declination.

definition (1) #The degree of clarity and sharpness of an image.#

The term, in this sense, does not have the intrinsic objective and quantitative connotations of *resolution*.

(2) #The subjective impression of clarity and sharpness made on an observer by a photograph and resulting from the combined effects of *resolution*, sharpness, contrast, graininess, and tonal reproduction.#

Also referred to as "photographic definition".

deflection anomaly #The difference between a *deflection of the vertical* calculated from astronomical observations and the deflection calculated from data on gravity.#

The term is rare and its meaning is inconsistent with that given to anomaly in other terms.

deflection of the plumb line #Equivalent to *deflection of the vertical.*# When using "deflection of the plumb line", an observer considers himself on the surface looking downward and measuring from the normal (to the ellipsoid of reference) through the point in the direction of gravity (the plumb line) at the point. When using "deflection of the vertical", the view is upward. The magnitudes and directions of both are, however, the same.

deflection of the vertical #The angle at a point on the surface of the Earth (from the geoid) between the *vertical* at that point, and the line through the point which is normal to the given reference surface.#

If the point is on the geoid and has been obtained from a point on the Earth's surface by the intersection of the plumb line through the surface point with the geoid, then the term reduced deflection of the vertical is often used.

Of the two lines which define the deflection of the vertical, the vertical at the point is fixed (except for temporal changes), but the other line depends on the definition of the reference surface. If the reference surface is an ellipsoid referred to a specific geodetic datum, the deflection can be computed by comparing the astronomic and geodetic coordinates of the point. In this case, the term astrogeodetic deflection is used. If the reference surface is a *normal ellipsoid* referred to an absolute geodetic datum, the deflection can be computed by utilizing gravimetric measurements in *Vening Meinesz' formula.* In this case, the term gravimetric deflection is used.

These are the most common meanings of deflection of the vertical, but other meanings have also been used.

deflection of the vertical, absolute See *deflection of the vertical, gravimetric.*

deflection of the vertical, absolute gravimetric See *deflection of the vertical, gravimetric.*

deflection of the vertical, astrogeodetic #A *deflection of the vertical* obtained by comparing the astronomic and geodetic coordinates at a point on the surface of the Earth (or on the geoid).#

The deflection can be resolved into two components: ξ, in the meridional plane through the point and positive northward, and η, in the prime vertical through the point and positive eastward. The components of the deflection are given by

$$\xi = \Phi - \phi$$
$$\eta = (\Lambda - \lambda) \cos \phi$$

where (Φ, Λ) are astronomic coordinates, and (ϕ, λ) geodetic coordinates of the point on the surface (or suitably reduced to the geoid). The geodetic coordinates depend on the geodetic datum to which the reference ellipsoid refers. If it is not an *absolute datum*, the deflection is called a relative deflection of the vertical.

deflection of the vertical, astronomic-geodetic See *astrogeodetic deflection of the vertical.*

deflection of the vertical, external #The *deflection of the vertical* computed at a point outside the Earth's surface.#

deflection of the vertical, gravimetric #A *deflection of the vertical* obtained by applying gravimetric measurements in *Vening Meinesz' formula*.#

See *Vening Meinesz' formula* for the method of computation. The formula utilizes *gravity anomalies* obtained from gravimetric measurements. The reference surface for the gravity anomaly computation is a *normal ellipsoid* referred to an *absolute datum,* and for this reason, the deflection is called an absolute deflection of the vertical.

deflection of the vertical, reduced See *deflection of the vertical.*

deflection of the vertical, relative See *deflection of the vertical, astrogeodetic.*

deflection of the vertical, topographic #The portion of the *gravimetric deflection of the vertical* that is caused by the *indirect effect* of topographic masses.#

deflection of the vertical, topographic-isostatic #A topographic deflection of the vertical in which *isostatic gravity reductions* contribute to the *indirect effect.* #

deflection of the vertical, Vening Meinesz' formula for See *Vening Meinesz' formula.*

deflection of the vertical anomaly See *deflection anomaly.*

degaussing #Reducing or removing the magnetization of a body.#

degree (unit of angle) See *angle (1).*

degree, square (1) #A unit of measure of solid angle corresponding to the area, on a sphere of unit radius, of a quadrangle composed of great arcs 1° on a side.#

There are approximately 41,251 square degrees on a sphere, and approximately 3,283 square degrees in a steradian.

(2) #The square degree is sometimes defined as 1/64,800 of the surface of a unit sphere.# This definition and definition (1) do not define the same angle.

A solid angle (figure) having a solid angle (measure) of 1 square degree is not necessarily square. The quadrangle used in definition (1) is not rectangular—the interior angles are slightly greater than 90° and the sides bow out. They cannot be assembled into a uniform packing of the sphere's surface.

degree of curve See *curve.*

Delaunay element See *element, Delaunay.*

delimitation #The drawing of a boundary on a map.#

Dellen's method See *Doellen's method.*

demarcation #The marking off of a boundary on the ground.#

densitometer #An instrument for measuring the opacity of translucent materials such as photographic negatives, optical filters, and liquids.#

The densitometer passes a beam of light through the material and measures the ratio of the intensity of the light emerging from the material to the intensity of the light entering the material. If the beam is of very small diameter at its place of entry into the material, the instrument is called a microdensitometer.

The transmission densitometer measures the full density range of negatives, and the reflection densitometer measures the reflection range (density) of opaque copy.

density (photography) #The common logarithm of the reciprocal of the *transmittance* of a translucent medium such as a photographic negative or transparency.#

density layer (1) #A mathematical surface and a function, defined at each point of the surface, whose values have dimension: mass per unit area.#

The surface is called a single-layer surface if it is considered one-sided. It is called a double-layer surface if it is considered two-sided and at each point the positive value of the function is associated with one side and the negative value with the other. The solution to *Poisson's equation* can be expressed as the sum of the potentials from three distributions of density: the distribution on a single-layer surface, the distribution on a double-layer surface, and the distribution throughout the volume.

(2) #A mathematical surface and a function defined at each point of the surface, whose values are $(\partial\ \Phi/\partial n)/4\ \pi$ (single-layer surface density) or $\Phi/4\pi$ (double-layer surface density); Φ is a function twice-differentiable in the entire space and continuously differentiable on the surface, and $\partial\Phi/\partial n$ denotes the gradient of Φ at the surface.#

departure (plane surveying) #The orthogonal projection of a line onto an east-west axis of reference.# (Departure is abbreviated to "dep." in notes).

The departure of a line is the difference of the *meridian distances* or longitudes of the ends of the line. It is east or positive, and sometimes called the easting, for a line whose azimuth or bearing is in the northeast or southeast quadrant; it is west or negative, and sometimes called the westing, for a line whose azimuth or bearing is in the southwest or northwest quadrant.

depth (1) #The vertical distance, in the direction of gravity, from a specified equipotential surface (the geoid, if not specified otherwise) to a specified point.#

(2) #The vertical distance, in the direction of gravity, from a specified water level to a specified point.#

For example, the vertical distance from a point on the surface of a body of water to the bottom.

depth, charted #The vertical distance from the tidal datum to the sea bottom.#

depth, dynamic See *dynamic depth*.

depth finder #An instrument for determining the depth of water.#

In particular, an *echo sounder*.

depth of compensation See *isostasy.*

depth of field #The distance between those points nearest to and farthest from the camera which can be imaged with acceptable sharpness.#

depth of focus #The distance that the focal plane can be moved forward or backward from the point of exact focus, and still give an image of acceptable sharpness.#

Also called focal range.

dereliction #The gradual, natural, and more or less permanent recession of water from land that changes the boundary between land and water.#

descending node See *node.*

description #Information on the location and type of a bench mark or triangulation station sufficient to enable anyone to go to the immediate locality and identify the mark with certainty.#

description, bounds #A description of the boundary of a piece of land in terms of adjoining land or waters.#

For example, "... bounded on the north by Potomac River, on the west by Turkey Run Park, on the south by the land of Joseph Taylor, and on the east by Turkey Run."

description, metes and bounds #The designation of a piece of land by giving the courses and distances around the piece, or by referring to natural features or recorded monuments.# See also *metes and bounds.*

description, plat #Designation of a piece of land by referring to a map (plat) that has been filed in a public office.#

detail, junction See *junction detail.*

deviation #The difference between the actual and the theoretically expected value of a quantity.#

See also *residual: error, residual;* and *discrepancy.*

Deviation is not the same as *error.*

deviation, standard See *standard deviation.*

deviation of the vertical See *deflection of the vertical.*

diaphragm (1) (optics) #A thin, opaque piece of material with a hole (aperture) through which light can pass.#

It is placed in an optical system to keep unwanted light from reaching the image plane or detector, e.g., to limit the field of view or to absorb internally scattered light. The *stop* is the theoretical counterpart of the diaphragm. A shutter is a diaphragm whose aperture can be opened and closed, usually for a predetermined interval of time.

(2) (surveying) #The thin disk of glass on which lines forming a *reticle* are placed.#

However, the term reticle is often used to denote both the diaphragm and the lines.

diaphragm, iris #A continuously variable, approximately circular opening in a lens system which regulates the amount of light passing through the system.#

diapositive #A positive photograph on a transparent medium.#

The term generally refers to a transparent positive on a glass plate used in a stereoscopic plotting instrument, a projector, or a comparator. In Europe, the term usually refers to a positive-film transparency that would be identified as a "slide" by an American user.

dioptric #Containing only refractive elements (lenses, prisms, or both).#

dip (1) (geology) #The angle that the plane of a stratum or fault makes with a horizontal plane.#

(2) (geomagnetism) #The inclination of the geomagnetic field.#

(3) See *dip of the horizon.*

dip needle (1) #An instrument for measuring geomagnetic *inclination.*#

It consists of a magnetic needle suspended so that it rotates in a vertical plane; the amount of rotation is indicated on a graduated vertical circle.# Also called a dip circle.

(2) #An instrument similar to (1) used for detecting strong magnetic anomalies.#

dip of the horizon #The angle between a *horizontal plane* at the observer and a line from the observer to the apparent (visible) horizon.#

The apparent horizon lies below the horizontal plane because of the curvature of the Earth, but the angle between the two can be affected by refraction of the light traveling from the horizon to the observer.

direction (surveying and mapping) #The angle between a line or plane and an arbitrarily chosen reference line or plane.#

At a triangulation station, observed horizontal angles are reduced to a common reference line, and are called horizontal directions. They are usually collected into a single list of directions, starting with the 0° direction followed by the other directions in increasing clockwise order.

direction, astronomic #A direction referred to astronomic north.#

direction, cardinal #One of the astronomic directions—north, south, east, and west—on the surface of the Earth.#

The term cardinal, without qualification, is sometimes used to indicate any or all of the above directions.

direction, principal See *curvature, radius of normal.*

direction instrument See *theodolite* and *transit.*

direction of gravity #The direction, toward the Earth's center, indicated by a *plumb line*.#

Gravity is a force and therefore has both magnitude and direction. The direction of gravity is independent of any coordinate system, but its components may be described with respect to two mutually perpendicular planes through the local normal, one being that of the local meridian. Both components are given in terms of the *deflection of the vertical* from those planes.

discontinuity (1) (geologic) #Any abrupt change in geological structure or characteristics.#

(2) (seismic) #A region within the Earth across which sudden changes in structure or characteristics have been inferred from observed changes in the speed of seismic waves. The changes in speed usually are more than 0.2 km s^{-1}.#

The principal discontinuities of this kind are the Mohorovičić and the Conrad discontinuities.

discontinuity, Conrad #A region, at depths of 17 to 20 km under some parts of the continents, in which the speed of seismic P-waves increases from about 6.0 to about 6.5 km s^{-1}.#

Unlike the deeper Mohorovičić discontinuity, the Conrad discontinuity seems to be absent over large regions.

discontinuity, Mohorovičić #A region, lying at depths of from 5 to 10 km beneath oceanic basins to more than 45 km under mountain ranges, across which the speed of seismic P-waves (longitudinal waves) jumps from about 6.5 to about 8.0 km s^{-1}.#

This discontinuity has been assumed to mark the boundary between *crust* and *mantle.*

discrepancy #A difference between two values of the same quantity when a common value is expected.#

In particular: (a) a difference between results of duplicate or comparable measures of a quantity, (b) a difference in computed values of a quantity, or (c) a difference in computed values of a quantity obtained by different processes using data from the same survey.

Examples are: the difference in the length of two measures of the same line; or the amount by which the values of the location of the third point of a triangle, as computed from the two other points may fail to agree, when the triangle has not been corrected for misclosure. Discrepancy is closely associated but not identical with misclosure. See *discrepancy, accumulated.*

discrepancy, accumulated #The sum of the separate discrepancies that occur in the various steps of making a survey or computing a survey.#

For example, if two level lines, run independently over the same series of bench marks, are computed separately, differences between the two sets of values of elevations will accumulate. This does not mean that the accumulated discrepancy will necessarily increase in magnitude.

dispersion (electromagnetism) #The differential change in phase or direction undergone by radiation of different frequencies on traveling through matter.#

All matter affects the velocity of radiation passing through it. The size of the effect depends on the frequency of the radiation. With suitable geometric relationship between beam and medium, the waves in a polychromatic beam will be separated and spread out or "dispersed" according to frequency.

A medium having a strongly dispersive effect (dispersion) is called a dispersive medium. Dispersion is effective only over a limited part of the spectrum; e.g., the ionosphere is a dispersive medium for radio waves longer than a few centimeters, but not for shorter radio waves or for light.

The best-known example of dispersion is the effect of a glass prism on light. A beam of white light entering one side of a triangular glass prism is fanned out into a spectrum of different colors on leaving the prism. See also *refraction.*

dispersion (statistics) (1) #A general term for the spreading out of values of a quantity from a specific value.#

In this sense dispersion is distinguished from the *standard deviation* or *variance*. For example, one would speak of the *dispersion* of the heights in a particular group of people but of the *standard deviation* of the measurements of those heights.

(2) Either *standard deviation* or *variance*, depending on the user.

displacement (photogrammetry) #Any shift in the position of an image on a photograph that does not alter the perspective characteristics of the photograph.# Relief displacement is an example.

displacement, height See *displacement, relief.*

displacement, principle of radial #The photogrammetric principle that points vertically above each other on the ground appear to be displaced radially with respect to each other on the photograph, the center being the principal point or the nadir.#

The amount of displacement is approximately proportional to the difference in elevation.

displacement, relief #Radial displacement of an image point from the principal point when the object point is moved parallel to the optical axis. In particular, the radial displacement of an image point toward or away from the nadir, respectively, when the corresponding ground point is below or above the ground nadir.# Also called height displacement.

displacement, tilt #Radial displacement of images on a tilted photograph, outward or inward with respect to the *isocenter*, respectively, when the images are on the low or high side of the isometric parallel (the low side is the one closer to the object plane).#

distance #A number indicating the separation of two points.#

The distinction between *distance* and *length* is that for length, the two points are the extremities of a particular object, while for distance the two points refer to different objects.

distance, conjugate #The corresponding distances of object point and image point from the nodal points of a lens.#

The conjugate distances L_o and L_I and the focal length f of the lens are related by the equation:

$$1/f = 1/L_o + 1/L_I.$$

The total distance from object point to image point equals the sum of the two conjugate distances plus or minus (depending on design of the lens) the distance between nodal points.

distance, double meridian See *meridian distance, double.*

distance, double zenith See *angle, double zenith.*

distance, focal See *focal length.*

distance, meridian See *meridian distance.*

distance, plus #The distance along a surveyed line from a survey station or the last whole-numbered survey point to a supplementary point.#

For example, if a stake is set at 515.56 feet from the initial point of a surveyed line and is not the terminal of that line, the whole-numbered 500-foot point on the line is station No. 5; the stake is a plus station (No. 5 + 15.56), and the

15.56 is a plus distance.

distance, polar #The complement of the declination, i.e., 90° minus the declination.#

Also called codeclination. The arc corresponding to polar distance is one side (celestial body to pole) of the *astronomical triangle*. It is opposite the *zenith*.

distance, principal (1) #The perpendicular distance from the internal perspective center to the plane of a photographic negative or print.#

This distance is equal to the calibrated focal length of the camera that took the original photograph, corrected both for the enlargement or reduction ratio and for the shrinkage or expansion of the film or paper since the photograph was taken.

(2) #The perpendicular distance from the internal perspective center of the projector of a stereoscopic plotting instrument to the plane, in the projector, of the emulsion side of the diapositive.#

distance, tangent #The distance from the *point of intersection* (vertex) of a curve to its *point of tangency* or *point of curvature*.#

distance, zenith See *angle, zenith.*

distance angle See *angle.*

distance-measuring equipment (DME) #An instrument plus auxiliary gear used for measuring distances between points.#

Several distinct categories of DME are recognized on the basis of the nature of the measuring instruments contained in the equipment. A DME purely mechanical in nature, such as base line apparatus and accessories, is called a mechanical DME. A DME containing instruments that measure arrival-time, phase, or frequency of electromagnetic radiation is classified as a radio, an infrared, or an optical DME depending on the wavelengths of the radiation used.

distance-measuring equipment, electronic #Distance-measuring equipment of which the measuring part is electronic.#

Often written as EDME.

distance-measuring equipment, electro-infrared #Distance-measuring equipment which modulates CW or pulsed infrared radiation electronically.#

It is usually considered by geodesists to be a kind of electro-optical DME. Also called electro-optical distance-measuring equipment.

distance-measuring equipment, electro-optical (1) #Distance-measuring equipment that modulates CW or pulsed light by electronic means, such as a Kerr cell.#

(2) See *distance-measuring equipment, electro-infrared.*

distance-measuring equipment, infrared #Distance-measuring equipment sending modulated CW or pulsed infrared radiation from one end of the distance being measured to the other end and measuring the distance in terms of the time needed for the modulation to make a round trip from one end to the other and return.#

Most infrared DME does not sent out sharp pulses but modulates the infrared radiation with continuous waves at one or more radio frequencies; the difference in phase between the emitted and returned waves is measured. Most DME using a laser as the source of radiation is infrared DME.

distance-measuring equipment, optical #Distance-measuring equipment that contains an optical system essential to the measuring process.#

Probably two types can be distinguished—one that involves the formation of an image, and one that involves the modulation of light. The first includes instruments such as range finders and the equipment used in the stadia method of distance measurement. The second includes the Väisälä base line apparatus and those DME that send and receive pulses of light.

distance-measuring equipment, radio #Distance-measuring equipment that determines the distance between two points by sending radio waves (waves longer than 0.3 mm) from the one point to the other and (usually) back, and either measuring the difference in phase between the outgoing and returned waves or by measuring the difference in time between emission and return of a group of waves.#

Equipment for measuring distances to objects high above the Earth's surface, such as aircraft, artificial satellites, or planets, is usually at a fixed location, and uses considerable power and pulsed radiation. It usually also measures direction. Such equipment is called *radar*. Small radars are mounted in aircraft for measuring the altitude of the aircraft or for obtaining the profile of the terrain. The principal exception to use of pulsed radiation is the *radio interferometer*, which does not measure distance but differences in phase.

distance-measuring instrument #A distance-measuring instrument (DMI) is usually compact and self-contained, and consists of a single piece.#

When accessories, such as reflectors for radio or electro-optical DMI, a tape stretcher, stools for a surveyor's tape, etc., are attached, the instrument, plus its accessories, is then considered DMI equipment, or DME.

distance-measuring instrument, mechanical #A distance-measuring instrument entirely or almost entirely mechanical in nature.#

Examples are the *odometer* and the surveyor's tape.

distance wedge #A thin *prism* placed in front of the objective of a telescope and rotatable through an accurately measured angle about a horizontal or vertical axis.#

Rotation of the prism through a known angle deflects the line of sight through a measurable distance on a graduated staff. For a given angle of rotation, the distance of the observer from the staff is a function of the distance the line of sight is deflected along the staff and can be determined from these two quantities. The principle is used in some *tachymeters*.

distortion #A *Seidel aberration* that causes the scale of the image to change from point to point in the image.#

It is commonly separated into two components: radial distortion, which is change of scale along a line radially outward from the optical axis, and tangential distortion, a change of scale in a direction perpendicular to a radial line.

distortion, relief See *displacement, relief.*

distribution (statistics) #A function of one or more variables which assigns to each set of values of these variables either a probability or a relative frequency of occurrence.#

The two most-used distribution functions are (a) the distribution density, which gives the probability or relative frequency of finding values of the variables within a specified range and (b) the cumulative distribution, which accumulates the relative distribution density over a given range. Unless otherwise stated, the lower limit of the range for a cumulative distribution is $-\infty$.

distribution, Bernoulli See *distribution, binomial.*

distribution, binomial #The function

$$p(x) = \binom{n}{x} a^x (1-a)^{n-x}, \ (x = 0, 1, \ldots n)$$

that gives the probability of an event appearing x times in n observations if the probability of its appearing in one observation is a.#

distribution, Gaussian #The *function*

$$p(x) = [1/\sigma\sqrt{2\pi}] \exp [-(x - \xi)^2/2\sigma^2]$$

for $-\infty < x < +\infty$, that assigns the probability $p(x)\,dx$ to a variable x over the interval dx.#

The probability $P(x)$ that x is less than or equal to x_o is therefore

$$P(x) = \int_{-\infty}^{x_o} p(x)\,dx.$$

The multivariate Gaussian distribution or k-variate Gaussian distribution function for k variables is:

$$p(x) = \left[\sqrt{\left|\vec{\Sigma}^{-1}\right|}/(2\pi)^{k/2}\right] \exp [-(1/2)(\vec{x} - \vec{\xi})^T \vec{\Sigma}^{-1} (\vec{x} - \vec{\xi})].$$

In these formulas, σ is the standard error of x, and $\vec{\xi}$ the average value of x; $\vec{\xi}$ is the average value of the k-vector $\vec{x}$, and $\vec{\Sigma}^{-1}$ is the inverse of the covariance matrix of $\vec{x}$. Also called a normal distribution.

distribution, normal See *distribution, Gaussian.*

distribution, Poisson #A function

$$p(x) = e^{-\xi}\,\xi^x/x!,$$

giving the probability $p(x)$ of x discrete occurrences of an event in a very large number N of trials if the probability a of the event occurring in one trial is very small, and $\xi = Na$.#

disturbing function #The non-central portion of a gravitational potential.#

The term is usually applied in connection with determination of orbits of celestial bodies.

diurnal variation #The component of a periodically varying quantity that passes through a complete cycle in one *day.*#

Such a component is said to have a periodicity of one day. Magnetic declination for example, has a diurnal variation.

divergence (leveling) #The difference between the numerical values of two runnings over the same section of a level line.#

Divergence and the synonymous term "partial" are rarely used now in leveling.

divergence, accumulated (leveling) #The algebraic sum of the divergences or "partials" for the sections of a level line, from the beginning of the line to the end of any section at which it is desired to compute the total divergence.# The term is seldom used.

division (1) #Marks placed on an instrument or device to represent standard values thereon.#

(2) #The placing of division marks.#

The term graduation is almost synonymous with division, but is more often used to indicate the placing of intermediate marks on an instrument or device (tape, thermometer, etc.) by interpolation.

Doellen's method #A method for determining time or longitude by observing the passage (transit) of one or more time-stars through the vertical plane through Polaris.#

Döllen method See *Doellen's method.*

Doodson number #A number, also called an argument number, identifying a component of the tides.#

In the equation for the amplitudes of the tides as a function of time (atmospheric, oceanic, or Earth), the trigonometric series used contains as argument a linear function $a\tau + bs + ch + dp + eN' + fp_s$ where $b, \ldots f$ are integers lying between -4 and $+4$, and a ranges from zero to a large positive integer. Also, τ is mean lunar time, s the mean longitude of the Moon, h the mean longitude of the Sun, p the longitude of lunar perigee, N' the negative longitude of ascending node of the Moon, and p_s the longitude of perihelion. A particular term is therefore identified by the coefficients $a \ldots f$ in the argument. +5 is added to coefficients $b \ldots f$ and, using B for $b + 5$, C for $c + 5$, etc., the Doodson number is written: aBC.DEF. For example, the M_2 component, the semidiurnal tide caused by the Moon, has the Doodson number 255.555; the S_2 term has the number 273.555; etc.

Doolittle method #A method of solving a set of linear equations by successively solving for each variable in terms of the others and then eliminating it; originated by M. H. Doolittle for greater ease of computation and easier checking of results.#

See, e.g., Dwyer (1942) and Doolittle (1881). It is also called the Gauss-Doolittle method, which may be preferable since Gauss invented the basic method.

Doppler count #A count of frequency difference from the *Doppler shift* that measures the change in distance between source and observer during a specified interval of time.#

Doppler effect See *Doppler shift.*

Doppler frequency #The observed (received) frequency in the *Doppler shift.* #

Doppler navigation #*Navigation* that obtains the craft's velocity from observations of *Doppler shift* in a received signal.#

Two kinds of equipment are in use for this kind of navigation. The first kind consists of beacons emitting signals at known frequencies which are established at fixed points of known location; the moving vehicle measures the difference between the frequency of the signal it receives and that of the emitted signal. In the second kind, the craft itself carries the emitter. Here the radiation emitted is reflected from the ground or ocean bottom and is recorded by a receiver on board the craft.

Doppler shift #The difference between the frequency of radiation received at a point and the frequency of the radiation at its source, when observer and source are moving with respect to each other.#

Let f_o and f_s be the received and emitted frequencies, respectively. Then the Doppler shift, Δf, is given by

$$\Delta f = f_o - f_s = -f_s\,(v/c)$$

where v is the speed of the observer with respect to the source, positive for the two moving apart, and c is the speed of the radiation. (This formula neglects relativistic effects.)

double meridian distance See *meridian distance, double.*

double-sighting #Taking two readings on a transit, once with the telescope in its normal position and once with the telescope inverted, and then taking the average of the two readings.#

drag (1) (instrumental) #A slight movement of the graduated circle of a theodolite, produced by the rotation of the *alidade.* #

Drag may be caused by excessive friction in the instrument centers, excessive spacing in the fit of the centers, or instability in the instrument supports.

(2) (atmospheric) #The retarding force exerted by an atmosphere on a body moving through it.#

See *drag, air* and *drag, atmospheric.*

drag, air #Resistance of the air to motion of a body moving in it.# In particular, resistance of the air to aircraft, projectiles, and artificial satellites.#

A good, approximate formula for the resistance $\vec{F}_a$ is

$$\vec{F}_a = k\,\rho\,A\,(\vec{v}\cdot\vec{t}\,)^2\,\vec{t}/2$$

where k is a dimensionless coefficient whose value is determined by the shape of the moving body; ρ is the density of the air, A is the maximum area of cross-section of the body in the direction of motion, $\vec{v}$ is the velocity of the body relative to the air velocity, and $\vec{t}$ is the unit tangent in the direction of motion. In regions where the mean free-path of the molecules of air is much greater than the diameter of the satellite, k is nearly independent of the shape of the object and can be assumed to have a value between 2 and 2.5.

Air drag gradually decreases the major axis and eccentricity of an orbit, shortens the period of revolution, and increases the angular velocity of the satellite.

drag, atmospheric #The retarding force exerted by an atmosphere on a body moving through it.#

For atmospheres similar to the Earth's, the formula is the same as that given under *drag, air.* However, atmospheres like those of Jupiter or Venus may produce forces that may have different effects on bodies moving through them.

drag, instrumental See *drag* (1).

drag-free satellite #An artificial Earth satellite constructed with a device which negates the effect of atmospheric drag.#

drift (1) #The gradual lateral movement of a ship or aircraft caused by currents, winds, or other external lateral forces.#

Aerial photography taken without rotating the camera to compensate for drift of the aircraft results in a sequence of pictures with sides approximately parallel but with centers displaced laterally by the amount of drift between exposures. This condition is known as crab.

(2) #The slow and secular change in accuracy of an instrument.#

dumpy level See *level, dumpy.*

dynamical ellipticity #The quantity $(C - A)/C$ where A and C are the moments of inertia of an ellipsoidal solid about the major axis and the minor axis, respectively.#

The Earth's dynamical ellipticity is determined by measurement of the lunisolar precession, and by other factors such as the ratio of the mass of the Moon to the mass of the Earth.

dynamical form factor #The coefficient of the second-degree zonal harmonic in the *spherical harmonic* expansion of the *potential*, adjusted to be dimensionless.#

Its non-normalized value for the gravitational potential of the Earth has a magnitude of 10^{-3}. It is usually designated by J_2.

dynamic correction See *leveling correction, dynamic.*

dynamic depth #The work needed to move a unit mass from one equipotential surface (usually the geoid) to a surface of lower equipotential.#

The term as used by oceanographers takes account only of work done against gravity. It does not include work done by expansion or contraction, or work against pressure from currents, for example. Also called dynamic height.

dynamic depth anomaly #The excess of actual geopotential difference ΔD between two isobaric surfaces, over the geopotential difference in a homogeneous water column with a salinity of 35 parts per thousand and a temperature of 0°C.#

$$\Delta D = \int_{P_1}^{P_2} [(1/\rho) - (1/\rho_0)]\,dP$$

P_1 and P_2 are the pressures at two depths, ρ is the actual mean density of the water between those pressures, and ρ_0 is the mean density of the homogeneous water column.

Also called dynamic height anomaly.

dynamic elevation See *height, dynamic.*

dynamic height (1) See *height, dynamic.* (2) See *dynamic depth.*

dynamic height anomaly See *dynamic depth anomaly.*

dynamic meter #The unit of *geopotential number,* equal to 10 square meters per second per second.#

Also called geodynamic meter.

dynamic number #*dynamic height* (1)#

A distinction is sometimes made between dynamic number and dynamic height in that the latter has the dimension of height, whereas the former is in dimensions of potential (or work per unit mass) scaled through division by the numerical value of *normal gravity* at 45° latitude. In this sense, the dynamic number is a scaled *geopotential number*. Numerically, dynamic number and *dynamic height* (1) are equivalent.

dynamic number, normal #The same as the *dynamic height* (1), except that the value of gravity is obtained from a standard gravity formula; equivalent to the *normal dynamic height.* #

dynamic topography #The *topography* of a surface (usually isobaric) specified in terms of the *dynamic height* of that surface above a specified surface of reference.#

dynamostat #An apparatus used for applying tension to a surveyor's tape and consisting basically of a lever having one short and one long arm, set at an oblique angle to each other. The lever is pivoted at the junction of the two arms. The pivot moves in a slide.#

A weight is hung from the end of the long arm, and one end of the tape is attached to the end of the short arm.

dyne #The force which gives a mass of 1 gram an *acceleration* of 1 centimeter per second per second.#

The dyne is the unit of force in the c.g.s. system of units. It has been replaced by the newton in the SI. See *gal* and *newton.*

E

Earth #The third planet from the Sun in the Solar System.#

The Earth is an approximately spherical body that revolves about the Sun at an average distance of about 150,000,000 km in a period of 1 year. It rotates about its own axis once per day. It has one satellite, the Moon (mass about 1/81 that of the Earth), that orbits the Earth at an average distance of about 384,000 km. The numerical values (as of 1980) of the most important geodetic characteristics of the Earth are:

Characteristic (symbol)	*Value*
radius, equatorial (a)	6,378,137 m
flattening (f)	1/298.257 222
mass of the Earth (M_E)	5.9742×10^{24} kg
gravitational constant times mass (GM_E)	$3.986\ 005 \times 10^{14}$ m^3 s^{-2}
rate of rotation (ω)	$7.292\ 115 \times 10^{-5}$ rad s^{-1}
dynamical constants	
J_2 (dynamical form factor)	1.08263×10^{-3}
H (dynamical flattening)	3.2756×10^{-3}
acceleration of gravity on terrestrial ellipsoid at Equator (γ_e)	9.780 327 m s^{-2}
volume	1.0832×10^{21} m^3
mass of atmosphere	5.24×10^{18} kg
moments of inertia divided by $a^2 M_E$	
A (minimum)	0.3309
C (maximum)	0.3320

Earth, effective radius of the #A fictitious value for the Earth's radius; used for computing the distance from a point to the *apparent horizon* rather than to the *geometric horizon.* #

If the Earth were spherical and did not have an atmosphere, tangents drawn to the surface from a point of observation above the Earth's surface would define a circle (sometimes called the geometric horizon) outside of which no points on the sphere could be seen by the observer. If an atmosphere were added, points outside that circle would become visible because the line of sight would be curved by atmospheric refraction, allowing the observer to see beyond the geometric horizon to a larger circle (sometimes called the apparent horizon). The distance to the apparent horizon can be calculated using the formula for the distance to the geometric horizon, by substituting the greater value of the "effective radius" for the radius-of-the-Earth factor of the formula. For points within the troposphere, the effective radius is larger than the true radius and increases with wavelength of the radiation under consideration. The effective radius is particularly useful for determining whether two points a considerable distance apart can receive radiation directly from each other or will be within line of sight of each other at optical frequencies. For UHF radio waves the effective radius is about 4/3 the true radius.

Earth, flattening of the #The flattening of the rotational ellipsoid taken to represent the Earth or the geoid.#

Earth, model See *model Earth.*

earth inductor #An instrument used in magnetic surveys for determining the magnetic dip; it works on the principle of a small dynamo whose magnetic field is provided by the Earth.#

The current generated by the dynamo is sent to a galvanometer which indicates the amount of dip.

Earth model (1) #A hypothetical body with approximately the geometrical and physical characteristics of the Earth which can be represented by a tractable set of mathematical equations.#

(2) See *ellipsoid, terrestrial.*

Earth-spherop #The equipotential surface obtained by assigning to the *spheropotential function,* a value such that the volume enclosed by the resulting surface is the same as the volume enclosed by the geoid.#

Earth tide #The periodic movement of the solid Earth caused by the attraction of the Moon, the Sun, and the other planets.#

It is completely analogous to tides in the open ocean, but its amplitude (a maximum of about 30 cm) is less than half that of the tides.

easement #The right given to a person, a group, or an organization to use land belonging to another.#

A very common easement is one that gives a power company the right to bring its lines across private property. Another is the legal establishment of a public trail across private property.

easterly #A direction within 22.5° of east.#

easting (1) #The *grid coordinate* of a point eastward (positive) or westward (negative) from a reference meridian.#

It is common practice to use positive *westings* instead of negative eastings.

(2) #The grid coordinate eastward (positive) or westward (negative) from the central (zero) meridian (the line of zero eastings or the y-axis) on a gridded map.#

The central meridian is frequently replaced by another called the false meridian, sufficiently far to the west of the central meridian so that all eastings on the map are then positive with respect to the false meridian.

See also *departure (plane surveying).*

easting, false #A constant value added to all negative eastings so that only positive values of easting are recorded.#

See also *easting (2).*

eccentricity (1) (mathematics) #A quantity, e, indicating the amount by which a given conic section deviates from a circle; given by

$$e = [1 - k(b/a)^2]^{1/2}$$

where a is the length of the semimajor axis of the section, b the length of the semiminor axis, and k is a constant equal to $+1$ for an ellipse, 0 for a parabola, and -1 for a hyperbola.#

It is also called the "first eccentricity" when necessary to distinguish it from the "second eccentricity", e', which is sometimes used for algebraic convenience. The second eccentricity is defined as

$$e' = [k(a/b)^2 - 1]^{1/2}$$

and is related to the first eccentricity by the equation

$$1 = (1 - e^2)(1 + e'^2).$$

The eccentricity of a surface is the eccentricity of a designated section of the surface. For example, on a triaxial *ellipsoid,* the meridional eccentricity is that of the ellipse formed by a section containing both the longest and the shortest axes (one of which is the polar axis), and the equatorial eccentricity is the eccentricity of the ellipse formed by a section through the center perpendicular to the polar axis.

(2) (instrumentation) #The distance of a point from a center or axis.#

The term is generally applied either to (a) the distance of a surveying instrument from the control point it should be occupying or to (b) the rotation of a part of an instrument about an axis other than the proper axis. See *eccentricity of instrument; station, eccentric; eccentricity of alidade;* and *eccentricity of circle.*

eccentricity of alidade #The distance between the center defined by the index points on the *alidade* and the center defined by the graduated circle.#

The index points (of *vernier* or *micrometer microscope*) are on the alidade, and any eccentricity of alidade combines with eccentricity of circle to form the *eccentricity of instrument.*

eccentricity of circle #The distance between the center defined by a graduated circle and the axis of rotation of the part whose rotation is referred to the circle.#

Eccentricity of circle is usually expressed in terms of its equivalence in seconds of arc on the circle. It may be made quite small by adjustment. Its effect on an observed direction is eliminated by reading the circle at equally spaced points around its circumference. See *eccentricity of instrument.*

eccentricity of compass #A linear error in the readings from a compass, resulting from one or more of the following conditions: a straight line through the ends of the magnetic needle fails to pass through the center of rotation of the needle; the center of rotation of the needle is not coincident with the center of figure of the graduated circle; or the line of sight fails to pass through the vertical axis of the instrument.#

eccentricity of instrument #The combination of the *eccentricity of circle* and the *eccentricity of alidade.*#

The effect of eccentricity of instrument on an observed direction is eliminated by having the *verniers* or *micrometer microscopes* with which the circle is read spaced at equal distances around the circle.

eccentric reduction #The correction that must be applied to an observed direction made with an eccentrically placed instrument or signal, or both, to compensate for those eccentricities.# See *eccentricity (2).*

echogram #The graphic record produced by an *echo sounder* and showing, as a function of time, the strength of the echo signal and the time taken for the echo to return.#

If the ship's velocity is constant, the echogram is a distorted profile of the bottom or, if the sound penetrates the bottom for a considerable distance, a distorted cross-section of the underlying layers.

echo sounder #An instrument for determining the depth of water by measuring the time of travel of a sound-pulse from the surface of a body of water to the bottom and back.#

An echo sounder consists of an oscillator for generating the pulses, a *hydrophone* for detecting the echo, a clock for timing the pulses, and a recorder for converting the time of travel to a depth and plotting that depth on a continuous chart. Early models of echo sounders used hammers or similar devices for generating pulses. Today, submerged loudspeakers or magnetostrictive or piezoelectric oscillators are used.

echo sounding #Determining the distance from the surface of water to the bottom by measuring the time interval required for sound waves to go from a sound generator to the bottom and back again.# The principal source of error in echo sounding is uncorrected refraction; another source is schools of fish that reflect sound back before it reaches the bottom.

eclipse (1) #The partial or total shadowing, relative to a designated observer, of one celestial body by another.#

The term *occultation* is used for those eclipses in which the source of light is a star other than the Sun and the shadow is thrown by the Moon or some other moon or planet in the Solar System. When the source of light is the Sun, the event is a solar eclipse if the shadow is thrown by the Moon onto the Earth; it is a lunar eclipse if the shadow is thrown by the Earth onto the Moon.

Occultations and solar eclipses have been used in the determination of longitude and latitude. The principle is the same for either phenomenon. The time of passage of the Moon's shadow past a point of known latitude and longitude is measured, as is the time of passage of the same point of the shadow past a second point of unknown latitude and longitude. The difference in times of passage is a function of (a) the differences in longitude and latitude and (b) the velocity of the Moon's shadow across the Earth's surface. The last of these quantities can be calculated from the data in astronomical ephemerides. Hence, the observation of several occultations or eclipses gives enough data for calculation of the differences of longitude and latitude.

(2) #The period of time during which an eclipse (1) takes place.#

ecliptic #The *great circle* traced on the celestial sphere by the Earth's orbit about the Sun.#

More precisely, the ecliptic is the great circle in which the plane of the Earth's orbit intersects the celestial sphere. Since the Earth's orbit is not exactly planar, because of perturbations by other bodies in the Solar System, an average orbit is used to define the ecliptic. The points at which the ecliptic intersects the celestial Equator are the equinoxes; the acute angle of intersection between the ecliptic and the celestial Equator is the obliquity of the ecliptic.

ecliptic, obliquity of the #The acute angle of intersection between the ecliptic and the celestial Equator.#

The obliquity of the ecliptic is about 23° 27′ and is decreasing at the rate of about 0.″5 per year.

ecliptic, true #The actual ecliptic at a specified instant.# The term distinguishes this concept from that of an average or otherwise mathematically derived ecliptic.

elasticity correction See *tape length, tension correction to.*

element, Besselian See *Besselian elements.*

element, Delaunay #A transformation of the *Keplerian elements* which simplifies the equations of motion of a celestial body.#

element, Keplerian #One of the following six constants *(orbital elements)* specifying an orbit:

a	semimajor axis of the osculating ellipse;
e	eccentricity of the osculating ellipse;
i	inclination of the plane of the osculating ellipse to a reference plane through the center of attraction (a focus of the ellipse);
or Ω	angle from a reference line in the reference plane to the intersection (line of nodes) of that plane with the plane of the osculating ellipse;
ω	angle from the line of nodes to the semimajor axis of the osculating ellipse; and
σ_0	angle from the radius vector (to the body) at time t_0 to the radius vector (to the body) at pericenter.#

The constants a, e, and σ_0 characterize the osculating ellipse and the location of the body on that ellipse at a particular time. The constants Ω, i, and ω are the Eulerian angles specifying the orientation of the ellipse with respect to the reference plane and reference line. The center of attraction is at one of the foci of the ellipse; this focus lies on the reference plane and reference line. The time t_o at which the body is at a particular point in the ellipse, or M, the *mean anomaly* at a particular time, is often used instead of σ_0. An ellipse other than the osculating ellipse may be used to represent the orbit. The six constants associated with it are then referred to as Keplerian elements.

element, magnetic See *geomagnetic element.*

element, optical #A single piece of optical material, such as a lens, mirror or prism, designed to reflect, refract, or diffract light in a specified way.#

The material between lenses, mirrors, etc., may be an optical element in certain kinds of optical system.

element, orbital #One of the six constants of integration resulting from the solution of the three second-order differential equations describing the motion of a point mass in a gravitational field.#

These six constants are sufficient to specify the path; together with the time, they specify the *orbit.* When the differential equations are in terms of Cartesian coordinates, three of the elements are the location of the body at a particular time, and the other three elements are the components of the velocity of the body at that time. When polar coordinates are used, *Keplerian elements* are more convenient.

elevation (1) #The distance of a point above a specified surface of constant *potential*; the distance is measured along the direction of gravity between the point and the surface.#

The surface usually specified is the geoid or an approximation thereto. Mean sea level was long considered a satisfactory approximation to the geoid and therefore suitable for use as a reference surface. It is now known that mean sea level can differ from the geoid by up to a meter or more, but the exact difference is difficult to determine.

The terms *height* and *level* are frequently used as synonyms for elevation. In geodesy, height also refers to the distance above an ellipsoid; it is used in this sense in this glossary, except where custom has established a different usage. "Level" has such a variety of meanings that it is best not to use the term to mean elevation. See also *altitude.*

(2) #An approximation to elevation in sense (1) above.# Most so-called "elevations" are of this kind; the true elevation is often impossible or extremely difficult to determine.

(3) #The quantity obtained by adding differences in elevation (definition (1)).#

This is the quantity obtained by spirit leveling without correcting the data for deflection of the vertical.

(4) See *elevation, angular.*

elevation, adjusted (1) #The elevation resulting from the application of an *adjustment correction* to an *orthometric elevation*.#

(2) #The elevation resulting from the application of both an *orthometric correction* and an adjustment correction to a *preliminary elevation*.#

elevation, angular #The angle, at a point between the horizontal plane through that point and a line from the point to a designated object.#

It is the complement of zenith distance and is positive if measured upward, and negative if measured downward from the horizontal. It is also called elevation, altitude, angular altitude, or angle of elevation.

elevation, Baranov #An approximate value H_N^B found for the elevation of a point P_N by dividing the *geopotential number* W_N at that point by an approximation $(1/2)(\gamma_\phi + g_N)$ to the average value of gravity between the geoid and P_N. g_N is the value of gravity at P_N, γ_ϕ is the value of the gravity (calculated from a gravity formula) on the geoid at the latitude ϕ of P_N.# The Baranov elevation is also called the Baranov height.

elevation, field #An elevation in a *line of levels* computed in the field.#

elevation, fixed #An elevation which has been obtained either from tidal observations or from a previous leveling adjustment, and which is held at its accepted value in any subsequent adjustment.#

elevation, Helmert #An approximate value H_N^H found for the elevation of a point P_N by dividing the *geopotential number* W_N at that point by an approximation (g_N^H) to the average value of gravity along the vertical between P_N and the geoid. The value g_N^H is calculated from the measured value g_N of gravity at P_N, the *Bouguer gravity correction* δg_B, and the *free-air gravity correction* δg_f. The equation used is:

$$g_N^H = g_N - \delta g_B + \delta g_f/2.\#$$

The Helmert elevation is also called the Helmert height.

elevation, Molodensky See *height, normal.*

elevation, Niethammer #An approximate value H_N^N found for the elevation of a point P_N by dividing the *geopotential number* W_N at the point by an approximation (g_N^N) to the average value of gravity along the vertical between P_N and the geoid. The value g_N^N is calculated from the measured value g_N of gravity at P_N, the *Bouguer gravity correction* δg_B, the *free-air gravity correction* δg_f, and two *topographic gravity corrections* δg_{t1} and δg_{t2}. The equation used is:

$$g_N^N = g_N - \delta g_B + \delta g_f/2 + \delta g_{t1} + \delta g_{t2}.\#$$

The first topographic gravity correction accounts for the effect of the terrain at P_N; the second topographic gravity correction accounts for the average effect of terrain along the plumb line between P_N and the geoid. The Niethammer elevation is therefore equivalent to a Helmert elevation which has been corrected for topographic effects. The Niethammer elevation is also called the Niethammer height.

elevation, normal See *height, normal.*

elevation, normal orthometric #An approximation H_N^{no} to elevation, calculated by

$$H_N^{no} = \left[\int_{P_{msl}}^{P_N} \gamma_\phi dH\right] / \overline{\gamma}_N$$

where γ_ϕ is a theoretical value of gravity calculated from a gravity formula for elevation H and latitude ϕ along the path of integration, dH is the corresponding elevation-increment, and the integration is taken over the leveling route between point P_{msl} at mean sea level and P_N on the surface. $\overline{\gamma}_N$ is the value of gravity calculated by the same gravity formula for the latitude of P_N and an elevation midway between the elevation of P_N and the elevation of P_{msl}.#

If the gravity formula used does not contain a term involving H, $\overline{\gamma}_N$ may be computed by adding a free-air gravity correction.

elevation, orthometric (1) #The distance between the geoid and a point measured along the *plumb line* and taken positive upward from the geoid.#

If g is the value of gravity along the leveling route on the surface of the Earth, and g' is the corresponding value of gravity on the same level surface as g but on the plumb line through the point P_N on the surface of the Earth, then the orthometric elevation H_N of P_N relative to a point P_1 on the geoid is given by

$$H_N = \int_{P_1}^{P_N} (g/g')dH$$

where g is measured over a continuous route from P_1 to P_N. The value g' is not measurable and must be calculated. The closest approximation to H_N is Niethammer's elevation H_N^N or a modification of it.

(2) #A preliminary elevation to which the *orthometric leveling correction* has been applied.#

elevation, practical See *height, practical.*

elevation, preliminary #An elevation computed after the *index, level, rod,* and *temperature corrections* have been applied to the observed differences of elevation.#

elevation, quasidynamic #An approximate value H_N^{qd} found for the elevation of a point P_N by dividing the geopotential number W_N at that point by γ_ϕ. γ_ϕ is a theoretical value of gravity calculated from a gravity formula for some chosen latitude ϕ (which may not be the same as the latitude of P_N) at an elevation halfway between the geoid and the equipotential surface through P_N. When the gravity formula does not contain a term that takes elevation into account, a free-air gravity correction is subtracted from the calculated gravity to obtain γ_ϕ.#

elevation, spot #An elevation of a point of particular significance (and not usually part of a leveling network).#

Spot elevations are typically determined for tops of hills and mountains, intersections of roads, mountain passes, and plateaus. They are commonly indicated on a map by dots or crosses with the corresponding elevations written alongside.

elevation, Vignal #An approximation H_N^V to the elevation at a point P_N by dividing the potential number by

$$\gamma_\phi - \delta g_f/2.$$

δg_f is the *free-air gravity correction* to γ_ϕ at P_N, ϕ is the latitude of P_N, and γ_ϕ is calculated from a gravity formula.#

elinvar #A specific variety of *invar*. #The spring in spring-type gravimeters is sometimes made of elinvar.

ellipse #A second-degree, planar curve characterized geometrically as the locus of all points whose distances d_1 and d_2 from two fixed points called the "foci" have a constant sum:

$$d_1 + d_2 = \text{constant}.\#$$

The straight line of greatest length within an ellipse is called the major axis and passes through the two foci. The "center" of the ellipse is the point which divides the major axis in half. The minor axis is the shortest straight line through the center and is perpendicular to the major axis.

ellipse, eccentricity of See *eccentricity* (mathematics).

ellipse, ellipticity of See *ellipticity*.

ellipse, flattening of #The ratio f of the difference between the lengths a and b of the semimajor and semiminor axes, respectively, of an ellipse to the length of the semimajor axis:

$$f = (a - b)/a.\#$$

Sometimes called ellipticity.

The flattening f, is related to the *eccentricity* e by

$$e^2 = 2f - f^2.$$

ellipse, great #The curve in which a plane through the center of an ellipsoid cuts the ellipsoid.# It is both a *normal section*, and an ellipse.

ellipsoid #A closed surface, whose planar sections are either ellipses or circles.#

Algebraically, an ellipsoid with center at the point (x_o, y_o, z_o) and with axes parallel to the coordinate axes is given by the set $\{x, y, z\}$ of coordinates satisfying the equation

$$(x - x_o)^2/a^2 + (y - y_o)^2/b^2 + (z - z_o)^2/c^2 = 1.$$

The general form of the equation is obtained by rotating the coordinate system to a different position.

An ellipsoid is specified by giving the values of three characteristic dimensions. The most common method is to fix the lengths a, b, and c of the three semiaxes, with a the longest and c the shortest. Another is to give the length (usually the longest, a) of one semiaxis, and the *eccentricities* of the equatorial and polar sections.

The *ellipsoid of revolution* is biaxial, and is obtained by rotating an ellipse about either its major or its minor axis. The ellipsoid with a different length for each of its three axes is called a triaxial ellipsoid.

ellipsoid, Earth See *ellipsoid, terrestrial*.

ellipsoid, equipotential See *ellipsoid, level*.

Ellipsoid, International #An *ellipsoid of revolution* adopted by the International Association of Geodesy in 1924 for international use. The dimensions are given by:

semimajor axis:	6,378,388 m
flattening:	1/297.#

It is numerically the same as that derived by John Hayford in 1909 from measurements in the United States of America. The dimensions yield a semiminor axis of 6,356,912 m.

ellipsoid, Jacobi #One of a series of triaxial ellipsoids describing the figure of a homogenous, rotating fluid body in hydrostatic equilibrium.#

The ellipsoids are stable at low rates of rotation; above a certain rate of rotation, Jacobi ellipsoids merge into a set of biaxial ellipsoids called *MacLaurin spheroids*.

ellipsoid, Krassovski (1940) (1) #A *triaxial ellipsoid* characterized by the following constants:

length of semimajor axis	6,378,245 m
flattening in meridian	1/298.3
flattening in Equator	1/30,086.#

Therefore, the shorter axes have half-lengths of 6,378,033 m and 6,356,863.019 m.

(2) See *spheroid, Krassovski*.

ellipsoid, level (1) #An *ellipsoid of revolution* on which the gravity potential is constant.#

(2) #A level ellipsoid (sense(1)) whose gravity field is given by a *standard gravity formula*. #

In the case of (2), the external gravity field is completely determined by four quantities: two determining the size and shape of the ellipsoid, one for the mass of the ellipsoidal body, and one for the rate of rotation of the body. See also *ellipsoid, normal*.

ellipsoid, MacLaurin See *spheroid, MacLaurin*.

ellipsoid, mean Earth (1) #A (biaxial) ellipsoid that has the same mass and the same rotational velocity about its shortest axis as the Earth, a constant potential on its surface which is the same as that of the geoid, and the same value of the coefficient J_2 in the representation of the Earth's potential by a Legendre series.# The above conditions fix the dimensions of the ellipsoid.

(2) #The ellipsoid which most closely approximates the *geoid*. #

ellipsoid, normal #A self-gravitating body of given mass and rotational rate whose surface is an equipotential ellipsoid of specified dimensions.#

The numerical values of the specified quantities are taken as close as possible to those of the actual Earth.

The figures defined by *Geodetic Reference Systems 1967* and *1980* are normal ellipsoids. The *mean Earth ellipsoid* is that normal ellipsoid whose defining quantities are exactly the same as those of the actual Earth, hence not strictly realizable.

ellipsoid, reference (1) #An ellipsoid of specified dimensions and associated with a *geodetic reference system* or a geodetic datum.#

Coordinates given in this system are said to be "with respect to the reference ellipsoid". Reference ellipsoids are most commonly ellipsoids of revolution and are sometimes called reference spheroids.

(2) #An ellipsoid on which the potential of gravity is constant and to which the potentials of other points are referred.#

(3) #An ellipsoid on which the potential of gravity is constant and which approximates the geoid in size and position.# See also *ellipsoid, terrestrial.*

ellipsoid, terrestrial #A body which rotates with the same angular velocity and on the same axis of rotation as the Earth, whose surface is equipotential, and whose gravitational potential is defined by assigning values to the zero-th and second-degree terms in the representation of the Earth's gravitational potential as a series of Legendre functions.#

Also called Earth ellipsoid. See also *ellipsoid, mean Earth.*

ellipsoid, triaxial #An ellipsoid with a different length for each of its three axes.#

ellipsoid of reference See *ellipsoid, reference* and *spheroid, reference.*

ellipsoid of revolution #An ellipsoid formed by rotating an ellipse about one of its axes (oblate, if minor; prolate, if major).# Also called a *spheroid.*

ellipticity #The *flattening* of an ellipse or ellipsoid.#

ellipticity, dynamical See *dynamical ellipticity.*

elongation (1) #The angular distance of a celestial body from the Sun, as viewed from the Earth.#

An elongation of 0° is called conjunction; one of 180° is called opposition; and one of 90° is called quadrature.

(2) #The point in the apparent daily motion of a star about the celestial pole at which the star's rate of change of azimuth becomes zero; the point at which the star is seen to cease increasing its bearing east or west of the celestial pole and to reverse its direction of motion eastward or westward.#

An equivalent definition is, #the point at which the parallactic angle of star and observer is 90°.#

embayment #An indentation of a coast regardless of width at the entrance or depth of penetration into land.#

energy #The capacity, or a numerical or mathematical expression of that capacity, for changing the location, position, or shape of a body.#

This concept is also called, specifically, mechanical energy, which was the first kind identified by Galileo in his study of moving bodies. However, other kinds of energy such as thermal, chemical, electromagnetic, and so on, seem to be concepts invented to avoid having energy appear in or disappear from apparently closed physical systems. In this way, a universal law of conservation of energy can be stated.

Energy is conventionally considered to be the sum of two kinds: kinetic, which depends on velocity; and potential, which depends on location (and, perhaps, other factors). Or energy can be considered the sum of (a) kinetic energy, (b) potential energy which depends only on location, and (c) an energy which depends on factors other than motion or location such as temperature or state of magnetization.

energy, kinetic #The capacity of a system for changing its location, position, or shape by virtue of the velocities of the moving masses in the system.#

The kinetic energy of a body of mass M moving with velocity $\vec{V}$ is $M\vec{V}\cdot\vec{V}/2$. It is equal to the work that would have to be expended to bring the body to rest.

Kenetic energy (k.e.) is additive, in the sense that the k.e. of a system composed of several moving bodies is the sum of the k.e.'s of the individual bodies.

energy, law of the conservation of #The statement that, in any closed physical system, energy cannot be created or destroyed.#

The law is as much a matter of definition as of physical reality. Whenever a situation has been found in which the law seems to be violated, a new form of energy has been defined to account for the discrepancy. For example, a pendulum in motion has the kinetic energy of the motion. This energy is stored as potential energy in the pendulum at the extremes of its arc. However, the motion of the pendulum gradually dies down, and kinetic and potential energy become zero. To keep the law of conservation of energy valid, the existence of heat is postulated. The lost kinetic and mechanical potential energies are supposed to be transformed into heat, which manifests itself by a rise in the temperature of the surrounding air and of the supports.

energy, mechanical See *energy.*

energy, potential See *potential.*

entropy (1) #The thermodynamic function S in the equation

$$\Delta S = \int (dQ/T)$$

where ΔS is the change in S that occurs when integrating over given limits, and Q is the amount of heat added (reversibly) to a system at absolute temperature T.#

The concept has been extended into the fields of statistical mechanics and, thence, into information theory.

(2) #A quantity proportional to the logarithm of the state, as defined by the equation $S = k \ln P +$ constant, where S is the entropy, k is the Boltzmann constant, and P is the statistical probability of the state.#

(3) #The amount of information per elementary unit or symbol of a message.#

entropy, method of maximum #A method of finding particular values of a set of randomly variable unknowns by requiring that the entropy $-\Sigma\, p_i \log p_i$ of the set of probabilities p_i associated with the unknowns x_i be a maximum.#

The principal application of this method has been to determine frequencies present in signals that can be expressed as a mixture of frequencies.

Eötvös balance See *torsion balance.*

Eötvös correction #The difference between the value of gravity acceleration actually measured by a gravimeter on a horizontally moving platform and the value that would be measured if the gravimeter were stationary.#

The correction is the sum of the vertical components of the accelerations produced by the *Coriolis force* and the centrifugal acceleration caused by the gravimeter's motion. The correction is given by

$$\delta g_E = 2\ \omega\ v \cos \phi \sin A_z + v^2/(N + h)$$

where ω is the angular velocity of the Earth, v is the horizontal speed of the gravimeter, A_z the azimuth of the direction in which the gravimeter is moving, φ the *geodetic latitude*, and h the *geodetic height* of the gravimeter. N is the *radius of curvature in the prime vertical* of the reference ellipsoid. In most cases $v^2/(N + h)$ may be expressed as v^2R, where R is the radius of the Earth. The second term on the right side of the above equation is sometimes omitted.

Eötvös effect #The fictitious, vertical force experienced by a body on the rotating Earth.#

See *Eötvös correction.*

Eötvös unit #A unit for rate of change of acceleration with distance, i.e., gradient of acceleration. Its magnitude is 10^{-9} m s^{-2} m^{-1}.#

Sometimes this is given as 10^{-9} s^{-2}, which is dimensionally correct but not as physically informative. The principal application of the Eötvös unit is to the measurement of the gravity gradient. *Gravity gradiometers* typically have sensitivities of 0.1 to 1.0 Eötvös units. Both "E.U." and "E" are used as symbols for the unit.

ephemeris #A tabulation of the locations and related data for a celestial body for given epochs (dates) at uniform intervals of time.#

In particular, a publication containing such data for a number of celestial bodies. The *Astronomical Almanac* is an example.

ephemeris, broadcast #The ephemeris of a satellite broadcast from it, from which Earth-fixed satellite positions can be computed.#

The term applies particularly to the *Navy Navigation Satellite System* and the *Global Positioning System.* The broadcast ephemeris is designed to provide orbital elements quickly, and is not as accurate as a corresponding *precise ephemeris* for the same satellite.

ephemeris, precise #The ephemeris of a satellite computed by adjustment of observations obtained from a worldwide tracking network in order to obtain maximum accuracy.#

The term applies particularly to the *Navy Navigation Satellite System* and the *Global Positioning System.* Contrast with *broadcast ephemeris.*

epipole #In the perspective projection of two photographic images onto a surface, either of the two points where the planes of the photographs are cut by the *air base*.#

In the case of a pair of truly vertical photographs, the epipoles are infinitely distant from the *principal points*.

epoch (1) #A particular instant of time from which an event or a series of events is calculated; a starting point in time to which events are referred.#

See *time, origin of.*

(2) #Angular lag of the maximum of a constituent of the observed tide or tidal current behind the corresponding maximum of the same constituent of the theoretical *equilibrium tide*.#

When the theoretical local equilibrium tide is meant, the epoch is represented by κ. When the corresponding equilibrium tide at Greenwich is meant, it is called the Greenwich epoch and is represented by G.

(3) #A specific period of time.# For example, the *National Tidal Datum Epoch.*

Epoch, National Tidal Datum See *National Tidal Datum Epoch.*

equal-altitude method See *azimuth determination by the method of equal altitudes.*

equal-altitude observation #Observation (by, e.g., an astrolabe) of celestial bodies at a fixed altitude; the observations are taken at more or less uniformly spaced directions around the horizon.#

The purpose is to obtain a number of lines of position by a method that reduces the effects of vertical refraction.

equal-altitude method of azimuth determination See *azimuth determination by the method of equal-altitudes.*

equation See specific entries below, e.g., *equation, latitude.*

equation, angle #A *condition equation* that expresses the relationship between the sum of the measured angles of a closed figure and the theoretical value of that sum, the unknowns being the corrections to the observed directions or angles used in the adjustment.#

Sometimes called a triangle equation, an angle equation is used to make the sum of the three observed angles of a triangle, with corrections applied, equal to 180° plus the spherical excess of the triangle.

equation, annual #An *inequality* (perturbation) in the Moon's motion; its amplitude is −11′ 8.″93 and its period is one *anomalistic year*.#

equation, azimuth #A *condition equation* that expresses the relationship between the fixed azimuths of two lines connected by triangulation or traverse.#

When triangulation or traverse connects two lines whose azimuths are fixed by direct observations or by previous surveys, an azimuth equation is used to make the azimuth of either line (as computed through the adjusted survey) from the other line agree with its previously fixed value.

equation, condition (1) #An equation that expresses a relationship, independent of any observational values, among its unknowns.#

Also called conditioned equation and constraint equation. For example, in measuring the angles of a triangle, no relationship exists between the measured angles until all three angles have been measured. The condition that the three measured angles plus certain corrections must equal 180° plus the spherical excess of the triangle is then expressed as a condition equation.

(2) #An equation expressing a condition that must be satisfied by the unknowns, given certain measured values.#
This type of condition equation is commonly formed by combining a condition equation of the type defined in (1) with an observation equation. Solving equations of this kind is generally done using *correlate equations*.

The various condition equations set up in geodesy are defined under terms that are descriptive of the conditions, such as *angle equation, side equation, length equation, latitude equation, longitude equation,* and *azimuth equation*.

equation, correlate #An equation derived from *observation* and *condition equations,* in which undetermined multipliers are used, and expressing the condition that the sum of the squares of the residuals (or corrections) resulting from the application of these multipliers to the resulting equations shall be a minimum.#

In the least-squares adjustment of triangulation, correlate equations are formed directly from the observation and condition equations, with as many correlate equations as there are corrections to be determined, but only as many undetermined multipliers as there are condition equations. From these correlate equations, equations equal in number to the undetermined multipliers which constitute the unknowns are formed. The solution of these equations determines values for the multipliers which, when substituted in the correlate equations, give values for corrections that will satisfy the condition equations, will make the observations and their functions mutually consistent and, at the same time, make the adjusted values those most probable considering the given observations.

equation, error #An equation stating the probability of an event as given by the *Gaussian distribution.* #

This term is probably in limited use.

equation, Laplace See *Laplace equation.*

equation, latitude #A *condition equation* that expresses the relationship between the fixed latitudes of two points connected by triangulation or traverse.#

When triangulation or traverse connects two points whose latitudes have been fixed by direct observation or by previous surveys, a latitude equation is used to make the latitude of either point, as computed through the survey from the other point, agree with its previously fixed latitude.

equation, length #A *condition equation* that expresses the relationship between the fixed lengths of two lines connected by triangulation.#

When a section of triangulation connects two lines whose lengths are fixed by direct measurement or by previous triangulation, a length equation is used to make the length of either line, as computed through the adjusted survey from the other line, agree with its previously fixed length.

equation, longitude #A *condition equation* that expresses the relationship between the fixed longitudes of two points connected by triangulation or traverse.#

When triangulation or traverse connects two points whose longitudes have been fixed by direct observation or by previous surveys, a longitude equation is used to make the longitude of either point, as computed through the survey from the other point, agree with its previously fixed longitude.

equation, normal #One of the equations resulting when a system of N linear equations in M unknowns (N greater than M) is converted to a system of M linear equations in M unknowns by imposing the condition that the sum of the squares of the *residuals* shall be a minimum.#

In matrix notation, if the unknown is the vector $\vec{x}$, then the original system of equations can be written as

$$\vec{y} = A\,\vec{x},$$

the vector $\vec{y}$ and the matrix A being known. The system of normal equations is

$$A^T\vec{y} = (A^TA)\vec{x}.$$

The term (A^TA) is referred to as the "normal matrix" and is square and symmetric. In most geodetic problems, it is positive definite of rank M.

equation, observation #Any equation containing an observed value, a correction to an observed value, or a function of observed values.#

The observed value (or its correction) may occur as an implicit function of the unknowns or, as is more usual in geodetic problems, may appear alone on one side of the equation with the unknowns on the other side.

equation, perpendicular #A *condition equation* imposing the condition that the algebraic sum of the projections of the separate lines of a traverse upon perpendiculars to a fixed line (with which the traverse forms a closed figure) shall be zero.#

The perpendicular equation and the *azimuth equation* are used together to remove the misclosure from a traverse that forms a loop with some fixed line (such as a line of adjusted triangulation) by determining corrections to the observed angles of the traverse. The projections of the lines of the traverse upon lines perpendicular to a fixed line correspond to *departures* of those lines when the fixed line is used as the meridian of reference.

equation, personal #A constant or systematic deviation, caused by personal characteristics of the observer, of the observed values from values used for reference.#

If the values used for reference are values obtained by another observer, the deviation is called the relative personal equation; if the values used for reference are correct by assumption or definition, the deviation is called the absolute personal equation.

In astronomy and geodesy, the observation is often the time at which an event occurs. The personal equation is then the interval between the observer's perception of an event and his reaction to the event.

equation, photogrammetric #The equation of a straight line that joins an identified point in *object space* to the corresponding point in the image and passes through the *perspective center*.#

A system of six photogrammetric equations referring to points on a single photograph suffices to determine the location and orientation of the photograph if the coordinates of the points in *image space* and in object space are known.

equation, side #A condition equation that expresses the relationship between the various sides in a triangulation figure as derived by computation from one another.#

A side equation is used to make the computed length of a triangle side the same for all routes through the triangulation by which it is derived.

equation of the center #An equation for the difference between *true anomaly* and *mean anomaly* in an elliptical orbit, as a function of either the mean anomaly or the true anomaly.#

equation of the equinoxes #The *right ascension* of the *mean equinox*, referred to the *true Equator* and the *true* equinox.#

Also called the nutation in right ascension, or, alternatively, the apparent sidereal time minus the mean sidereal time.

equation of time #The difference between *mean solar time* and *apparent solar time*.#

An equivalent definition is #the difference between the *hour angle* of the *true Sun* and the hour angle of the *mean Sun*.#

The difference varies from about -15 min near the middle of February to about $+17$ min in the early part of November. A graphical display of the equation of time is the *analemma* which is usually found on a globe.

Equator See specific entries below, e.g., *Equator, geodetic*.

Equator, astronomic #The line, on the surface of the Earth, on which the *astronomic latitude* at every point is 0°.# Also called the terrestrial Equator.

Because of the deflection of the plumb line, the astronomic Equator is not a plane curve. However, the verticals at all points on it are parallel to one and the same plane, the plane of the *celestial Equator;* i.e., the zenith at every point on the astronomic Equator lies in the celestial Equator.

Equator, celestial #The great circle on the celestial sphere whose plane is perpendicular to the axis of rotation of the Earth.#

In astronomy, because parallel lines meet at infinity, the plane of the celestial Equator is sometimes assumed to pass through the point of observation.

Equator, fictitious #A line on the ellipsoid, other than the Equator, used as reference for measuring angles analogous to latitude.#

Equator, geodetic #The circle on the *reference ellipsoid* midway between its poles of rotation.#

The geodetic Equator is the line on which *geodetic latitude* is 0° and from which geodetic latitudes are reckoned, north and south, to 90° at either pole. The plane of the geodetic Equator cuts the celestial sphere in a line coinciding with the celestial Equator, if the axis of the ellipsoid of reference is parallel to the axis of rotation of the Earth.

Equator, geomagnetic #The terrestrial great circle everywhere 90° from the *geomagnetic poles*.#

See also *Equator, magnetic*.

Equator, magnetic #The line on the surface of the Earth connecting all points at which the *magnetic dip* is zero.#

Also called aclinic line or dip Equator. See also *Equator, geomagnetic*.

Equator, mean See *Equator, true*.

Equator, terrestrial See *Equator, astronomic*.

Equator, true #The actual *celestial Equator* at a specified instant.# This term distinguishes the concept from that of an average (mean) or other mathematically derived Equator.

equatorial (noun) #An *equatorial telescope*.#

equiangulator #An *astrolabe*. #The term is obsolescent.

equilibrium, geostrophic #An equilibrium in the atmosphere or the oceans that results when the horizontal pressure gradient is exactly balanced by the horizontal *Coriolis force*.#

equilibrium, hydrostatic #The state of a fluid when complete balance exists between gravity or gravitation and the vertical force of pressure.#

Thus an equipotential surface of a body in hydrostatic equilibrium is also a surface of equal pressure. Also called fluid equilibrium.

equilibrium theory of the tides See *tide, equilibrium*.

equinox #One of the two points in which the *celestial Equator* intersects the *ecliptic*.# See *equinox, autumnal* and *equinox, vernal*.

equinox, autumnal #The point of intersection of the *celestial Equator* and the *ecliptic* through which the Sun apparently passes from north to south.#

equinox, mean See *equinox, true*.

equinox, true #The actual *equinox* at a specified instant.#

This term distinguishes the concept from that of an average (mean) or other mathematically derived equinox.

equinox, vernal #The point of intersection of the *celestial Equator* and the *ecliptic* through which the Sun apparently passes from south to north.#

The vernal equinox is also called the first point of Aries or the first of Aries. It is the point from which right ascension is reckoned along the celestial Equator and celestial longitude along the ecliptic. The true location of the equinox is affected by precession and nutation, while the average location (the mean equinox) is affected by precession but not by nutation. See *day, sidereal* and *time, sidereal*.

equinox of date #One of the two points on the celestial sphere where the *celestial Equator* intersects the *ecliptic* at the time of an observation (usually the *vernal equinox)*.#

Both the celestial Equator and the ecliptic rotate in inertial space. The epoch (date) as well as coordinates of the points of intersection must be given to specify completely the locations of the equinoxes. The epoch is specified either by giving the *Besselian year* (and fraction thereof) or by using the words "of date", implying that the date is that of the instant or of the observation being considered.

equipotential surface See *surface, equipotential.*

erosion In riparian law, #the washing away of land by a stream or a body of water such as a lake or sea.#

Erosion may be distinguished from *avulsion* by the absence of identifiable upland between former and new channels.

error (1) #The difference between the observed value of a quantity and the theoretical or defined value of that quantity. Symbolically,

$$\epsilon \text{ (error)} = y \text{ (observed)} - y \text{ (theoretical)}.\#$$

(2) #The difference between an observed or calculated value of a quantity and the ideal or true value of that quantity.#

This definition differs from (1) in using the words "ideal" and "true". Theoretically, the definitions are quite different. Practically, they are equivalent, except that the second permits use of calculated values as well as observed values.

Since the ideal or true value of a quantity cannot, with few exceptions (see below), be known with exactness, the term "error" is applied to a difference between an observed value of a quantity and some value determined by established procedure and used in lieu of the ideal or true value. The exceptions are as follows. The ideal or true value of a quantity can be known exactly if it is (a) mathematically determinable and independent of observation (for example, the sum of the angles of a plane triangle is 180°); and (b) if it is a conventional (defined) value (for example, the length of the meter as defined by the wavelength of the orange line of the spectrum of Kr^{86}_{30}).

Errors are of various kinds, depending upon how and where they originate. An appropriate adjective or qualifying clause is used to designate the kind of error, such as accidental error, index error, or error of observation. In some usage the sign of the error as previously defined is reversed.

error, accidental #An error, produced by irregular causes whose effects upon individual observations are governed by no known law that connects them with circumstances and so cannot be corrected by use of standardized adjustments.#

An accidental error is sometimes called an irregular error. The term random error is preferred in many disciplines.

error, accumulative See *error, cumulative.*

error, actual #The difference between the measured value and the true value of a physical quantity.#

According to Gossett (1959), "It is the sum of all the systematic and accidental errors which have not been eliminated from the final, adopted, measured value." This statement is not necessarily in agreement with the definition. However, relationships between the terms "true value" and "systematic and accidental errors" is not clear in most theories of error.

error, apparent #A *residual error* (2).#

error, average (1) #The absolute value of the average of a set of errors.#

(2) #The absolute value of the average of the differences between the values in a set and the average value for the set.#

This is expressed by:

$$\epsilon_{average} = \sum_{n} (y_n - \bar{y})/(N - 1)$$

where y_n is one of the N values in the set and $\bar{y}$ is the average value of all the y_n's.

Average error is sometimes defined as the absolute value of the average of the positive errors and the average of the negative errors. Since there will be about the same number of positive errors as negative errors in a well-balanced series of observations, this method of obtaining the average error will give practically the same result as the other methods. Also called average absolute error and mean of the errors. It should not be confused with mean error.

error, average absolute See *error, average.*

error, clamping #A *systematic error*, occurring in observations made with a repeating theodolite, caused by strains set up by the clamping devices of the instrument.#

error, constant #A *systematic error* which is the same in both magnitude and sign through a given series of observations.#

A constant error tends to have the same effect upon all the observations of a series or any part thereof. Therefore, it does not usually have any influence on the standard deviation of the series. An example of a constant error is the *index error* of a precise instrument.

Also called bias.

error, cumulative #An error which adds to or increases the total error.#

The simplest type of cumulative error is the constant error. A systematic error which retains the same sign, but not necessarily the same magnitude, throughout a series of observations, is also a cumulative error. Also called accumulative error.

error, external #A *systematic error* arising from natural physical conditions, outside the observer.#

External errors are caused by such things as the effect of atmospheric refraction in spirit leveling, by changes in the length of a tape because of thermal expansion, and by the effects of atmospheric pressure on elevations determined with a barometer. External errors may be controlled to some extent by making observations only when natural conditions are favorable, such as by measuring the length of a line with a steel tape at night or in cloudy weather.

External errors are determined by using formulas and data observed especially for the purpose. An example: determining the length of a metallic tape by using a formula that involves the coefficient of thermal expansion and the observed temperature of the tape.

error, gross #A very large error.#

The usual implication is that such a large error was made by a person rather than an instrument. If the supposition is correct, the error is called a *blunder*.

error, index #A *systematic error* caused by the misplacement of an index mark or zero mark on the scale or vernier of an instrument.#

error, instrumental #A *systematic error* arising from imperfections in the observing instrument.#

Instrumental errors may arise from imperfections built into an instrument, such as those in the graduation of a horizontal circle, or may arise from lack of complete adjustment of some part of the instrument, such as incomplete collimation. Instrumental errors can be determined in the laboratory, and may be eliminated from resultant data by adjusting observational procedures, or by using corrections.

error, mean See *error, mean-square.* This term is sometimes confused with *average error,* so its use should be avoided.

error, mean-square #The square of the *root-mean-square error.* #

error, observed (1) #The average value of a random variable minus a particular value of that variable.#

(2) #The average value of a random variable minus the average value of a subset of that variable.#

Also called observational error, However, this term is inappropriate since errors cannot be observed.

error, parallactic #An error caused by *personal* or *instrumental parallax*.#

error, personal #A *systematic error* caused by an observer's personal manner of making observations, or by the deviation of his physical characteristics from those of an ideal observer.#

A systematic error arising from a personal manner of observing, such as the observer's standing in the same position relative to the end of a tape when measuring the length of a line, may be eliminated from a result by an observing program (shift of position) which makes the error positive for half of the observations and negative for the remainder of the observations. A systematic error arising from an observer's physical characteristics can often be eliminated by calibrating the observer. For example, most observers mark the time of transit of a star shortly before or shortly after the actual transit, and this error is approximately constant for and characteristic of each observer. The amount of lead or lag can be determined by tests. See also *equation, personal.*

error, principal-point See *principal-point error.*

error, probable #A quantity of such size that the probability of the occurrence of an error larger than that quantity is the same as the probability of the occurrence of an error of lesser magnitude.#

Also referred to as "50 percent uncertainty", Probable error $p_{1/2}$ is related to *standard deviation* σ by

$$p_{1/2} = 0.6745\ \sigma$$

if the error has a one-dimensional *Gaussian distribution*.

Probable error is currently little used in geodesy or the other sciences. Standard deviation is almost universally used instead.

error, random See *error, accidental.*

error, residual (1) #The value, corrected for known systematic errors, of one observation in a series minus the value of the quantity obtained statistically as a representative of that series.#

Residual errors are sometimes called simply errors or residuals. The term residual is generally used in referring to actual values in a specific computation. In practice, it is the residual errors which enter into a computation of *standard error*.

(2) A residual, in its primary sense, is not the same thing as a residual error as defined above. A residual error can be defined as a residual obtained by explicitly including corrections for systematic errors. Such corrections need not be included, in general, in calculating a residual.

error, root-mean-square #A quantity measuring the deviation of a random variable from some standard or accepted value; its value is determined by

$$s = \sqrt{\Sigma\,(x_n - \bar{x}_n)^2/N}$$

where $\{x_n\}$ is the set of N random variables, and $\{\bar{x}_n\}$ the corresponding set of accepted values.#

The $\bar{x}_n$ are often all equal to a single value $\bar{x}$, in which case the formula becomes

$$s = \sqrt{\Sigma\,(x_n - \bar{x})^2/N}\ .$$

$\bar{x}$ *is* frequently the average of the $\{x_n\}$,

$$\bar{x} = (\Sigma\, x_n W_n)/(\Sigma\, W_n)$$

where W_n is the weight assigned to x_n. The root-mean-square error is not, in general, the same as the *standard deviation.*

error, round-off #The error dependent on the number of digits to which an instrument can be read, or to which a computation can be carried out.#

error, standard #Equivalent, for the most part, to *standard deviation.* # However, standard error has also been used to mean a number of things, such as the standard deviation of the mean and the standard deviation calculated from large samples.

error, stochastic See *error, accidental.*

error, systematic #An error whose algebraic sign and, to some extent, magnitude bears a fixed relation to some condition or set of conditions.#

A systematic error is, in theory at least, predictable, and therefore is not random; such errors are regular, and so can be determined *a priori*. They are generally eliminated from a set of observations before applying the method of least-squares to eliminate or reduce random errors. Systematic errors are classified as external (theoretical) errors, instrumental errors, and personal errors, according to their origin and nature.

error, theoretical (1) # An error whose value can be theoretically predicted.#

(2) #An *external error*.#

error, true #The observed or calculated value of a quantity minus the true value of that quantity.# See also *error* and *error, actual*. Sometimes "true error" and "error" are used interchangeably. However, it is best to limit the meaning of true error to that given above.

error budget #A catalog or listing of the natures and magnitudes of the errors that affect the results of a project.#

The term is also used when the project is hypothetical, as in the planning of an experiment.

error equation See *equation, error*.

error of closure See *misclosure*.

error of commission #The error introduced in a computation by using incorrect data or incorrect theory.#

error of observation #The difference between the observed value of a quantity and a value adopted as representing the ideal or true value of that quantity.#

Errors of observation are composed of either one or both of two general classes of error: *accidental errors* and *systematic errors*. *Constant errors* are sometimes considered to constitute a third class, but are more often considered to be systematic errors. Errors of observation are also classified according to their origin, such as *external errors, instrumental errors,* and *personal errors*. The algebraic sign of the error of observation is determined from the equation: error of observation = observed value − adopted (ideal) value.

error of omission #The error introduced into a computation by leaving out pertinent data or by omitting terms of an equation.#

error of representation #The error committed by assuming that one member of or one sample from a statistical population is a valid representative of that population.#

In particular, in the analysis of data on gravity, the error committed by using the value of gravity of one or more points in an area instead of the average value of gravity over the area; often used with respect to gravity anomalies.

error of run #The difference between the intended or nominal value of one turn of the screw of a micrometer and the actual value of one turn, in seconds of arc.#

Also called the run of the micrometer.

error of the level See *collimation correction factor*.

error of the mean, standard #The *standard deviation* of the averages calculated from a number of sets of samples.#

If the standard deviation of measurements (from all samples) is σ_p and if the number of measurements in a set is N, then the standard error σ_m of the mean is given by

$$\sigma_m = \sigma_p N^{-1/2}$$

errors, mean of the See *error, average*.

establishment #The interval of time between upper or lower transit of the Moon and the next *high water* at a place.#

Sometimes called *establishment of the port* which also has a different meaning. Also see *interval, lunitidal*.

establishment, corrected #The average of all *high water intervals*.#

This is usually 10 to 15 minutes less than the *establishment of the port. See interval, lunitidal.*

establishment of the port #The average *high water interval* at a particular place on days of new and full moon.#

Also called common establishment; high water full and change; and vulgar establishment.

Euclidean space #A space in which a coordinate system can be chosen so that the distance between two points is given by the square root of the sum of the squares of the coordinate differences.#

Euler equations of motion #The equations

$$M_i = A_i\omega_i - (A_j - A_k)\omega_j\omega_k$$

where i, j, k take on the values 1, 2, 3 cyclically, M_i is a component of the forces applied to a rigid body about an axis in that body, ω_i is the corresponding angular velocity, and A_i is the corresponding moment of inertia. The axes are the *principal axes* of the body.#

Also called Euler's dynamical equations or, simply, the Euler equations.

Euler's formula #A formula relating the radius of curvature R of a normal section in any azimuth α on the reference ellipsoid to the *radius of curvature in the meridian*, M, and in the *prime vertical*, N, by

$$1/R = (\cos^2 \alpha)/M + (\sin^2 \alpha)/N.\#$$

The formula also applies to surfaces more general than an ellipsoid. Also known as Euler's Theorem.

evection #The largest periodic perturbation in the Moon's longitude.#

In Brown's theory of the Moon's motion, the term is given by

$$1^\circ\ 16'\ 26.''4 \sin(\lambda - 2\lambda' + \omega)$$

where λ and λ' are the average longitude of the Moon and Sun, respectively, and ω is the longitude of perigee of the

Moon. This term was known to Hipparchus, although Ptolemy is often credited with its discovery. The period is about 31 4/5 days.

excess, spherical See *spherical excess.*

excess, spheroidal See *spheroidal excess.*

excess, triangular #The amount by which the sum of the interior angles of a triangle exceeds or falls short of 180°.#

Triangular excess is positive for triangles on a sphere or spheroid, zero for triangles on a plane, and negative for triangles on a hyperboloid.

exosphere #The outermost portion of the Earth's atmosphere; its lower boundary is estimated to be between 500 and 1000 km above the Earth's surface.#

expansion, coefficient of thermal #The relative change (expansion or contraction) in a linear dimension of a body corresponding to a change of 1° in the temperature of the body.#

The coefficient of expansion, as it is generally called, may be in terms of the Celsius, Fahrenheit, or other temperature scale. To a very great extent, its magnitude is peculiar to the material; a steel tape has a coefficient of expansion about 25 times as great as that of an invar tape. In a measure of length, such as the length of a base line, it enters as a correction that is a product of the coefficient of expansion of the apparatus used, the length measured, and the difference between the temperature at which the measurement was made and the temperature (standard or calibration temperature) at which the length of the apparatus is known.

explement of angle See *angle.*

exposure #The amount of electromagnetic radiation per unit area that falls on a radiation-sensitive surface during a given interval of time.#

The term is used particularly with reference to radiation wavelengths shorter than radio wavelengths.

extension (1) (geodesy) #The establishment of control of the same order and class as the order and class of the control to which it is or will be connected.#

Establishment of control of lower order or class is called densification.

(2) (photogrammetry) #The determination, by photogrammetric methods, of horizontal or vertical coordinates of points (ground control) to be used for the absolute orientation of other photogrammetric models, i.e., the establishment of ground control by photogrammetric methods.#

See also *bridging* and *extension, cantilever.*

extension, cantilever (1) *#Aerotriangulation* from a region containing control to a region without control.#

(2) #The connection, by relative orientation and scaling, of a series of photographs in a strip to obtain coordinates of points in the strip.# The term is often shortened to extension.

extensometer (1) #A device for measuring small changes in distance between two points on the Earth.#

The term applies to a device such as a wire extended between two points, used to measure small, dimensional changes in a material body. Another such instrument, sometimes called a strainmeter, uses a laser for making the measurements.

(2) #A device used for measuring the effect of torsion, compression, tension, etc., on a specimen.#

Also called *strain gauge* or strainmeter.

F

face (1) (leveling) #The side of a leveling rod on which there are graduations, or the graduated side of a scale.#

(2) (photography) #The side of a negative or photographic plate on which there is emulsion.#

factor, C- See *collimation correction factor.*

Fahrenheit scale of temperature See *temperature scale, Fahrenheit.*

falling #The distance measured along an established line from its intersection with a random line to the *corner* on which the random line was intended to close.#

fathogram #A graph of depth measurements produced by an acoustical sounding apparatus.#

fathom #A measure of water depth equal to exactly 6 feet.#

Faye's correction See *gravity correction, Faye's.*

Ferrero's formula #The approximate formula for the standard deviation of the angles in a triangulation network, given by

$$m_f = \left[\left(\sum_{n=1}^{N} \epsilon_n^2\right)/3N\right]^{1/2}$$

where ϵ_n is the angular misclosure of triangle n, and N is the number of triangles.#

It yields a measure of the precision of the angles of a network when only misclosures of triangles are available.

field (adjective) #Referring to work done or equipment used for or during operational work.# For example, field party, field data, field computations, etc.

field (1) #A region of space and a quantity defined at every point of that space.#

(2) #A region at every point of which a vector is defined.#

(3) #The region specified in (1) above, and the associated set of vectors.#

In physics, the type of field is often identified by prefixing to "field" the name of the quantity involved, e.g., gravity field or geomagnetic field. It is then sometimes called a "force field" to distinguish it from a field in which the vectors represent quantities that are not forces, such as for example, velocities. For definitions of particular types of fields, see under the name of the force, such as *geomagnetic field* or *gravity.*

field completion #Inspections or surveys made in the field to complete, check, or correct photogrammetrically prepared portions of a map manuscript.#

A field completion may, despite its name, be done either before or after photogrammetric compilation. Among the items checked or added are place names, boundaries, elevations, distances, types of roads, and nature of vegetation.

field inspection #The process of comparing what is shown on aerial photographs with what is actually on the ground, thus supplementing or clarifying what cannot be readily inferred from the photographs alone.#

Surveying is not a part of field inspection but, together with field inspection, constitutes *field completion.*

field of view (1) #The angle that the entrance window of an optical system subtends at the center of the entrance pupil.#

(2) #The angular extent of the portion of *object space* imaged on photographic material.#

field stop See *stop, field.*

figure of the Earth #A general term, used as indicated by context to mean the *geoid,* the shape of the geoid, a mathematical representation of the shape of the geoid, or the shape of the Earth.#

film, photographic #A thin, flexible, transparent sheet of stable, plastic material coated with a light-sensitive material; used for taking photographs.#

Photographic film is distinguished from a photographic plate in that the base for the emulsion of a photographic plate is a rigid material, usually glass.

filter (1) (electricity) #A circuit for removing specified frequencies from a varying voltage or current.#

Low-pass filters remove frequencies below a specified frequency, high-pass filters remove frequencies above a specified frequency, and band-pass filters remove frequencies within a specified range of frequencies. Passive filters are a combination of resistances, capacitances and inductances; they contain no power source. Active filters contain, in addition to the other components, power sources such as transistors that differentially amplify wanted frequencies or diminish unwanted frequencies.

(2) (mathematics) #Any mathematical transformation that represents a set of N points by a formula containing fewer than N constants.#

The term is used interchangeably with "polynomial", "integral", or other mathematical term, when the purpose of filtering is smoothing.

(3) (optics) #A device that removes a certain band or bands of frequencies from light or infrared radiation.#

The most common filter is the absorption filter, which transmits the desired frequencies with little attenuation but absorbs most of the unwanted radiation. Also called optical filter. Interference filters reflect the radiation between surfaces in such a way that light at undesired frequencies is canceled by interference but light at the desired frequencies is reinforced.

filter, anti-vignetting #An optical filter whose density decreases radially from the center to compensate for the radially decreasing illumination produced by certain kinds of lens systems, particularly wide-angle systems.#

filter, Kalman #Sequential analysis applied to problems of mechanics, e.g., the method of least squares applied sequentially.#

filter, optical See *filter* (3).

filter, vignetting #An optical filter whose density increases gradually from the center towards the edges.#

A vignetting filter is sometimes used in photography or printing to produce a positive photograph of uniform (optical) density by compensating for gradual decrease in density of the negative with distance from the center.

filtering (1) #Smoothing or fitting.# See *fit*.

(2) #The process of trying to separate, from a set of data, the part that does not contain information from the part that does.#

The part that does not contain information is called noise, error, or misinformation; the part that does is called information or signal.

finder circle See *circle, finder*.

finder telescope See *telescope, finder*.

finite-element method #A method of obtaining an approximate solution to a problem, for which the governing equation and boundary conditions are known, by dividing the region involved into numerous, interconnected subregions (finite elements) over which simple approximating functions are used to represent the unknown quantities.#

The method, backed up by rigorous mathematical theory, has been applied to problems in stress, heat flow, fluid flow, gravity fields, and other disciplines.

First Point of Aries #The point where the *ecliptic* and the *celestial Equator* intersect and the Sun crosses from south to north (the Sun's declination changes from negative to positive).#

Because of precession, the First Point of Aries is no longer in the constellation of Aries but is in Pisces; in 300 years, it will be in Aquarius. By definition, the right ascension and declination of First Point of Aries are zero.

The First Point of Aries is also called the *vernal equinox*. However, vernal equinox also means the time when the Sun is at the First Point of Aries.

fit (1) (statistics) #Representation of a set of N points by a function containing fewer than N constants.#

(2) #Representation of a set of N points in a space by a surface in that space, with the surface specified by less than the number of parameters necessary for it to pass through all N points.#

A fit is also called a *smoothing* or *adjustment*; the process of obtaining a fit is called fitting, smoothing, adjusting, or filtering.

fix (1) #The location of a point of observation obtained by surveying. Also, the act of determining such a location.#

The term is usually applied to the designation of the location on a map.

(2) #A location obtained as the intersection of *lines of position*, e.g., from astronomical observations.#

The act of obtaining such a location is called "obtaining a fix" or "getting a fix".

(3) #A location used as a control point and obtained by computation from data obtained at other locations.#

flare See *hotspot (photography)*.

flare triangulation See *triangulation, flare*.

flash apparatus #An auxiliary apparatus used for timing a pendulum's oscillations during measurements of gravity; this device produces a flash of light every time the pendulum passes through a reference position.#

flat (optics) #A surface, usually of glass, ground and polished to be plane to within a fractional part of a wavelength of light.#

Also called an optical flat.

flattening (1) See *ellipse, flattening of*.

(2) #The flattening of an ellipsoid of rotation is the flattening of the ellipse used to generate the ellipsoid.#

(3) #The flattening of the Earth is defined by the flattening of the ellipsoid of rotation used to represent the shape or figure of the Earth.#

flicker method (of comparing images) (1) #The projection of a pair of corresponding images (photographic or other), alternately and repeatedly in rapid succession, onto a flat surface such as a tracing table or screen, or into the optical train of a photogrammetric instrument for simultaneous viewing with both eyes.#

The viewer observes a flickering in those regions of the composite image where the corresponding images differ in detail.

(2) #The viewing of first one photograph of a stereoscopic pair with one eye and then of the other photograph with the other eye by blinking rapidly to give the viewer the impression of a single, fused picture.#

A flickering will be noticed in those regions of the composite where the two separate photographs differ appreciably.

float gauge See *tide gauge*.

float well #A vertical pipe or box with a relatively small opening in the bottom, used to enclose the float of a tide gauge so the float will be little affected by nontidal motions of the water.# Synonymous with *stilling well*.

flow (1) #A general term for the motion of a fluid.#

(2) #The volume or mass of a fluid passing through a specified surface per unit of time.#

flow, geostrophic #Flow in which the horizontal component of the *Coriolis force* exactly balances the horizontal pressure gradient force at all points of the flow.#

Flow in the oceans is never precisely geostrophic, but in many regions can be considered geostrophic without significant error. Also called geostrophic current by oceanographers.

f-number #A number expressing, approximately, the ratio between a camera's aperture and its focal length.#

This ratio provides a means for estimating the illumination, relative to that obtained with a standard f-number, on the photographic film.

focal distance See *focal length*.

focal length #A general term for the distance between the center, vertex, or *rear node* of a lens (or the vertex of a mirror) and the point at which the image of an infinitely distant object comes into critical focus.#

The term must be preceded by an adjective such as "equivalent" or "calibrated" to have a precise meaning in photogrammetry. See *focal length, calibrated* and *focal length, equivalent*.

focal length, back #The distance, measured along the optical axis, of a lens system from its rear vertex to the plane of best average *definition*.#

Also called back focal distance.

focal length, calibrated #An adjusted value of the *equivalent focal length*, calculated to distribute the effect of distortion more evenly over the entire field of view.#

This value is often specified as the distance along the axis of the system from the interior *perspective center* to the image plane; the interior perspective center is selected to balance the positive and negative areas of the distortion for some specified field of view.

focal length, equivalent #The distance, measured along the optical axis, of a lens system from its rear *nodal point* to the plane of best average *definition*.#

In general usage, the term also applies to the distance from the rear nodal point to the plane of best axial definition.

focal plane (1) #A plane perpendicular to the *principal axis* of an optical system and passing through a focal point on that axis.#

Also called a principal or primary focal plane.

(2) #The locus of all points in *image space* that are the images of points on a plane in *object space*.#

The focal plane exists only for ideal imaging systems. Most optical systems project points in object space onto a more or less curved surface, the focal surface.

(3) #The plane of best average *definition*.#

focal point #One of two points of intersection of monochromatic rays entering an optical system parallel to and close to the optical axis.#

More specifically, the point determined by the entrance of rays through the objective lens is called the second focal point. The first focal point is found by passing rays through the optical system from the other end (the eyepiece).

focus (1) #The point at which rays of light converge after passing through a lens system.#

If the incident rays are parallel, they come to a focus in the principal *focal plane*. The distance along the axis of the lens system from the second *nodal point* of the lens to this plane is called the *focal length* of the lens.

(2) #Any small region to which rays of light from a point source converge after passing through an optical system; the set of all *image points* corresponding to one point in *object space*.#

(3) #The same as (1) but not restricted to a lens system.#

(4) #The same as (2) and (3) but applicable to monochromatic rays in any part of the spectrum.#

focus, Cassegrainian #In a *Cassegrainian telescope*, the point behind the primary mirror at which light from the secondary mirror is brought to a focus.#

The term is sometimes used to refer to a focal point behind the primary mirror in any kind of *reflecting telescope*.

focus, Coudé #The location at which the light entering a *reflecting telescope* is focused by bringing the light through the declination axis and then reflecting it along the polar axis.#

focus, Newtonian #The point in a *reflecting telescope* at which light is focused by inserting a flat mirror at 45° to the principal axis of the primary mirror.#

Light is thus focused to one side of the telescope. It is distinguished from the *Coudé focus* in that, in the latter, light entering through the declination axis is reflected from the secondary mirror through the polar axis.

focus, sidereal #The location of the principal focal plane of a lens system.#

A camera or telescope is said to be in sidereal focus when incident rays from a great distance come to a focus in the plane of the photograpahic plate or of the reticle. The sidereal focus is sometimes called the solar focus.

foot #A unit of length defined to be 1/3 of a *yard* and equal in the United States of America, since 1866, to exactly 1200/3937 of a *meter*.# Also known as the *survey foot*.

(2) #A unit of length defined (for scientific purposes) by the 1959 agreement between the U.S. National Bureau of Standards and similar organizations in other countries to be 1/3 of the *international yard*, or exactly 0.3048 meter.# Also known as the international foot.

The foot used in the triangulation of Great Britain was defined as 1/10 of the length of the 10-foot bar 0_1 of the Ordnance Survey, and equal to 0.304 800 756 of an *international meter*. The Indian foot used by the United States and Great Britain for computing triangulation in India and neighboring countries is 0.304 798 42 meter. The foot used at present by the Survey of India is 0.304 799 6 meter.

See also *yard*.

foot, French #A unit of length defined as 1/6 of a *toise*.#

foot, square #A unit of area in the English system; the area on a plane surface contained within a square with each side 1 foot in length.#

The square foot is not usually used as a measure of area of land; the *acre* is preferred except where land is very costly. A square foot is 0.092 903 04 square meter.

foot, survey #The unit of length defined by the relationship

$$1 \text{ foot} = (1200/3937) \text{ meters},$$

established by the U.S. Coast and Geodetic Survey in its Bulletin No. 26 (April 5, 1893).#

Although the meter was not defined in Bulletin No. 26, it was probably the International Prototype Meter in Paris. Practically, it was the meter derived from Meter Bars 27 (primary standard) and 21 (auxiliary standard) of the U.S. Coast and Geodetic Survey and later of the National Bureau of Standards.

foot plate (1) #The plate or other type of bearing surface on which the screws used for leveling an instrument rest.#

(2) #A metallic plate used to support a leveling rod at a turning point in leveling operations.#

Also called a turning plate. In the United States, metallic pins (turning pins) are preferred to foot plates for supporting leveling rods, except on hard surfaces such as roads.

force #The product of the mass and the acceleration of a moving body.#

Force is defined as a vector or scalar, according to the corresponding definition of acceleration. It can be defined for a stationary body by the introduction of fictitious and balancing accelerations (i.e., by using Newton's law that to every action there is an equal and opposite reaction).

force, Coulomb See *force, electrostatic.*

force, electrostatic #The force of repulsion or attraction between two electrically charged particles of negligible mass with either the same or opposite signs of charge.#

If the charges are shown as q_1 and q_2, and the shortest vector distance between the particles by $\vec{r}$, the force $\vec{f}$ is given by

$$\vec{f} = k_e^2 q_1 q_2 \vec{r} / r^3$$

where k_e is a constant of proportionality and r is the absolute value of $\vec{r}$. Magnetic force is related to electrostatic force through Maxwell's equations.

force, gravitational #The force of interaction between two bodies because they have mass.#

If the bodies have masses m_1 and m_2, respectively, and are of negligible size, and if $\vec{r}$ is the vector distance from the first body to the second, then the force $\vec{f}$ acting between the two bodies is given by

$$\vec{f} = -G m_1 m_2 \vec{r} / r^3$$

where r is the absolute value of $\vec{r}$. G is the factor of proportionality and is called the *gravitational constant* or the constant of gravitation.

force function #A scalar function of location whose gradient at a point is the force at that point.#

If the force is attractive, potential and force function are identical; if the force is repulsive, the potential is the negative of the force function. See also *potential.*

forepoint #The point to which an observation is made, in surveying i.e., the point to which a foresight is directed.#

foreshore (1) #According to riparian law, the strip of land between the high and low water marks that is alternately covered and uncovered by the flow of the tide.#

(2) #The part of a beach normally exposed to the action of waves.# Also called the beach face.

foresight (1) #In a survey made between an initial point and a final point through a succession of intermediate points, the sighting made to a succeeding point of the reading or the measurement obtained by that sighting.#

The situation at the time sights are taken is called a setup, so the distinction between preceding point and succeeding point (backsight and foresight) is peculiar to each setup. Ordinarily, what was the succeeding point in one setup becomes the preceding point in the next, and a new point becomes the succeeding point.

(2) (leveling) #In leveling from an initial point to a final point through a sequence of intermediate points, a sight to or a reading on a leveling rod held on a succeeding point of the sequence.#

The sight to or reading on the preceding point is called the backsight. If the sequence consists of only two points, it does not matter which sight is called the backsight and which the foresight.

Note that in these definitions, the survey must be made through the sequence of points. Sights taken to points not directly in the sequence are called side sights or side shots (exception: extra foresight). See also *backsight.*

foresight, extra #The reading made at an instrument station in a level line and on a leveling rod standing on a bench mark or other point not in the continuous level line.#

In spirit leveling there may be one or more extra foresights from a single instrument station or setup, but there can be only one backsight and one primary foresight from any one instrument station.

form, physiographic See *physiographic form.*

format #The dimensions of the part of the negative that lies within the field of view in the focal plane of a camera.#

form line #A line, usually dashed, drawn to represent the contour of the terrain.#

Unlike contour lines, form lines are drawn without regard to a vertical datum and without any regular vertical interval. They are sketched in on the basis of visual observations or unverified data.

frame of reference #A *coordinate system.*#

frame of reference, inertial #Properly, any *coordinate system* that has no translational acceleration and that is not rotating with respect to the distant galaxies.#

Also called a Galilean frame of reference; less precisely, any coordinate system that can be considered nonrotating. It is the reference frame in which Newton's laws of motion hold.

free-air correction See *gravity correction, free-air.*

free-air reduction See *gravity reduction, free-air.*

frequency #The number of times, per specified unit interval, that a periodic phenomenon recurs, i.e., returns to its original form.#

For example, the frequency of a light wave at a particular point in space is the number of times per second its average intensity passes through zero in the same direction. Most periodic phenomena are composite; that is, they are made up of components having different frequencies. Frequency is inversely proportional to wavelength.

frequency band (of electromagnetic radiation) #Electromagnetic radiation at all frequencies between two given limiting frequencies.#

It is often more convenient to specify a frequency band by its limiting frequencies than to list the full spectrum of frequencies within the band.

frequency band (of electromagnetic radiation), **classification of** #Electromagnetic radiation is classified roughly into the following groups of frequencies (frequency bands): *radio waves*, with wavelengths from infinity to about 0.3 mm; *infrared radiation*, with wavelengths between 0.3 mm and 0.7 μm; *light*, with wavelengths between 0.7 and 0.4 μm; ultraviolet radiation, with wavelengths between 0.4 and 0.01 μm; and X-rays, with wavelengths shorter than 0.01 μm.#

frequency drift #A slow, nearly monotonic variation in frequency.#

For example, a slow rise or fall of the temperature of a crystal oscillator or the aging of the components in its circuit will cause the frequency emitted by the oscillator to change slowly in one direction.

frequency function #A function giving the number of times a randomly varying vector assumes a value lying within a unit interval of the vector's range.#

frequency function, Rayleigh #The *frequency function*

$$p(r) = (r/\sigma^2)e^{-r^2/2\sigma^2}$$

where r is the modulus of a vector of two randomly varying components and σ is the standard deviation.#

frequency-measuring equipment (geodesy) #Equipment which, by measuring the frequency of the electromagnetic radiation from a moving body, can determine the velocity of that body.#

At present, a common kind of frequency-measuring equipment measures the Doppler shift in radio waves.

fringe #Lines in a spectrum formed by interference between waves of electromagnetic radiation.#

The fringe is so called because it appears usually as a pair of lines, one on each side of the strong line produced by the radiation received directly (without interference). Fringes of light can be observed as a series of parallel light and dark lines. If the light is polychromatic, the fringes have colored edges. The distance between two neighboring fringes depends on the difference in phase of the interfering waves and can be used to determine the difference in distance traveled by each of the two waves. The *Väisälä base line apparatus* depends for its accuracy on the counting of fringes. The same principle is used in radio interferometry.

fringe, Moiré See *Moiré fringe.*

full and change See *water full and change* (high or low).

function, covariance See *covariance function*

function, harmonic #Any solution of the *Laplace equation* (3)#.

The Laplace equation was first solved using Fourier series, the terms of which (sines and cosines) are harmonically related, so the term harmonic function was applied to all solutions of the equation. However, functions less obviously harmonic than sines and cosines are also solutions of the Laplace equation. Among them are Bessel functions, *spherical harmonics*, and Lamé functions. The kind of harmonic function most suitable as a solution depends on the coordinate system in which the Laplace equation is expressed. Fourier series are best for Cartesian coordinate systems, Bessel functions for cylindrical coordinate systems, Lamé functions for ellipsoidal coordinate systems, and so on.

function, line-spread (1) #The illuminance, as a function of location in the image surface, perpendicular to the image of a line in object space.#

(2) #The illuminance of an *image*, or the density of a photographic image, of a line in object space as a function of distance from the ideal image of the line.#

It is the line integral of the *point-spread function.* The line in object space is a geometric line lying in a plane perpendicular to the optical axis of the optical system.

function, point-spread #The illuminance of an image or the density of the photographic image of a point source in object space, as a function of location with regard to the ideal point image.#

function, potential See *potential function.*

function, spheropotential See *spheropotential function.*

function, transfer See *transfer function.*

functional #A function whose domain is a function space.#

function space #A mathematical set whose elements are functions, e.g., Hilbert space.#

fundamental table See *gravity table, fundamental.*

G

gal #A unit of acceleration equal to 1 centimeter per second per second.#

The milligal, 0.001 gal, is more commonly used in geodesy. However, neither "gal" nor "milligal" is an approved unit in SI (Système International d'Unités).

gamma (1) (photography) #The tangent of the angle which the straight portion of the *characteristic curve* makes with the abscissa (axis plotting logarithm of the exposure).#

It is a measure of the extent of development and contrast of the photographic material.

(2) (magnetism) #The unit formerly used as a measure of *magnetic flux density.* #

In SI units, the unit is the *tesla,* equal to 10^9 gamma. See also *gauss.*

gap (1) #A lack of photographs over a small region between two regions which are shown on photographs.#

The term may be used to indicate either the region not shown or missing photographs of that region.

(2) #An unintentional gap, as defined above, resulting from human error or from equipment malfunction.#

The term is used particularly with reference to aerial photographs. Also called a "hiatus".

gauss #A unit primarily used as a measure of the *magnetic flux density* of a magnetic field, but also used as a measure of the magnetic field intensity.#

As a unit of magnetic flux density, it is equal to 10^{-4} *webers per square meter;* as a unit of *magnetic field intensity,* it is equal to 1 oersted, or 79.577 472 amperes per meter.

In geomagnetism, where the magnetic flux density of the Earth varies according to latitude from 0.25×10^{-4} to 0.70×10^{-4} teslas (tesla = weber per square meter) and is almost equal, numerically, to the magnetic field intensity, it has been common practice to treat geomagnetic flux density and geomagnetic field intensity as equivalent, and to use the gamma (10^{-5} gauss) as a unit of magnetic field intensity. In SI units the gamma is equal to 10^{-9} tesla, the gauss is equal to 10^{-4} tesla.

Gauss' equation (optics) #The equation

$$(1/s) + (1/s') = 1/f$$

relating the distances s and s′ of a point in *object space* and in *image space,* respectively, from the *principal plane* of a thin lens to the *focal length f* of the lens.#

The formula applies only to *paraxial rays* going through a thin lens, but is very useful for getting approximate answers even for thick lenses.

Gaussian constant See *gravitational constant.*

Gaussian elimination See *Gauss' method.*

Gauss' method #A method for solving a set of *normal equations* by applying multiplying factors to successively eliminate unknowns so that only one equation in one unknown remains. The solution for this is then the start of a reverse process to recover the values of the remaining unknowns.#

The procedure leading to the solution of the first unknown is called the forward solution. The ensuing set of steps is called the back solution.

Gauss' variational equations #A set of six first-order differential equations relating the rate of change of each of the six *orbital elements* to the rectangular components of the (vector) derivative of the *disturbing function* on a satellite.#

The components are usually the radial and its perpendicular in the orbital plane, plus the perpendicular to the orbital plane; or the tangential and the corresponding perpendiculars. Compare with *Lagrange's variational equations* which employ, instead of the rectangular components of the derivative of the disturbing function, the partial derivatives of the disturbing function with respect to the orbital elements.

gazetteer #An alphabetical list of names of places; each entry is identified as a specific kind of place (city, river, mountain, etc.) and its geographic or grid coordinates are given.#

Some gazetteers also give the approximate populations of cities, towns, countries, etc. However, a gazetteer giving much more than the minimal information is usually called a geographical dictionary or geographical encyclopedia.

geländereduktion #A correction to gravity needed to account for attraction by the terrain (topography).# It is closely related to the *topographic gravity correction.*

generalization (cartography) #The gradual loss of resemblance between a symbol on a map and the object represented by that symbol as the scale of the map becomes smaller.#

For example, on a large-scale map, a town may be shown by lines accurately representing streets and by small rectangles showing the shapes and locations of buildings. On a medium-scale map of the same region, the symbols representing individual buildings will have disappeared, as will most of the symbols representing streets; only the size and shape of the town as a whole will be shown. On a small scale map on which the town is shown, the town will be represented merely by a dot or circle, usually representing some category of population or area.

geocentric (adjective) #Referred to the center of the Earth.#

The exact meaning of "center" must usually be inferred from the context. The following kinds of center are in common use: (a) the center of an ellipsoid representing the Earth's shape or figure, as in "geocentric longitude"; (b) the Earth's center of mass, as in "geocentric orbit"; (c) the point at which the Earth's axis of rotation intersects the plane of the celestial Equator.

geodesic #The line of extremal distance between two points.#

In geodesy, the term is understood to mean the shortest line on a surface between two points on that surface. The geodesic between two points on a plane is the straight line segment between those two points. The geodesic between two points on a sphere is the shorter arc of a great circle joining the two points. The geodesic on an ellipsoid is, in general, more complex than a second-degree curve. It is also called a geodesic line, or a *geodetic line*.

geodesy (1) #The science concerned with determining the size and shape of the Earth.#

This is essentially Helmert's definition of 1880. In practice, it is equivalent to determining, in some convenient coordinate system, the coordinates of points on the Earth's surface. For political and technological reasons, a large number of different coordinate systems are in use today.

(2) #The science that locates positions on the Earth and determines the Earth's gravity field.#

The definition can be extended to other planetary bodies.

(3) #The branch of surveying in which the curvature of the Earth must be taken into account when determining directions and distances.#

The above three definitions are not exclusive. The term "geodesy" is commonly understood to include them all.

Geodesy can be divided into lower geodesy that concerns mainly techniques, instrumentation, and theory which does not require a knowledge of the Earth's curvature; and higher geodesy which takes the Earth's curvature into account. (See (3) above.)

Geodesy can also be divided into *physical geodesy* which is concerned with the gravity field, and *geometric geodesy* which is concerned with determining positional relationships by geometric means.

Other subdivisions, such as satellite geodesy, marine geodesy, etc., refer to special data sources or to determinations in particular locations.

geodesy, astronomical See *astronomy, geodetic.*

geodesy, geometric #The part of geodesy which is concerned with positional relationships in the Earth's environment obtained by geometric (rather than physical) methods.#

Compare with *physical geodesy*.

geodesy, gravimetric #The part of geodesy concerned with the measurement of the magnitude or direction of gravity and the determination of the Earth's gravity field from such measurements.#

Gravimetric geodesy is sometimes equated with *physical geodesy*, but is more properly identified with the application of *gravimetry* to geodesy.

geodesy, intrinsic #A geodetic theory, introduced by Antonio Marussi, in which the coordinate system is completely defined by the Earth's gravity field, and all of geodetic theory is developed using only that coordinate system.#

The reference ellipsoid, geoidal heights, and similar concepts involving an ellipsoid as referent are therefore not relevant in intrinsic geodesy. The theory was formulated by Marussi in the language of tensor analysis and was considerably extended by Martin Hotine (1969).

geodesy, marine #Geodesy in the marine environment.#

Marine geodesy is a general subarea of geodesy which includes determination of positions at sea (such as buoys or platforms, or at the bottom), determination of gravity at sea, and determination of the geoid over the ocean surface.

geodesy, physical #The part of geodesy concerning the study and determination of the Earth's gravity field.#

Physical geodesy deals with those portions of geodesy that involve the principles and methods of physics, as opposed to geometric geodesy, which deals primarily with geometrical relationships. When positional relationships can be determined by physical methods (e.g., via satellite orbits), the procedures are considered physical geodesy.

geodesy, satellite #The part of geodesy dealing with the use of satellites to obtain geodetic data.#

Geometric satellite geodesy deals with the use of satellites, geodetic targets, or signals. Satellites differ from the usual targets or signals of surveying principally in their greater height above the Earth's surface. Because satellites are constantly in motion, nearly simultaneously observations must be made on them from several points to compensate for their motion.

Physical satellite geodesy deals with satellites as part of a dynamical system involving the Earth's gravitational field and requires that orbits be determined precisely. Determinations of direction, distance, or rate of change of distance are made over a period of time to permit determination of the satellite's orbit and, often, of the gravitational field. When both simultaneous and nonsimultaneous observations are plentiful, the theories of geometric and physical satellite geodesy can be combined.

Satellite geodesy, in principle, uses both natural and artificial satellites.

geodesy, three-dimensional #The complete determination of positions in three-space by a unified, consistent theory.#

Three-dimensional geodesy differs from the so-called classical methods (which use, e.g., triangulation to obtain the horizontal components of position, and leveling to obtain the vertical component independently) in that three-dimensional methods are sufficiently flexible to use both traditional (as per above) and modern (e.g., satellite observations) types of data.

geodetic constant (1) #A value adopted by the International Association of Geodesy and the International Union of Geodesy and Geophysics and advocated for general use in geodetic calculations#

For examples of geodetic constants, see *Ellipsoid, International*; *Gravity formula, International*; *Geodetic Reference System 1967*; *Gravity Formula 1967*; *Geodetic Reference System 1980*; *Gravity Formula 1980*; *Conventional International Origin*; *gravity, Potsdam system of*; *light, velocity of*; *atmosphere, refractive index of.*

(2) #Any set of constants used principally in geodesy.#

Such sets have been compiled by the International Association of Geodesy. See, for example, Heiskanen and Moritz (1967: pp. 79-81).

geodetic line See *line, geodetic.*

Geodetic Reference System 1967 #The set of values:

a	6,378,160 m
GM	$398{,}603 \times 10^{9}\ m^{3}\ s^{-2}$
J_2	0.001 082 7
ω	$7.292\ 115\ 146\ 7 \times 10^{-5}$ rad s^{-1}

for an *equipotential ellipsoid,* where a is its semimajor axis, ω its angular velocity, GM the product of the gravitational constant G by its mass, and J_2 its dynamical form-factor.#

The values of a, GM, and J_2 were adopted in 1967 by the International Union of Geodesy and Geophysics. A special issue of *Bulletin Géodésique*, authorized by the International Association of Geodesy, and published in 1970, adopted the value of ω in order to complete the definition of a geodetic reference system. In addition this issue listed the derived values:

f^{-1}	(reciprocal of flattening)	298.247
γ_e	(equatorial gravity)	978.0318 gal

and standard gravity formulas (see *Gravity Formula 1967*). The results contained in this special issue were approved by the International Association of Geodesy in 1971.

Geodetic Reference System 1980 #The following set of values adopted in 1979 by the International Union of Geodesy and Geophysics:

a	6,378,137 m
GM	$398{,}600.5 \times 10^{9}\ m^{3}\ s^{-2}$
J_2	0.001 082 63
ω	$7{,}292{,}115 \times 10^{-11}$ rad s^{-1},

defined on an *equipotential ellipsoid.* The symbols have the same meanings as those given for them in the definition of *Geodetic Reference System 1967*.#

A complete description of Geodetic Reference System 1980 is contained in *Bulletin Géodésique,* vol. 54, no. 3 (1980), pp. 395-405, in particular the derived values:

f^{-1}	(reciprocal of flattening)	298.257
γ_e	(equatorial gravity)	978.0327 gal.

For standard gravity formulas, see *Gravity Formula 1980.*

geodynamics (1) (geodesy) #The study and determinations of geodetic parameters (viz., position and gravity) as a function of time.#

Two classic examples are *polar motion* and *earth tides*. Recent improvements in measuring techniques have enabled geodesists to detect and measure systematically horizontal and vertical crustal motion to the 1 cm level, and variations in gravity to the 0.1 mgal level.

(2) (general) #The science concerned with natural changes of the Earth's form or structure.#

geographic (adjective) #Related to the Earth considered as a general globular body.#

The term is applied alike to data based on the geoid, ellipsoid, or sphere. For example, "geographic coordinates" may mean astronomic coordinates or geodetic coordinates, or merely coordinates expressed as longitude and latitude. See also *coordinates, geographic* and *position, geographic.*

geographic information system #A system of spatially referenced information, including computer programs that acquire, store, manipulate, analyze, and display spatial data.#

See *land information system.*

geoid (1) #The *equipotential surface* of the Earth's gravity field which best fits, in the least squares sense, mean sea level.#

In practice, the average position of mean sea level and a corresponding average over the time-varying *geopotential* must be accepted.

(2) #The equipotential surface of the Earth's gravity field which would coincide with the ocean surface if the latter were undisturbed and affected only by the Earth's gravity field.#

This is the original definition as given by Listing (1873). The definition is deficient because it assumes that the oceanic surface specified is an equipotential surface.

(3) #The equipotential surface coinciding with mean sea level in the oceans.#

Since mean sea level is not an equipotential surface, the definition is inconsistent.

(4) #The equipotential surface, through a given point, chosen near mean sea level, that would exist if only the rotation of the Earth and the Earth's gravitational field affected the potential.#

This definition was given by Jensen (1950). It is a function of the position of the chosen point.

geoid, co- See *cogeoid.*

geoid, compensated #A mathematical surface derived from the geoid by the application of values of the *deflection of the vertical* adjusted for the effects of topography and *isostatic compensation*.#

The data for adjustment are obtained from measurements on topographic maps; the effect is then computed in accordance with the assumptions made about the depth and distribution of isostatic compensation.

geoid, ideal #The mathematical surface that corresponds to a hypothetical Earth in the same way that the geoid corresponds to the real Earth.#

geoid, isostatic #A mathematical surface derived from the reference ellipsoid by the application of values of the *deflection of the vertical* adjusted for the effects of topography and *isostatic compensation*.#

The adjusted values of the deflection of the vertical used in obtaining the isostatic geoid are similar to those used for obtaining the compensated geoid, but are opposite in sign. If the theory and assumptions about isostasy were correct and exact, and there were no gravity anomalies, the isostatic geoid would agree with the geoid.

geoid, quasi- See quasi-geoid.

geoid, regularized #The surface which results by removing all masses outside the geoid and then replacing them within the geoid in such a way as to give an equipotential surface differing little from the geoid.#

geoid contour See *contour, geoidal.*

geoid determination, astrogeodetic method of #A method of determining *geoidal heights* by measuring *astronomic longitude* and *latitude* at closely spaced points at which the *geodetic longitudes* and *latitudes* are also known.#

The *deflections of the vertical* are calculated (reduced to the geoid) and the changes in the deflection from point to point are converted, using the distances between points, into changes in geoidal height. Also called astrogeodetic leveling and astronomic leveling. The astrogeodetic method yields absolute or relative geoidal heights depending on whether or not the geodetic coordinates are geocentric.

geoid determination, gravimetric method of #A method of determinining *geoidal heights* from measurements of the acceleration of gravity.#

Stokes' formula, or a modification thereof, which requires gravity values over the entire Earth, is usually used. The gravimetric method yields *absolute geoidal heights.*

geomagnetic anomaly See *magnetic anomaly.*

geomagnetic electrokinetograph #An instrument for measuring the potential (EMF) generated in an oceanic current by the movement of the water across the lines of geomagnetic force.#

Usually called a GEK.

geomagnetic element #One of the seven quantities characterizing the Earth's magnetic field: declination, horizontal intensity, vertical intensity, total intensity, *inclination* or *dip,* strength of the geomagnetic force toward geographic north, and strength of the geomagnetic force toward geographic east.#

geomagnetic Equator See *Equator, geomagnetic.*

geomagnetic field #The magnetic field of the Earth.#

Its intensity varies from about 0.25 (10^{-4}) tesla in a small region around northern Argentina to over 0.70 (10^{-4}) tesla near the south magnetic pole. The magnetic force is vertical at the magnetic poles. Its direction varies considerably elsewhere. The field is usually represented, to a first approximation, as a magnetic dipole with a moment of about 0.8 (10^{16}) weber-meters and an angle of about 11° with the Earth's axis of rotation. It can be well represented by one large magnetic dipole and 8 to 10 small dipoles placed about 1640 km from the Earth's center at various longitudes and latitudes.

The field has a slow secular variation, fairly periodic variations that depend on the positions of the Moon and Sun, and large random variations that are related to disturbances in the Sun's atmosphere.

geomagnetic field, main #The part of the *geomagnetic field* left after daily and short-term (a few days) variations in this field are removed.#

geomagnetic field, residual #The difference between the observed *geomagnetic field* and the dipole field which best approximates the geomagnetic field.#

Also called the nondipole geomagnetic field.

geomagnetic field, variations of See *magnetic variation.*

geomagnetic variation See *magnetic variation.*

geometer #A surveyor.#

The term is obsolete in English except when it is used to designate a surveyor in ancient (e.g., Greek, Roman) times. A form of the word is still used in Romance languages to designate land surveyors. The English word "surveyor" originally meant a person who kept track of property—a steward.

geomorphology (geophysics) #The study of the physical features of the Earth, the arrangement and form of the Earth's crust and of the relation between the physical features and the geological structures beneath.#

geop #An *equipotential surface* of the Earth's gravity field.#

Geop is a shortened form of geopotential surface. J. de Graaf-Hunter used the term (1958) to designate an equipotential surface of the actual Earth, as distinguished from a spherop, which denotes an equipotential surface defined by a *normal gravity field.*

geophone #A receiver for listening to sounds transmitted through the Earth.#

The sounds are those produced by intentional explosions or by special devices.

geophysics #The branch of physics concerned with the forces that act in and on the Earth and with the changes caused by these forces.#

Included within or overlapping the domain of geophysics are meteorology, hydrology, oceanography, geomagnetism, seismology, volcanology, tectonophysics, and geodesy.

geopotential (1) #The sum U of the gravitational potential V_g of the Earth, at a point P, and the rotational potential V_c at the same point: $U = V_g + V_c$, where

$$V_g = G\int_V (\rho/r)dV, \text{ and } V_c = \omega^2 p^2/2.$$

Here, G is the gravitational constant, ρ the density at a point Q in the Earth, dV an element of volume, r the distance PQ, p the distance from P to the axis of rotation of the Earth, and ω the rate of rotation of the Earth. Integration is over every point Q of the entire volume V of the Earth and its atmosphere.#

(2) #The negative of the sum of V_g and V_c:

$$U = -(V_g + V_c).\#$$

Geodesists usually use the first definition.

geopotential anomaly See *dynamic depth anomaly.*

geopotential number (1) #The quantity W given by the integral

$$W = \int_{P_O}^{P_N} g dh$$

where P_O is a point on the geoid, P_N is the point at which the geopotential number is wanted, the integration is carried out along the plumb line between P_N and P_O, and g is the actual value of gravity along that line.#

(2) #The sum, from $i = 1$ to $i = I$, of the quantities $\Delta h_i \bar{g}_i$ obtained in going from an equipotential surface of reference, through a sequence of equipotential surfaces from $i = 1$ to $i = I - 1$, to the equipotential surface through the point for which the equipotential number is wanted. Successive surfaces S_{i-1} and S_i are separated by the very small distance Δh_i, expressed in meters, and $\bar{g}_i$ is the average value of the acceleration of gravity, expressed in kilogals, along the distance h_i.#

The geopotential number at a point is approximately equal numerically to the *elevation* of that point in meters because $\bar{g}_i$ in kilogals at the surface of the Earth is approximately unity.

geopotential number, normal See *spheropotential number.*

geopotential unit #The quantity 1 kilogal-meter.#

geosphere (1) #The solid and liquid portions of the Earth; i.e., all of the Earth except the atmosphere.#

(2) #A sphere having its center at the center of mass of the Earth and a radius such that the sphere is below the actual surface of the Earth at all points.#

geostrophic parameter #The quantity $2\omega \sin \phi$, in which ω is the angular rate of rotation of the Earth and ϕ is the geodetic latitude.#

gimbal #A ring carrying, along a diameter, an internal axis about which the ring can rotate, and a pair of internal or external trunnions on a diameter perpendicular to that on which the internal axis lies.#

If it were not for the friction at the trunnions and at the supports for the internal axis, an object attached to the internal axis could be rotated in either of two perpendicular directions without affecting the gimbal's support. Or an object attached to the internal axis could be kept in a fixed orientation without being affected by motion of the gimbal's support.

Gimbals have two major geodetic uses: to support a compass so that the compass (with attached, pendulous mass) remains horizontal no matter how the craft or vehicle carrying the compass may move; and to support a gyroscope so that the gyroscope maintains a given orientation regardless of the motion of the support. Gimbals are often nested one inside the other so that there can be free, rotary movement in three mutually perpendicular directions.

gisement #The angle between the grid meridian and the geographic meridian.#

Gisement is sometimes called the "declination of grid north", and is reckoned east and west from geographic north. The term is used in the United States principally with military grids and is not used with the State plane coordinate systems, where the corresponding angle on the grid used with the transverse Mercator map projections is the convergence of the local with the central geographic meridian. In the grid associated with the Lambert map projection, the angle is known as the mapping angle (formerly called the theta angle).

glare See *hotspot* (photography).

glint #Angular variation in the direction from which radio waves arrive at an antenna, and caused by interference at the target.#

Global Positioning System (GPS) #A navigational and positioning system, under development (1986) by the U.S. Department of Defense, by which the location of a position on or above the Earth can be determined by a special receiver at that point interpreting signals received simultaneously from several of a constellation of special satellites.#

The official Department of Defense designation for this system is NAVSTAR. The presently anticipated satellite constellation will consist of 18 satellites, each in a polar orbit about 16,000 km above the Earth, with the orbits arranged to lie in sets of 3 on 6 planes 60° apart, and the satellites equally spaced in each plane. With this arrangement, three to four satellites will be visible simultaneously from any point in the world.

The satellites carry beacons sending out long sequences of pseudo-random code, each pulse precisely timed. A GPS receiver also has a precise clock and, by comparing the time of reception with time of emission, determines the distance from the receiver to the satellite. Several such measurements of distance to different satellites determine the receiver's location.

globe (1) #A spherical body.#

In geodesy and astronomy, a globe is usually a spherical body on whose surface a map of the Earth (terrestrial globe) or of the heavens (celestial globe) is printed. Terrestrial globes are usually between 20 and 100 cm in diameter and are made by cementing flat, gore-shaped segments of maps to the spherical surface. Larger terrestrial globes may be several meters in diameter and may have the Earth's surface shown in sculptured relief. See also *horizon ring*; *meridian ring*; *time dial*; *globe, terrestrial.*

(2) #The surface of the Earth.#

globe, celestial #A sphere on which the locations and brightness of stars and other heavenly bodies are shown symbolically. Usually the outlines of constellations are also shown.#

The celestial globe commonly has a blue background on which stars are indicated by black or white dots, with sizes proportional to the stellar magnitudes. Lines on a celestial globe indicate meridians of right ascension and parallels of declination.

globe, generating (1) #The sphere upon which lie the points to be mapped, by perspective projection, onto the plane. The radius of the generating globe bears the same relation to the radius of the Earth as denoted by the representative fraction of the required map.#

(2) #An ellipsoid whose characteristic dimensions bear a specified ratio to the corresponding dimensions of an ellipsoid representing the Earth; the ratio is chosen close to the scale at which the Earth is to be mapped.#

globe, terrestrial #A spherical body, on the outer surface of which the features of the surface of the Earth are shown in their relative locations by means of symbols and reference lines.#

Essentially, a terrestrial globe is a spherical body onto which a map of the surface of the Earth has been fitted. See *globe* and *gore.*

gon #A *grad* (also called new grad, Neugrad).#

Because the term grad has been used in continental Europe for both the degree (1/360 of a circumference) and for the Neugrad (1/400 of a circumference), the term gon has been legally adopted in Germany to designate the latter.

goniasmometer #A compact surveying instrument for observing horizontal angles and bearings. It consists of a vertical cylinder divided horizontally into two parts. The lower edge of the upper part is graduated in circular measure and revolves on the lower part, which carries a vernier on its upper edge. A magnetic needle is centered in the upper part, which is also provided with slits or a telescope for sighting.#

The instrument has been used in France, where it served the same purposes as a surveyor's compass or transit.

goniometer #In general, any one of various instruments used for measuring angles, in disciplines such as crystallography, anthropology, etc. In surveying, an instrument for measuring horizontal angles or directions, such as a theodolite.#

gore (1) #A small, generally triangular piece of land, usually occurring as a gap between adjoining pieces of land or as a piece common to two such pieces.#

Also called gap or hiatus, especially when no connotation of shape is wanted.

The gore may result from surveying error, from the use of different, independent origins for the surveys leading to the titles, from an error in recording the titles, or from similar error-producing actions.

(2) #A lune-shaped map which may be fitted to the surface of a globe with a negligible amount of distortion.#

A terrestrial or celestial globe may be constructed by covering a sphere with a complete set of gores, each a lune so narrow it can be mounted on the sphere without appreciable stretching or shrinking.

grad #The angle subtended at the center of a circle by an arc of 1/400 of the circumference of the circle.#

See also *gon.*

grad, square #A unit of measure of solid angle. It is the solid angle which intercepts, on a unit sphere, an equiangular quadrangle with each side 1 *grad* long.#

Also called the square gon. There are approximately 50,927.49 square grads on a sphere.

grade (1) #Rate of slope or degree of inclination.#

For example, a 1 to 100 grade is a slope on which the elevation changes by 1 m for every 100 m change in horizontal distance; it is also called a "1-percent grade". See *gradient.*

(2) #In surveying for construction, the term is also used to mean a difference in elevation above or below a reference surface.#

grade, broken #The change in slope when the middle point of a tape is not in a straight line with its ends.#

If the support for the middle of the tape is not on a straight line with supports for the ends, the fact is noted as "broken grade at...", naming the particular segment that contains the broken grade.

grade, correction for See *taped length, grade correction to.*

grade correction See *taped length, grade correction to.*

grade stake #A stake driven into the ground and indicating a difference in elevation with respect to some previously selected surface.#

The top of the grade stake may be driven to the desired difference of elevations or, more commonly, the difference is indicated by a chalk mark on the side of the stake. Grade stakes are frequently offset from a surveyed line, with the amount and direction of offset marked on the stake.

gradient (1) (general) #The rate at which a variable quantity changes.#

(2) (mathematics) #The vector whose components are the partial derivatives of a scalar function with respect to the independent variables of that function.#

Given a scalar V defined in a Cartesian coordinate system (x,y,z), the gradient of V is the vector

$$(\partial V/\partial x,\ \partial V/\partial y,\ \partial V/\partial z).$$

The gradient is perpendicular at each point to the curve (isopleth) or surface of constant V. The gradient is usually expressed as a negative quantity.

(3) (geodesy) #A *grade* expressed as a tangent of the angle of inclination.#

For example, a grade of 1 to 100 is a gradient of 0.01.

gradienter #An attachment to an engineer's transit with which an angle of inclination is measured in terms of the tangent of the angle instead of in degrees and minutes.#

A gradienter may be used as a *telemeter* in observing horizontal distances.

gradual and imperceptible A term used to #describe changes in riparian lands that bring them within the scope of the doctrine of *accretion* and *erosion.* # The test of what is gradual and imperceptible has been held to be that, "Though the witnesses may see, from time to time, that progress has been made, they could not perceive it while the progress was going on."

graduation See *division.*

graticule #A network of lines on a map representing geographic parallels and meridians.#

grating #Generally, any set of parallel lines placed in the path of a beam of light (or other electromagnetic radiation) to create a diffraction pattern.#

The principal kinds of gratings are: (a) opaque lines drawn or photographed onto a transparent surface such as glass or plastic; (b) parallel, closely spaced wires or threads (useful at radio or infrared wavelengths); and (c) ruled gratings consisting of parallel, sharp-edged grooves cut close together in a metallic, plastic or glass surface.

Although gratings and prisms can both be used to produce spectra, a grating can produce a much wider spectrum than a prism and is effective over an almost unlimited range of wavelengths. A disadvantage of the grating is it does not produce a single spectrum, as does the prism, but a series of spectra of decreasing intensity. This difficulty is partly overcome by shaping the grooves to direct light into one particular spectral region of the series.

grating, objective #A *grating* placed in front of the objective of a telescope to produce stellar spectra.#

Each star in the field of the telescope is shown as a short spectrum rather than as a point. (The grating must be coarse to keep each spectrum short and to prevent overlapping between neighboring stars). Objective prisms are also used to produce stellar spectra.

Gravatt rod See *leveling rod, Gravatt.*

gravimeter #An instrument for determining either the value of gravity at a point, or the difference in gravity between that point and another point.#

Also called a gravity meter.

Gravimeters come in two different basic forms: static and dynamic. In a static gravimeter, the force of gravity is balanced against a known and adjustable force, such as that of a spring. A common variety of static gravimeter consists of a nearly horizontal beam pivoted at one end and carrying a heavy mass at the other, with the beam kept in position by a helical or torsional spring. A change in gravity causes a change, by rotation, in the position of the beam and mass. The amount of this rotation is converted to a difference in gravity. In a dynamic gravimeter, the force of gravity is converted to linear or rotatory motion and the acceleration of gravity is inferred from the measured rate of motion. Until recently, the pendulum was the most common type of dynamical gravimeter; the rate of oscillation of a pendulum of fixed length was measured. Pendulums have now been replaced mainly by apparatus that measure the rate of fall of a freely falling body or the rate of vibration of a string under tension. See also *pendulum apparatus.*

gravimeter, absolute #A *gravimeter* that measures the actual value of gravity at a point.# Contrast with *gravimeter, relative.*

gravimeter, astatic #A *gravimeter* in which the sensing mass is placed in a position of nearly unstable equilibrium, so that a small change in gravity produces a very large change in the position of the mass.#

Common gravimeters of this kind are the Lacoste-Romberg, the Worden, and the North American. Also called astatized or unstable gravimeter.

gravimeter, drift of #A gradual change in the calibration constants of a gravimeter.#

gravimeter, free-fall #An instrument for determining the acceleration of gravity by measuring the time required for a mass to travel a known distance under the influence of gravity.#

Two types are in use. In one, a corner-cube reflector is dropped in an evacuated chamber and the time it takes the reflector to travel a known distance between marks is measured, usually with a laser interferometer. In the second type, a mass is thrown upward and the time it takes the reflector to travel both upward and downward is measured.

gravimeter, Haalck #A device which determines gravity from measurement of barometric pressure.#

Essentially, it is a *barometer* in which the end ordinarily open to the air is sealed off, but with a predetermined amount of air enclosed below the mercury. The height of the mercury column in the tube then depends on the weight of the mercury and the pressure of the contained air, which, in turn, is temperature dependent. An accuracy of 1 mgal can be obtained only when the height of the mercury and the temperature of the air are measured with extremely high accuracy.

gravimeter, pendulum-type See *pendulum apparatus.*

gravimeter, relative #A *gravimeter* that measures, at a point, the difference in the value of gravity between that point and another point.#

Contrast with *gravimeter, absolute.*

gravimeter, stable #A *gravimeter* with a single weight or spring arranged so that its sensitivity is proportional to the square of its period.#

gravimeter, tare of #A correction for a sudden change in the calibrated value of the readings of a gravimeter made during the course of a survey.#

gravimeter, trifilar #A weighted, horizontal disk suspended by a spiral spring attached at its center and by three threads attached at equal distances around its rim. The disk is in torsional equilibrium, i.e., the weight of the disk tends to pull the disk down and to turn it so the tension on the threads will be lower, but the torsion of the spring keeps the disk in place.#

Changing gravity turns the disk, which is brought back to its original position by turning the spring through a measured angle. The measurement of the angle is converted to a gravity reading.

gravimeter, unstable See *gravimeter, astatic.*

gravimeter, unstable-type #A *gravimeter* whose mechanism operates with a configuration close to that at which instability would occur.#

A very small change in gravity therefore produces a very large change in the configuration of the mechanism. See *gravimeter, astatic.*

gravimeter, vibrating-string #A wire in which vibration is maintained at a fixed rate in an electrostatic or magnetic field by passing a current of fixed, precise frequency through it. The rate of vibration, which is proportional to the force of gravity, is determined by the weight of the wire and by the frequency of the current.#

A change in gravity can be detected by the change in electrical frequency needed to keep the wire vibrating at a constant frequency. There are many variants of this principle, e.g., vibrating-string instruments have also been used to measure the density of the medium surrounding the wire, and for other purposes.

gravimeter, zero-length spring #A static gravimeter with a spring wound so the elongation of the spring under the weight of the attached mass is equal to the distance between the points of attachment of the spring.#

The spring effectively has a length of zero when it is not elongated.

gravimetric #Referring to data or information obtained by measurement of gravity.#

gravimetric deflection of the vertical See *deflection of the vertical, gravimetric.*

gravimetry (1) (geodesy) #The science, or technique, of measuring gravity.#

Although literally the term applies to measurements made with a *gravimeter,* it generally refers to any instrument measuring gravity, e.g., a pendulum.

(2) (general) #The measurement of weight or density.#

gravitation #One of the fundamental forces in the universe, observed as the attraction between two bodies, and, according to Newton's law of gravitation, proportional to the product of their masses and inversely proportional to the square of the distance between them.#

The above definition is adequate for geodetic application, although it has been superseded in modern physics by Einstein's theory of general relativity. The other fundamental forces are the strong nuclear, the weak nuclear, and the electrodynamic forces.

"Gravitation" and "gravity" are occasionally used as if they were synonymous. Such usage can be misleading. See *gravity.*

gravitation, constant of See *gravitational constant.*

gravitational constant #The proportionality factor, usually designated by G, appearing in the formula for the force $\vec{f}$ of gravitational attraction between two points having masses M_1 and M_2 and located at $\vec{r_1}$ and $\vec{r_2}$, respectively:

$$\vec{f} = G\, M_1 M_2\, (\vec{r_2} - \vec{r_1})/|\,\vec{r_2} - \vec{r_1}\,|^3.\#$$

The standard value of G, adopted in 1976 by the International Astronomical Union, is 6.672×10^{-11} m^{3}kg^{-1}s^{-2}.

The symbol k^2 is reserved for the gravitational constant when the masses are expressed in units of the mass M_S of the Sun, distance in terms of the astronomical unit (A.U.), and time in ephemeris days (E.D.) The quantity k, also called the Gaussian constant or Gaussian gravitational constant, has the defined value 0.017 202 098 950 000 000 $(\text{A.U.})^{3/2}\ (M_S)^{-1/2}\ (\text{E.D.})^{-1}$. This definition then specifies the astronomical unit, through Kepler's third law

$$k^2 M_S\ (1 + M_1/M_S) = (2\ \pi/T_o)^2\ a^3$$

where T_o is the period of an orbiting point of mass M_1 and a is the radius of the circular orbit of the point. Note that the astronomical unit used here is not the same as the average semimajor axis of the Earth's orbit; the difference is about 3×10^{-8} A.U. The discrepancy arose because Gauss, in calculating k, used a value for M_1 (the mass of the Earth) that was about 7 percent too small.

gravitational constant, Gaussian See *gravitational constant.*

gravitational radius See *radius, gravitational.*

gravity (1) #The force which is the resultant of *gravitation,* the force exerted by the mass of the Earth, and the *centrifugal force,* caused by the rotation of the Earth.#

(2) #The acceleration of the force defined in (1).#

The acceleration is a function of the body's location but is independent of the mass, shape, size, or other properties of the body. The term gravity is used for both the force and for the acceleration, and for both the vector and its magnitude. Thus the word may have any one of four different meanings. The terms "force of gravity" and "acceleration of gravity" can be used to avoid possible confusion. More often, the meaning must be determined from the context. The sense (2) is most common in geodetic application.

The term gravity also applies with the same meaning as above to environments other than that of the Earth.

At the Equator and close to the surface, the acceleration of gravity is approximately 978.03 cm/s^2; at the poles, it is approximately 983.22 cm/s^2. The quantity "1 cm/s^2" is called the *gal.*

gravity, absolute #The value of the acceleration of gravity found by direct measurement, as by use of a pendulum apparatus or a body in free fall.#

gravity, acceleration of See *gravity.*

"Gravity" is used by geophysicists to mean acceleration of gravity as well as force of gravity, and the term "acceleration of gravity" is, in fact, mainly used only to prevent misunderstanding.

gravity, anomaly of See gravity anomaly.

gravity, Bouguer (1) #A value of gravity at a point P, on the ground, obtained by adding to a hypothetical value of gravity on a reference surface (a) the *free-air gravity correction* δg_f and (b) the *Bouguer gravity correction (1)* δg_B.# Also called "simple Bouguer gravity" or "incomplete Bouguer gravity".

In this calculation, one assumes that there is no mass outside the reference surface. The first correction calculates the decrease in gravity in going from the reference surface to the point in question; the elevation H_P of the point is usually used in making the correction. The second correction assumes that the effect of matter actually outside the reference surface can be represented by the effect of a flat, infinite plate (the Bouguer plate) of thickness H_P lying between the point and the surface and of standard density (usually 2.67 g/cm^3).

(2) #The value of gravity, at a point Q on the geoid, obtained by subtracting from a measured value of gravity at point P, at elevation H_P above Q, the corrections as in (1).#

(3) #The value of gravity at a point P, at elevation H_P, obtained by adding to a hypothetical value of gravity on a reference surface containing the entire mass of the Earth: (a) the free-air gravity correction δg_f, to take account of the decrease in gravity with elevation above the reference surface; (b) the Bouguer gravity correction δg_B for the approximate attraction of matter between the reference surface and P; and (c) a topographic gravity correction δg_t that takes into account the departure of the terrain from the plate assumed in applying the Bouguer gravity correction.# Also called "complete Bouguer gravity", "expanded Bouguer gravity", or "Bouguer gravity with topographic correction".

The topographic gravity correction is usually calculated as if the terrain between the geoid and elevation H_P has its base on the lower surface of the Bouguer plate, i.e., as if the geoid were flattened and placed, with the matter above it, on the lower surface of the Bouguer plate. An additional correction, δg_c, is therefore sometimes added to account in part for the curvature of the geoid. Bouguer gravity calculated with this correction added is sometimes called "Bouguer gravity with topographic and curvature corrections".

(4) #The value of gravity obtained for a point Q on the geoid, at a distance H_P below a point P on the ground, by subtracting from the measured value at P the corrections δg_B, δg_f, and δg_t as in (3).#

(5) #Gravity calculated as in any one of the above definitions, but using a cylindrical Bouguer gravity correction δg_{Bc} for the attraction of a disk instead of the Bouguer gravity correction δg_B for the attraction of an infinite plate.#

(6) #Gravity calculated as in any of the definitions (1) through (4), but using a spherical Bouguer gravity correction δg_{Bs} for the attraction of a spherical shell instead of the Bouguer gravity correction δg_B for the attraction of an infinite plate.#

gravity, Cassinis' formula for See *gravity formula, Cassinis'*.

gravity, Clairaut's theorem on See *Clairaut's theorem (1)*.

gravity, correction to See *gravity correction*.

gravity, direction of #The direction, at a point, of *gravity*, considered as a vector.#

The downward direction is that indicated by an infinitesimal plumb line suspended at the point. See also *nadir* and *zenith*.

gravity, Eötvös correction to See *Eötvös correction*.

gravity, force of See *gravity*.

gravity, formula for See *gravity formula*.

gravity, Hayford template for See *template, Hayford*.

gravity, intensity of #The magnitude of *gravity*.#

Often designated simply as "gravity".

gravity, isostatic compensation of See *isostatic compensation*.

gravity, normal (1) #A value of the acceleration of gravity calculated from a *normal gravity formula*.#

Unless stated otherwise, normal gravity can be assumed to mean the acceleration calculated by the *International Gravity Formula, Gravity Formula 1967*, or *Gravity Formula 1980*.

(2) #The value of the acceleration of gravity calculated by use of a particular gravity formula, not necessarily a normal one. Also, the set of all such calculated values.#

(3) #The value of the acceleration of gravity on an ellipsoid which is at constant *geopotential*.#

Most gravity formulas, and almost all normal gravity formulas, give the acceleration on such a surface.

(4) #A value of gravity, between 978 gals and 982 gals, close to those values which gravity has on the Earth's surface.#

This value may be an average or even merely a rough approximation. This usage is most common in astronomy, but is also found in the theory of inertial navigation.

(5) #Gravity along the direction of the normal to a specified ellipsoid.#

gravity, Potsdam standard of #An assigned value for the acceleration of gravity at a specific position in the Geodetic Institute at Potsdam.#

The value, $g_t = 981.274 \pm 0.003$ gals, measured by Kuhnen and Furtwangler between 1898 and 1905 using reversible pendulums, was the average of acceleration on two piers in the northeast corner of the pendulum room of the Geodetic Institute in Potsdam. The value of the Potsdam standard was therefore defined to be 981.274 gals at the point midway between the two piers. The coordinates of this point are

$\lambda = +13°\ 04.'06$ E (approximately),
$\phi = +52°\ 22.'86$ N (approximately),
H = 86.24 m (exactly) above *Normaal Amsterdams Peil*

A large number of other measurements throughout the world with pendulum apparatus after 1906 showed that the value defined above was higher than the actual value by about 14 mgal. Therefore, in 1967, the International Association of Geodesy defined the Potsdam standard of gravity to be exactly 981.260 gals. This standard has, however, been replaced in a large part of the world by the values of the acceleration of gravity in the *International Gravity Standardization Net 1971* (IGSN 71).

gravity, Potsdam system of #The set of all values of gravity referred to the *Potsdam standard of gravity*.#

The accepted value of the acceleration of gravity at Potsdam until 1967 was 981.274 gal. The International Association of Geodesy in 1967 approved a correction of −14 mgal, changing the value to 981.260 gal.

Most measurements of gravity are made by spring-type gravimeters, which give relative values. Such values were referred to the Potsdam standard from about 1904 to about the time of the Second World War. In 1971 the International Association of Geodesy adopted a new system, called the *International Gravity Standardization Net 1971* (IGSN 71) which, in many countries, has replaced the Potsdam standard and system.

gravity, relative #The value of the force, or acceleration, of gravity, found by measuring weight (or acceleration) at one place with respect to weight (or acceleration) at another where the value is taken as standard.#

For example, values of acceleration determined with spring-type gravimeters are relative to the value of acceleration at Potsdam (see *gravity, Potsdam standard of*) or to the value obtained by averaging over a number of stations.

gravity, specific #The ratio of the density of a substance at a given temperature and the density of some other substance used as a standard.#

For liquids and solids, the usual standard is the density of distilled water at standard atmospheric pressure (760 mm of mercury) and temperature (4°C). Sometimes called "density" by oceanographers.

gravity, standard (1) See *normal gravity (1)*.

(2) #A value of gravity used as the referent when calculating values of some function of gravity.#

For example, the rate of precession of a gyroscope may be separated into its rate in a field of standard gravity and as the variation of this rate from standard gravity.

gravity acceleration #The acceleration caused by gravity alone.#

gravity adjustment #The process of calculating theoretical values of gravity at a number of points on the Earth's surface from measurements made at those or nearby points.#

The calculation is usually carried out so that the resulting values are the "best" (in a statistical sense) approximations to the measured values.

gravity anomaly (1) #The difference Δg between the value g of the acceleration of gravity observed at a point P, and the value of the acceleration of gravity γ calculated in the *normal gravity field* at a point Q, related to P as follows.

Consider the *spherop* U of the same value as the *geop* through P. Then Q is the point of intersection with U of the *normal plumb line* passing through P.

$$\Delta g = g_P - \gamma_Q .\#$$

The above is the rigorous definition (see Hirvonen 1960: pp. 37-38). In order to compute γ in the normal gravity field, the coordinates of Q must be known. In practice, it is assumed that Q is the point of intersection with U of the normal to the equipotential ellipsoid which passes through P, thus assigning the same geodetic latitude to both P and Q, so that γ can be calculated from a standard gravity formula. This leads to the following, more practical, definition:

(2) #The difference between the value of the acceleration of gravity observed at a point P, and the value of the acceleration of gravity calculated by a *standard gravity formula* for a point with the same *geodetic latitude* as P and with *normal height* based on the value of the geopotential at P.#

In the most common application, the observed value of gravity at P is first transformed by a *gravity reduction* to the geoid. Then the gravity anomaly can be defined as:

(3) #The difference between the value g in the actual field of the acceleration of gravity at a point P on the geoid and the value of the acceleration of gravity γ in the normal field at a point Q on the equipotential ellipsoid, Q lying on the ellipsoidal normal through P.#

In this case, a formula like *Gravity Formula 1980* can be used to compute γ.

Gravity anomalies in sense (3) are given specific names based on the method of *gravity reduction* used, e.g. *free-air gravity anomaly*, *Bouguer gravity anomaly*, etc.

The term "gravity anomaly" has been defined in many other ways. For example, the definition given in Mitchell (1948) is equivalent to what is now usually termed the *gravity disturbance*.

gravity anomaly, Airy-Heiskanen #An *isostatic gravity anomaly* Δg_{AH} calculated according to *Airy's hypothesis*.#

Equivalently, a *topographic gravity anomaly* from which is subtracted the *Airy-Heiskanen gravity correction* (q.v.). Also known as the Airy-Heiskanen isostatic gravity anomaly.

gravity anomaly, Bouguer (1) #The result Δg_B of subtracting from observed gravity g_P at a point P: (a) the *free-air gravity correction* δg_f, which gives the decrease in the acceleration of gravity in moving from the terrestrial ellipsoid to P (ignoring the effect of mass outside the terrestrial ellipsoid on this change); (b) the *Bouguer gravity correction* δg_B, which approximates the effect of matter outside the terrestrial ellipsoid by substituting for that matter a flat plate of thickness equal to the elevation of the point of measurement, of infinite extent horizontally, and with its upper surface horizontal through the point of observation, and (c) normal gravity on the equipotential ellipsoid γ computed for the same geodetic latitude as P.

$$\Delta g_B = g_P - \delta g_f - \delta g_B - \gamma .\#$$

The Bouguer gravity anomaly is also called the "simple Bouguer gravity anomaly". It is a first approximation to the difference between the acceleration of gravity measured at a point and the acceleration predicted at the point.

(2) #The *spherical Bouguer gravity anomaly*, Δg_{Bs}.#

This differs from the Bouguer gravity anomaly (1) in that it introduces the *spherical Bouguer gravity correction* δg_{Bs} instead of the *Bouguer gravity correction* δg_B.

(3) #The *cylindrical Bouguer gravity anomaly* Δg_{Bc}.# See *gravity correction, cylindrical Bouguer*.

(4) #The *refined Bouguer gravity anomaly*.#

(5) #The quantity obtained by subtracting from a Bouguer gravity anomaly a topographic gravity correction and adding *Bullard's term* to it.#

The effect of adding Bullard's term is to substitute for the Bouguer plate a spherical cap of the same thickness and extending out to *Hayford's zone* O_2.

gravity anomaly, combined #*Glennie's gravity anomaly*.# Introduced by E. N. Lyustikh in 1947.

gravity anomaly, condensation #A quantity Δg_c obtained by subtracting from a gravity anomaly Δg the following gravity corrections: (a) the *condensation gravity correction* δg_c; (b) the *free-air gravity correction* δg_f; and (c) either a *Bouguer gravity correction* δg_B, a *modified Bouguer gravity correction* δg_{Bm} or a *refined Bouguer gravity correction* δg_{Br}.#

Applying the first correction δg_c amounts, physically, to removing from the terrestrial ellipsoid a mass equal to that replaced later between the ellipsoid and an equipotential surface through the gravity station. The mass is assumed to be present as a thin layer at a selected distance (possibly zero) beneath the surface of the ellipsoid. Applying the second correction, δg_f, moves the point of prediction from the ellipsoid up to the gravity station. Applying the third correction, δg_{Bm} or δg_B, fills the space between ellipsoid and equipotential surface with a mass equal to that removed from the ellipsoid by the first correction.

If the distance (called the "depth of condensation") of the layer of "condensed" matter below the ellipsoid's surface is zero, i.e., if the condensed matter is layered onto the ellipsoid, the condensation gravity anomaly is referred to as *Faye's gravity anomaly*.

In practice, the terrestrial ellipsoid is assumed to coincide with the geoid at all points, so that the elevation of the gravity station can be used as the distance above the ellipsoid.

gravity anomaly, cylindrical Bouguer #The same as *gravity anomaly, Bouguer (1)*, except that the *cylindrical Bouguer gravity correction* δg_{Bc} is used instead of the *Bouguer gravity correction* δg_B.#

gravity anomaly, expanded Bouguer #The result of subtracting from a *Bouguer gravity anomaly* with *topographic gravity correction* a further gravity correction for the curvature of the Earth.#

This is practically equivalent to using a *spherical Bouguer gravity anomaly* with topographic gravity correction.

gravity anomaly, external #A gravity anomaly for which the point of observation is outside the Earth's surface.#

gravity anomaly, Faye's (1) #The result Δg_F obtained by subtracting from observed gravity g_P at a point P the following gravity corrections:

(a) the *free-air gravity correction* δg_f,

(b) the *cylindrical Bouguer gravity correction* δg_{Bc},

(c) the *condensation gravity correction* δg_c for zero depth of the condensation layer, and

(d) normal gravity on the equipotential ellipsoid, γ, computed for the same geodetic latitude as P.

$$\Delta g_F = g_P - \delta g_f - \delta g_{Bc} - \delta g_c - \delta.\#$$

Use of Faye's gravity anomaly implies that there is a layer of matter on the terrestrial ellipsoid whose effect is the same as that of the matter missing from outside the ellipsoid. Subtracting the condensation gravity correction releases, in effect, an equivalent amount of matter which can then be stuffed into the space between P and the ellipsoid.

Denoting by H the elevation of P, by a the radius of the cylinder, by ρ the density of the cylinder, by G the gravitational constant, and by R a suitable radius of the Earth near P, a common formula for Faye's gravity anomaly is

$$\Delta g_F = g_P - \gamma - 2kH/R - (2\pi G\rho H^2/2a).$$

In this formula γ is the value calculated from a standard gravity formula, and k is a constant defined by $k = 1 + f + m - 2f\sin^2\phi$; where f is the flattening of the ellipsoid used for the standard gravity formula, m is the ratio of centrifugal force to gravity at the Equator, and ϕ is the latitude of P. The height h of P above the terrestrial ellipsoid should, properly, be used instead of H, but h is usually unknown. If the term $(2\pi G\rho H^2/2a)$ representing the difference between the attraction of a cylinder and the attraction of an equivalent layer is dropped, Faye's gravity anomaly becomes identical to a free-air gravity anomaly.

(2) #The *free-air gravity anomaly*.#

Since a free-air gravity anomaly is only a special case of Faye's gravity anomaly (1) the two definitions are not consistent. The first definition is preferred.

gravity anomaly, free-air #The quantity Δg_f obtained by subtracting from observed gravity g_P at a point P the *free-air gravity correction* δg_f and normal gravity on the equipotential ellipsoid γ computed for the same geodetic latitude as P.

$$\Delta g_f = g_P - \delta g_f - \gamma.\#$$

The free-air gravity correction is the total change in gravity that occurs in moving (without taking intervening masses into account) from the geoid or ellipsoid to P.

gravity anomaly, Glennie's #The quantity Δg_G obtained by subtracting from a *Bouguer gravity anomaly* Δg_B, *Bullard's term* B a topographic gravity correction $\delta g_t'$ for Hayford zones 18 to 1, and an isostatic gravity correction $\delta g_{is}'$ for the same zones:

$$\Delta g_G = \Delta g_B - B - \delta g_t' - \delta g_{is}'\ .\#$$

Bullard's term converts the Bouguer gravity anomaly to a *modified Bouguer gravity anomaly*, substituting a spherical cap for the Bouguer plate. This takes care of *Hayford zones* A through O. The last two corrections then account for the other zones.

gravity anomaly, Hayford See *Pratt-Hayford gravity anomaly.*

gravity anomaly, Hayford-Pratt See *gravity anomaly, Pratt-Hayford.*

gravity anomaly, isostatic #The value obtained by adding the *isostatic gravity reduction* to a *gravity anomaly.* #

Types of isostatic gravity anomaly are identified by the authors' basic assumptions and designated by their names, such as the Vening Meinesz, the Airy-Heiskanen, and the Pratt-Hayford gravity anomalies.

gravity anomaly, mean #The average value of gravity anomalies over a given subdivision of the surface of the Earth (or other planet).#

The mean gravity anomaly is theoretically computed by integration over the surface, but in practice by a summation over the points in the subdivision for which gravity is known. Mean gravity anomalies are also often obtained by interpolation or extrapolation in the absence of known values.

gravity anomaly, mixed *#Gravity anomaly.* #

The terms "mixed gravity anomaly" and "proper gravity anomaly" are sometimes used in place of "gravity anomaly" and "gravity disturbance", respectively.

gravity anomaly, modified #Any *gravity anomaly* which involves a *gravity correction*.#

gravity anomaly, modified Bouguer #The difference Δg_{Bm} between a measured value g of gravity at a point P and a value obtained by adding to the value γ calculated from a standard gravity formula a *modified Bouguer gravity correction* δg_{Bm}, approximating the value caused by the attraction of matter between the terrestrial ellipsoid and an equipotential surface through P, by the acceleration produced by attraction of some simple body other than a plate (such as a cylinder, a sphere, or a spherical cap).#

See *gravity anomaly, cylindrical Bouguer*; *gravity anomaly, spherical Bouguer*; and *Bullard's term.*

gravity anomaly, Pratt-Hayford #An *isostatic gravity anomaly* Δg_{PH} obtained by applying the *Pratt-Hayford gravity correction* δg_{PH} as the *isostatic gravity correction.* #

Also called the "Hayford gravity anomaly," the "Hayford anomaly," and the "Pratt-Hayford isostatic gravity anomaly".

gravity anomaly, Prey's #The quantity Δg_P that results after subtracting *Prey's gravity reduction* from a *gravity anomaly*.#

gravity anomaly, proper *#Gravity disturbance.* # See *gravity anomaly, mixed.*

gravity anomaly, refined Bouguer #The result Δg_{Br} of subtracting from a *Bouguer gravity anomaly* Δg_B the *topographic gravity correction* δg_t:

$$\Delta g_{Br} = \Delta g_B - \delta g_t,$$

or

$$\Delta g_{Br} = g - (\gamma + \delta g_f + \delta g_B + \delta g_t).$$

Here, g is the value of gravity measured at a point P, γ is the value of gravity calculated for a point on the terrestrial ellipsoid with the same latitude as P using a standard gravity formula, δg_f is the *free-air gravity correction*, and δg_B is the *Bouguer gravity correction*.#

gravity anomaly, root-mean-square #The root mean square (r.m.s.) of *gravity anomalies* over the whole Earth.#

gravity anomaly, Rudzki #The quantity Δg_R obtained by subtracting from a *gravity anomaly* Δg the *Rudzki gravity reduction* δ_R.#

Subtracting the Rudzki gravity correction is equivalent to moving masses from inside the terrestrial ellipsoid to outside the ellipsoid in such a way that the potential on the ellipsoid does not change. Because an element of mass inside the ellipsoid has a slightly greater effect on the potential than an element of mass at the corresponding point outside, it is not possible to fill the space between the ellipsoid and an equipotential surface through the gravity station with matter from inside without changing the potential. An additional gravity correction is sometimes subtracted to take this into account.

gravity anomaly, simple Bouguer #The *Bouguer gravity anomaly (1)*.#

gravity anomaly, spherical Bouguer #The result Δg_{Bs} of subtracting from a *gravity anomaly* Δg: (a) the *free-air gravity correction*, δg_f, moving the point for which the acceleration of gravity is predicted from a point on the terrestrial ellipsoid to the corresponding point of measurement, but ignoring the effects of intervening masses outside the ellipsoid, and (b) the *spherical Bouguer gravity correction* δg_{Bs}, which represents the effects of masses outside the terrestrial ellipsoid by the effect of a spherical shell horizontal at the point of measurement, of thickness equal to the elevation of that point, and of outer radius equal to the radius of curvature at that point (or some other suitably close radius).

$$\Delta g_{Bs} = \Delta g - (\delta g_f + \delta g_{Bs}).\#$$

Alternatively, it can be defined as a *Bouguer gravity anomaly* in which the *Bouguer gravity correction* has been replaced by the *spherical Bouguer gravity correction*, i.e., the flat plate used in the Bouguer gravity anomaly to represent the masses outside the terrestrial ellipsoid has been replaced by a spherical shell. See also *gravity anomaly, refined Bouguer.*

gravity anomaly, surface #A *gravity anomaly (1)* for which the point of observation is on the Earth's surface.#

gravity anomaly, topographic (1) #The difference between gravity measured at a point P and the corresponding value calculated from a standard gravity formula, corrected for the effect of matter between the terrestrial ellipsoid and an equipotential surface through P.#

(2) #A *Bouguer gravity anomaly* from which is subtracted the *topographic gravity correction.* #

gravity apparatus, Brown See *pendulum apparatus, Brown.*

gravity base See *base, gravity.*

gravity correction (1) #A quantity, usually denoted by δg with a subscript (e.g., δg_f, δg_{Bs}), which is added to a theoretical value of gravity to obtain a better approximation to the measured value and which is a function of a single variable such as elevation or mass.#

Gravity corrections may be subtracted from the measured value, instead of being added to the theoretical value, of acceleration.

Most data on the acceleration of gravity are stored as and used as *gravity anomalies*—the difference between acceleration as measured and acceleration calculated from a standard gravity formula. Gravity corrections are therefore subtracted from gravity anomalies, resulting in *modified gravity anomalies*. The sum of a number of gravity corrections is termed a *gravity reduction*. The most important gravity corrections are the *free-air*, the *Bouguer*, the *topographic*, and the *isostatic gravity corrections*.

(2) #The negative of the quantity defined in (1) above.#

gravity correction, Airy-Heiskanen #An *isostatic gravity correction* δg_{AH} giving the amount by which the value of gravity calculated on the basis of a standard density value of the Earth's crust must be changed because the base of the crust extends below its average depth into the denser mantle in some regions (such as under mountainous regions) or lies considerably above it and is replaced by mantle in other regions (such as under oceans).#

The isostatic theory of Airy and Heiskanen (see *isostasy*) has the following approximations for use in computations:

density of crust: 2,670 kg/m^3;
density of oceans: 1,030 kg/m^3;
density of mantle: 3, 270 kg/m^3.

The gravity correction is the difference between the attraction of matter extending from the bottom of the crust down to the depth of compensation and of the same density as the crust, and the attraction of matter actually in the same region and of density 3,270 kg/m^3. It is usually calculated by taking the sum of the effects from cylindrical shells, or sectors patterned according to the *Hayford zones*, and extending from the average depth of the base of the crust to the actual position of the base.

gravity correction, Bouguer (1) #The quantity δg_B (which is equal to $2\ \pi\ \rho\ G\ H$ or approximately $0.0418\ \rho\ H \times 10^{-3}$ m/s^2) which is added to the acceleration of gravity calculated from a standard gravity formula, or subtracted from a gravity anomaly.# It approximates the matter between the geoid and an equipotential surface through the point of measurement by a horizontal plate (Bouguer plate) of infinite horizontal extent and of thickness H (the elevation of the point above the geoid). The density ρ of the plate is constant and usually taken to be 2,670 kg/m^3. G is the gravitational constant.

This is the gravity correction invented and used by Bouguer for analyzing the results of the 1735 to 1745 expedition to Peru.

(2) #The same as the previous definition, but using h, the distance of the point of measurement above the terrestrial ellipsoid, instead of H, the elevation.#

This definition implies that either the distribution of mass outside the ellipsoid is known or that the terrestrial ellipsoid and the geoid coincide.

(3) #A gravity correction similar to the Bouguer gravity correction as defined previously but using, instead of a plate, some other figure such as a sphere (spherical Bouguer gravity correction), a cylinder (cylindrical Bouguer gravity correction) or a spherical cap.#

This is called the modified Bouguer gravity correction.

(4) #The sum of the free-air, Bouguer, and topographic gravity corrections.#

This is called the refined Bouguer gravity correction.

gravity correction, Bowie #The quantity $2H\ \gamma'/R$, denoted by $\delta_2 g$, where γ' is the calculated value of gravity at point P on a surface, H is the elevation of that surface at P (i.e., the distance of the surface from the geoid), and R is a suitable radius for the Earth. The surface is either (a) the equipotential surface that results from removing matter outside the geoid, calculating the new position of the "geoid", removing matter outside the new position, and repeating the process until two successive "geoidal" surfaces show no change; or (b) the terrestrial ellipsoid.#

The Bowie gravity correction, also called the "Bowie effect" or the "indirect effect", may be calculated with an *isostatic gravity correction* added to the standard value of the gravity (calculated from a standard gravity formula) as well as with a gravity correction obtained by adding matter to the oceanic basins to bring them up to the density assumed for land.

gravity correction, Browne's #The *gravity correction* δg_{Browne} given by $-g\ (\theta^2/2)$ and applied to a value of gravity acceleration measured with a gravimeter carried on a moving vehicle.#

The measured value g is in error because the vehicle's horizontal acceleration causes the sensitive axis of the gravimeter to make, on the average, an angle θ with the vertical.

gravity correction, combined #The sum of the *Bouguer gravity correction* and the *topographic gravity correction*.#

gravity correction, complete topographic #The *gravity correction* δg_{tc} added to the theoretical value of gravity to account for the presence of matter outside the level surface used as reference (and to which the theoretical value belongs), and affecting the point of observation.#

It may be calculated as the sum of the *Bouguer gravity correction* δg_B and the *topographic gravity correction* δg_t, or may be calculated directly from the topography. In the first case, it is also called the *combined gravity correction*.

gravity correction, condensation (1) #The change δg_c in the calculated value of gravity on the surface of the terrestrial ellipsoid when matter in the form of a thin disk, of radius r, at depth D in the ellipsoid, is removed.#

The matter in the disk is used, after applying a *free-air gravity correction*, to fill a (Bouguer) cylinder external to the surface. The mass M in the cylinder is given by

$$M = \rho\pi r_c^2 h$$

where h is the height of the cylinder, r_c its radius and ρ its density. The change δg_c is

$$\delta g_c = 2GM[\{(h + D)/((h + D)^2 + r_c^2)^2\} - 1]/r_c^2$$

in which G is the gravitational constant.

(2) #The same as the previous definition, but with elevation H being used instead of height h, and the geoid is the surface of reference rather than the terrestrial ellipsoid.#

(3) #The same as either of the preceding definitions, but with the condensed mass lying in a thin layer on a surface parallel to the surface of reference and equal to the topographic masses outside that surface.#

gravity correction, cylindrical Bouguer #The quantity

$$\delta g_{Bc} = 2\pi\rho Gh^2/2a,$$

representing the attraction of a solid cylinder of density ρ, radius a, and height h on a unit mass located at the intersection of the cylinder's axis with the top surface. G is the gravitational constant.#

The cylindrical Bouguer gravity correction is used in calculating *Faye's gravity anomaly*.

This differs from the *Bouguer gravity correction* (1) in that the effect of matter between the terrestrial ellipsoid and an equipotential surface through the gravity station P is approximated by a vertical cylinder whose axis passes through P. The height of the cylinder is the same as the thicknesss of the Bouguer plate. The Bouguer gravity anomaly is the limiting case of the cylindrical Bouguer gravity anomaly as the radius of the cylinder becomes very large.

gravity correction, Eötvös See *Eötvös correction*.

gravity correction, Faye's #The sum of the *free-air gravity correction*, the *cylindrical Bouguer gravity correction*, and the *condensation gravity correction*.# See *gravity anomaly, Faye's*.

gravity correction, free-air (1) #The *gravity correction*

$$\delta g_f = \sum_{n=1}^{\infty} \frac{h^n}{n!}\frac{\partial^n \gamma}{\partial h^n}$$

giving the change in gravity going from a point Q on the terrestrial ellipsoid to the point P on the normal through Q. h is the distance QP and γ is the value of gravity calculated for Q.#

The first two terms are, explicitly, $-2\gamma h/(R + h)$ and $+3\gamma h^2/(R + h)^2$. If P is at an elevation of less than 2 km, terms of degree two and higher are usually not needed. In such a case, δg_f is approximately $-2\gamma h/R$ or $-0.3086\ h$ mgal. It is sometimes, but erroneously, referred to as "Faye's gravity correction".

(2) #The same as (1) above, but with g, the actual value of gravity at P, used instead of γ, and H, the elevation of P, used instead of h.#

This definition is used when, instead of comparing observed values of gravity with theoretical values of gravity, one compares two theoretical values. With the second definition, a theoretical value of gravity at Q on the terrestrial ellipsoid (actually, on the geoid) is calculated from the observed value at P and compared with a theoretical value for Q calculated from a standard gravity formula.

gravity correction, Hayford template for See *template*.

gravity correction, Helmert condensation #A quantity δg_{H_c} which is added to the value of gravity calculated from a gravity formula (or subtracted from a gravity anomaly) to take into account the attraction of topographic masses "condensed" into a thin layer on or below the terrestrial ellipsoid or on or below the geoid.#

Masses outside the ellipsoid are condensed into a layer on or within the ellipsoid to prevent, as far as possible, the drastic changes in gravity and the geoid that are caused by simply removing matter from between the ellipsoid and the *geop* through the gravity station.

gravity correction, Helmert template for See *template*.

gravity correction, Honkasalo's #The quantity

$$-5(1 - 3\sin^2\phi)\ \mu\text{gal}$$

added to a theoretical value of gravity or subtracted from a measured value to correct for the existence of a permanent Earth tide which produces an increase of gravity with latitude ϕ.#

gravity correction, isostatic #A *gravity correction* δg_i added to the value of gravity calculated from a standard gravity formula to correct for the limited ability of that formula to predict gravity on the terrestrial ellipsoid.#

The isostatic gravity correction is an ad hoc correction invented to make predicted values of acceleration agree better with measured values. There are many different kinds of isostatic gravity corrections; each kind is characteristic of a particular theory on how density varies within the crust and upper mantle. All the theories postulate that the crust and part of the upper mantle "float" on a underlying material of greater density. They differ in their assumptions regarding the depths to which the floating materials extend, the density of that floating material under the geoid, and in other particulars. Seismological regimes of the lithosphere are only casually related to the the regimes involved in explaining the isostatic gravity corrections. See also *isostatic compensation*; *isostasy*; *gravity reduction, isostatic*; *gravity correction, Pratt-Hayford*; *gravity correction, Airy-Heiskanen*; and *gravity anomaly, isostatic*.

gravity correction, modified Bouguer See *gravity correction, Bouguer (3)*.

gravity correction, Pratt-Hayford #An *isostatic gravity correction* δg_{PH} which is added to the value of gravity given by a standard gravity formula (or subtracted from a gravity anomaly or measured gravity) to correct the theoretical value according to the isostatic theory of Pratt and Hayford. (See *isostasy, Pratt's hypothesis of*).#

The theory assumes that the crust extends everywhere to the same depth, but that the density of matter between the geoid and that depth is a function of the elevation of the land, according to the formula

$$\Delta\rho = H\rho/T$$

in which ρ is the density of matter outside the terrestrial ellipsoid, H the elevation, T the distance to the bottom of the crust, and $\Delta\rho$ is the difference between the density of crust under the ellipsoid and the density of crust above the ellipsoid.

The value of the Pratt-Hayford gravity correction is found from the formula

$$\delta g_{PH} = (2\pi G\rho h/D)\,[(r_1 + D^2)^{1/2} - (r_2 + D^2)^{1/2} - r_1 + r_2)]$$

where G is the gravitational constant, ρ the density of the matter in the quadrangular prism, D the assumed depth of compensation, and r_1 and r_2 the inner and outer radii, respectively, of the zone in which the quadrangle lies. h is the distance of the point (for which the reduction is calculated) above the base of the prism. For prisms lying between 29 km and 167 km, approximately, Hayford prepared a table giving the small corrections needed to allow the formula to be used.

gravity correction, refined Bouguer See *gravity correction, Bouguer (4)*.

gravity correction, Rudzki #The change in the acceleration of gravity at a point P caused by converting mass outside the geoid to equivalent mass inside the geoid according to the following method. If we denote the element of mass and its coordinates before inversion by dm_1, r_1, θ_1 and ψ_1, the gravitational constant by G and the radius of the sphere by R, then the contribution of dm_1 to the acceleration at P (which is at $h + R$, 0, 0) is

$$dg_1 = G(R + h - r_1 \cos\theta_1)dm_1/ [(R + h) + r_1^2 - 2(R + h)r_1 \cos\theta_1]^{3/2}.$$

The contribution dg_2 of element dm_2 of mass at (r_2, θ_2, ψ_2) is obtained from this equation by substituting r_2 for r_1, θ_2 for θ_1, ψ_2 for ψ_1. The Rudzki correction δg_R is

$$\delta g_R = \int\int\int (dg_2 - dg_1)$$

where the integration is over the entire mass M outside the geoid.#

gravity correction, spherical Bouguer #The *gravity correction* given by

$$\delta g_{Bs} = (4\pi\rho G/3)[(R + h) - R^3/(R + h)^2]$$

which is the acceleration caused by attraction of a spherical shell of density ρ, inner radius R and thickness h. G is the gravitational constant. The radius R is usually the average radius of the Earth, although it is more properly chosen so that the outer surface passes through the point of measurement, P, which is at an elevation equal to the thickness, h.#

The spherical Bouguer gravity correction approximates the matter outside the terrestrial ellipsoid by a spherical shell that has an outer radius of curvature equal to the radius of curvature of the Earth at the point of observation and lying in the direction of the vertical there. This results in a closer estimation of the value of the acceleration of gravity at the point of observation and in a smaller difference between observed and predicted values.

gravity correction, terrain #The *topographic gravity correction.* #

gravity correction, tidal #A quantity applied to a theoretical value of gravity or subtracted from a measured value to account for the gravitational attraction of the Moon and the Sun.#

The effect of the permanent Earth tide is accounted for by *Honkasalo's gravity correction*.

gravity correction, topographic (1) #The difference δg_t at a point P between the acceleration caused at P by attraction of matter outside the terrestrial ellipsoid, and that caused by the attraction of a Bouguer plate at P.#

(2) #The difference δg_t at a point P between the attraction of matter between the terrestrial ellipsoid and a geop through P, and the attraction of a Bouguer plate at P.#

(3) More generally, #the difference δg_t at a point P between the attraction of matter between the terrestrial ellipsoid and a geop through P, and the attraction of some simple body such as a Bouguer plate, or a sphere.#

Also called a "terrain gravity correction" or "Geländereduktion", "terrain correction", "topographic correction", etc. Usually, the terrestrial ellipsoid and the geoid are assumed to coincide, so that elevations can be used instead of geodetic heights.

gravity disturbance (1) #The difference between the actual or measured value of gravity at a point on the Earth and the value predicted by a standard gravity formula for the same point.#

(2) #The difference between the actual (measured) value of the gravity vector at a point and the value predicted by theory.#

gravity field (1) #*Gravity* considered as a whole rather than as a force or acceleration at a particular point.#

For example, the Earth's gravity field.

(2) #*Gravity* considered as a function of location.#

For example, as a function of generalized spatial coordinates.

Note that, in general, the gravity field exists only at points that rotate with the Earth. The gravitational field exists at all points, whether they rotate with the Earth or not.

gravity field, normal (1) #A *gravity field* generated by a mathematically explicable mass configuration.#

In geodesy, this mass configuration is usually defined as follows:

(2) #A gravity field generated by a body of given mass and rotational rate whose surface is an equipotential ellipsoid of specified dimensions.# This field is the basis for the *International Gravity Formula*, *Gravity Formula 1967*, and *Gravity Formula 1980*.

gravity field, standard #Equivalent to *gravity field, normal*.#

gravity formula #Any formula giving the value of gravity at a point as a function of the coordinates of that point.#

Most gravity formulas give gravity as a product of (a) the value of gravity at sea level at some location, and (b) a power series in the sine of the latitude or a Fourier series having latitude as argument; usually, no more than two or three terms are present. Other gravity formulas also include terms for variation of gravity with longitude, elevation, or both.

Such formulas are approximations to the formula for gravity on or above the *terrestrial ellipsoid*, which is at a fixed potential, or (like *Helmert's 1901 gravity formula*) approximate the values of gravity on a surface based on slightly different assumptions. See also *gravity formula, normal*.

gravity formula, Cassinis' #The *International Gravity Formula*.#

gravity formula, Helmert's 1901 #A development by Helmert (1901) of a gravity formula using the gravity observations available at the time but not using any preassigned value of the Earth's ellipticity. Referred to the *Potsdam standard of gravity*, Helmert's gravity formula of 1901 is:

$$\gamma_0 = 978.030\ (1 + 0.005\ 302 \sin^2 \phi$$
$$- 0.000\ 007 \sin^2 2\ \phi).$$

where γ_0 is the acceleration of gravity and ϕ is the geodetic latitude.#

gravity formula, Helmert's 1915 #A development by Helmert of a *gravity formula*, based on a triaxial ellipsoid, and including a term containing the longitude.#

See *gravity formula, longitude term in*.

Gravity Formula, International #The formula

$$\gamma = 978.049\ (1 + 0.005\ 2884 \sin^2 \phi$$
$$- 0.000\ 0059 \sin^2 2\ \phi)$$

where γ is the acceleration of gravity and ϕ is the geodetic latitude.#

This is a development of a gravity formula based on the representation of the Earth by an *equipotential ellipsoid* having the dimensions of the *International Ellipsoid* rotating about its minor axis once in a sidereal day, and with an acceleration of gravity at the Equator of 978.049 gals. The International Gravity Formula was adopted by the International Association of Geodesy at its meeting in Stockholm in 1930.

gravity formula, longitude term in #A term in a formula for values of gravity explicitly containing the geodetic longitude λ as well as the geodetic latitude ϕ as arguments and implying that the geoid is represented by an ellipsoid having three unequal axes.#

With this additional term, the gravity formula could be as follows:

$$\gamma_0 = \gamma_e[(1 + \beta_1 \sin^2\phi + \beta_2 \sin^2 2\phi$$
$$+ \beta_3 \cos^2\phi \cos 2(\lambda - \lambda_0)]$$

where γ_e is the average value of the acceleration of gravity at the Equator, and β_3, like β_1 and β_2, is a dimensionless number. The two equatorial semi-axes differ in length by $2a\ \beta_3$, where a is the length of the longer equatorial semi-axis. Longitude terms in gravity formulas are now of historical interest only.

gravity formula, normal #A formula giving the value in a *normal gravity field* of gravity at a point as a function of geodetic latitude (and possibly also of geodetic longitude and height).#

Four gravity formulas—the *Helmert (1901) gravity formula*, the *International Gravity Formula*, *Gravity Formula 1967*, and *Gravity Formula 1980*—have been most recognized by geodesists. Normal formulas usually have one of the three forms

$$\gamma = \gamma_0\ (1 + \beta_1 \sin^2 \phi + \beta_2 \sin^4 \phi),$$

$$\gamma = \gamma_0\ (1 + \beta_1 \sin^2 \phi + \beta_2 \sin^2 2\ \phi), \text{ or}$$

$$\gamma = \gamma_0\ (1 + b_1 \sin^2 \phi)\ (1 - b_2 \sin^2 \phi)^{-1/2}$$

where the third formula is an exact representation of gravity on an equipotential ellipsoid, and the first two are series approximations. The quantities γ_0, β_1, β_2, b_1, and b_2 are parameters of the normal field and ϕ is the geodetic latitude.

gravity formula, standard Equivalent to #*gravity formula, normal*.#

gravity formula, theoretical Equivalent to #*gravity formula, normal*.#

Gravity Formula 1967 #One of the three equations

$$\gamma = \gamma_e (1 + 0.005\,278\,895 \sin^2 \phi + 0.000\,023\,462 \sin^4 \phi),$$

$$\gamma = \gamma_e (1 + 0.005\,3024 \sin^2 \phi - 0.000\,0059 \sin^2 2\,\phi),$$

and

$$\gamma = \gamma_e (1 + 0.001\,931\,663\,383\,21 \sin^2 \phi)(1 - e^2 \sin^2 \phi)^{-1/2}$$

calculated from the geodetic constants of *Geodetic Reference System 1967*. The constants γ_e and e^2 in these formulas have the values 978. 031 845 58 gal and 0.006 694 605 328 56, respectively.#

Gravity Formula 1980 #One of the three formulas

$$\gamma = \gamma_e (1 + 0.001\,931\,851\,353 \sin^2 \phi)(1 - e^2 \sin^2 \phi)^{-1/2},$$

$$\gamma = \gamma_e (1 + 0.005\,279\,0414 \sin^2 \phi + 0.000\,023\,2718 \sin^4 \phi + 0.000\,001\,262 \sin^6 \phi + 0.000\,000\,0007 \sin^8 \phi), \text{ and}$$

$$\gamma = \gamma_e (1 + 0.005\,3024 \sin^2 \phi - 0.000\,0058 \sin^2 2\phi)$$

where $\gamma_e = 978.326\,771\,5$ gal,

$e^2 = 0.006\,694\,380\,022\,90$, and ϕ is the geodetic latitude.#

The first formula is exact (to the number of significant digits in the constants). The second has an error of 10^{-4} mgal. The third has an error of 10^{-1} mgal.

These formulas are derived from the constants of *Geodetic Reference System 1980* recommended by the International Association of Geodesy and Geophysics in 1979 as replacements for the constants of *Geodetic Reference System 1967*. Values γ_{1980} given by this formula are related to values γ_{1967} given by *Gravity Formula 1967* by the approximation

$$\gamma_{1980} - \gamma_{1967} = (0.8316 + 0.0782 \sin^2\phi - 0.0007 \sin^4 \phi) \times 10^{-3} \text{ gal}.$$

gravity gradient #The rate of change of gravity with respect to position.#

It is expressed as a set of 9 second derivatives of the *potential* with respect to the 3 coordinates of position.

gravity gradiometer #An instrument for measuring the gradient of gravity, i.e., the rate of change of gravity with change of location.#

The *torsion balance* has been the best known type. It relies on the static balancing of gradient by torsion on a wire. However, instruments depending on dynamical principles and involving rapidly revolving masses have been devised, which have the advantages over the torsion balance of being sturdier, requiring less time for measurement, and being able to measure the gravitational gradient when carried in airplanes or artificial satellites.

gravity meter #A *gravimeter*.#

gravity network #A *network* in which the points represent gravity stations and the lines represent the sequence in which the gravity stations were occupied, or connect gravity stations between which comparisons were made.#

gravity potential (1) #The *potential* created at a point rotating with the Earth by the combined action of gravitational and centrifugal forces.# The term is also applied to the potential created on any other planet by the combined action of that planet's gravitational and centrifugal forces, although its definition is primarily related only to the Earth.

(2) #The gravity potential, as defined above, per unit mass.#

(3) #The quantity whose gradient is the negative of the gravity vector.#

gravity reduction (1) #A quantity which is added to a computed value of gravity on the geoid or other surface of reference to obtain a computed value for gravity at a point where gravity was measured.#

(2) #A quantity which is subtracted from a measured value of gravity to obtain a corresponding value on the geoid or other surface of reference for comparison with a value obtained from a gravity formula.#

In either definition the gravity reduction is usually the sum of several quantities, called *gravity corrections*, each of which accounts for a single change in gravity with change in a single variable such as elevation, mass, etc. However, in some instances, like the free-air gravity reduction, the gravity reduction may consist of only one gravity correction. In the case of a Bouguer gravity reduction, the gravity reduction consists of two gravity corrections.

(3) #The process of applying the quantity defined in (1) or (2) to the theoretical (or measured) value.#

gravity reduction, Airy-Heiskanen #A gravity reduction δ_{AH} which is the sum of the *free-air gravity correction* δg_f, the *complete topographic gravity correction* δg_{tc} and the *Airy-Heiskanen gravity correction* δg_{AH}.#

gravity reduction, Bouguer (1) #The sum δ_B of the *free-air gravity correction* δg_f and *Bouguer gravity correction* δg_B.#

(2) #The sum of the *free-air gravity correction* δg_f and the *complete topographic gravity correction* δg_{tc}.#

This meaning is rare and it is better designated the "Bouguer gravity reduction with topographic correction".

The "incomplete Bouguer gravity reduction" is the application of the Bouguer gravity correction only. The "complete Bouguer gravity reduction" is the process of applying both corrections.

gravity reduction, Bullard method of See *gravity reduction, Hayford-Bullard method of*.

gravity reduction, condensation #The sum of the *gravity corrections* applied in obtaining the *condensation gravity anomaly*.#

The condensation gravity reduction is also called *Faye's gravity reduction* and the Helmert gravity reduction.

gravity reduction, expanded Bouguer #The sum of a *spherical Bouguer gravity correction* and a *topographic gravity correction*.#

gravity reduction, Faye's #A *condensation gravity reduction* in which the depth of the layer of condensed matter is zero, i.e., the layer is on the surface of the terrestrial ellipsoid (or the geoid).#

gravity reduction, free-air (1) #The *free-air gravity correction*.#

(2) #The sum δ_f of the *free-air gravity correction* and the *topographic gravity correction*:

$$\delta_f = \delta g_f + \delta g_t.\#$$

(3) #The process of obtaining (1) or (2).#

gravity reduction, Hayford-Bowie method of #A method devised by Hayford and Bowie for calculating the complete topographic and isostatic gravity corrections in the *Pratt-Hayford gravity reduction*.#

The complete topographic correction δg_{tc} in this method accounts for all matter outside the level surface of reference and having an effect at the point of observation. It is calculated by laying a polar grid (the Hayford template) on a topographic map, with the origin at the point in question, reading off the average elevation within each quadrangle of the grid, and calculating the corresponding complete topographic gravity correction from a formula or from a table. To this term is added the *Pratt-Hayford gravity correction* δg_{PH}.

gravity reduction, Hayford-Bullard method of #A modification of the *Hayford-Bowie method of gravity reduction*. The topographic effect of an infinite slab of density 2.67 g/cm^3 and a thickness equal to the elevation of the gravity station is first computed, then corrected for curvature of the geoid, and finally for variation of the actual topography from the slab.#

The first step in the computation gives the ordinary Bouguer correction for topography; the second step takes account of the departure of the actual topography from a smooth cap or plate of thickness equal to the elevation of the station.

Applying the correction for curvature up to a radius of 1°29′58″ (through *Hayford zone* 0) around the point reduces the effect of the flat slab to that of a plateau extending to the outer limits of those zones and curved to fit the mathematical surface representing the Earth. This curvature correction is known as *Bullard's term*. Topography is taken into account by applying a correction for the deviations of the topography from the surface of the plateau or cap.

This method was devised by E. C. Bullard as a substitute for the Hayford-Bowie method of gravity reduction in the lettered zones of the Hayford templates; it is described in Bullard (1936) and Swick (1942).

gravity reduction, Helmert See *gravity reduction, condensation*.

gravity reduction, Hunter's #A non-isostatic gravity reduction δH in which a *Model Earth* obtained by averaging elevations over regions 150 km in radius is used. The reduction is

$$\delta_H = 2\pi G\rho(H - H') - 2\,\gamma(H - H')(1/R - 1/R') + \delta g_t$$

where δg_t is the *topographic gravity correction* appropriate to the representation, H and H' are the elevations of the real Earth and the terrestrial ellipsoid, respectively, R and R' are the radii of curvature of the real Earth and terrestrial ellipsoid, respectively, ρ is the density of the Earth, G is the universal gravitational constant, and γ is the theoretical value of gravity.#

gravity reduction, isostatic (1) #The process of adding to the theoretical value of gravity calculated from a standard gravity formula the following gravity corrections:

(a) an *isostatic gravity correction* δg_i;

(b) a *free-air gravity correction* δg_f;

(c) a *Bouguer gravity correction* δg_B or a *modified Bouguer gravity correction* δg_{Bm}; and

(d) a *topographic gravity correction* δg_t or a topographic gravity correction modified to go with the modified Bouguer gravity correction.#

The gravity reduction is carried out theoretically in the above order. Practically, the isostatic and topographic gravity corrections or the isostatic, topographic, and Bouguer gravity corrections are calculated more or less simultaneously, often using gravity tables for this purpose.

The most important isostatic gravity reductions are the Pratt-Hayford, the Airy-Heiskanen, and the Vening Meinesz gravity reductions. The U.S. Coast and Geodetic Survey used the Pratt-Hayford gravity reduction, computing it by the Hayford-Bowie and Hayford-Bullard methods.

(2) #The sum δ_i of the *isostatic*, *free-air*, *Bouguer* (or *modified Bouguer*) and *topographic gravity corrections*:

$$\delta_i = \delta g_i + \delta g_f + \delta g_B + \delta g_t.\#$$

gravity reduction, non-isostatic #A gravity reduction not involving the theory of isostasy.#

gravity reduction, Poincaré-Prey #*Prey's gravity reduction*.#

gravity reduction, Pratt-Hayford (1) #The process of adding to a theoretical value of gravity calculated from a standard gravity formula the sum of the following gravity corrections:

(a) the *Pratt-Hayford gravity correction* δg_{PH},

(b) the *free-air gravity correction* δg_f; and

(c) the *complete topographic gravity correction* δg_{tc}.#

In the past, the Pratt-Hayford and the complete topographic gravity corrections have commonly been applied simultaneously by use of special tables for distances out to about 167 km. Such tables are now obsolescent; the needed values are now calculated directly on electronic computers.

(2) #The sum δ_{PH} of the gravity corrections listed in (1) above:

$$\delta_{PH} = \delta g_{PH} + \delta g_f + \delta g_{tc}.\#$$

gravity reduction, Prey's (1) #A gravity reduction based on the assumption that the theoretical value predicted by a standard gravity formula is for a point on a terrestrial ellipsoid surrounded by topographic masses. Prey's gravity reduction, therefore, proceeds by first removing the topographic masses (and perhaps also adding isostatically compensating masses), moving the point of computation from the reference surface to the gravity station by applying the *free-air gravity correction*, and then restoring the masses that had been removed (and if necessary subtracting the compensating masses). A gravity correction is added, if necessary, to account for the difference between the nominal value (usually 2.67 g/cm^3) used for density during the rest of the reduction and the actual value of the density of the topographic masses.#

Removing the topographic masses from above the point of calculation and then, in the last step, replacing them below the point in its new location adds, in each case, to the calculated value of gravity. The change brought about by Prey's gravity reduction is therefore about twice as large as that effected by a *Bouguer gravity reduction*.

(2) #The sum δ_P of the gravity corrections introduced in the process defined above.

$$\delta_P = \delta g_B' + \delta g_t' + \delta g_\rho' + \delta g_\rho + \delta g_t + \delta g_B + \delta g_f,$$

in the case of a non-isostatic gravity reduction. $\delta g_B'$, $\delta g_t'$ and $\delta g'_\rho$ are, respectively, the *Bouguer gravity correction*, the *topographic gravity correction*, and the density gravity correction (see (1) above) appropriate to a point on the terrestrial ellipsoid. δg_B, δg_t, and δg_ρ are the corresponding quantities appropriate to the point on the Earth's surface. δg_f is the free-air gravity correction. *Isostatic gravity corrections* $\delta g_i'$, and δg_i are added for the case of an isostatic gravity reduction.#

gravity reduction, Rudzki's (1) #A *gravity reduction* obtained by applying to a value of gravity the following corrections:

(a) the *free-air gravity correction* δg_f;

(b) the *Rudzki gravity correction* δg_R; and

(c) a *topographic gravity correction* δg_{tR} corresponding to the plate, sphere, or cylinder assumed for the Rudzki gravity correction.#

(2) #The sum δ_R of the above corrections.#

gravity reduction, topographic (1) #A *gravity reduction* consisting of applying the *free-air gravity correction* δg_f, the *Bouguer gravity correction* δg_B, and the *topographic gravity correction* δg_t, to a calculated or measured value of gravity.#

(2) #The sum δ_t of the above corrections.#

gravity reduction, Vening Meinesz #A modification of the *Airy-Heiskanen gravity reduction* in which the compensation or contribution of each shell is made to vary according to a "bending curve" representing the flexure of the Earth's crust under the weight of mountains, etc.#

gravity standard See *gravity, Potsdam standard of*, and *International Gravity Standardization Net*.

gravity station #A station at which observations are made to determine the value of gravity.#

gravity system #A set of values of gravity referred to the value at one place as standard or defined.#

See *gravity, Potsdam system of* and *International Gravity Standardization Net*.

gravity table (1) #A mathematical table giving the gravitational effects of simple bodies of various sizes and used for calculating gravity corrections or deflection-of-the-vertical corrections.#

(2) #A tabulation of measured values of gravity at various points.#

gravity table, Bowie's #One of a set of tables (Bowie 1917) giving combined topographic and isostatic gravity corrections, according to the Pratt-Hayford theory of isostatic compensation, for depths of 56.9, 85.3, 127.9, 156.2, and 184.6 km.#

gravity table, Cassinis' #One of a set of tables (Cassinis et al. 1937) giving the gravity correction, for each *Hayford zone*, for a complete cylindrical shell of unit density, whose bottom (or top) is at the same elevation as the point of measurement and which extends upwards (or downwards) to all possible elevations (or depths of compensation to 200 km).#

The total topographic and isostatic gravity corrections can then be found by simple arithmetic. See also *gravity table, fundamental*.

gravity table, fundamental #A table giving the deformation of the geoid and its effect on the acceleration of gravity, computed for masses of unit density extending to various distances above and below the surface of the geoid.#

Fundamental gravity tables serve as the basis for the preparation of special tables corresponding to particular assumptions respecting density, isostasy, etc. Several such fundamental tables have been prepared, each designed for a particular effect:

(a) The tables by Cassinis et al. (1937) determine the direct effect on gravity of masses of unit density extending to various distances above and below the geoid. This direct effect is known as the Hayford effect; it neglects the differences of elevation between the ellipsoid and the geoid.

(b) The tables by Lambert and Darling (1936) determine the indirect effect of masses of unit density extending to various distances above and below the geoid. This indirect effect is known as the Bowie effect; it takes into account the differences of elevation between the ellipsoid and the geoid.

(c) The tables by Darling (1949) give the horizontal effect (deflection of the vertical) of masses of unit density extending to various distances above and below the geoid. For mathematical development and formulas, see Lambert and Darling (1936) and Darling (1948).

gravity table, Hayford-Bowie #One of a set of tables (Hayford and Bowie 1912) giving combined topographic and isostatic gravity corrections for a depth of 113.7 km.#
Also called Hayford gravity table.

gravity variometer See *gravity gradiometer*.

gray scale #A strip of film or a glass plate whose transparency diminishes in graduated steps from one end to the other.#
It is often used to determine the density in a photograph. Also called a *step wedge*.

gray scale, continuous-tone #A scale of shades from white to black or from transparent to opaque, each shade of which blends imperceptibly into the next without visible texture or dots.#
Also called a continuous wedge.

grid (1) #A network composed of two families of lines such that a pair of lines, one from each family, intersects in no more than two points.#
An example of a grid on a globe is a family of great circles intersecting each other at two points called the poles and a family of small circles concentric about the poles. The small circle equidistant from the two poles is also a great circle and is called the Equator.
The grid on a flat surface is most commonly composed of two families of straight lines intersecting at right angles. Another common grid in the plane consists of a pencil of straight lines radiating from a point and a family of concentric circles having that point as center. A grid differs from a *coordinate system* in that the grid consists of a finite number of lines intersecting in a finite number of points of the surface on which the grid lies. A coordinate system consists, in concept, of an infinite number of lines so that *every* point of the surface is at the intersection of two lines. The term is sometimes applied to the figure resulting by erasing all of each line except the small portions in the immediate vicinity of points of intersection. The resulting figure is an array of small crosses and is more commonly called a *reseau*.
(2) (geodesy) #A grid (sense (1)) composed of two sets of uniformly spaced straight lines intersecting at right angles (derived from a square Cartesian coordinate system).#
It usually refers to these families of lines on a map sheet. In this sense, *grid* is contrasted with *graticule*, the latter representing the meridians and parallels on a map. Only in the case of the *Plate Carrée map projection* does the grid coincide with the graticule.

grid, atlas #A grid, in which one set of lines of one family is labeled numerically while a set of lines of the other family is labeled alphabetically.#
Also called an alphanumeric grid.

grid, Canadian See *grid, perspective*.

grid, false origin of #A point not coincident with (and usually to the south and west) of the center of a grid, from which grid lines are numbered and from which distances are measured (usually positively eastward and northward) on the grid.#

grid, Gauss-Krüger See *grid, Transverse Mercator*.

grid, Lambert #An informal designation for a *State plane coordinate system* based on a Lambert conformal map projection with two standard parallels.#

grid, map #A *graticule*.#

grid, military See *grid (2)*.

grid, National #The grid used on the British Ordnance Survey's maps of the United Kingdom.#
The origin is south-west of the Scilly Isles, and all of these maps are drawn so that the margins coincide with lines of the grid. The central meridian of the grid is at 2° west.

grid, overlapping #A grid that is extended beyond its normal limits on a map to cover maps of areas governed by a different grid.#
Normally, large-scale maps of areas that lie within approximately 25 km of the dividing line between two grids will bear an overlapping grid, indicated by ticks drawn outward from the neat line of the map.

grid, parallactic #A *rectangular grid* drawn or engraved on some transparent material, usually glass, and placed either over the photographs of a stereoscopic pair or in the optical system of a stereoscope, in order to provide a floating grid rather than, or in addition to, a *floating mark*. #

grid, perspective #The network of lines resulting from the *perspective projection* of a *rectangular grid* on one plane onto another plane oblique to the first.#
Perspective grids are used in photogrammetry to transfer, by visual interpolation, detail from an oblique photograph to a map. The appropriate perspective grid is laid over the oblique photograph. It is also called a Canadian grid. See *grid method, perspective*.

grid, polar (1) #A grid composed of a family of straight lines radiating from a point and a family of concentric circles having that point as center.#
(2) #A *rectangular grid* used for aerial navigation in the polar regions. It consists of a rectangular grid with x- and y-axes aligned with the 0° − 180° and the 90°E − 90°W meridians respectively, with the origin at the pole.#
When plotted on a *transverse Mercator map projection* of the polar regions, it represents a graticule of transverse meridians and parallels whose poles are at the intersections of the Equator and the 0° − 180° meridian.

grid, rectangular #A grid composed of two families of straight lines, the lines in each family being equidistant and parallel, and the lines of one family intersecting lines of the other at right angles.#

If the spacing is the same in the two families, the grid is sometimes called a square grid or a quadrillage. The term grid (see *grid (2)*) is often used synonymously for rectangular grid.

grid, secondary #In regions now covered by the *Universal Transverse Mercator* or *Universal Polar Stereographic grids* but formerly covered by grids now considered obsolete, the obsolete grid—called the secondary grid—is sometimes indicated also.#

grid, transverse Mercator (1) #A *rectangular grid* placed on maps drawn on the *transverse Mercator map projection*.#

(2) #An informal designation for a *State plane coordinate system* based on a *transverse Mercator map projection*.#

grid, Universal Polar Stereographic #A *polar grid* applied to maps on the *polar stereographic map projection.* #

grid, Universal Transverse Mercator #The grid associated with the *Universal Transverse Mercator grid system*.#

grid convergence (1) #The angle, at a point on a map, between the line on the map representing the meridian through that point and the meridional line (through the same point) of a *graticule* on that map.#

(2) #The angle between a meridional line of a graticule and the central meridional line of that graticule.# Also called meridional convergence.

grid inverse #The computation of length and azimuth from coordinates on a grid.#

grid length #The distance between two points as obtained by computation from the plane rectangular coordinates of the points.#

In the *State plane coordinate systems*, a grid length differs from the length of a geodetic line by the amount of a correction based on the scale factor for the given line.

grid method, perspective #The plotting of detail from an oblique photograph onto a map by superposing a perspective grid on the photograph and transferring by visual interpolation from a location referred to the perspective grid to the corresponding location on the grid of the map.#

grid method of photogrammetry See *photogrammetry, grid method of*.

grid north #The positive direction, on a map, of the set of grid coordinate lines oriented north-south.#

grid system #A collection of *grids* and schemes for labeling the lines of the grids.#

grid system, British #A collection of rectangular grid systems devised or adopted by the British for use on military maps.#

There is no related global plan for the many grids, belts, and zones which make up the British grid system. It is being replaced by the *Universal Transverse Mercator (UTM) grid system*.

grid system, Universal Transverse Mercator (UTM) #A grid system having the following specifications. (a) Maps and grids are on the *transverse Mercator projection* in zones 6° wide longitudinally. (b) Various reference ellipsoids are used for various parts of the Earth. (c) For North America the current (1985) datum is the *North American Datum of 1927*. (d) The longitude of the origin lies on the central meridian of each zone. (e) The latitude of the origin is 0°. (f) The unit of length is the meter. (g) The false northing is 0 m for the northern hemisphere and 10,000,000 m for the southern hemisphere. (h) The false easting is 500,000 m. (i) The scale factor at the central meridian is 0.9996. (j) The zones are numbered beginning with 1 on the zone from 180°W to 174°W, and increasing eastward to 60 on the zone from 174°E to 180°E. All grid zones are identical in size and shape. (k) The limits of latitude are 80°N and 80°S. (l) The zones are bounded by meridians whose longitudes are multiples of 6° west or east of Greenwich.#

On large-scale maps and in tables an overlap of approximately 40 km (25 miles) on either side of the junction is provided for the convenience of surveyors and for artillery surveying and firing. This overlap is never used, however, in giving a reference from the grid.

grid tick #A very short line (tick) drawn perpendicularly to the neat line of a map, to indicate a point on the neat line through which a line of a grid would pass if drawn.#

Grid ticks come in pairs, one on each of two opposite neat lines.

ground gained forward #The net increase, in distance or area, per photograph in the direction of flight for a specified overlap.#

Abbreviated as GGF. It is used to compute the number of exposures in a strip of aerial photographs.

ground gained sideways #The net lateral increase, in distance or area, per flight for a specified sidelap.#

Abbreviated as GGS. It is used to compute the number of flight lines needed to completely photograph a given region.

ground pyramid See *pyramid, ground*.

ground swing #A condition under which distance-measuring instruments using radio waves give erroneous results because the waves are reflected before reaching the instrument directly.#

If radio waves travel from or to the far point by other than a direct route—for example, by reflection from the ground, water, buildings or other objects—the waves arriving indirectly interfere with the waves that arrive directly and give erroneous or uninterpretable readings.

The term is also applied to the erroneous measurements themselves.

Gunter's chain See *chain, Gunter's*.

gyrocompass See *compass, gyroscopic*.

gyroscope #Any device using a spinning mass to establish or maintain a direction.#

A spinning mass resists any attempt to change the direction in which the axis of rotation is pointing. A torque applied to the mass perpendicularly to the axis results in precession of the axis. Gyroscopes can therefore be used to find north (as in gyroscopic compasses and gyrotheodolites) or to maintain the orientation of a structure (such as an inertial navigation system).

gyrotheodolite #A *theodolite* with a *gyroscopic compass* attached so that directions can be measured with respect to the north indicated by the compass.#

The instrument is particularly applicable for use in mines and other places where direction is difficult to establish.

H

hack #A horizontal, V-shaped notch cut into the trunk of a tree at about breast height.#

half section See *section, half.*

Hansen's method #The two-point method of *resection.* #

It is the method of solving the *two-point problem* (Hansen's problem). An auxiliary point is established and angles are measured from that point and from the unknown point to the two given points.

Hansen's problem See *two-point problem* and *Hansen's method.*

harmonic, spherical #A solution, in spherical coordinates of the *Laplace equation*(2).#

Global models for the Earth's gravitational field are conveniently expressed as a series of spherical harmonics of ascending degree. The zeroth degree term represents a spherical Earth with uniform mass distribution (equivalently, a point mass). The higher degree terms represent deviations from sphericity. Terms independent of longitude are called zonal, terms that are functions of differing degrees of latitude and longitude are called tesseral, and terms that are functions of both latitude and longitude to the same (nonzero) degree are called sectorial. The coefficients of the terms are often normalized so that the average of the square of each term over a sphere is unity. Normalization serves to make the coefficients in all terms of a given degree more nearly the same order of magnitude.

Hayford-Bowie method of isostatic reduction of gravity See *gravity reduction, Hayford-Bowie method of.*

Hayford-Bullard method of isostatic reduction of gravity See *gravity reduction, Hayford-Bullard method of.*

Hayford template See *template, Hayford.*

Hayford zone See *zone, Hayford.*

heading (navigation) #The azimuth of the longitudinal axis of a vehicle; the "straight-ahead" direction.#

headland (1) #A land mass having a considerable elevation.#

(2) #The apex of a salient of the coast, the point of maximum extent of a portion of the land into the water, or a point on the shore at which there is an appreciable change in direction of the general trend of the coast.#

headland, termini at See *termini at headlands.*

headland-to-headland line See *line, headland-to-headland.*

hectare #A metric unit of area, equal to 10,000 square meters.#

Equivalent to 2.471 acres in the English system.

height (1) #The distance, in the direction of the zenith, between the top and bottom of an object, e.g., the height of a building or the height of a person.#

By analogy, one speaks of the height of a mountain when one thinks of the mountain as an object with a top and a bottom. However, for historical reasons connected with the use of barometers for measuring heights, one speaks of a point on the object as being at a certain *altitude*; e.g., "The peak is at an altitude of 3000 meters above mean sea level".

(2) #The distance, measured along a perpendicular, between a point and a reference surface, e.g., the height of an airplane above the ground surface.#

In this example, the reference surface is the surface of the Earth below the aircraft or a plane fitted to that surface. For the term geodetic height, the reference surface is an ellipsoid.

(3) #The distance, measured upwards along a *plumb line* (line of force), between a point and a reference surface of constant geopotential.#

Elevation is preferred if the reference surface is the geoid unless convention or definition dictates otherwise, i.e., measured elevation, orthometric elevation, etc., but normal height, etc. The term height is also applied to elevation of the tide above or below a specified level. The term orthometric height is also in common use. Use of the term geoidal height also is proper since it is the geodetic height of a point on the geoid.

height, absolute geoidal (1) #The *geoidal height* based on a geocentric reference ellipsoid.#

height, auxiliary See *height, normal.*

height, dynamic (1) #The value, assigned to a point, determined by dividing the *geopotential number* for that point by the value of gravity on the reference ellipsoid at 45° latitude, as calculated from a standard gravity formula.#

(2) #The same as (1) above, except that the reference value of gravity may be calculated for any selected latitude.# See also *dynamic number.*

Dynamic height is sometimes (unfortunately) used as a synonym for *geopotential number.*

height, geodetic #The perpendicular distance from an ellipsoid of reference to a point.# It is a *geodetic coordinate.*

height, geoid See *height, geoidal.*

height, geoidal #The distance, taken along a perpendicular to the ellipsoid of reference, from that ellipsoid to the geoid.# Also called geoid height.

height, geometric (1) #The perpendicular distance from a given point on a surface.#

(2) See *height, geodetic.*

(3) #A height determined geometrically, as opposed to a height determined dynamically.# See *altitude.*

height, Helmert See *elevation, Helmert.*

height, Molodensky See *height, normal.*

height, Niethammer See *elevation, Niethammer.*

height, normal (1) #For a given point P_n, the distance from the *normal ellipsoid* to the *spherop* which has the same potential as the *geop* through P_n measured along the normal plumb line through P_n.#

This definition was introduced by Hirvonen (1960). If the point on the spherop corresponding to P_n is designated as Q_n, then the locus of all Q_n corresponding to all P_n on the surface of the Earth is called the *telluroid.* Thus the normal height is the distance of Q_n above the normal ellipsoid.

(2) #For a given point P_n, the same length as (1) above, but measured from P_n (if positive, taken downward) along the normal plumb line through P_n.#

This definition was introduced by Molodensky in 1945. The locus of endpoints of normal heights measured from the Earth's surface is called the *quasigeoid.* Since the quasigeoid has the same distance relationship (*height anomaly*) to the normal ellipsoid as the Earth's surface has to the telluroid, definitions (1) and (2) yield the same numerical value for a particular P_n. However, in (2) the normal height refers directly to the distance of P_n from the quasigeoid, while in (1) it refers to the distance of the auxiliary point Q_n from the normal ellipsoid.

The normal height (2) is also called the auxiliary height or the Molodensky height.

height, normal dynamic (1) #The value, assigned to a point, determined by dividing the *spheropotential number* for that point by the value of the acceleration of gravity on the reference ellipsoid at 45° latitude, as calculated from a standard gravity formula.#

(2) #The same as (1) above, except that the value of gravity may be calculated for any selected latitude.#

The normal dynamic height is distinguished from the dynamic height by employing the *spheropotential number* instead of the *geopotential number.*

height, normal orthometric See *elevation, normal orthometric.*

height, orthometric See *elevation, orthometric.*

height, practical #Any *elevation* published and intended for general use.#

Also called approximate height or approximate elevation. The term practical height was introduced to designate elevations derived by formulas known and intended to be approximate. The *Baranov elevation*, e.g., is usually considered to be a practical height.

height, quasidynamic #The value, assigned to a point P_n, determined by dividing the *geopotental number* for that point by a value of the acceleration of gravity γ_q obtained as follows. Let γ_o be the value of the acceleration of gravity on the reference ellipsoid at a selected latitude ϕ, as calculated from a standard gravity formula. Let δg_f be the *free-air gravity correction* from the geoid to the *geop* through P_n computed along the plumb line passing through the point at latitude ϕ on the same geop. Then

$$\gamma_q = \gamma_o + (1/2)\ \delta g_f.\#$$

Note that the free-air gravity correction is negative for a point above the geoid.

height, relative geoidal (1) #At a given point, the change in *geoidal height* with respect to that at another point.#

(2) #The geoidal height based on a non-geocentric reference ellipsoid.#

height, scale See *scale height.*

height, Vignal See *elevation, Vignal.*

height above mean sea level (1) #The elevation of a point calculated from the data of a leveling survey, based on the elevations of certain tide-gauge bench marks that have been given specified values.#

This concept dates from a period when mean sea level and the geoid were thought to be the same or to differ only negligibly from each other.

(2) #The distance, vertically, of a point above the geoid.#

This definition applies to those instances, such as in the legends on maps, where heights are stated as distances above mean sea level but are actually above the geoid.

height anomaly (1) #The difference between the *geodetic height* of a point and the *normal height* corresponding to that same point.#

For the *normal height* (1), it is the distance between the Earth's surface and the *telluroid*; for the *normal height* (2), it is the distance between the *quasigeoid* and the *normal ellipsoid.* Just as in the case of the two kinds of normal height, these are numerically equivalent. See *height, normal.*

heighting, barometric #The determination of altitudes by using a barometric altimeter.# Usually called *barometric altimetry.*

height of instrument (1) #In spirit leveling, the elevation, above the adopted surface of reference, of the intersection of the line of sight with the axis of rotation of a leveling instrument.#

(2) #In *stadia surveying,* the height of the center of the telescope (horizontal axis) of a transit or telescopic alidade above the ground or station mark.#

(3) #In *trigonometrical leveling,* the height of the center of the theodolite (horizontal axis) above the ground or station mark.#

height of target #The height of an observed point above the ground or above the top of the marker with which it is associated.#

heliotrope #An instrument composed of one or more plane mirrors mounted and arranged so that a beam of sunlight reflected by it may be aimed in any desired direction.#

Placed over a survey station, a heliotrope can be used to direct a beam of sunlight toward a distant survey station, where it can be observed through a theodolite, thus providing a target for observing horizontal directions at distances approaching 300 km. The heliotrope was invented by Gauss early in the nineteenth century.

Helmert blocking #A method of network adjustment in which the network is broken up into a hierarchy of smaller networks. Adjustment is carried out first in the smallest members of the hierarchy, which are then combined by means of common points into next-larger members which also are adjusted. The process continues until the entire network has been adjusted.#

The final result is the same as that of a simultaneous least squares adjustment of the entire network. Helmert blocking is a special form of solving by partitioning of the normal matrix, where the observations and unknowns are partitioned geographically. The method is especially applicable to the large, sparse systems of equations typical of large geodetic networks.

hertz #One cycle per second.#

The symbol in SI units is Hz; e.g., 16 Hz means 16 cycles per second.

hiatus (land surveying) #A region between two surveys of record and described in the record as having one or more common boundary lines, but in which no mention is made of an area between them.#

The title to the hiatus, except possibly for adverse possession, would appear to remain where it was before the surveys were placed on record. Judicial opinion and court decree may be required to clarify the record. See also *gore.*

hide #An obsolete English unit of area, common in the Domesday Book and old English charters.# Its size varied with the nature of the land and with the period of use. The normal hide of the Domesday Book is 120 acres.

high seas #The open sea beyond and adjacent to the *territorial sea.* #

Although a territorial sea is subject to the exclusive jurisdiction of only one nation, the high seas are basically international territory. Nevertheless, littoral nations frequently exercise limited jurisdiction over portions of the high seas adjacent to their coasts for enforcing customs and other regulations. The Geneva Convention on the High Seas defines them as "all parts of the sea that are not included in the territorial sea or in the internal waters of a state".

high water full and change See *establishment of the port.*

high water line (1) #The intersection of the land with the water surface at an elevation of *high water.* #

The high-water line is the boundary line between the bed and the bank of a stream. The average high water line usually determines the boundary of the land of the proprietor having riparian rights.

(2) See *high water mark.* Use of "high water line" for "high-water mark" should be discouraged.

high water mark #The place, on the bank or shore, where the usual and long-continued presence and action of water has impressed on the bed of the stream a character distinct from that of the banks with respect to vegetation and the nature of the soil.#

hinterland (1) #The zone containing the flanks of the beach and the region inland from the coastline to a distance of 5 miles (8 km).#

(2) #The region lying behind the coastal zone.#

hiran #An improved version of *shoran,* emitting a sharper pulse with more carefully controlled amplitude than is emitted by shoran. Phase is also measured more accurately in the receiver.#

Other characteristics of hiran are much the same as those of shoran. Hiran (high-precision shoran) was developed principally for geodetic use after the spectacular success of shoran. The standard deviation of a measurement by hiran is approximately 0.36 of a meter for each kilometer of measured distance. Among the major geodetic projects completed using hiran were the connection of Crete to Africa and Rhodes in 1943, and the connection of the North American Datum of 1927 to the European Datum from Canada to Norway and Scotland by way of Greenland and Iceland in 1953-56.

hodograph #The curve described by connecting the ends of a set of vectors defined as originating in a fixed point.#

A hodograph is a graphic method for showing changes of motion in space, time, or both. Thus a hodograph can be used to depict polar motion or to describe changes in the direction of fluid flow in the vertical, e.g., by a flow-measurement device lowered into the ocean or lifted up into the atmosphere.

holiday #In hydrographic surveying, an unintentionally unsurveyed part of a region that was to have been completely surveyed.#

A holiday is particularly likely to occur at the junction between two hydrographic surveys. It is similar to *gore* and *hiatus* in land surveying.

hologram #A photograph of the interference pattern created by interference between two beams of mutually coherent radiation, one of which is diffracted by an object in its path.#

Usually, one original beam is involved. This is split into two parts, one of which travels directly to the camera; the other part is diverted to illuminate an object which diffracts a portion of the radiation toward the camera. A hologram appears to show a three-dimensional image rather than the two-dimensional representation of a three-dimensional object as in normal photography.

hologrammetry (1) #The techniques associated with making holograms or with reproducing images from holograms.#

(2) #The science concerned with measurement of holograms.# Sometimes mistakenly called holography.

horizon #The line which separates the region visible from a real or hypothetical observation point, from the region not visible from that point.#

Usually the region visible to a human observer, on or close to the Earth's surface, is limited principally by the curvature of the Earth and is bounded by the horizon. It is common practice to calculate a horizon for a camera or other detector situated some distance above the Earth's surface. The radiation to be detected by such an instrument is specified to be in a particular part of the spectrum. See also *horizon, apparent*; *horizon, celestial*; and *horizon geometric,* all of which are often simply called horizon.

horizon, apparent #The irregular line on the Earth's surface that bounds the regions outside of which no points are visible from the point of observation.#

The apparent horizon is the line where the visible surface of the Earth appears to meet the sky. When the apparent horizon appears to be on the surface of a body of water, it is sometimes used as a reference in observing vertical angles. See *horizon, dip of the.*

The apparent horizon is farther from the observer than the *geometric horizon* except where a temperature inversion causes rays of light to bend upward instead of downward. Thus, location depends not only on the topography and on the point of observation but also on the refractivity of the atmosphere.

horizon, artificial #A device consisting of a flat reflecting surface which can be adjusted to coincide with the *plane of the horizon.* #

One form of artificial horizon consists of a disk or trough filled with mercury (or an amalgam of mercury and tin), the upper surface of which is free and horizontal. Another form is a plane mirror equipped with spirit levels and leveling screws so that it can be adjusted into the plane of the horizon. The artificial horizon used for aerial navigation is usually kept parallel to the plane of the horizon by a gyroscopic pendulum. In observing a celestial body such as a star or the Sun, the angle is measured between the body as seen directly (with transit or theodolite) or by reflection (in the horizon glass of a sextant) and its image reflected in the artificial horizon; this is a vertical angle, and is double the angular altitude of the body.

horizon, celestial #The *great circle* on the celestial sphere 90° away from the zenith.#

Among navigators, it is usually just called the horizon. It defines the *plane of the horizon,* and is also called the true horizon.

horizon, closing the #Measuring the last of a series of horizontal angles at a station so that the sum of the series is a multiple of 360°.#

At any station, the sum of all horizontal angles between adjacent lines should equal 360°. The amount by which the sum of the observed angles fails to equal 360° is the misclosure. The misclosure is distributed as a correction among the observed angles to bring their sum to exactly 360°.

horizon, dip of the #The *vertical angle* between the plane of the horizon and a line tangent to the apparent (visible) horizon.#

horizon, geometric (1) #The line on the Earth's surface at which straight lines from an observer are tangent to the Earth's surface.#

The term surface must be interpreted loosely, since the surface proper may be hidden by forest, buildings, etc. The geometric horizon is usually closer to the observer than the *apparent horizon,* which is defined by the concave paths of rays from the surface to the observer. Also called true horizon (although this term is also used for *plane of the horizon*), the *celestial horizon,* or the *apparent horizon.*

(2) #The curve on an ellipsoid at which straight lines through a point (the point of observation) are tangent to the ellipsoid.#

horizon, plane of the (1) #A plane through the celestial horizon.#

This term is often confused in meaning with "horizontal plane". A horizontal plane is defined as perpendicular to a specified vertical; the plane of the horizon is defined as passing through the celestial horizon. A horizontal plane through a specific point on a vertical defines a unique celestial horizon. However, a plane through a specified celestial horizon does not define a unique point on the corresponding vertical. Also called horizon plane.

(2) #A plane passing through the average position of the *apparent horizon.* #

horizon, true See *horizon, geometric.*

horizon, visible See *horizon, apparent.*

horizon photograph #A photograph of the horizon, taken simultaneously with a vertical photograph, to obtain an indication of the tilt of the vertical camera at the instant of exposure.#

horizon plane See *horizon, plane of the.* Note that this is not the same as a *horizontal plane.*

horizon ring #A graduated ring fitted to a globe so its plane contains the center of the globe; the ring also is adjustable into the plane of the horizon for any point on the globe.#

The horizon ring is used for measuring angles around the horizon at a given point.

horizon sweep #The observation, in a clockwise sequence from the farthest known visible point, of angles or directions to objects such as tanks, spires, or signals, for identification of the objects and subsequent use of the angles or directions observed.#

horizon trace #An imaginary line, in the plane of a photograph, which represents the image of the celestial horizon; it corresponds to the intersection of the plane of a photograph and the horizontal plane containing the perspective center or rear nodal point of the lens.#

Horrebow-Talcott method of determining latitude See *latitude determination, Horrebow-Talcott method of.*

hotspot (1) #In aerial photography, the portion of an image at which light has been received from the Sun directly or by reflection rather than by scattering.#

It is overexposed (washed-out) with respect to the rest of the image. Also called flare or glare.

(2) #A region in the Earth's mantle which is so much hotter than its surroundings that it causes volcanic activity in the crust immediately above it.#

In the theory of continental drift, hotspots are responsible for chains of volcanic islands such as the Hawaiian Islands.

hour #A time interval defined as equal to 3600 seconds, 60 minutes, or 1/24 of a day.#

hour, cotidal #The average time interval between the Moon's transit over the meridian of Greenwich and the time of the following *high water* at a place.#

The interval may be expressed either in solar or lunar time. When solar time is used, it is the same as the Greenwich high water interval; when lunar time is used, it is equal to the Greenwich high water interval multiplied by 0.966.

hour angle #The angle, measured westward from a selected *celestial meridian,* between the plane of the *hour circle* passing through a celestial body and the plane of the selected celestial meridian.#

The hour angle is reckoned from the meridian (0 hours or 0°) westward through 24 hours or 360°.

hour angle, Greenwich #The angle, measured westward from the Greenwich *celestial meridian*, between the plane of the *hour circle* passing through a celestial body and the plane of the celestial meridian at Greenwich.#

Usually abbreviated as G.H.A. It may also be defined as the arc of the celestial Equator, or the angle at the celestial pole, between the upper branch of the Greenwich celestial meridian and the hour circle of a point on the celestial sphere, measured westward from the Greenwich celestial meridian through 360°. It is the *local hour angle* at the Greenwich meridian.

hour angle, local #The angle, measured westward from the local *celestial meridian*, between the plane of the hour circle passing through a celestial body and the plane of the local celestial meridian.#

It may also be defined as the arc of the celestial Equator, or the angle at the celestial pole, between the upper branch of the local celestial meridian and the hour circle of a point on the celestial sphere, measured westward from the local celestial meridian through 360°.

hour angle, sidereal #The angle, measured westward from the *vernal equinox*, between the plane of the hour circlepassing through a point on the celestial sphere and the plane of the hour circle of the vernal equinox.#

It may also be defined as the arc of the celestial Equator, or the angle at the celestial pole, between the hour circle of the vernal equinox and the hour circle of a point on the celestial sphere, measured westward from the hour circle of the vernal equinox through 360°.

hour circle #Any *great circle* on the celestial sphere lying in a plane perpendicular to the plane of the celestial Equator.#

Equivalently, any great circle on the celestial sphere passing through the poles. Hour circles are also called circles of declination. The hour circle that contains the *zenith* is identical to the *celestial meridian*.

hoverscope #An optical device used by the pilot of a helicopter to help him hover precisely over a marked point on the ground. The device consists of an *autocollimator* mounted vertically on a silicone-dampened pendulum.#

The image of the mark on the autocollimator reticle is superimposed on an image of the ground.

hub #A temporary *marker*, usually a wooden stake with a tack or small nail on top to indicate the exact point of reference for angular and linear measurements that is driven flush with the ground at a traverse station.#

hydrography (1) #The study of waters (including oceans, lakes, and rivers) embracing either (a) their physical characteristics, from the standpoint of the oceanographer or limnologist; or (b) the elements affecting safe navigation, from the point of view of the mariner.#

It is distinguished from physical oceanography by dealing with rivers and lakes, etc., as well as with oceans and seas. It is distinguished from hydrology in that it deals only with surface waters; hydrology deals, in addition, with underground waters and usually is taken to be limited to non-marine waters. Hydrology also deals with effects of waters of the Earth on precipitation and evaporation.

(2) #Hydrography, in the above sense, but limited to dealing with only the geometric properties of the waters.#

In this sense, it is synonymous with charting.

(3) #The science of the Earth's surface waters.#

This is probably the term's original meaning; however, present custom is to use oceanography if marine waters are being considered, and hydrology if rivers, lakes, etc., are being considered.

hydrology See *hydrography*.

hydrophone #The receiver for the echoes produced in echo sounding.#

hydrosphere #The water portion of the Earth.#

The term includes ground water; water in the atmosphere is not considered part of the hydrosphere.

The term is used to distinguish the water portion of the Earth from the solid portion and gaseous envelope of the Earth (atmosphere).

hygrometric (adjective) #Relating to the humidity, or amount of moisture, in the atmosphere.#

Since the atmosphere penetrates bodies in varying degrees, the amount of moisture in the air will affect the shapes and dimensions of certain instruments and equipment used in surveying and mapping. Thus it is necessary to select materials which are not sensitive to moisture for the construction of leveling rods, plane table sheets, etc., and for the construction and printing of maps.

hygrometry #The science of the measurement of the humidity (water content) of the atmosphere and of other gases.#

hyperstereoscopy #Stereoscopic viewing in which the scale (usually vertical) along the *line of sight* is exaggerated in comparison with the scale perpendicular to the line of sight.#

Also called appearance ratio and stereoscopic exaggeration.

hypsograph #A circular instrument of the slide-rule type used to compute elevations from vertical angles and horizontal distances.#

Commonly used in plane table surveys.

hypsographic feature #A *topographic feature* with elevations referred to the geoid.#

hypsography (1) #The description of elevations or heights of land surfaces with reference to a specified surface (usually the geoid).#

(2) #The *topography* (relief) of a region referred to a specific datum.#

hypsometer (1) #An instrument used for obtaining elevations of points on the Earth's surface in relation to sea level by determining atmospheric pressure through observation of the boiling point (temperature) of water at each point.#

(2) #An instrument used in forestry for determining the heights of trees.#

hypsometric (adjective) #Relating to elevation above a datum, usually the geoid.#

In a limited sense, hypsometric relates to those elevations that are determined with a hypsometer.

hypsometry (1) #The determination, by any method, of elevations of the Earth's surface with respect to the geoid.#

(2) More generally, #the science of height measurement.#

hypsometry, barometric #The determination of elevations using barometers.#

This is not the same as barometric altimetry, with which it is sometimes confused. Barometric *hypsometry* uses the geoid, specifically, as the reference surface. Barometric *altimetry* may use the geoid, but more frequently uses a particular *mean sea level* or other convenient surface.

I

iconogrammetry See *ikonogrammetry.*

iconometry #The process of making maps from photographs.#

identification post See *post, identification* and *witness mark.*

ikonogrammetry #The science of inferring the physical dimensions of objects from measurements taken on images of the objects.#

Also called iconogrammetry. It includes photogrammetry, in which photographic images formed by light from the object are used; radargrammetry, in which images created (indirectly) by radio waves reflected from the object are used; and X-ray photogrammetry. Photogrammetry may be considered a general term equivalent to ikonogrammetry.

image #A pattern formed by electromagnetic radiation that approximately duplicates the pattern formed by a real object or a physical field detectable by the radiation.#

This definition is more general than the usual definition because many instruments used for detection operate at other than light frequencies but in ways similar or analogous to those used for forming optical images. The kind of radiation forming an image is usually specified by adding a word that identifies the part of the spectrum involved, e.g., radio image, infrared image, optical image, and X-ray image. However, the terms "radar image" and "X-ray image" are used to refer to optical images of the images formed by radar or X-ray.

image, corresponding #A second image of a particular object as seen from a different point of view.#

The term is more often applied to points or lines in the images than to the images as a whole. One speaks of corresponding image points or lines when the points or lines on two images represent the same points or lines on an object.

image, inverted #An image which has been turned upside down with respect to an original, so that top and bottom are interchanged but right and left sides are not.#

image, optical (1) #An image formed by light.#

(2) #A visible record, such as a photograph, of an optical image as defined above.#

An optical image is formed by an *optical system*. The segment of a light-ray in front of an optical system lies in object space; the segment that passes through the optical system lies in image space. A point in object space is called an object point; its counterpart in image space is called an image point. If rays from an object point converge to a point in image space, the image is called a real stigmatic image; if the rays merely converge to a point-like region, the image is called a real image or real image patch. If rays in image space diverge, but asymptotes to them converge to a point-like region, the image is called a virtual image. Both real and virtual optical images can be seen, but only real optical images can be recorded photographically.

image, photographic #A *photograph.*#

image, pseudoscopic #An image in which the shading creates the impression that high relief appears to be low relief and low relief appears to be high relief.#

image, reverted #An image in which right and left sides are interchanged with respect to an original, but top and bottom are not.#

image, stereoscopic #A three-dimensional impression given by viewing one of a pair of overlapping pictures of an object with the left eye and the other with the right eye, either simultaneously or in rapid succession.#

image, stigmatic See *image, optical.*

image analysis #The science of inferring characteristics of an object by studying images of the object.#

The term includes image interpretation and *ikonogrammetry* and the more specialized subjects of *photogrammetry, radargrammetry,* and *photo-interpretation.*

image-motion compensation #Holding an image motionless on a camera's focal plane even though the camera is moving with respect to the object as the image is being formed.#

Image-motion compensation is used in aerial photography when the scale of the photographs or the aircraft's speed is so great that the image of the ground would move on the photographic emulsion while the shutter is open, thus blurring the photograph. Aerial cameras equipped for image-motion compensation move the film at the same rate and in the same direction that the image is moving while the shutter is open.

image patch See *image, optical.*

image point (1) #A point in image space to which a wave-front from a point on the object converges.#

Because no optical system is perfect, each point on an object is imaged as a volume rather than as a single point, that is, each object point produces a family of image points all close together. See also *image, optical*.

(2) #The same as definition (1), except that the point may be at the convergence of tangents to the rays.#

Such image points are virtual image points.

(3) #A point in an image, usually one which is identifiable with a point in the imaged object.#

image point, conjugate See *image point, corresponding.*

image point, corresponding #One of a pair of points that are images of the same point in an object.#

imagery (1) #The process of creating an image of an object by using the electromagnetic or acoustical radiation emitted, scattered, or reflected by the object.#

(2) #An image or set of images.#

image space See *image, optical.*

imaging system #Any device, mechanism, or instrument that produces an image of an object.#

An imaging system includes both photographic devices and instruments that produce images from radiation at wavelengths other than those of visible light.

imbalance (leveling) #The difference in distances from the leveling instrument to the two leveling rods (or two locations of a single leveling rod).#

inch (1) #A unit of length defined to be 1/36 of a yard and equal in the U.S.A., since 1866, to exactly 1/39.37 of a meter.#

This equivalence was established by Act of Congress, July 28, 1866, but was put into practice only after the United States received copies of the International Prototype Meter in 1893. With changing definitions of the meter, the definition of the inch and yard change accordingly. See also *meter* and *yard.*

(2) #A unit of length defined (for scientific purposes) by the 1959 agreement between the U.S. National Bureau of Standards and similar organizations in other countries, to be 1/36 of the *international yard* (defined as exactly 0.9144 meter).#

This correspondence yields 1 inch = 2.54 cm.

inch, circular See *area.*

inclination (1) #The angle, measured positively northward, from a plane of reference to the plane of an orbit.#

"Northward" here means counterclockwise on viewing inward from the orbit to the center of attraction. The inclination is customarily one of the six elements that completely define an elliptical orbit. In the case of artificial satellites of the Earth, the plane of reference is usually the plane of the celestial Equator, although the plane of the ecliptic has also been used.

(2) #The vertical angle between a horizontal plane and a magnetic needle freely suspended in a plane parallel to the surface of the Earth.#

The magnetic needle gives the direction of the magnetic field at a point, so the inclination is the vertical component of the direction of the field. Also called dip.

inclination of the horizontal axis #The vertical angle between the horizontal axis of a surveying or astronomical instrument and the plane of the horizon.#

Inclination of the horizontal axis is measured with a *striding level* or a *hanging level.* The inclination causes the axis of collimation of a theodolite or transit to describe an inclined plane instead of a vertical plane when the telescope is rotated about the horizontal axis of the instrument. This produces an error in the observed horizontal direction of an object not situated in the plane of the horizon, and so requires the application of a correction for this inclination.

inclination of the horizontal axis, correction for #A correction applied to an observed horizontal direction to eliminate any error caused when the horizontal axis of the instrument is not exactly horizontal.#

If the horizontal axis of the instrument is not exact, the axis of collimation will not cut the horizon at a point directly underneath (or above) an observed point; i.e., a plane described by the axis of collimation when the telescope is rotated about its horizontal axis will not be vertical. As the inclination of the horizontal axis may involve either or both of two conditions—the failure of the horizontal and vertical axes of the instrument to meet exactly at a right angle, or a possible deviation of the vertical axis from the direction defined by the plumb line—a determination of the correction requires that both the inclination of the axis and the angular elevation of the observed object be known.

inclinometer (1) #A small device for measuring the inclination of a surface from the horizontal. It consists of a graduated arc held firmly at one end by a rigid arm and traversed by a rotating arm carrying a level, which is pivoted on the fixed arm.#

In use, the fixed arm is placed on the surface whose inclination is to be determined, the graduated arc is held vertically, and the movable arm is rotated until the level indicates that it is in a horizontal position. The angle is then read on the graduated arc.

(2) #A *dip needle*.#

index, refractive See *refraction, index of.*

index correction #The correction applied to an observed difference of elevation to eliminate the *index error*.#

In modern precise practice, an index correction is not applied because the error is negligible.

index error #The distance upwards from the foot of a leveling rod (the lowest horizontal surface) to the theoretical zero of the scale.#

index of refraction See *refraction, index of.*

indicatrix of Dupin #The curve obtained by the intersection of a plane with a surface as the plane approaches tangency with the surface.#

It characterizes the curvature of the surface at the point of tangency.

indicatrix of Tissot #The ellipse on the plane into which an infinitesimally small circle on a curved surface is transformed when the curved surface is mapped onto the plane.#

The size and shape of the indicatrix depend on the nature of the curved surface and on the kind of mapping used.

indirect effect #The change in gravity, potential, or the geoid caused by the removal or shifting of masses in the process of reducing gravity from the Earth's surface to the geoid.#

The correction to a gravity reduction is $2\gamma N'/R$ where γ is the mean value of gravity, R is the mean radius of the Earth, and N' is the difference in elevation between the geoid and the *cogeoid* corresponding to the type of reduction used. This correction is also referred to as Brun's term or the Bowie correction (or Bowie effect).

inequality (1) (astronomy) #The angular deviation of a celestial body from the location it would have if it were moving in an elliptical orbit.#

The term is most commonly applied to irregularities in the Moon's orbit, but is also used in describing the orbits of the planets and their satellites.

(2) (hydrography) #A systematic departure from the average value of a tidal quantity.#

inequality, age of diurnal #The *time interval* between the time of greatest semimonthly declination of the Moon, north or south, and the time of greatest effect of that declination upon the range of tide or speed of the tidal current.#

Also called age of diurnal tide and diurnal age. The age T_{di}, can be computed from the formula

$$T_{di} = 0.911\ (K_1 - O_1) \text{ hours},$$

where K_1 is the lunisolar diurnal *constituent* and O_1 is the lunar diurnal constituent.

inequality, age of parallax #The *time interval* T_i between the time of perigee of the Moon and the time of greatest effect of the distance of the Moon upon the range of tide or speed of tidal current.#

Also called parallax age. It is given by the formula

$$T_i = 1.837\ (M_2 - N_2) \text{ hours},$$

where M_2 is the principal lunar semidiurnal *constituent* and N_2 is the large lunar elliptic semidiurnal constituent.

inequality, age of phase #The *time interval* T_{pi} between the time of new or full Moon and the time of maximum effect of these phases of the Moon upon the range of tide or speed of tidal current.#

Also called age of tide or phase age, it is given by the formula

$$T_{pi} = 0.984\ (S_2 - M_2)$$

where M_2 is the principal lunar semidiurnal constituent and S_2 is the principal solar semidiurnal constituent.

inequality, annual #A more or less periodic seasonal variation in water level or current that is caused by seasonal changes in air pressure, wind direction, and other meteorological factors.#

inequality, diurnal (tidal) (1) #The difference in elevation of the two *high waters* or the two *low waters* of each day.#

(2) #The difference in speed between the two tidal flood currents or the two tidal ebb currents of each day.#

The difference changes with the declination of the Moon and, to a lesser extent, with the declination of the Sun. In general, the inequality increases with an increasing declination and diminishes as the declination decreases.

The mean diurnal high-water inequality is one-half the average difference between the two high waters of each day observed over an extended interval. It is obtained by subtracting the average of all high waters from the average of the *higher high waters*.

The mean diurnal low-water inequality is half the average difference between the two low waters of each day observed over an extended period of time. It is obtained by subtracting the average of the *lower low waters* from the average of all low waters. Mean diurnal inequalities, as here defined, are applicable only when the tide is either semidiurnal or mixed.

The National Ocean Service specifies the periods of observation for the diurnal inequalities as particular 19-year intervals called *National Tidal Datum Epochs*.

inequality, lunar #A deviation from elliptical motion of the Moon that is caused by attraction of Earth, Sun, and other bodies in the Solar System.#

inequality, lunar parallactic See *inequality, parallax*.

inequality, parallactic #An *inequality* in the longitude of the Moon caused by variations in the Sun's pull on the Moon as the Earth's distance from the Sun varies throughout the year.#

The argument is the difference in solar and lunar longitudes, the amplitude is −124.″8 and the period is one mean synodic month (29.530 589 days or $29^d\ 12^h\ 44^m$).

inequality, parallax #The variation, in the range of tide or in the speed of a tidal current, caused by the varying distance of the Moon from the Earth.#

The ranges of tides and speeds of tidal currents tend to increase as the Moon approaches perigee and to decrease as it approaches apogee, the complete cycle being the anomalistic month. There is a similar but relatively unimportant inequality caused by the Sun; this cycle is the anomalistic year.

inequality, phase #A variation in the tide or tidal currents associated with changes in the phase of the Moon.#

At new and full moon, the tide-producing forces of the Sun and Moon act in conjunction causing greater than average tides (spring tides) and speeds of tidal currents. At first and last quarters of the Moon the tide-producing forces oppose each other, causing smaller than average tides (neap tides) and tidal currents.

inequality, tropic #The average difference between the two *high waters* or two *low waters* of the day at the time of *tropic tides*. #

The first is called tropic high-water inequality, the second, tropic low-water inequality.

inequality, variational #A variation in the Moon's angular rate of motion that is caused mostly by the tangential component of the Sun's attraction.#

inertia, moment of #The sum of the products formed by multiplying the mass (or its equivalent) of each element of a body by the square of its distance from a specified axis of rotation.# Also called rotational inertia.

There are three mutually perpendicular lines through a point such that the moment of inertia about one of the lines is less than the moment about any other line through the point, and the moment of inertia through another of the lines is greater than the moment about any other line through the point. These are called the principal axes of inertia of the body or, usually, the principal axes.

infrared, near *#Infrared radiation* with wavelengths in the range 0.8 to 4 micrometers.#

infrared radiation #The portion of the electromagnetic spectrum containing radiation at wavelengths from about 0.8 micrometer to 300 micrometers.#

Also referred to as infrared or infra-red.

inshore #The zone of variable width between the *shoreface* and the seaward limit of the *breaker zone*. #

instrument, alt-azimuth #An instrument rotatable in angular altitude and azimuth.#

instrument, direction #A *theodolite* in which the horizontal circle remains fixed during a series of observations on different targets.# See also *theodolite, direction.*

instrument, stereoscopic #An instrument that uses a stereoscopic pair of images to produce a visual effect of depth or solidity, numerical data, or topographic maps showing depth (height).#

An instrument which produces the visual effect of depth is called a stereoscope. A stereoscope which also draws a topographic map from the pictures is called a stereoscopic plotter or a stereoscopic plotting instrument. A stereoscopic instrument which produces data or topographic maps without producing a visual image is called an analytical plotter.

interferometer #An instrument which measures differences between the phases of two different electromagnetic signals originating from a common source, but which have traversed different paths.#

The phase differences are measured by combining the two signals. The amplitude of the combined signal is a function of the phase difference between the two signals. The phenomenon of fluctuations in the amplitude of the combined signals in response to phase changes in the input signals is sometimes referred to as interference.

interferometer, connected-element #A *radio interferometer* in which the antennas are connected directly (usually by cable) to the receiver.#

interferometer, Michelson See *interferometer, optical*

interferometer, optical #An *interferometer* operating at optical wavelengths.#

The most-used type is the Michelson interferometer. This instrument splits a beam of light from a single source into two beams, each taking a different path, and then recombines the two parts to cause an interference pattern which indicates the difference in optical length between the paths taken by the two parts of the beam.

The optical interferometer has been used for accurately measuring the length of short base lines (see *base line apparatus, Väisälä*), as a means for determining gravity by measuring the rate of fall of an object, and for measuring the flexure in the support of pendulum-type gravity apparatus.

interferometer, radio #An *interferometer* operating at radio wavelengths.#

Interferometers used in astronomy and geodesy generally have two separate antennas that sample the wavefront from a single source at two different points. The voltages from the antennas are either conducted by cable to a single amplifier and mixer (interferometer) or, if the antennas are too far apart (hundreds or thousands of kilometers), are recorded separately and with timing marks are added to permit later comparison.

interferometer, Väisälä See *base line apparatus, Väisälä.*

interferometer, very long baseline #A pair of *radio telescopes* separated by a a great distance—usually 1000 km or more—that act as radio interferometers on signals of common origin.#

The radio signals are recorded and later compared to determine the difference in phase of the radiation received at the two telescopes. From this information, the direction and structure of the source, and the distance and direction between telescopes can be determined. The ability to determine the location of one telescope relative to the other to within a few centimeters makes the device geodetically important. Often referred to as a VLBI.

interferometry See *interferometer.*

International Gravity Standardization Net (IGSN 1971) #A set of adjusted values for the acceleration of gravity, at various places throughout the world, that was adopted by the International Association of Geodesy in 1971 to replace the *Potsdam system of gravity* as an international system.#

Also called International Gravity Standardization System.

International Gravity Standardization System See *International Gravity Standardization Net.*

International Latitude Service (I.L.S.) #An organization, established by the International Astronomical Union and the International Association of Geodesy, that was responsible for determining polar motion by measuring the astronomical latitudes of the observatories it uses.#

The Service was established in 1900. All observatories were located as closely as possible to the parallel of 39° 08′ 10″ N, and used the same kind of instrument (zenith telescope), and the same method of observation (Horrebow-Talcott). In 1962 the headquarters of the I.L.S. was incorporated in the headquarters of the *International Polar Motion Service.* Only three I.L.S. observatories presently (1985) remain active—Carloforte, Italy: Kitab, U.S.S.R.: and Misuzawa, Japan.

International Map of the World #A series of topographic maps started in 1913 with the aim of mapping the world at a uniform scale and projection, with each country mapping its own area. A scale of 1:1,000,000 and the Lambert conformal conic map projection were adopted, together with specifications on contour intervals, coloring, symbols for boundaries, etc.# See also *map projection, International Map of the World.*

International Polar Motion Service #An organization established in 1962 to take over the work of the *International Latitude Service* and to include, with the I.L.S. data, data from a large number of other observatories now also determining latitude.#

A wide variety of instruments is used. The principal varieties are the visual zenith telescope, the photographic zenith telescope, and the Danjon astrolabe.

intersection (geodesy) #Determining the position of an unoccupied station as the intersection of two lines drawn with specified directions from two other stations of known location.#

See also *resection.*

interval, equatorial #One of the angles, expressed in units of time, between the various lines on the reticle of an astronomical transit and the average position (central axis) of those lines.#

The equatorial interval for a given line of a reticle is equal to the interval required for the image of a star on the Equator (declination 0°) to travel from the line in question to the central axis of the reticle, or from the central axis to the line in question (the instrument is oriented in the meridian). In determining time with an astronomical transit, equatorial intervals are used to reduce incomplete observations to an average value.

interval, Greenwich #An interval based on the Moon's transit of the Greenwich celestial meridian.#

This is not the same as a local interval based on the Moon's transit of the local celestial meridian.

interval, high water See *water interval, higher high,* etc.

interval, local See *interval, Greenwich.*

interval, lunar #The difference in time between the transit of the Moon over the Greenwich meridian and over a local meridian.#

The lunar interval equals the difference between the Greenwich and local intervals of a phase of the tide or tidal current. The average value of this interval, in hours, is $-0.069\ \lambda$, where λ is the local longitude in degrees.

interval, lunitidal #The difference in time between the Moon's transit (upper or lower) over the local or Greenwich meridian and the following *high* or *low water*. #

The mean high water lunitidal interval, abbreviated to high water interval, is the average of all lunitidal intervals from transit to following high water for all phases of the Moon.

The mean low water lunitidal interval, abbreviated to low water interval, is defined similarly. The interval is described as local or Greenwich according to whether reference is to the transit of the Moon over the local or over the Greenwich meridian. When not otherwise specified, the local meridian is implied. Also called establishment.

When there is considerable *diurnal inequality* in the tide, separate intervals may be obtained for the higher high waters, the lower high waters, the higher low waters, and the lower low waters. These are designated, respectively as higher high water interval, lower high water interval, higher low water interval and lower low water interval. In such cases, and also when the tide is diurnal, it is necessary to distinguish between the upper and lower transits of the Moon with respect to its declination.

interval, stadia See *stadia interval.*

interval, tropic #*Lunitidal intervals* pertaining to either the *higher high water* or the *lower low water* at the time of the *tropic tides*.#

interval, water See *interval, lunitidal*.

intervalometer #A device that operates the shutter of an aerial camera at intervals that take into account the airplane's velocity so that successive photographs overlap by a predetermined amount.#

invar #An alloy of nickel and steel that has a very low coefficient of thermal expansion (about 1/25 that of steel).#

A similar alloy has replaced steel in the construction of tapes for measuring geodetic base lines; it is used wherever a metal is desired that does not change its dimensions appreciably with temperature. Invar also is used for the scale of some leveling rods, in first-order leveling instruments and in pendulums.

inverse See *inverse, geodetic.*

inverse, geodetic #Computation of the distance and direction between two points, on an ellipsoid, with known coordinates.#

Also referred to simply as an inverse.

inverse, geographic See *position computation, inverse.*

inverse position computation See *position computation, inverse.*

inversor (1) #A mechanism used to maintain proper geometric relationship (collinearity and correct conjugate distances) between object plane, lens, and image plane in automatically focusing copy-cameras and rectifiers.#

(2) #A mechanical device in a camera for ensuring that Newton's law

$$xx' = f^2$$

for the relationship between object distance x, image distance x', and focal length f is always satisfied.#

inversor, cam #An *inversor* embodying a cam following a specially shaped track is used in rectifiers and similar instruments to keep the lens and the two focal planes in proper relationship with changing distances of projection.#

inversor, Carpentier #An *inversor* consisting of a long rod pivoted a fixed distance below the lens plane and having sliding sleeves on the upper and lower arms through which pass rods rigidly connected to the negative and easel planes.#

inversor, Peaucellier #An *inversor* consisting of four pivots connected by four rods that form an equilateral rhombus with one vertical and one horizontal diagonal. The two pivots on the horizontal diagonal are connected by another pair of rods, shorter in length than the others, pivoted at a point on the vertical diagonal. The lowest pivot is a fixed distance above the easel, which does not move; the uppermost pivot is the same fixed distance (the focal length of the lens) below the plane of the negative, which does move. The other pivot on the vertical axis is in the plane of the lens, which also moves.#

Also called a scissors inversor.

inversor, Pythagorean See *inversor, right-angle.*

inversor, right-angle #An *inversor* consisting of (a) a right-angled lever pivoted at a fixed point in the plane of the lens and (b) two rods, one connected rigidly at one end to the plane of the easel and by a sliding sleeve at the other end to the longer arm of the lever; the other is connected rigidly at one end to the plane of the negative and by a sliding sleeve to the shorter arm of the lever at the other end.#

Also called a Pythagorean inversor.

ionosphere #The atmospheric shell characterized by layers of high ion density. Its base lies at between 70 and 80 km; its top is indefinite.# The ionized layers cause appreciable dispersion of radio waves with frequencies of less than 1 GHz.

island (1) #A body of land extending above and completely surrounded by water at mean high water.#

This definition is universally used in surveying and mapping in the United States of America and is fully supported by Federal court decisions relating to the ownership of land. In other parts of the world, however, international negotiations are affected by a number of different conceptions of what constitutes the boundary line between the land and the water.

(2) #A naturally formed area of land, surrounded by water, which is above water at high tide.# (according to Geneva Convention)

isobar (1) #A line on which all points are at the same atmospheric pressure.#

(2) #The line on a chart, representing the *isobar* (1).# A surface representing a constant pressure level in the atmosphere is called an isobaric surface.

isocenter (1) #The unique point common to the plane of a photograph, its *principal plane*, and the plane of a hypothetical photograph assumed truly vertical and taken from the same camera station and having the same *principal distance.* #

(2) #The point of intersection, on a photograph, of the *principal line* and the *isometric parallel.* #

(3) #The point on a photograph intersected by the bisector of the angle between the plumb line and the photograph perpendicular.#

The isocenter is significant because it is the center from which tilt-caused displacements of images radiate.

isogram See *isopleth.*

isoline (photography) #A line representing the intersection of the plane of a vertical photograph with the plane of an overlapping, oblique photograph.#

If the vertical photograph were free of tilt, the isoline would be the *isometric parallel* of the oblique photograph.

isopleth (1) #A line along which a particular quantity is constant; e.g., *contour, isobar, isotherm.* #

(2) #The line on a map or chart representing the isopleth on the Earth.# Also called an isogram.

isopor #A line on magnetic charts showing points of equal annual change.#

isopycnic line (1) #A line along which density is constant.#

(2) #The line on a map or chart representing a line of constant density on, above, or below the surface of the Earth.#

Also called, simply, an isopycnic.

isostasy #A condition of approximate equilibrium, in the outer part of the Earth, under which the gravitational effect of masses extending above the surface of the geoid in continental areas is approximately counterbalanced by a deficiency of density in the material beneath those masses; the effect of a deficiency of density in ocean waters is counterbalanced by an excess of density in the material under the oceans.#

The two principal theories as to the relative distribution of the matter producing isostasy are those of Airy and of Pratt. The Pratt theory postulated that the continents and islands project above the average elevation of the solid surface of the Earth because there is material of less density beneath them: the higher the surface, the less the density below. Under this theory, complete equilibrium exists at some uniform depth below sea level and should be at the same depth in oceanic regions as in land regions. The Pratt theory was used in the investigations of isostasy by Hayford and Bowie of the U.S. Coast and Geodetic Survey.

The Airy theory postulated that continents and islands are supported hydrostatically on highly plastic or liquid material, with roots or projections penetrating the inner material of the Earth, just as icebergs extend downward into the water, i.e., the greater the elevation, the deeper the penetration.

The fundamental difference between the two theories is that Pratt postulated uniform depth with varying density, while Airy postulated uniform density with varying depth.

isostasy, Airy's hypothesis of #The hypothesis that the pressure of matter above a certain level surface is balanced by the pressure of matter of constant density beneath that surface.#

This implies that the depth of isostatic compensation varies as a function of the topography (both on land and in the oceans). See also *isostasy.*

isostasy, Pratt's hypothesis of #The hypothesis that the pressure of matter above a certain level surface is balanced by the pressure of matter beneath that surface down to a constant depth (the depth of isostatic compensation).#

This implies that the density of matter varies as a function of the topography (both on land and in the oceans). See also *isostasy.*

isostatic adjustment #The process of restoring and maintaining the crustal condition of equilibrium of the Earth known as *isostasy.* #

The distribution of material in the outer part of the Earth is undergoing continual change by erosion, sedimentation, and other natural forces. The unbalanced condition which would naturally result from such disturbing processes is offset by the movement of material at considerable depths below the surface of the Earth. See also *isostatic compensation* and *isostatic compensation, depth of.*

isostatic compensation #The balancing of masses above and below the geoid so that vertical pressure in regions close to the geoid is approximately constant regardless of the elevation (or depth) of the physical surface.# See *isostasy.*

Such regions are said to be in isostatic equilibrium. If all parts of the region are in isostatic equilibrium, compensation is said to be local; if isostatic equilibrium holds for the region as a whole but not for all parts of the region, compensation is said to be regional. The terms completely compensated and undercompensated are also used to describe such compensations.

isostatic compensation, depth of #The depth at which the condition of equilibrium known as *isostasy* is complete.#

isostatic reduction See *gravity reduction, isostatic.*

isostatic reduction, Bullard method of See *gravity reduction, Hayford-Bullard method of.*

isotherm (1) #A line along which the temperature is constant.#

A surface on which the temperature is constant is called an isothermal surface.

(2) #The line on a map or chart representing a line along which the temperature is constant.#

J

Jacob's staff #A single staff or pole on which a surveyor's compass or other instrument can be mounted.# (Term not currently in use.)

A Jacob's staff, which was used in place of a tripod, was fitted with a ball-and-socket joint at its upper end, so that an instrument mounted on it could be adjusted to a level position. The foot was fitted with a metallic spur so the staff could be pressed firmly into the ground. Many of the early land surveys in the United States were made with surveyor's compasses mounted on Jacob's staffs.

Jäderin's method #A method for precisely measuring distance by using surveyor's tape or wire freely suspended between two marks on supports about 25 meters apart and kept under a constant tension.#

This method does not involve a support midway between the two marks as do other methods in which much longer tape or wire is used.

Julian century #36,525 days.#

Julian date See *date, Julian.*

Julian day #*Julian day number.*#

Julian day number #The number of days that have elapsed at Greenwich noon on the day designated, since Greenwich mean noon on January 1, 4713 B.C. (Julian calendar).#

The day starting at that epoch has Julian day number 0, and each following day is numbered consecutively.

Julian day number, modified #The number obtained by subtracting 2,400,000.5 from the *Julian day number.*#

Also called modified Julian day.

junction (leveling) #The place where two or more level-lines join (are connected together).#

junction detail #A sketch or diagram showing the details of the various levelings at a *junction.*#

junction figure #A configuration in a triangulation network in which three or more triangulation arcs meet or two or more arcs intersect.#

K

kappa (photogrammetry) #An angle of rotation about the z-axis.#

Usually denoted by the Greek letter κ. Also called swing.

Kavraisky's constant #A constant devised by Kavraisky for determining the latitudes for the standard parallels of a conic map projection by criteria that depend on the size and shape of the region being mapped.#

Kelvin scale See *temperature scale, Kelvin.*

Kennelly-Heaviside layer #An old name for a heavily ionized atmospheric layer, now known as the E-layer.#

Kepler ellipse #The ellipse generated by a set of *orbital elements* fixed at a particular time.#

The Kepler ellipse continuously changes with time if the *disturbing function* is nonzero.

Keplerian element See *element, Keplerian.*

Kepler's equation #The equation $M = E - e \sin E$ relating the *mean anomaly* M to the *eccentric anomaly* E of a body moving in an elliptical orbit of *eccentricity* e.#

Kepler's laws #The three laws governing the motions of planets (stated by J. Kepler in 1609 and 1619). The laws are: (1) Each planet moves in an elliptical path with the Sun at one focus of the ellipse; (2) the line from the Sun to any planet sweeps out equal areas of space in equal lengths of time; and (3) the squares of the sidereal periods of the several planets are proportional to the cubes of their average distances from the Sun.#

The first and second laws refer to the motion of an individual planet; the third law expresses a relationship between the motions of different planets. The laws are not strictly true, for they assume that the movement of one planet does not affect the movement of any other, that planetary movements do not change the location of the Sun, and that the Sun has no translational motion of its own.

Kerr cell #A transparent container containing a transparent medium of large dielectric constant (such as nitrobenzene) and a pair of metallic plates to which is applied a large voltage, producing a strong electric field across the material.#

The cell is usually placed between a pair of prisms that transmit only plane-polarized light. The prisms are oriented so that light transmitted by the one is normally not transmitted by the other because the direction of polarization is wrong. With the voltage turned off, the electric field is zero and no light can pass through the system. When the voltage is applied, the electric field rotates the plane of polarization of light passing through the cell so that the light can now pass through the second prism also. The Kerr cell is used as a shutter, either to generate pulses of light or to time the intervals between pulses. Some distance-measuring instruments use Kerr cells.

K-factor #The *base-height ratio* in photogrammetry.#

kilogram #The SI unit of mass, defined by a platinum-iridium body kept at the International Bureau of Weights and Measures near Paris and accepted internationally as the standard of mass.#

Kimura term #A very small variation (0.″03) in *polar motion.*#

The reason for the variation is not known. It has been attributed to seasonal variations of the personal equation of the observers, to seasonal refractive effects, and to the effect of a liquid core on the Earth's rotation. Details are given in Ross (1915) and Wako (1972). Also called the z-term and Kimura's z-term.

knife-edge See *pendulum.*

knot #A unit of speed defined (1978) as 1 *international nautical mile* per hour.#

It was previously defined as 1 *nautical mile* per hour, but this led to confusion because the American and British nautical miles differ by 1.184 m.

The knot is equal to 1.852 km/h.

krakovian #A rectangular array of numerical or algebraic quantities in which multiplication of two arrays is carried out column-by-column, rather than row-by-column as in matrix multiplication.#

The krakovian (also written "cracovian") was invented to decrease the chance of blunders in manual computations or on nonprogrammed calculators. However, the advent of large, programmable computers has eliminated the need for krakovians so they are no longer much used.

L

Lagrange's planetary equations See *Lagrange's variational equations.*

Lagrange's variational equations #A set of six first-order differential equations relating the rate of change of each of the six *orbital elements* to the derivatives of the *disturbing function* with respect to the elements.#

The exact form of the equations depends on what kind of orbital elements are chosen (Keplerian, Delaunay's, rectangular, etc.). See also *Gauss' variational equations.*

Lagrangian multiplier See *correlate.*

Lallemand's formulas #A set of formulas derived by L. Lallemand to indicate the increase of error with distance in spirit leveling; adopted as standard by the International Geodetic Association in 1912.#

The formulas were used by the Association in defining "leveling of high precision" and by various countries in evaluating their leveling networks.

Lambert grid See *grid, Lambert.*

Lambert's theorem (celestial mechanics) #The time required for a body to move between two points in its orbit depends only on the length of the chord between the two points and on the length of the perimeter of the triangle formed by the chord and the two radii to the points.#

Lambert "twin" tower See *tower, Lambert "twin".*

Lamé function #A solution of *Laplace's differential equation* 2 in ellipsoidal coordinates.#

Such functions are useful for expressing the potential of almost ellipsoidal bodies.

land, submerged #Land covered by water at any stage of the tides.#

Submerged land differs from *tideland* in that the latter is covered and uncovered by the tides.

land boundary See *boundary, land.*

land court #A tribunal established to administer legislative statutes relating to land boundaries and titles.#

land form #A shape into which the Earth's surface has been sculptured by natural forces.#

land information system #A *geographic information system* that focuses primarily on the land.#

The data content may relate to either the natural or cultural aspects of the physical environment.

land line #A real or imaginary line drawn on the ground.#

For example, the line connecting two monuments on a boundary is, in general, an imaginary line. A boundary marked by a line drawn on rocks or marked by a fence can be considered a real land line.

land-line adjustment #The depiction of *land lines* on a map to indicate their location relative to adjacent terrain and culture; the information shown on plats and field records of the Bureau of Land Management together with evidence, on the ground, of the locations of the lines are used to determine their locations on the map.#

landmark (1) #Any fixed object (monument or other material mark) used to identify the location of a boundary of a piece of land.#

(2) #Any prominent object, on land, which can be used for determining a location or a direction.#

land survey See *survey, land* and *surveying, land.*

land surveying See *surveying, land.*

lane (1) #The region on the ground within which the phase of a signal emitted by a radio station transmitting a continuous wave signal at a fixed frequency changes by 1 cycle.#

The boundaries of a lane are usually taken at whole wavelength intervals from a starting point where the phase is assumed to be zero.

(2) #The region on the ground within which the sum or difference of the distances from two fixed radio stations (each transmitting continuous-wave, fixed-frequency signals) changes by a whole number of wavelengths.#

If the sum is used, the boundaries of the lanes are ellipses; if the difference is used, the boundaries are hyperbolas.

lap #Those parts of two aerial photographs, taken from adjacent air stations, that show the same region on the ground.#

Forward lap occurs between successive photographs in the line of flight. Side lap occurs between successive photographs taken on adjacent lines of flight. Also called overlap, a term that appears to be replacing the term lap.

Laplace condition #The condition imposed by the *Laplace equation (1)* on a *geodetic azimuth* or *longitude*.#

Laplace correction See *Laplace equation (1)*

Laplace equation (1) (geometric geodesy) #The equation

$$\alpha_A - \alpha_G = +(\lambda_A - \lambda_G)\sin\phi_G$$

which expresses the relationship between *astronomic azimuth,* α_A, and *geodetic azimuth,* α_G, in terms of *astronomic longitude,* λ_A, *geodetic longitude,* λ_G, and *geodetic latitude* ϕ_G.#

The plus sign above differs from Mitchell (1948) because east longitudes, rather than west longitudes, are taken as positive.

The right side of the above equation is known as the Laplace correction. It is subtracted from the astronomic azimuth to yield the geodetic azimuth.

The *Laplace condition* (expressed by the Laplace equation) arises from the fact that, in the plane of the prime vertical, a component of the deflection of the vertical will yield a difference both between astronomic and geodetic longitude and between astronomic and geodetic azimuth; or conversely, that the differences between astronomic and geodetic values of the longitude and of the azimuth may both be used to determine the component of deflection in the plane of the prime vertical. Imposing the Laplace condition establishes a relationship between astronomic longitude and astronomic azimuth. Since longitudes can be carried through a triangulation network with very good accuracy, but azimuths cannot, the value of the deflection of the vertical is usually computed from the component in longitude (in the prime vertical). The value of the azimuth so obtained is known as a Laplace azimuth.

The deflection of the vertical at the initial station will affect all Laplace equations of the network.

(2) (physical geodesy) #The partial differential equation $\nabla^2 V = 0$ for the gravitational *potential function* V, or, if the coordinate system is rotating with rate ω, $\nabla^2 W = 2\omega^2$ for gravity potential function W.#

Since the Earth and the geoid are nearly spherical, when the Laplace equation is used as a condition on V, it is convenient to write the equation in the spherical (geocentric) coordinates, λ, ϕ', and r, where r is the radius of the sphere and λ and ϕ' are geocentric longitude and latitude respectively. The equation then is:

$$\frac{\partial^2 V}{\partial r^2} + \frac{2}{r}\frac{\partial V}{\partial r} + \frac{1}{r^2}\frac{\partial^2 V}{\partial \phi'^2} - \frac{\tan\phi'}{r^2}\frac{\partial V}{\partial \phi'} + \frac{1}{r^2\cos^2\phi'}\frac{\partial^2 V}{\partial \lambda^2} = 0$$

The equation applies to the gravity potential function if W is substituted for V and $2\omega^2$ is substituted for 0 on the right.

(3) #More generally the equation is $\nabla^2 V = 0$, where V is any function that has second derivatives with respect to the coordinates.#

Laplace station See *station, Laplace.*

lapse rate #The rate of decrease of an atmospheric characteristic, usually air temperature, with increasing altitude.#

Normally, the lapse rate is expressed as an absolute value; e.g., air temperature decreases at an average rate of 3.5°F per 1000-foot increase in elevation from close to the Earth's surface to the tropopause.

Larmor precession #The precession of a particle rotating in a magnetic field.#

laser #A *maser* generating emission in the visible spectrum.#

laser ranging #The measurement of distance by *laser* equipment.#

The distance measured is between the laser instrument and an optical retroreflector, and is obtained by halving the round trip time of the beam and applying suitable corrections for environmental conditions. Two widely used applications are in *distance-measuring equipment* and in *satellite geodesy*. In the latter, the reflector is placed on the satellite and the laser at a ground station. Lageos, launched in 1976 at an altitude of 6000 km, contains more than 400 reflectors and has provided valuable data on polar motion, Earth rotation, time-variations in the gravitational field, etc.

laser ranging, lunar #*Laser ranging* from the Earth to optical reflectors on the Moon placed by both manned and soft-lander unmanned missions.#

Because of the great distance between the Earth and the Moon, high energy lasers and long aperture telescopes must be used. Very few stations on Earth can satisfy these requirements. Most of the successful lunar ranging has been carried out from the McDonald Observatory near Ft. Davis, Texas. These observations have improved lunar dynamic theory and determination of Earth rotation.

latitude (1) #In general, the angular coordinate of a point specified as the angle from an *equatorial plane* to a suitably chosen line through that point.#

An angle measured northward or upward from the equatorial plane is considered positive; one measured southward is considered negative. The definition of "northward" is conventional. The equatorial plane in the case of the Earth is the Equator, but it can also be the plane of the ecliptic. (See *latitude, celestial.)*

(2) #The length of the arc, on an ellipsoid representing the Earth and in a plane through the polar axis, between the equatorial plane and a specified point of the ellipsoid.#

(3) #In plane surveying, the perpendicular distance, in a horizontal plane from an east-west reference line to the specified point.#

The difference in latitudes (in this sense) of the two ends of a line is sometimes called the "latitude" of the line. This term also describes the perpendicular distance of the middle of a line from the east-west reference line.

latitude, astronomic #The angle between the vertical and the plane of the *celestial Equator* or of the *equatorial plane*; also defined as the smaller of the two angles between the plane of the horizon and the axis of rotation of the Earth.#

Astronomic latitude is determined directly from observations on celestial bodies, uncorrected for *deflection of the vertical*. The term is applied only to locations on the Earth, and is reckoned north and south from the celestial equator at 0° to the celestial poles at 90°.

latitude, authalic #The quantity β in the equation below. β is related to the *geodetic latitude* ϕ of a point on an ellipsoid of revolution with semimajor axis a and eccentricity e by the equation

$$a_A^2 \sin\beta = a^2(1-e^2)\left[\frac{\sin\phi}{2(1-e^2\sin\phi)} + \frac{1}{4e}\,\ell n\left(\frac{1+e\sin\phi}{1-e\sin\phi}\right)\right]$$

or, to order e^2

$$\sin\beta = \sin\phi\left(1 - \frac{2}{3}e^2\cos^2\phi\right)$$

where a_A is the radius of the *authalic sphere* (a sphere whose area equals the area of the ellipsoid).#

latitude, celestial #The arc of a great circle perpendicular to the *ecliptic* and included between the ecliptic and the point whose latitude is to be defined.#

latitude, conformal See *latitude, isometric* (2).

latitude, difference of (plane surveying) #The difference in perpendicular distance, in a plane tangent to the ellipsoid, of the two ends of a line from an east-west axis of reference in that plane.#

latitude, fictitious #Angular distance from a *fictitious Equator*. #

latitude, geocentric (1) #The angle at the center of the ellipsoid between the equatorial plane of the ellipsoid and a line from the center to a given point. The center of the ellipsoid is at a specified center (mass, geometric, etc.) of the Earth. The equatorial plane passes through that same center and is perpendicular to a specified axis of the ellipsoid.#

The axis is usually, but not always, specified as being parallel to a rotational axis of the Earth.

(2) #The angle formed with the major axis of the ellipse, in a meridional section of the ellipsoid, by the radius vector from the center of the ellipse to a given point.#

In astronomy, geocentric latitude is also called reduced latitude, a term that is sometimes applied to parametric latitude in geodesy.

latitude, geodetic #The angle that the normal to the ellipsoid at a point makes with the equatorial plane of the ellipsoid.#

Geodetic latitudes depend on the chosen *geodetic datum*, which determines the orientation and dimensions at the ellipsoid.

A geodetic latitude differs from the corresponding *astronomic latitude* by the amount of the meridional component of the local *deflection of the vertical.*

latitude, geographic #A general term, applying alike to *astronomic latitude*, *geodetic latitude*, and *geocentric latitude*.#

latitude, geomagnetic #The angle from the *geomagnetic Equator,* measured northward or southward through 90° and labeled N or S to indicate the direction of measurement.#

Geomagnetic latitude should not be confused with *magnetic latitude.*

latitude, isometric (1) #The coordinate τ which forms with longitude a pair of *isometric coordinates* on the ellipsoid of revolution.#

In terms of geodetic latitude ϕ and eccentricity e of the ellipsoid it is given by

$$\tau = \ell n \left[\tan\left(\frac{\pi}{4}+\frac{\phi}{2}\right)\left(\frac{1-e\sin\phi}{1+e\sin\phi}\right)^{e/2}\right]$$

(2) #The quantity χ defined by

$$\tan\left(\frac{\chi}{2}+\frac{\pi}{4}\right) = \tan\left(\frac{\pi}{4}+\frac{\phi}{2}\right) / \left(\frac{1-e\sin\phi}{1+e\sin\phi}\right)^{e/2}$$

where ϕ and e have the same meaning as in (1).#

See Adams (1921) for a full discussion. Adams refers to (2) as the isometric latitude and (1) as an isometric coordinate. However, Thomas (1952) prefers isometric latitude for (1) and conformal latitude for (2).

latitude, magnetic #The angle between the horizontal and the lines of force of the Earth's magnetic field at any point.#

latitude, parametric #The angle θ defined by

$$\tan\theta = (b/a)\tan\phi$$

where ϕ is the *geodetic latitude,* and a and b are the semimajor and semiminor axes of the ellipsoid.#

Geometrically, the parametric latitude of a point P on the ellipsoid can be visualized as follows. It is the angle at the center of the ellipsoid between the equatorial plane and the line to a point A on a concentric sphere tangent to the ellipsoid at the equator, A being the point where a straight line perpendicular to the equatorial plane and passing through P hits the sphere.

latitude, rectifying #Given a sphere of radius such that a meridional circle on it has the same length as a meridional ellipse on the ellipsoid, the rectifying latitude is a latitude such that a length along a meridian from the Equator to that latitude on the sphere is exactly equal to the corresponding length on the ellipsoid.#

For the mathematical definition of the term, see Adams (1921).

latitude, reduced See *latitude, parametric.*

latitude, variation of #A quasiperiodic variation of about 0.″25 in the astronomic latitude of points on the Earth's surface caused by variation of the pole.# See *polar motion* and *pole, variation*.

A secular change of 0.″001 or less per annum may also be present.

latitude determination, Horrebow-Talcott method of #A precise method for determining astronomic latitude by measuring the difference of the meridional zenith distances of two stars of known declination, with one north and one south of the local zenith.#

The observations are made with a *zenith telescope* or with an *astronomical transit* that can be converted to serve as a zenith telescope. The two stars should have approximately the same meridional zenith distances, and their *culminations* should occur within a few minutes of each other. The astronomic latitude of the point of observation is computed to be one-half the sum of the declinations of the two stars, plus or minus one-half the difference of their zenith distances. The method is also called the zenith-telescope method of latitude determination.

latitude determination, Pevtsov method of #The hour angles h_1 and h_2 of a pair of stars are measured when the stars are at the same distance from the zenith. The astronomic latitude ϕ is then given by

$$\tan\phi = (\cos h_1 \cos\delta_1 - \cos h_2 \cos\delta_2)/(\sin\delta_2 - \sin\delta_1)$$

where δ_1 and δ_2 are the corresponding declinations.#

Correction is made for the inclination of the telescope according to the reading of the level of the telescope. To reduce systematic errors in timing, the pairs of stars selected should be within 10° to 40° of the meridian whenever possible.

latitude determination, secant method of See *secant method.*

latitude determination, Sterneck method of #The zenith distances of stars are observed as the stars transit the meridian, and the astronomic latitude is calculated from the equation

$$\phi = 0.5\ [(\delta_s + \delta_n) + (z_s - z_n)]$$

where δ_s and δ_n are the declinations and z_s and z_n zenith distances of stars south and north of the zenith.#

This method is similar to the Horrebow-Talcott method but does not require that pairs of stars lie at equal zenith distances from the observation points.

latitude determination, zenith-telescope method of See *latitude determination, Horrebow-Talcott method of.*

law of propagation of errors #The statement that the resultant error associated with the sum of two or more quantities is equal to the square root of the sum of the squares of the individual errors associated with those quantities.#

lead line #A long chain or line with a lead weight attached at one end.#

A lead line is used to measure water depths (usually up to 10 fathoms) by survey parties not equipped with electronic depth-measuring equipment; it also can be used to check such equipment.

league #A unit of distance which has varied in size, in different countries and eras, from about 2.4 to 4.6 miles, but in English-speaking countries is estimated at 3 miles.#

If the miles are statute miles, the unit is called a land league; if units are nautical miles, it is called a marine league.

least squares, Bayesian method of #The *method of least squares* that uses already known information about the covariances of the unknowns in deriving, from new measurements, new values of the unknowns and their covariances.# Equivalent to the method of *collocation.*

least squares, collocation method of See *collocation.*

least squares, method of #A method of determining those values for a set of independent variables, from a set of observed values (of the dependent variables) greater in number than the independent variables, which satisfy the condition that the sum of the squares of the differences between the observed values and the values (of the dependent variables) calculated using the determined values shall be less than the sum obtained by using any other values of the independent variables.#

The usefulness of the method rests in part upon the mathematical demonstration that if the errors in the measurements of any quantity follow a few reasonable laws, the most probable value of the quantity is the one for which the sum of the squares of the residual errors (or corrections) is a minimum. If the observations are of unequal *weight,* then the most probable value is the one for which the sum of the squares of the weighted residuals is a minimum.

leg See *course.*

Legendre equation #The differential equation

$$(1 - z^2)(d^2y/dz^2) - 2z(dy/dz) + [n(n+1) - m^2/(1 - z^2)]\,y = 0,$$

where m and n are constants.#

Legendre function #Any function satisfying the *Legendre equation*.#

Since the Legendre equation (q.v.) is of second order, two independent kinds of functions can satisfy the equation, Legendre functions of the first kind and Legendre functions of the second kind. If n is a non-negative integer, $m = 0$, and z is a real variable between -1 and $+1$, the functions of the first kind can be expressed as polynomials, called Legendre polynomials, in z. Legendre functions are geodetically important because they are solutions of *Laplace's equation* (2) when the latter is expressed in spherical coordinates.

Legendre polynomial #A polynomial $P_n(z)$ which is a solution of the *Legendre equation* with n a non-negative integer, $m = 0$, and the solution finite at the boundary values.#

See also *Legendre function* and *Legendre equation.* Given that $P_0(z) = 1$ and $P_1(z) = z$, the other polynomials can be found by using the recursion formula

$$(n+1)\,P_{n+1}(z) - (2n+1)z\,P_n(z) + n\,P_{n-1}(z) = 0.$$

Those polynomials can also be derived as the coefficients in the series expansion of the generating function

$$(1 - 2\rho z + \rho^2)^{-1/2} = \sum P_n(z)\rho^n.$$

Legendre series #A series whose terms involve *Legendre functions* or *Legendre polynomials*.#

Legendre's theorem #The angles A, B, and C of a spherical triangle whose sides are a, b, and c (supposedly very small with respect to the radius of the sphere) are equal to the corresponding angles of a plane triangle whose sides are a, b, and c, each increased by one-third the spherical excess of the triangle.#

Using Legendre's theorem greatly simplifies the treatment of spherical triangles by permitting their solution as plane triangles.

length #A number or quantity indicative of the separation of two connected points.#

The connection between the point can be either real or imaginary. For example, one refers to the length of a (geometric) line, although the line has no real existence. Compare *distance.*

length, end-standard of #A bar or block whose ends or sides are flat and are a defined or otherwise known length apart.#

The ends are usually optically flat, and polished to a mirror-like finish, so that the length may be measured by interferometry.

length, focal See *focal length.*

length, standard of #A physical representation of a unit of length that is approved by authority or is otherwise commonly agreed on.#

A standard of length is dependent on temperature, pressure, and other physical conditions around it; it is an exact embodiment of the unit it represents only under definite, prescribed conditions. See also *meter* and *yard*.

Standards of length are classified according to the accuracy and precision with which they represent the given unit. These are prescribed by their intended use and have been designated (Mitchell, 1948) as follows:

(a) primary—an international or national prototype standard of length, see *standard, primary*;

(b) secondary—a standard of length that has been compared directly with the primary standard;

(c) reference—a standard of length suitable for use in the construction of precise instruments to be used in scientific investigations;

(d) working—a standard of length suitable for all ordinary precise work, as in college laboratories, the general manufacture of precise instruments, and for the use of State and city sealers of weights and measures; and

(e) commercial—a standard of length satisfying the requirements of local sealers of weights and measures, drafting, machine work, etc.

Standards of length are also classified according to their design:

(a) line standard, on which the unit of length is defined as the distance between lines or marks on the surface of the standard, under prescribed conditions;

(b) end standard, on which the unit of length is defined as the distance between the ends of the standard, under prescribed conditions (also called a contact standard); and

(c) wavelength standard, in which the unit of length is defined as a specified multiple of some wavelength of electromagnetic radiation.

lens #An object of material transparent to the specific range of the electromagnetic spectrum under observation, bounded by curved surfaces (usually spherical and radially symmetrical), that redirects entering radiation to form an image of the source of the radiation.#

Lenses for light are commonly made of glass or quartz; lenses for infrared radiation are made of silica, fused halides, etc.; lenses for radio waves have been made from gases enclosed in plastic bags, etc. Properly speaking, a lens consists of one continuous body. However, a combination of two such bodies in direct contact or separated by a film of material is often also called a lens, although such an assembly, when used as part of a larger assembly, is properly referred to as a "component" or, if used alone, as a "compound lens". Any combination or assembly of lenses that is assembled as a unit is also often referred to as a lens. However, such an assembly is more properly called a lens system. The fixed combination of a lens system and the mechanical structure holding the components rigidly together is sometimes called the lens barrel, or, in aerial photography, the lens cone.

lens, achromatic #A lens system whose *chromatic aberration* is corrected for two different wavelengths.#

Alternatively, a lens system that brings rays at two different wavelengths from a single point in object space to a focus at a single point in image space.

This is done by using glass (or other material for invisible radiation) of different indices of refraction for the lenses. The indices are proportioned so that the chromatic aberration in one element is compensated by that in another. Achromatic systems are usually also aplanatic, that is, they are free of spherical aberration.

lens, anallactic #A *convergent lens* fitted between the objective lens and the diaphragm of a telescope which is used to bring the apex of the triangle of which the *stadia rod* is the base into the center of the telescope and so permit direct measurement of distance.#

lens, aplanatic #A lens system that transmits light without introducing *spherical aberration* into the image.#

lens, compound See *lens*.

lens, convergent #A lens or lens system that brings rays together to a focus.#

Sometimes restricted to the case where the rays originate from a point, i.e., a lens that creates a real image of a point source.

lens, divergent #A lens or lens system that causes rays to diverge and thus appear to emanate from some point other than the actual source.#

lens, Fresnel #A lens divided into circular zones so that, within each zone, the radius of curvature of the surface is the same as the curvature of the corresponding zone of a regular convex or plano-convex lens, but the thickness of the material is the same at the outer edge of each zone.#

A circular Fresnel lens therefore has a cross section that is saw-toothed, with curved rather than straight profile for the slant part of each tooth. Such a lens has about the same optical properties as a regular lens of the same diameter and focal length, but is much lighter because the material does not increase in thickness from edge to center of lens.

lens, Luneburg #A spherical lens in which the index of refraction n varies with the distance r from the center according to the formula

$$n = r^{m-1}/(1 + r^{2m}),$$

where m is a constant equal to or greater than 1. When $m = 1$, the lens is the "fisheye" lens. The general Luneburg lens has found most application in microwave radar.#

lens, narrow-angle (1) #A lens system that has a field of view not greater than 60°.#

(2) #A lens system that has a focal length approximately two times or more longer than the greatest dimension of the image.#

lens, normal-angle (1) #A lens system that has a field of view between 60° and 75°.#

(2) #A lens system that has a focal length approximately equal to the greatest dimension of the image.#

lens, objective #That part of a telescope or microscope which receives light directly from the object and forms the first image.#

In a camera, the image formed by the objective lens is the final image. Also called an objective.

lens, principal axis of #The line perpendicular to both surfaces of a lens.#

In a well-centered lens system in which the principal axes of the components are in the same straight line, that line is called the optical axis, or simply the axis, of the system.

lens, spherical #A lens in which all surfaces are sectors of spheres.#

Most lenses are of this type.

lens, super-wide-angle (1) #A lens system with a field of view greater than 100°.#

(2) #A lens system whose focal length is appreciably less than half the greatest dimension of the image.#

lens, wide-angle (1) #A lens system with a field of view of between 75° and 100°.#

(2) #A lens system whose focal length is approximately half the greatest dimension of the image.#

lens calibration See *lens system, calibration of.*

lens cone #In an aerial camera, the lens system together with the mechanical structure that holds the components rigidly in place with respect to each other.#

lens law #The equation relating the object distance (measured from the front nodal point of an optical system), the image distance (measured from the rear nodal point), and the focal length of the optical system.#

The simplest form of the lens law, and the one most often used in photogrammetry, is

$$1/d_0 + 1/d_i = 1/f$$

where d_0 and d_i are the object point and image point distances to the front and rear nodal points, respectively, and f is the focal length.

lens system, calibration of (photogrammetry) #Determination of the equivalent focal length, resolution, distortions, and other aberrations in a lens system.#

lens system, nodal point of #One of two points on the optical axis of a lens system at which a ray emergent from the second point is parallel to the ray incident at the first.#

The first nodal point is also called the front nodal point, the incident nodal point, or the nodal point of incidence; the second point is called the rear nodal point, the emergent nodal point, or the nodal point of emergence.

Sometimes called node.

lens system, process #A lens system for photographically copying, enlarging, or projecting images, that is nearly free from aberrations, usually has a small aperture and is symmetrical in construction.#

lens system, sidereal focus of #The location of the principal focal plane of a lens system.#

A camera or telescope is in sidereal focus when incident rays from a great distance focus in the plane of the photographic plate or of the reticle. Also called solar focus.

level (1) See *level, spirit.*

(2) #By extension, any instrument containing a spirit level or used for the same purpose as an instrument containing a spirit level.#

See *leveling instrument.*

(3) (adjective) #Horizontal; tangent to an equipotential surface (of the gravity field).#

(4) (adjective) #Equipotential.#

(5) See *elevation.*

level, Abney See *level, hand.*

level, automatic See *leveling instrument, automatic.*

level, axis of a spirit #The line tangent to the top inner surface of a *spirit level* at the center of its graduated scale, and in the plane of the tube and its center of curvature.#

Also called axis of the level and axis of the level bubble. When the bubble is in the center of the graduations, and the plane through the center-line of the vial and its center of curvature is vertical, the axis of the spirit level will be horizontal.

level, base #A surface that is level and from which vertical distances are measured or calculated.#

level, bull's-eye See *level, circular.*

level, chambered spirit #A *spirit level* with a partition near one end that partially cuts off a small air reservoir; this device permits regulation of the length of the air bubble.#

level, circular #A *spirit level* in which the inner surface of its upper part is ground to spherical shape.#

The outline of the bubble formed in such a level is circular, and the graduations are concentric circles. This form of spirit level is used where precision is not critical, such as for plumbing a level rod or for setting an instrument in approximate position. Also called universal level or bull's-eye level. See *level, spirit.*

level, compensator See *leveling instrument, compensator* and *leveling instrument, automatic.*

level, dumpy #A leveling instrument in which the telescope is permanently attached to the leveling base, either rigidly or by a hinge about which the telescope can be rotated by means of a micrometer screw.#

The dumpy level takes its name from the appearance of early types of this instrument, on which the telescope was short, had a large objective lens, and hence, a dumpy appearance.

level, Egault #A leveling instrument, no longer in general use, in which the spirit level is attached to a leveling bar with *wyes* in which the telescope rests.#

In the *wye level*, the spirit level is attached to the telescope and is reversed with it. In Egault levels, the telescope can be reversed in the wyes without disturbing the spirit level.

level, error of the See *C-factor.*

level, first-order See *leveling instrument, first-order.*

level, Fischer #A binocular *dumpy level,* constructed of *invar,* with the *spirit level* mounted in the tube of the telescope quite close to the *line of collimation*. An arrangement of mirror and prisms brings an image of the bubble to one eyepiece; the leveling rod is viewed through the other. The telescope is mounted so that its inclination can be adjusted through a small angle without altering its elevation.#

The observer views the leveling rod and the bubble simultaneously. The inclination of the telescope is adjusted by turning a screw until the bubble is visible in the middle of its tube; the leveling rod is read with the bubble in the average position. This level was designed by E. G. Fischer, and adopted by the U.S. Coast and Geodetic Survey in 1899. (The use of invar in its construction is of more recent date.) It is no longer used, because self-leveling instruments are more convenient.

level, Gravatt #A *dumpy level* with the *spirit level* mounted on top of a short telescope having a large objective lens.#

Later, the telescope was mounted on *wyes*. This is said to be the original dumpy level, a distinction also claimed for the *Troughton level*.

level, half-tide See *water level, half-tide*.

level, hand #A small leveling instrument, designed to be held in the hand, in which the *spirit level* is so mounted that the observer can see the bubble at the same time that he observes an object through a telescope.#

The bubble is viewed by means of a prism or mirror in the telescope. The instrument is used in reconnaissance for surveys, in taking cross sections and in other work where great precision or accuracy is not required. The Abney and Locke levels are well-known varieties.

level, hanging #A *spirit level* mounted with its tube lower in elevation than its points of support.#

A hanging level literally hangs from that part of the surveying or astronomical instrument whose position it measures with respect to a horizontal line. It is used in place of a *striding level* to measure the inclination of the horizontal axis of the *broken-telescope transit*.

level, Horrebow-Talcott #A very sensitive *spirit level* mounted on the axis of a *transit*; used for precise measurement of *zenith angles*. #

level, latitude #A sensitive *spirit level* attached to the telescope of an instrument used for observing astronomic latitude. When the telescope is clamped in position, the level measures variations in the direction of the *line of collimation* in the vertical plane.#

The latitude level is more sensitive than the finder circle level of an astronomical telescope.

level, Lenoir #A leveling instrument, now obsolete, in which each end of the telescope passes through a steel block; the upper and lower faces of these blocks are flat and closely parallel. The lower faces rest upon a brass circle and the upper faces support a spirit level, which is reversed in leveling the instrument.#

level, Locke's See *level, hand*.

level, pillbox See *level, circular*.

level, precise See *leveling instrument, precise*

level, spirit (1) #A small, closed container of transparent material (usually glass), with the upper part of its inner surface curved, either torically or spherically. The container is nearly filled with a fluid of low viscosity (alcohol or ether), with enough free space so that a bubble of air or gas always rises to the top of the container. The outer surface of its upper part carries an index mark or graduations.#

Much surveying depends upon using an instrument to establish a horizontal plane; this is done by use of a spirit level. For highly precise work, a spirit level of great sensitivity is used.

Two types of spirit level are used in surveying: in one, the internal, curved surface is spherical and the bubble appears circular when viewed from above. The other, a more generally used type, is shaped internally like a curved cylinder (a segment of a torus); this is the type usually referred to when the term spirit level is used.

The curved cylinder type of spirit level is used on surveying and astronomical instruments for precisely referring to the horizontal plane or to the zenith. The sensitivity (sometimes called sensibility) of a spirit level depends upon the radius of curvature of its longitudinal section; the longer the radius, the more sensitive the spirit level. The sensitivity is expressed by marking a division between graduations on the tube with its equivalent angular value at the center of curvature of the tube.

(2) #A leveling instrument that contains a spirit level.# See (1) above.

level, Stampfer #A type of leveling instrument, now obsolete, having the telescope mounted so it can be rotated about a horizontal axis by a known amount by using a *striding level* and an adjusting screw.#

level, striding #A *spirit level* mounted so it can be placed above and parallel to the horizontal axis of a surveying or astronomical instrument for use in measuring the inclination of the horizontal axis to a horizontal plane.#

It is used to make the inclination of the horizontal axis quite small and then to measure the magnitude of any remaining inclination.

level, tilting See *leveling instrument, tilting*.

level, Troughton #An English leveling instrument, now obsolete, with its spirit level permanently attached to the top of the telescope.#

This is said to be the original dumpy level, a distinction also claimed for the Gravatt level.

level, U.S. Geological Survey #A *dumpy level* constructed of stainless steel, with an internally focusing telescope. The bubble of the spirit level is centered by making the ends of two images of the bubble coincide by adjusting a prism and mirror.#

This instrument has been used by the U.S. Geological Survey in second- and third-order leveling. The interval between stadia wires is set so that the half-interval intercept on the leveling rod, multiplied by 1,000, gives the distance to the rod in feet.

level, universal See *level, circular* and *level, spirit*.

level, wye #A leveling instrument with its telescope and attached spirit level supported in *wyes* (Y's), in which it may be rotated about its longitudinal axis (collimation axis), and from which it may be lifted and reversed, end for end.#

The adjustments made possible by this mounting are peculiar to the instrument. It forms one of two general classes of leveling instruments, the other class is represented by the *dumpy level.*

level, Y See *level, wye.*

level collimation correction factor See *collimation correction factor.*

level collimation error See *collimation error, level.*

level constant See *collimation correction factor.*

level correction #The correction to an observed difference of elevation caused by the *level error.* #

It is calculated by dividing the *collimation correction factor* by the *stadia factor* and multiplying the result by the *imbalance*.#

level error (1) #The angle between the horizontal axis of a telescope mount and a horizontal plane through that mount.#

(2) #The angle from a horizontal plane through the vertical axis of a leveling instrument and the line of sight of the leveling instrument.#

It is the sum of the *level collimation error* and the amount by which the vertical axis is not exactly vertical.

leveling (1) #The process of finding vertical distances (elevations) from a selected equipotential surface to points on the Earth's surface, or of finding differences of elevation.#

Usually, leveling must be done either as the sum of incremental vertical displacements of a graduated rod (*differential leveling*) or by measuring vertical angles (*trigonometric leveling*). Unless some other method is specified, differential leveling is usually meant.

The term is sometimes used to refer to barometric altimetry and topographic photogrammetry. It is also used in referring to the astronomic determination of the geoid (see *geoid determination, astrogeodetic method of*), and may be known as astrogeodetic leveling or astronomic leveling. The reference surface required by the definition is, ideally, the geoid but, because the geoid is not accessible by any method of surveying, the surface actually used is one assumed to be close to the geoid, even though it may not be exactly an equipotential surface.

Leveling between two points relatively close to each other (within 2-3 meters vertically, and less than 100 meters horizontally) is done by holding a graduated leveling rod vertically at each point and reading, with a horizontal telescope placed midway between the two points, the place where each rod intersects the horizontal plane established by the telescope's line of sight. The difference in readings is, approximately, the difference in elevation. If the points are farther apart than the distances mentioned above, measurements are made at shorter distance intervals and the total difference in elevation is taken as the sum of the resulting smaller measured differences.

The elevation of a point is determined by proceeding as above, starting at a point that is either on the reference surface or at a previously determined elevation. The desired elevation is called the orthometric elevation; quantities approximating the orthometric elevation and derived from the measurements by applying various kinds of corrections are given special names such as Helmert height, Niethammer elevation, and the like.

(2) #The process of finding the elevation of mean sea level above the geoid without reference to measurements on land.#

This is more properly called oceanographic leveling.

(3) #A *leveling network*.#

leveling, aero- See *aeroleveling.*

leveling, astrogeodetic See *geoid determination, astrogeodetic method of.*

leveling, astronomic See *geoid determination, astrogeodetic method of.*

leveling, barometric See *altimetry, barometric.*

leveling, classification of #The category (order and class) of *leveling* and of a *leveling network* is the same as the category of the vertical control (elevations) established by the leveling or leveling network.#

See *control, classification of.*

In the United States of America, the following categories are recognized:

Category	*Standard errors (mm)*
First order	
Class I	$\leq 0.5\sqrt{K}$
Class II	$\leq 0.7\sqrt{K}$
Second order	
Class I	$\leq 1.0\sqrt{K}$
Class II	$\leq 1.3\sqrt{K}$
Third order	$\leq 2.0\sqrt{K}$

K is the horizontal distance in kilometers between pairs of points. The standard errors are the largest values permitted in a particular leveling network category. See Federal Geodetic Control Committee (1984) for details.

leveling, compensator #Leveling carried out with a leveling instrument having a compensator (e.g., a self-leveling leveling instrument) for making a line of sight horizontal.# See *leveling instrument, compensator.*

leveling, differential #Determining the difference in elevation between two points by the sum of incremental vertical displacements of a graduated rod.#

The two usual methods of differential leveling are *spirit leveling* and *compensator leveling,* which differ in how the leveling instrument determines the horizontal line of sight.

leveling, direct #Determination of differences of elevation by means of measurements over a continuous series of short horizontal lines. The vertical distances from the lines to marks underneath are determined by direct observations of graduated rods with a leveling instrument.#

leveling, double-rodded #Leveling carried out by a single observer using a single leveling instrument, but two sets of leveling rods. Foresights are taken on each of two rods at two separate turning points and backsights on two other rods at two other separate turning points, all from the same location of the leveling instrument.#

Also called double-simultaneous leveling.

leveling, double-run #Leveling done by proceeding from starting point to final point and then returning to the starting point in the opposite direction.#

Usually, the same general route is taken on returning as on going out, and points occupied in the morning on the forward part of the journey are occupied in the afternoon on the returning part. This and other precautions are intended either to cancel or to identify systematic errors as well as to reduce random errors.

leveling, double-simultaneous (1) #Leveling carried out with leveling rods marked with two different scales, both on the same face or one on each face, with each scale being read immediately after the other is read.#

(2) See *leveling, double-rodded.*

By comparing the differences of elevation as computed from the different scales, a blunder can usually be detected. Statistically, the method gives approximately the same effect as using two foresights and two backsights. It will not detect other kinds of random or systematic errors.

leveling, first-order (1) #Leveling that results in first-order vertical control.#

See *leveling, classification of.*

(2) #Leveling by the procedures specified for first-order leveling.#

See *leveling, specifications for.*

leveling, fly (1) #Leveling done at the close of a working day to check the results of leveling an extended line run in one direction only; longer sights and fewer setups are used, as the purpose is to detect blunders.#

(2) #Leveling done with the ordinary equipment but by a procedure yielding results with a distinctly lower order of accuracy.#

Sometimes referred to as fourth-order leveling or flying leveling. Greater tolerances are permitted in balancing lines of sight, misclosures, and so on. Fly leveling may also be done with alidade and planetable, etc. Misclosures may be as much as 20 cm per km.

leveling, fourth-order See *leveling, fly.*

leveling, geodetic (1) #Leveling to a high order of accuracy, usually extended over large areas, to furnish accurate vertical control for surveying and mapping.#

(2) #The same as definition (1), but with the provision that systematic errors in the leveling are reduced to tolerable limits by applying corrections to the measurements during reduction of the data.#

leveling, geostrophic #Determining the difference in elevation between two points at mean sea level by measuring the velocity of the current between known points and assuming that the water is in *geostrophic equilibrium*, i.e., that the hydrostatic pressure is balanced by the Coriolis effect.#

The basic equation is

$$k_g(v_2 - v_1) = (P_2 - P_1)/(\rho L)$$

where v_1 and v_2 are the speed of the current at stations 1 and 2, respectively, P_1 and P_2 are the corresponding pressures there, L is the distance between the two stations, ρ is the density of the water, and k_g is the Coriolis parameter $2\ \omega \sin \phi$, where ω is the angular rate of rotation of the Earth, and ϕ is the geodetic latitude. By measuring the velocity of flow, the difference in pressure and hence the difference in elevations can be calculated.

leveling, hydrodynamic #Determining the difference in elevation between two points at mean sea level by making use of the fact that a difference in elevation causes a difference in pressure, and a difference in pressure will cause water to flow.#

The particular case in which the water flows in response to the combined pressure gradient force and *Coriolis force*, in a direction at right angles to the line joining the two points, is called geostrophic leveling. In the more complex case, the flow of water may be hindered by a barrier.

leveling, hydrostatic (1) #Leveling between two points by connecting them with a tube open at both ends but filled almost to the ends with liquid.#

The liquid at one end is brought to the level of that point, and the vertical distance of the point at the other end of the tube is the difference between the level of the liquid (the same level as the first point) and the end of the tube. The ends of the tube may be graduated to make it unnecessary to bring the liquid to the end of the tube at either point. See *leveling, pipeline.*

(2) #Determining the difference in elevation between two points at mean sea level by measuring the salinity, temperature and pressure of the water and assuming that the water is in hydrostatic equilibrium above some identifiable isobaric surface that coincides with an equipotential surface.#

leveling, indirect #Determining differences of elevation by indirect means, e.g., (a) vertical angles and horizontal distances (trigonometric leveling), (b) deriving altitudes from values of atmospheric pressure measured with a barometer (barometric altimetry), or (c) deriving altitudes from values of the boiling point of water determined with a hypsometer (thermometric altimetry).#

leveling, motorized #Leveling in which the leveling rods and leveling instruments are carried on individual vehicles during a project.#

Leveling rods are fastened by linkages to the vehicles carrying them so that they may be swung on and off easily; the leveling instrument may be supported in a similar manner or may be mounted on and used from the vehicle.

leveling, oceanographic #Determining the vertical distance between mean sea level and the geoid (i.e., the elevation of mean sea level) by calculation from measurements of density, velocity, or other characteristics of the water.#

The two principal kinds of oceanographic leveling are hydrostatic, in which elevations are determined from measurements of salinity, temperature, and pressure; and hydrodynamic, in which velocity of currents is measured.

leveling, pipeline #Establishing a common level at two points by running an open-ended pipe or tube nearly filled with water from one point to the other.#

Knowing the elevation of the water surface at one end, the elevations of the points at each end can be determined from the heights of the points above the surfaces of the water. Also called hydrostatic leveling. Pipeline leveling usually refers only to hydrostatic leveling in which the fluid is water, the two ends are separated by a considerable distance, and great accuracy is not required.

leveling, precise (1) #First-order leveling.#

(2) #Leveling done with careful and frequent adjustment and calibration of the instruments used.#

leveling, profile (1) #Determining elevations at closely spaced points along a line in order to determine the profile of the ground.#

The points are marked by stakes 25, 50, or 100 ft apart. The points at 100-foot intervals, starting from the beginning of the line, are called full stations; all other marked points are called plus stations.

(2) #The plotting of changes in differences of elevation; these changes are determined by comparing the results of two surveys done at different times.#

leveling, reciprocal #Determining the difference of elevation between two points by taking foresights to two leveling rods from one setup and backsights to the rods from a second setup.#

The method is used mainly when it is not feasible to level between two points by ordinary methods, as is the case when the points are separated by a wide river or steep valley. This method eliminates errors caused by the curvature of the Earth or by lack of collimation, but does not usually eliminate all of the error caused by refraction.

leveling, second-order (1) #Leveling that results in second-order vertical control.# See *leveling, classification of.*

(2) #Leveling done by the procedures specified for second-order leveling.#

See *leveling, specifications for.*

leveling, single-run #Leveling done by proceeding from the starting point to the final point of a level line without leveling back to the starting point.#

leveling, specifications for #Specifications of certain leveling procedures and criteria that are considered essential for obtaining vertical control of each of several specified categories.#

The procedures and criteria considered essential for obtaining vertical control by leveling in the United States of America are given in Federal Geodetic Control Committee (1984). Leveling done according to specifications for a particular category will probably, but not necessarily, produce control satisfying the standards for that category. See *control, classification of.*

leveling, spirit #Leveling with a leveling instrument that depends on a *spirit level* for making its line of sight horizontal.#

A spirit level is attached to a telescope so that the axis of the level and the line of collimation of the telescope can be made parallel and the level can be adjusted so that its axis is horizontal. The difference of readings on leveling rods on two different points is the difference in elevation of the points. If the elevation of one point is known, the elevation of the other also becomes known.

Instruments used in spirit leveling are of various designs to satisfy needs based on speed, cost, accuracy, and precision.

leveling, stadia #Determining a sequence of consecutive differences of elevation by using a *transit* and *stadia rod.* #

leveling, steric See *leveling, hydrostatic (2).*

leveling, thermometric See *altimetry, thermometric.*

leveling, third-order (1) #Leveling that results in third-order vertical control.# See *leveling, classification of.*

(2) #Leveling done by the procedures specified for third-order leveling.#

See *leveling, specifications for.*

leveling, three-wire #A method of leveling using a leveling instrument that contains a reticle on which there are three horizontal lines. The leveling rod is read at each of the three lines and the average is used for the final result.#

leveling, trigonometric #Determining differences of elevation by observing vertical angles between points.#

Either the horizontal distance between the points must be known or the straight-line distance must be measured. See also *angulation, vertical.*

leveling, water #Determining relative elevations of points by measuring the difference of elevation of each point with respect to the surface of a body of still water.#

The surface of a body of still water, such as a lake, is very nearly a level surface and provides a common surface of reference for all the points. The term "water levels" is generally used with this meaning.

leveling adjustment #Determining corrections to measured elevations, or differences between elevations, of points in a leveling network so that the resulting elevations or differences in elevations are the best obtainable under the given conditions of observation.#

The adjustment removes the inconsistencies in a network that result from accumulation of small random and systematic errors.

leveling correction See *level correction.*

leveling correction, adjustment #The quantity added to an *orthometric elevation* or *geopotential number* to produce an adjusted value and to eliminate misclosures.#

Usually referred to as an adjustment correction.

leveling correction, dynamic #The quantity that must be added to the observed or calculated elevation of a point to obtain its *dynamic height.* #

leveling correction, level See *level correction.*

leveling correction, orthometric #The quantity added to an observed difference of elevation to correct for the error introduced when level surfaces at different elevations are not parallel.#

Usually called orthometric correction.

leveling correction, rod #The quantity added to an observed difference of elevation to correct for the error introduced when the intervals on the leveling rods are not actually of the length indicated by the numbers on the graduations.#

Usually called a rod correction. It is traditionally used as a correction to scale.

leveling correction, temperature #The quantity added to an observed difference of elevation to correct for the error introduced when the leveling rods are used at a temperature different from the temperature at which they were calibrated.#

Usually called a temperature correction. See also *calibration.*

leveling instrument #An instrument, consisting of a telescope and a device for making the line of sight horizontal, intended solely or primarily for establishing a horizontal line of sight.#

A leveling instrument, therefore, can be moved freely about a vertical axis, but vertical motion is restricted to that needed for adjusting the line of sight to a horizontal position. The most common type of leveling instrument has a *spirit level* for indicating when the line of sight is horizontal. Less common (because of higher cost) is the automatic leveling instrument. See *leveling instrument, automatic.*

leveling instrument, Abney See *level, hand.*

leveling instrument, automatic (1) #A leveling instrument whose line of sight is automatically kept horizontal even when the telescope is rotated about an axis that is not precisely vertical.#

Also called a self-leveling leveling instrument or a self-adjusting leveling instrument. Instruments using a pendulous element are also called compensator leveling instruments. Most instruments contain a pendulous mirror or prism in the optical system to establish a horizontal line of sight. Some, however, contain a small pool of mercury instead.

(2) #A leveling instrument that functions with minimal intervention by the operator.#

leveling instrument, compensator #An *automatic leveling instrument* in which the line of sight is kept horizontal by a set of prisms or mirrors that swing freely in response to gravity to compensate for the nonhorizontality remaining after the instrument has been leveled with a *circular level.* #

See also *leveling instrument, automatic.* The movable subsystem of prisms or mirrors is called a compensator, and may swing from wires or may be attached to a pendulum or a flexible spring.

leveling instrument, dumpy See *level, dumpy.*

leveling instrument, first-order #A leveling instrument designed for use in *first-order leveling*.#

A first-order leveling instrument is generally characterized by special design and by superior workmanship in construction. Sometimes called a geodetic level or geodetic leveling instrument.

leveling instrument, Fischer See *level, Fischer.*

leveling instrument, geodetic #A leveling instrument suitable for establishing vertical control.#

See *leveling instrument, first-order.*

leveling instrument, mercury-pool #A leveling instrument in which the line of sight is kept horizontal (to within several minutes of the vertical) regardless of the orientation of the vertical axis of the instrument by having the line of sight reflect from the free surface of a pool of mercury within the instrument.#

See *leveling instrument, automatic.*

leveling instrument, peg adjustment of a #A method of adjusting a leveling instrument like the *dumpy level,* to bring the *line of collimation* parallel to the axis of the *spirit level* and using two stable marks (pegs) on the ground placed one ordinary sighting distance apart.#

leveling instrument, pendulum #A leveling instrument in which the line of sight is kept horizontal by a prism or mirror mounted on a pendulum.#

See also *leveling instrument, automatic* and *leveling instrument, compensator.*

leveling instrument, precise #A leveling instrument for use where highly precise and accurate results are required.#

See *leveling instrument, first-order.*

leveling instrument, self-adjusting See *leveling instrument, automatic* and *leveling instrument, self-leveling.*

leveling instrument, self-leveling #Any leveling instrument in which the line of sight is made level with minimal intervention by the operator.#

See also *leveling instrument, automatic.*

leveling instrument, spirit-level type of #A leveling instrument having a *spirit level* attached to the telescope for leveling the line of sight.#

leveling instrument, Stampfer See *level, Stampfer.*

leveling instrument, tilting #A leveling instrument in which the line of sight is finally leveled by rotating the telescope on its trunnions.#

leveling instrument, Troughton See *level, Troughton.*

leveling instrument, U.S. Geological Survey See *level, U.S. Geological Survey.*

leveling instrument, wye See *level, wye.*

leveling line #A unit of field work consisting of *bench marks* and *temporary bench marks* connected by chains of differential leveling.#

leveling network #A collection of *level lines* connected together to form a network of loops or circuits extending over a region.#

Also called a vertical control network, a vertical network, or a level network.

leveling network, classification of See *leveling, classification of.*

leveling of high precision #A class of leveling adopted by the International Geodetic Association in 1912 and redefined by the International Association of Geodesy in 1936 and 1948.#

leveling party See *leveling unit.*

leveling rod #A straight rod or bar, designed for use in measuring a vertical distance between a point on the ground and the horizontal line of sight of a leveling instrument.#

A leveling rod, usually of wood, has a flat face that is graduated in some linear unit and fractions thereof, or to which is attached a metallic strip that is so graduated; the zero of the graduations is at the lower end of the rod. A leveling rod that has the graduations on a strip of invar is generally called an invar leveling rod. On some rods the numerical values of the graduations are intended to be read by the observer at the leveling instrument: such a leveling rod is called a speaking leveling rod or a self-reading leveling rod. Another type, called a target leveling rod, carries a disk (the "target") that is moved up or down on the leveling rod according to directions from the observer. When the disk is bisected by the line of sight, the numerical value of the graduation under the center of the disk is read by the rodman. The word leveling is commonly omitted when referring to these rods, e.g., Boston rod, invar rod, Philadelphia rod.

leveling rod, Barlow #A *self-reading leveling rod* on which graduations are indicated by triangles, each 0.02 of a foot in height.# It is no longer in general use.

leveling rod, Boston #A two-piece leveling rod with a target fixed on one end of the upper piece.#

The target is adjusted in elevation by moving one piece of the rod on the other. The scale on the rod is read against a vernier. For heights greater than 5.5 ft, the piece carrying the target end is used in upright position; for lesser heights, the target end is directed downward. The design is little used.

leveling rod, Conybeare #A *self-reading leveling rod*, no longer used, on which graduations are marked by alternately black and white tenth-of-foot divisions. Each division consists of three hexagons in either white or black.#

leveling rod, Gravatt #A *self-reading leveling rod*, no longer used, on which graduations are marked with rectangles each 0.01 of a foot high. The rectangles at the tenth-of-a-foot marks are longer; those at the 0.05 of a foot mark are identified by dots.#

leveling rod, invar #A leveling rod having the graduations marked on a strip of invar.#

The strip is set into the face of the rod, firmly attached to the rod shoe at the bottom of the rod, and held in place by guides and a spring at the top of the rod. Invar leveling rods are used in first-order leveling.

leveling rod, invar-band See *leveling rod, invar.*

leveling rod, Molitor precise #A *self-reading leveling rod*, no longer used, of T-shaped cross section, with graduations marked by triangles and rectangles. The smallest division is 2 mm.#

A thermometer and circular level are attached.

leveling rod, New York #A two-piece leveling rod, with a movable target; the rod is graduated to hundredths of a foot and read by vernier to thousandths of a foot.#

For heights greater than 6.5 ft, the target is clamped at 6.5 ft and is raised by extending the rod.

leveling rod, Pemberton #A *self-reading leveling rod* on which the graduations are marked with rows of alternately circular and diamond-shaped dots running diagonally across the rod.# It is no longer in general use.

leveling rod, Philadelphia #A leveling rod in two pieces, with a target; the graduations are designed so the rod may also be used as a *self-reading leveling rod*.#

For heights greater than 7 ft, the target is clamped at 7 ft and is raised by extending the rod. When the target is used, the rod is read by vernier to 0.001 of a foot. When the rod is used as a self-reading leveling rod, the rod is read to 0.005 of a foot.

leveling rod, self-reading #A leveling rod with graduations designed so that they can be read by the observer.#

The reading may be taken at the place on the rod where the central horizontal line on the reticle of the leveling instrument intersects the leveling rod, or may be calculated as the average of the places where the upper and lower horizontal lines on the reticle intersect the rod. Leveling rods used in current geodetic leveling are of this type.

Also called a speaking rod.

leveling rod, speaking See *leveling rod, self-reading.*

leveling rod, Stephenson #A *self-reading leveling rod* having graduations forming a diagonal scale with horizontal lines through the tenth-of-a-foot marks.# It is no longer in general use.

leveling rod, target See *leveling rod.* Target leveling rods are seldom used today in geodetic work except for leveling across wide rivers or steep valleys.

leveling rod, U.S. Coast and Geodetic Survey #A *target leveling rod* that had graduations on a metallic strip about 3 m long set in a wooden rod of cross-shaped (+) cross section. The lower end of the strip was firmly attached to the wooden rod, the upper end was free to respond to changes of temperature. Pointings were made on a target equipped with a small metallic scale.#

It was used by the U.S. Coast and Geodetic Survey in doing precise (now called first-order) and primary (now called second-order) leveling before 1895.

leveling rod, U.S. Coast and Geodetic Survey first-order #A *self-reading leveling rod* having a strip of invar that is held in place on one face by a spring at the top of the strip and by attachment at the bottom to the shoe of the rod. The strip is graduated alternately in black and white centimeter intervals, and is read by estimation to millimeters. The back side of the rod is graduated in feet and tenths. The rod carries a thermometer and circular level.#

Adopted in 1916, the rod was used until about 1967 in first- and second-order leveling.

leveling rod, U.S. Engineer precise #A *self-reading leveling rod* of T-shaped cross section; it is 12 ft long and is graduated in centimeters.#

leveling rod, U.S. Geological Survey precise (1) #A *self-reading leveling rod* graduated in yards and fractions of a yard.#

(2) #A *target leveling rod* of cross-shaped (+) cross section, a little over 12 ft in length. There are two forms of this rod: the single-target leveling rod, with graduations

on one face only; and the double-target leveling rod, with graduations on two opposite faces.#

leveling rod, yard (1) #A leveling rod graduated in yards and hundredths of a yard so that the sum of readings on the three horizontal lines of the reticle in the leveling instrument equals the length of the foresight or backsight in feet.#

(2) #A leveling rod graduated in yards and hundredths of a yard.#

leveling-rod constant #The difference in readings between marks at the same height on a leveling rod with two scales in the same units.#

leveling-rod stop #A small platform, fixed to a tide staff or to the support of a tide gauge, on which the foot of a leveling rod is placed in leveling from the tide gauge to the tide gauge bench mark.#

The leveling-rod stop itself is placed so that its upper surface, on which the leveling rod rests, is exactly at some integrally numbered mark on the tide staff or corresponds to some integral number in the recorder.

leveling-rod unit See *rod unit.*

leveling unit #A surveying team consisting of the smallest number of people ordinarily needed for leveling.#

A leveling unit consists of at least three people—an observer and two rodmen. Normally a recorder also goes along with the unit. The U.S. National Geodetic Survey has added a fifth person to the leveling unit to pace off the distances from rearward leveling rod to leveling instrument to forward leveling rod. A person whose duty it was to hold an umbrella over the instrument was formerly a standard part of the complement. Also called observing team, observing crew, observing unit, and level unit (jargon). The term "party" is used by the National Geodetic Survey for a group of leveling units, but "leveling party" is also commonly used synonymously with leveling unit.

level line #A set of measured differences of elevation, presented in the order of their measurement, and the similarly ordered set of points to which the measurements refer.#

It is also customary to refer, loosely, to either the set of points or the set of measured differences as a level line. The meaning intended by such use must be ascertained by context. See also *line of levels.*

level line, double-run #A *level line* in which the measurements are made from starting point to end point (the end point may be the same as the starting point, thus forming a looped level line) and then back again in the opposite direction.#

See also *leveling, double-run.*

level line, duplicate #A *level line* composed of two single lines run over the same route, but in opposite directions, and using different turning points for each.#

level line, multiple #Two or more single *level lines* run between the same terminal points, but along different routes.#

level line, simultaneous #A *level line* composed of two single lines run over the same route, both in the same direction, but using different turning points for each.#

Also called a simultaneous double line.

level line, single-run #A *level line* established by *single-run leveling*.#

level line, spur (1) #A *level line* that is connected to a leveling network but is neither part of the principal leveling network nor is it part of a loop.#

(2) #A level line run as a branch from the main level line, either to determine the elevations of bench marks not conveniently reached by the main level line or to connect with tidal or other previously established bench marks, used for obtaining checks on old leveling either at the beginning or end of a line of levels or at intermediate junctions along the new line of levels.#

A branching level line that is run from a bench mark on a spur line is called a double-spur line or a double-spur. Similarly, a branching level line that is run from a bench mark on a double-spur line is called a triple-spur line, and so on.

level net, fundamental #The various lines of *first-order leveling* considered as a whole.#

level of no motion #The depth at which it is assumed that *isobaric surfaces* in a layer of water coincide with *level surfaces*.#

level surface See *surface, level.*

level trier #An apparatus used for measuring the angular value of the divisions of a *spirit level.* #

One form of level trier consists of a beam mounted on a stable base. One end of the beam is hinged to the base, and the other end can be moved vertically by use of a graduated screw; the angular amount of the movement is measured with the screw. The spirit level is mounted on the beam, and the angle through which the beam moves while the bubble of the spirit level travels the length of a division is measured with the screw.

level unit See *leveling unit.*

level vial #The transparent, closed container of a *spirit level.* #

libration #The relative motion between an observer and a body which causes the body to appear to move back and forth about an average position or location.#

There are two kinds of libration: geometric and physical. Geometric libration is the result of the geometric relationship between observer and body. For example, part of the geometric libration of the Moon occurs because the observer is rotating with the Earth and so sees a little farther around one side of the Moon at the beginning of a day, and then, half a day later, a little farther around the other side than he does when the Moon is on the meridian. Additional geometric libration is caused by the ellipticity of the Moon's orbit and by the inclination of the Moon's axis of rotation to the plane of the Moon's orbit.

Physical libration, also called dynamical libration, is the result of actual oscillation of a body about an average position. For example, because the Moon is slightly bulged toward the Earth, the Earth's gravitational attraction on this bulge produces a physical libration of the Moon.

The Moon's geometric libration is about 8° in longitude and about 7° in latitude; the physical libration is about 0.°03 in longitude and 0.°04 in latitude.

lidar #An instrument that measures distance to a reflecting object by emitting timed pulses of light and measuring the time between emission and reception of reflected pulses. The measured time interval is converted to distance.#

The most common usage for this term is in meteorology for the detection of heights and distances of clouds.

light #The part of the electromagnetic spectrum perceived by the normal human eye (visible radiation).#

Visible radiation occurs at wavelengths of between about 0.4 and 0.8 micrometers and is bounded on the longer-wavelength side by infrared radiation and on the shorter-wavelength side by ultraviolet radiation.

The speed of light in a vacuum and far from dense concentrations of matter is a universal constant, independent of the velocity of the source or of the observer, and is the same as the speed of radio waves, x-rays, and all other electromagnetic radiation. See *light, speed of.*

light, speed of #A *geodetic constant* with the value 299,792,458 ± 1.2 m/s.# This value was adopted by the International Association of Geodesy in 1975 and by the International Astronomical Union in 1976 and still holds (1986).#

light, velocity of See *light, speed of.*

light-time #The time needed for light to travel between two specified points.#

The term is used in astronomy to denote, in particular, the time needed for light to travel from a celestial body (planet, comet, etc.) to the observer.

light-time, correction for #The correction in direction to the location of a moving body that accounts for its motion during the time the light was traveling from the body to the observer.#

ligne #An obsolete French unit of length equal to 1/144 of a *French foot*.#

This is about 1/443.296 meter. This unit is important because it was used in every survey of geodetic importance in the 17th and 18th centuries and even well into the 19th century.

limb #The edge of the apparent disk of a celestial body.#

The half of the limb that appears at the least angular elevation above the horizon is called the lower limb; the half at the greatest angular elevation above the horizon is called the upper limb.

line #A geometrical concept that is usually undefined and which has meaning only in relation to the axioms and postulates using it.#

Physically, a line may be considered the sequence of points occupied by a point in motion. In geodesy it is used both in its mathematical sense and as a term whose exact meaning may depend on the context. In cartography, "line" is added to other words to distinguish the physical from the geometrical concept, e.g., contour and contour line.

line, agonic #A line on the Earth's surface along which the *magnetic declination* is zero.#

line, boundary See *boundary line.*

line, cardinal #A line running north-south or east-west.#

line, correction See *parallel, standard* (2).

line, cotidal #A line drawn on a chart representing a line on the Earth passing through all points where *high water* occurs simultaneously.#

The lines show the lapse of time, usually in lunar hours, between the Moon's transit over a reference meridian (usually Greenwich) and the occurrence of high water for any point lying along the line.

line, dead-reckoning #A line drawn on a chart representing a ship's course as determined by *dead-reckoning*.#

line, envelope #A line in the marginal sea along which every point is at a distance (from the nearest point of the base line) equal to the breadth of the marginal sea.#

Geometrically, the envelope line is the locus of the center of a circle of fixed radius that moves so the circumference is always in contact with the base line. The name is derived from the fact that the line forms a continuous series of intersecting arcs which are farthest seaward of all the possible arcs that can be drawn from the base line with the same radius, thus enveloping all arcs that fall short of the seaward arcs.

See also *base line (5),* and *sea, marginal.*

line, established #A surveyed line.#

line, flight (1) #The path taken by an airplane during an aerial survey.#

(2) #The line, drawn on a map, that represents the path followed by an airplane while taking aerial photographs.#

line, geodesic See *geodesic.*

line, geodetic #A *geodesic* on an ellipsoid.#

A geodetic line is a line of double curvature, and usually lies between the two *normal section lines* determined by two points. If the two terminal points are in nearly the same latitude, the geodetic line may cross one of the normal section lines. Except along the Equator and along the meridians, the geodetic line is not a plane curve and cannot be sighted over directly. However, for conventional triangulation, the lengths and directions of geodetic lines differ inappreciably from those of corresponding pairs of normal section lines.

line, great-circle #In land surveying, the line of intersection of the surface of the Earth and the plane of a great circle on the celestial sphere.#

line, headland-to-headland #The line joining the termini at the outer headlands of a coastal indentation which has been determined to be inland waters either by the *semicircular rule* or on historic grounds.#

It marks the seaward limit of inland waters.

line, high water See *high water line.*

line, level (1) #A line tangent to an equipotential surface of the Earth's gravity field.#

(2) See *level line.*

(3) #A line on a *level surface.* #

line, lorhumb #A line along which the rates of change of the values of two intersecting families of hyperbolas are constant.#

line, lubber #A pair of marks, or a line, on the housing of a compass that indicate the fore and aft directions on the vehicle on which the compass is mounted.#

The angle between the lubber line and north shown by the compass indicates approximately the direction in which the vehicle is pointed.

line, median (1) #A line, in a body of water, equidistant from the nearest points on opposite banks (or other references).#

(2) #The line equidistant from two nonparallel lines.#

(3) #A line equidistant from the nearest points on the base lines from which the breadth of the territorial sea of each of two coastal nations is measured.#

line, meridian See *meridian line.*

line, normal section #The line on an ellipsoid which is the intersection of the ellipsoid with a plane perpendicular to the surface at a given point.#

A normal section line is, in general, elliptical. It is not, in general, a geodesic.

line, plumb See *plumb line.*

line, principal #The intersection of the *principal plane* with the plane of an aerial photograph.#

It is the line through the *principal point* and the *nadir* of the photograph.

line, radial See *radial.*

line, random #A line run, as nearly as circumstances permit, from one survey station toward another survey station out of sight from the first survey station.#

A correction to the initial azimuth of the random line can be calculated from the misclosure (the amount by which the second station is missed). Offsets from the random line, to establish points on the line between the survey stations, can also be calculated from the misclosure.

line, range See *range line.*

line, refraction #In surveying, a surveyed line between two points placed so that the two points are intervisible only when the line of sight is sufficiently curved by atmospheric refraction.#

line, rhumb See *rhumb line.*

line, ridge See *ridge line.*

line, right #A straight line between *corners*.# The term is obsolete.

line, straight (1) #A *geodesic* in *Euclidean space.*#

This is the most common usage. However, the term is used in geodesy in various ways to define particular curves on an ellipsoid.

(2) C. A. Schott (1901) listed the following eight different possible meanings.

#On an ellipsoid of revolution, between points A and B, a straight line is:

(a) a *normal section* from A to B.

(b) a normal section from B to A.

(c) a *curve of alignment*.

(d) a *geodesic.*

(e) a line of sight starting in the plane of the normal through A and through B, and in advancing keeping B constantly sighted.

(f) the same as (e) with A and B reversed.

(g) a forward and backward line of sight over limited distances starting from A.

(h) the same as (g) replacing A by B.#

line, true #A line of constant bearing between *corners*.# Formerly called a right line.

line, vanishing #The straight line, on an image formed by perspective projection, upon which lie all the *vanishing points* of all systems of parallel lines on a plane.#

line of alignment See *curve of alignment.*

line of apsides #The major axis of an elliptical orbit, extended indefinitely in both directions.#

See also *apsis.*

line of collimation See *collimation, line of.*

line of leveling See *line of levels.*

line of levels (1) #A continuous series of measured differences of elevation.# The individual, measured differences may be single observations in the case of *single-run leveling* or the averages of repeated observations in the case of *double-run leveling.*

(2) See *level line.*

line of position #Any line on which a point is known to be located.#

Line of position, or position line, is a more general term than the alternate term *Sumner line.*

line of sight #A line drawn between two reference points in an optical system and extended indefinitely in a forward direction.#

In telescopes, one of these points is a mark on the reticle, the other is the second (rear) nodal point of the objective lens. The line of sight need not coincide with the optical axis of the instrument. However, when it should coincide, but does not, the angular difference is called the collimation error or internal collimation error. The term collimation error is also used to designate the divergence between the line of sight and the *collimation axis.*

line-spread function #A function giving the intensity of light in the image of an illuminated slit as a function of transverse distance from the central, long axis of the image.#

The line-spread function is one way of expressing the acuteness of an optical system. It is a particular case of the modulation-transfer function.

line tree (1) #A tree intersected by a surveyed line on which legal *corners* are established and reported in the field notes of the survey.#

Also called a sight tree or fore-and-aft tree.

(2) #A tree intersected by a surveyed line, reported in the field notes of the survey, and marked in some manner on each of the sides facing the line.# Also called station tree, sight tree, or fore-and-aft tree; but line tree is preferred.

A tree whose trunk lies entirely upon one side of the boundary belongs exclusively to the owner of the land on that side. A tree whose trunk stands on the land of two or more adjoining owners is common property.

link (1) #One one-hundredth of a *chain*; equivalent to 7.92 in.#

See *chain, Gunter's*.

(2) #A level line, part of a level line, or a combination of level lines or parts of level lines which, taken as a unit, make a continuous piece of leveling directly from one junction bench mark to another junction bench mark without passing through or over any other junction bench marks.#

list of directions #A listing of the objects observed at a triangulation station, together with the horizontal directions in terms of circular arc from the direction of one of the objects assigned the direction zero.#

The directions listed are usually the average of a number of readings on the horizontal circle or the average of sets of observed directions.

lithosphere (1) #The relatively rigid part of the *crust* and upper *mantle* in which the velocity of seismic waves is high.#

This is the layer containing the plates of the Earth's outer shell which are in motion with respect to each other. When lithosphere is used with this meaning, the layer immediately beneath is the *asthenosphere*, a region of considerable plasticity.

(2) #The *crust* of the Earth.#

(3) #The massive part of the Earth, as distinguished from the gaseous part (the atmosphere) and the watery part (the hydrosphere).#

In this definition, the lithosphere includes the crust, mantle, and core. Definitions (2) and (3) are not currently in general scientific use.

lobe #A region in space that receives a local maximum of the power radiated from an antenna and is contained within lines of local minima.#

The power is usually expressed as a fraction of the total power radiated by the antenna. (Intensity may be used instead of power). If the local maximum is also the maximum in the field, the lobe containing it is called the main lobe. It is called a side lobe if its local maximum is less than the maximum in the field.

lobe, main See *lobe*.

lobe, side See *lobe*.

location #The numerical or other identification of a point (or object) sufficiently precise so the point can be situated.#

For example, the location of a point on a plane can be specified by a pair of numbers (plane coordinates) and the location of a point in space can be specified by a set of three numbers (space coordinates). However, location may also be specified in other terms than coordinates. A location may be specified as being at the intersection of two specific lines or by identifying it with some prominent and known feature (e.g., "on top of Pike's Peak" or "at the junction of the Potomac and Anacostia Rivers").

long-arc method #A method of determining the coordinates of an observer from observations on a satellite over a portion of its orbit sufficiently long so that an extremely precise mathematical representation must be used.#

The distinction between long-arc method and short-arc method is not sharp, but a method using arcs more than a quarter-revolution long is usually considered a long-arc method.

longitude (1) #The dihedral angle (usually taken counterclockwise) from a plane of reference to a plane associated in some specified manner with the point of interest, both planes being perpendicular to a third plane, which may be the equatorial plane, the galactic plane, the plane of the ecliptic, or another plane, as appropriate to the kind of point that is of interest.#

Examples are: astronomic longitude; geodetic longitude, if the third plane is the Earth's equator; or celestial longitude, if the third plane is the plane of the ecliptic.

(2) #A coordinate indicating distance, linear or angular, from a north-south line used as reference.#

longitude, astronomic #The angle between the plane of the *celestial meridian* of a point and the plane of an initial, arbitrarily chosen meridian.#

Astronomic longitude results directly from observations on celestial bodies. It differs from *geodetic longitude* by the amount of the *deflection of the vertical* in the prime vertical divided by the cosine of the latitude. Astronomic longitude is measured by the angle at the celestial pole between the tangents to the local and the initial meridians, or by the arc intercepted on the Equator by those meridians. At an international convention held in 1884, the Meridian of Greenwich was adopted as the initial or prime meridian for all longitudes, and is now generally so used.

Astronomic longitude has been determined by the following methods, among others: (a) Celestial events such as occultations of stars, eclipses of Jupiter's satellites, and eclipses of the Sun which have been timed at the new station and at the station of known longitude. (b) A clock has been carried from the known station to the new one and their times compared with local time. (c) The time at which the Moon culminates or has a certain angular elevation is compared with the corresponding time at the station of known longitude. (d) The time at the new station is compared with time at the known stations by transmitting time at the latter either over telegraph lines or by radio.

longitude, celestial #The arc of the *ecliptic* intercepted between the *vernal equinox* and the foot of a great circle perpendicular to the ecliptic and passing through the object whose longitude is to be defined.#

Celestial longitude is measured along the ecliptic from west to east.

longitude, fictitious #The particular case of *longitude* (1) for which the third plane is the *fictitious Equator*.#

longitude, geodetic #The angle between the plane of the local *geodetic meridian* and the plane of an initial, arbitrarily chosen, geodetic meridian.#

A geodetic longitude may be measured by the angle, at one of the poles of the ellipsoid, between the local and initial meridians, or by the arc of the ellipsoid's Equator intercepted by these meridians. In recording a geodetic location, it is essential that the geodetic datum on which it is based also be stated. A geodetic longitude differs from the corresponding *astronomic longitude* by the amount of the component, in the prime vertical, of the local *deflection of the vertical* divided by the cosine of the latitude. See also *longitude, astronomic.*

longitude, geographic #A general term for astronomic or geodetic longitude.#

longitude determination #The determination of *astronomic longitude*.#

Unlike *geodetic longitudes*, astronomic longitudes can be determined by measuring the difference in time between passage of a star through the local meridian and through the meridian of Greenwich. A number of methods have been invented for determining astronomic longitude either by itself or together with astronomic latitude or azimuth. The problem of determining longitude is inseparable from the problem of determining time with respect to Greenwich, and the same methods often serve for either purpose. See also *longitude, astronomic.*

longitude determination, Bessel's formula for See *Bessel's formula.*

longitude determination, chronometric method of #A clock is carried from a location of known longitude to the point whose longitude is to be determined; the clock is set to local time at the known location and its time at the new location is compared with local time there. The difference in time, converted to angular measure, is the difference in longitude.#

longitude determination, Dellen's method of See *Doellen's method.*

longitude determination, equal-altitude method of See *longitude determination, equal-zenith-distance method of.*

longitude determination, equal-zenith-distance method of #The determination of *astronomic longitude* by observing the times at which each of a pair of stars reaches the same zenith distance.#

See *longitude determination, Tsinger method of,* which is a variant of this method.

longitude determination, lunar methods for #Any method in which the Moon's right ascension is determined at two points, one of which is at a known longitude, and the difference in longitude is determined from the difference in right ascension and the Moon's hourly rate of motion in right ascension.#

For example by the lunar culmination method, the right ascension of the Moon is determined at a place of known longitude and at a place of unknown longitude, at the time of the Moon's culmination (passage of the Moon's center through the meridian), by comparing the Moon's location with the locations of several nearby stars. The difference in longitude is then the difference in right ascensions divided by the Moon's hourly rate of motion in right ascension.

The Moon may also be observed at equal altitudes, equal zenith distances, etc. These methods are no longer used in precise geodetic work.

longitude determination, Mayer's formula for See *Mayer's formula.*

longitude determination, radio method of #Determination of *astronomic longitude* by comparing the local time at which a radio signal (amplitude modulated) was received with the Greenwich and sidereal time at which the signal was broadcast from a station whose longitude and latitude are known.#

The longitude and latitude of both transmitter and receiver must be known approximately because the difference in times must be corrected for the time it took the signal to travel between the two points. This time is usually different from the time to travel along the chord or geodesic because the signal travels by successive reflections between the Earth's surface and the ionosphere.

longitude determination, Tsinger method of #The determination of *astronomic longitude* by observing the times at which each of a pair of stars reaches the same zenith distance; the pair selected should be near the prime vertical and symmetrical with respect to the local meridian. Corrections are applied for diurnal aberration and for the inclination of the horizontal axis of the telescope.#

loran #A *hyperbolic navigation system* for measuring distance differences with respect to fixed transmitters at known geographic locations.#

The location of a loran receiver may be determined to be on a particular hyperbola by measuring the difference in arrival times of pulses sent synchronously from a single pair of transmitters. The location may be be determined to be on a second hyperbola by a similar measurement relative to another pair of transmitters. The desired location is then at one of the intersections of the hyperbolas.

The term loran was originally an acronym for Lo(ng)-Ra(nge) N(avigation) and so was capitalized LORAN until the term passed into general usage.

loran-A #A radio navigation system, of the *loran* type, operating at 2 MHz (carrier) and emitting 50 μs pulses; the receiver matches the envelopes, not the phases, of the received pulses.#

Loran-A is not as accurate as other navigation systems which compare phase, and systems such as *omega* and *loran-C*, have made loran-A obsolete. Loran-A is useful out to a few hundred kilometers from stations with an accuracy of about 2 km. Fixes may be obtained at ranges of as much as 1400 km in daylight and 2500 km at night, and are very nearly independent of the weather. The precision of a fix is comparable to that obtained by high-grade celestial observations with a sextant.

loran-B #A later (now superseded) version of *loran-A* in which both envelope and phase of the pulse were matched as in *loran-C*.#

loran-C #A radio navigation system similar to *loran-A* but of greater range and higher accuracy. Phase-matching instead of envelope-matching is used together with different coding of the signals, more accurate time control, and higher output power. Frequency is 100 kHz.#

Location can be determined at distances of up to 1500 km over land and up to 3000 km over water, but accuracy is poorer at longer distances. At a distance of 600 km from the master station, an accuracy of about 150 m can be obtained.

lot (1) #A subdivision of a section (of land) which is not described as an aliquot part of the section but which is designated by number, e.g., LOT 2.#

(2) #A piece of land, generally a subdivision of a city, town, or village block of land or some other distinctive tract, represented and identified by a recorded *plat*.#

Love number #One of the two dimensionless numbers h and k, where h is the ratio of the height of the Earth tide to the height of the corresponding, static oceanic tide (for a hypothetical fluid Earth), and k is the ratio of the additional gravitational potential produced by an Earth tide to the gravitational potential producing the Earth tide. All quantities are determined at the Earth's surface.#

Current (1985) values are about 0.60 for h and 0.30 for k. The term has also been used with the *Shida number*, ℓ.

low-water line #The line defined by the boundary of a body of water at its lowest stage (lowest elevation).#

(2) #The intersection of the land with the water's surface at low water.#

Because the elevation of the low-water surface at a designated locality may vary appreciably with time, an average value of the elevation at low water should be used in determining the location, on land, of the low-water line. See also *water, mean low*.

low-water mark #Equivalent to *low-water line*.# However, low-water mark should not be used in reference to tidal waters.

loxodrome See *rhumb line.*

lubber line See *line, lubber.*

lunar laser ranging See *laser ranging, lunar*.

lunation See *month, synodical.*

M

magazine (photography) #A container for photographic film or photographic plates attached to the body of a camera.#

Aerial camera magazines have a mechanism for advancing the film between exposures. Small magazines are often called cassettes; magazines for photographic plates may be called plate holders.

magnetic anomaly #The difference between the intensity of the magnetic field at a particular place and the intensity predicted for that place by a standard formula, such as that for a magnetic dipole.#

magnetic declination See *declination, magnetic.*

magnetic dip See *dip.*

magnetic disturbance #An irregular, large-amplitude, rapid change of the Earth's magnetic field which occurs at approximately the same time worldwide.#

A magnetic disturbance is usually associated with the occurrence of solar flares or other strong solar activity. Also called a magnetic storm. Sometimes, the *daily magnetic variation* is called a magnetic disturbance.

magnetic element See *geomagnetic element.*

magnetic field intensity #Amount of magnetically generated current per linear distance.# SI units are ampere per meter. See *gauss*.

magnetic flux density #A quantity of magnetic inductance equivalent to energy per electrical current.# SI units are $(m^2)(kg)/s^2/A$. See *gauss.*

magnetic pole #Either of the two places on the surface of the Earth where the magnetic *dip* is 90°.#

Not the same as *geomagnetic pole.* Also called a dip pole.

magnetic storm See *magnetic disturbance.*

magnetic variation #A regular or irregular change, with time, of *magnetic declination, dip,* or intensity.#

In nautical and aeronautical navigation, and sometimes in surveying, the term "magnetic variation" is used for magnetic declination. The regular magnetic variations are: secular, the change from year to year in the same direction (which usually persists for many decades); annual, the change over a period of one year; and diurnal, the change over a period of one day (24 hrs). Irregular variations, when sudden, worldwide, and severe, are known as magnetic storms. The Earth's magnetic field also may be affected locally by direct-current electricity and other artificial disturbances. It was once a common practice of surveyors to denote as magnetic variation the net amount the compass departed from the direction taken as north in the description of a particular line, even when this was known to be slightly at variance with the celestial meridian.

magnetic variation, daily #The transient change in the Earth's magnetic field associated with the apparent daily motions of the Sun and Moon, and having a corresponding period of about one day.#

In most places the part of the daily magnetic variation caused by the Sun follows a fairly consistent pattern, although appreciable and unpredictable changes in form and amplitude do occur. Also known as the "diurnal magnetic variation".

magnetic variation, diurnal (1) #The *daily magnetic variation* .#

(2) #The simple harmonic component of the daily magnetic variation that has a period of 24 hours.#

magnetic variation, lunar daily #A periodic, daily variation of the Earth's magnetic field that is in phase with the Moon's hour angle.#

magnetic variation, secular #The monotonic or long-period change of declination, inclination, and intensity of the *main geomagnetic field* at a point.#

magnetic variation, solar daily #A periodic variation of the Earth's magnetic field that is in phase with the Sun's hour angle.#

magnetometer #Any instrument used for measuring the intensity of a magnetic field.#

In particular, in geomagnetism, an instrument used for measuring the intensity of the Earth's magnetic field. The types in common use today are the dip needle and field balance (mechanical), fluxgate (saturable-core reactor), proton precession magnetometer, and instruments that measure the frequency of atomic or molecular resonance in a magnetic field.

magnetometer, flux-gate #A *magnetometer* that measures the effect of the Earth's magnetic field on a single, or pair of oppositely wound, saturable-core reactors.#

magnetometer, Gauss #A *magnetometer* that measures H, the horizontal intensity of the Earth's magnetic field. A magnet suspended horizontally is set to swinging and its period of oscillation is measured. The period is a function of the intensity MH at the magnet, where M is the magnetic-dipole moment. The suspended magnet is then taken down and placed near a suspended standard magnet of the same kind. Interaction of the two magnets causes one of them to turn by an amount which is proportional to M/H. The value of H can then be calculated from the two sets of measurements.#

magnetometer, nuclear #A *magnetometer* that uses the magnetic moment of atomic nuclei for measuring a magnetic field.#

Typical nuclear magnetometers are the proton-precession magnetometer and the spin-precession (or Overhauser) magnetometer. Nuclear magnetometers are sensitive to 0.1 gamma or less.

magnetometer, nuclear-precession See *magnetometer, proton-precession.*

magnetometer, optical-absorption #A *magnetometer* that measures the geomagnetic field by determining the Larmor precession frequency of atomic electrons moving in the field.#

The frequency is measured by passing light of a specified frequency through a gas and measuring the radio frequency (equal to the *Larmor precession* frequency) at which the light undergoes a sharp absorption when modulated by a weak magnetic field applied to the gas.

magnetometer, proton-precession #A *magnetometer* that measures the effect of a magnetic field on the spin of hydrogen nuclei (protons).#

magnetometer, quartz horizontal #A *magnetometer* that measures the intensity and direction of the horizontal component of the geomagnetic field. It consists of a short magnetic bar suspended from its middle by a long quartz fiber attached at its upper end to the casing of the instrument.# See *magnetometer, Gauss.*

magnetometer, sine #A *magnetometer* that measures the horizontal intensity of the Earth's magnetic field. It consists of a magnetic bar suspended by a torsion-free fiber inside a Helmholz coil wound on a marble cylinder.#

See *magnetometer, Gauss* and *magnetometer, quartz horizontal.*

magnitude (astronomy) #A measure of the brightness of celestial objects.#

There are two types of magnitude: apparent, which is a measure of the brightness of one celestial object compared to the brightness of another; and absolute, which is the brightness of a celestial object compared to the brightness of a standard at the same distance. In ordinary use, the term magnitude usually refers to apparent magnitude.

magnitude, absolute #The *apparent magnitude* a celestial body would have (relative to a standard) if the body were at a distance of 10 *parsecs*.#

Designating the absolute magnitude by M, the apparent magnitude by m, and the distance, in parsecs, by d, the formula for absolute magnitude is

$$M = (m + 5) - (5 \log d).$$

The absolute magnitude of the Sun is +4.87; its apparent magnitude is −26.7.

magnitude, apparent #The apparent magnitude m of a celestial body of apparent brightness b_m is given by

$$m = n + (5/2)\,(\log b_n - \log b_m)$$

where m depends upon the apparent magnitude, n, and apparent brightness, b_n, of another celestial body taken as standard.#

This equation defines the scale of apparent magnitudes, except for the location of the zero-point. The zero-point of the scale of *visual magnitudes* is, by convention, found by assigning the magnitude +1 to the average brightness of the two stars Altair and Aldebaran. On this scale, a star of magnitude 1 is exactly 100 times as bright as a star of magnitude 6. The Sun has an apparent magnitude of −26.7.

magnitude, bolometric #The magnitude of a celestial object calculated from the body's total radiation over the entire spectrum.#

The term originated because bolometers were used for the total radiation measurements.

magnitude, correction to bolometric #The quantity added to a *visual magnitude* to arrive at the corresponding *bolometric magnitude.* #

magnitude, photoelectric #The magnitude of a celestial object determined by measuring the radiation with a photoelectric detector.#

Most photoelectric detectors in use are highly sensitive to the blue end of the spectrum but not so sensitive to the red end, so that red objects have larger (darker) photoelectric than visual magnitudes, while blue objects have smaller (brighter) photoelectric than visual magnitudes.

magnitude, photographic #The magnitude of a celestial object determined from measurements made on a photograph of the object.#

Because photographic material is sensitive to different wavelengths than the human eye, photographic magnitudes are different from *visual magnitudes*. The difference between the two (the color index) is a rough indication of the color of the object.

magnitude, photovisual #The magnitude of a celestial object determined by measurement of a photograph taken with emulsions and filters that approximate the sensitivity of the human eye.#

Photovisual magnitudes are practically equal to visual magnitudes.

magnitude, visual #The visually estimated magnitude of a celestial object.#

manometer #A gauge for measuring the pressure of gas.#

A common form is a U-shaped tube, containing mercury, which is either closed at one end and open at the other to the gas, or is connected at one end to a container of gas at a reference pressure and at the other end to a container of the gas whose pressure is to be measured.

mantle #The concentric layer of the Earth that extends downward from the bottom of the *crust* (the *Mohorovičić discontinuity)* to about 2900 km. The upper surface is marked by a jump of the speed of longitudinal seismic waves from about 7 km/s to over 8 km/s; the lower boundary is marked by the failure of transverse seismic waves to propagate beyond (below) it.#

Close to the upper boundary of the mantle, about 100 to 200 km below the Earth's surface, is a zone in which seismic waves travel at speeds lower than those occurring at greater depths. This zone, the upper mantle, has also been called the rheosphere or the *asthenosphere*.

manuscript #The original drawing of a map as compiled or constructed from various data, such as ground surveys and photographs.#

map (1) #A conventional representation, usually on a plane surface and at an established scale, of the physical features (natural, artificial, or both) of a part or the whole of the Earth's surface. Features are identified by means of signs and symbols, and geographical orientation is indicated.#

(2) #A similar representation of any physical feature#, e.g., electrical circuiting, floor layout in a building, or the celestial sphere.

A map may emphasize, generalize, or omit the representation of certain features to satisfy specific requirements.

The type of information which a map is designed to show frequently appears in its title. The map projection used normally is indicated on the map.

(3) (mathematics) #A single-valued function.# Also called mapping.

map, aerial See *chart, aeronautical.*

map, aerial navigation See *chart, aeronautical.*

map, anaglyphic #A map printed in two complementary colors (such as red and blue-green) so that, when viewed through eyeglasses fitted with filters of corresponding colors, the map appears to have depth.#

map, arbitrary #A map made by a title company, assessor, or others for their own convenience in locating property in a region in which all the descriptions are by *metes and bounds*. On the map, the individual pieces of land (lots) are given arbitrary numbers.#

map, aviation See *chart, aeronautical.*

map, base (1) #A map on which information may be placed for comparison or geographical correlation.#

(2) #A map from which other maps are prepared by the addition of information.#

In particular, a *planimetric map* used in the preparation of topographic maps.

map, butterfly #An *interrupted map*, described by B. Cahill in 1929, constructed by mapping the sphere on an octahedron and unfolding the octahedron into a butterfly-like arrangement of faces.#

Cahill devised several variants of the butterfly map using a different projection for each. The most common variant is that using Adam's rhombic conformal map projection. Also called the butterfly map projection. See *map projection, Adam's rhombic conformal.*

map, cadastral #A map showing the boundaries of subdivisions of land, usually with their bearings and lengths, and the areas of individual tracts, for purposes of describing and recording ownership.#

A cadastral map may also show culture, drainage, and other features relating to the value and use of land.

map, chorographic (1) #Any map representing large regions, countries or continents on a small scale.#

The term has been almost entirely replaced by the name small-scale map. Atlases and wall maps belong to this class.

(2) #A map at a larger scale than those used for maps of the entire world but at a smaller scale than those used for metropolitan regions, counties, etc.#

map, compiled #A map based on information used primarily in the preparation of other maps.#

Most small-scale maps of large areas are compiled maps.

map, composite #A map which contains information of two or more general types.#

A composite map is usually a *compiled map*, bringing together data that were originally shown on separate maps. For example, a map showing air routes and surface routes would be a composite map.

map, contour #A map that shows the relief (or topography) of a region by means of *contour* lines.#

map, demographic #Any map that shows primarily political or social data, such as political divisions, populations, or occupations.#

The map may show merely that the product, etc., is to be found in certain regions, but may also show how much of it is produced or occurs there.

map, dynamic #A map that shows motion, action, or change.#

A dynamic map involves time. The term may be applied to maps depicting the flow of traffic, migration, military movements, progress in an engineering project, historical geography, and so on. Various symbols, such as flow lines and arrows, are used to show movement. A dynamic map also may be composed of two or more *static maps*, showing comparable data at separate times or dates.

map, engineering #A map that shows information essential for planning and estimating the cost of an engineering project or development.#

An engineering map is usually a large-scale map of a comparatively small area or of a route. It may be made entirely from the data gathered by an engineering survey, or from information collected from various sources and assembled on a base map.

map, Fisher's polygnomonic See *map, polygnomonic.*

map, geomorphological #A map which shows the appearance, dimensions, slopes, and ages of features in the region mapped.#

Geomorphological maps are produced by adding to topographical maps a considerable amount of information on the geological interpretation of the topography and on the structural geology of region.

map, Goode's homalographic #The *interrupted map* obtained by using the *Mollweide map projection* to map a varying number of regions in such a way that the individual maps match along the Equator with their centers on several (usually five or six) different meridians.# Also spelled "homolographic".

First described by J. P. Goode in 1916.

map, hemispherical #A map of one-half of the Earth's surface (or of one-half of a sphere) with the hemisphere bounded either by the Equator or by another great circle.#

The Earth is usually considered to be divided either at the Equator into the Northern and Southern Hemispheres, or along some meridian (continued around the globe) between Europe and America into the Eastern and Western Hemispheres.

map, homalosine #An *interrupted map* obtained by using five or six different central meridians in such a way that the maps match along the Equator and the center of each map is on a separate meridian. The *sinusoidal map projection* is used for the zone between about 40°N and 40°S; the *Mollweide map projection* is used for the region outside this zone.# Also spelled "homolosine".

It is similar to *Goode's homalographic map*. This map is widely used for atlases and for thematic maps because the interruptions can be made to occur in oceanic regions.

map, hypsographic #A *topographic map* which shows elevations with respect to the geoid.#

map, hypsometric See *map, hypsographic*.

map, index #A map which shows where to find collections of related data such as other maps, statistical tables, or descriptions of terrain.#

Index maps may be used to show references to the origin, place of deposit or filing, or other identifying characteristics of such reference data.

map, International (Map) of the World See *International Map of the World.*

map, interrupted #A map produced by fitting together maps of separate regions, that may not have been depicted on the same kind of map projections or with the use of the same constants, into a particular kind of map projection.#

For example, the Goode homalosine map projection is produced by using both the Mollweide and the sinusoidal map projections. The gnomonic map projection of a cube is produced by use of only the gnomonic map projection but six different locations of the tangent points are used. An interrupted map is also called an interrupted map projection or a recentered map projection. Interrupted maps were produced as early as 1507 by Waldseemüller and by Rumbold Mercator.

map, isarithmic See *map, isoplethic.*

map, isogonic #A map showing lines of constant magnetic inclination for a particular base date (shown on the map).#

Lines of equal annual change in declination are generally also shown. If the map is designed for use in navigation, it is called an isogonic chart.

map, isometric #A map on which lines are drawn true to scale.#

A true isometric map of the sphere or any portion thereof is not possible, but if the part shown is sufficiently small, error in scale can be made insignificant.

map, isoplethic #A map carrying lines joining points that have the same numerical values.#

Examples of isoplethic maps are topographic maps (with contour lines), population-density maps which outline areas along which the population density is constant, and thermal-outflow maps on which lines join points along which the rate of outflow of heat is constant. Also called an isarithmic map.

map, large-scale See *scale, fractional* and *scale, map.*

map, medium-scale See *scale, map.*

map, outline #A map which shows just enough geographic information to permit the correct placement of additional details.#

Outline maps correspond to what were at one time known as base maps; they usually show only coast lines, principal rivers, major civil boundaries, and large cities. As much space as possible is left for placing additional details or data. An outline map presents less detail than a base map.

map, photographic See *map, photographic-index.*

map, photographic-index #An *index map* showing the area depicted by each photograph in a set of photographs of a region.#

Three kinds of photographic-index maps are in common use:

(a) A photographic copy of the assemblage of photographs, with each photograph in its proper position relative to the others. The copy is generally made at a scale 1/8 to 1/10 that of the original photographs.

(b) A map, planimetric or topographic, on which are drawn the outlines of the area covered by each photograph of the set.

(c) A transparent overlay, keyed to a base map, on which are drawn the outlines of the area depicted by each photograph.

Photographic-index maps of the first kind are usually used only when all the photographs in the set were taken at approximately the same scale along the flight lines.

map, physical #A map representing the surface of the land or the floor of the oceans.#

In addition to representing relief, a physical map may show natural phenomena such as oceanic currents, swamps, sands, and deserts. Man-made structures and vegetation are not shown.

map, planimetric #A map which shows only the horizontal positions of the features represented.#

Unlike a topographic map, a planimetric map does not show relief in measurable form. Natural features usually shown include rivers, lakes, and seas; mountains, valleys, and plains; forests, prairies, marshes, and deserts. Cultural features shown include cities, farms, transportation routes, and public utility facilities; and political and private boundary lines.

map, polygnomonic #An *interrupted map* produced by mapping the sphere onto an inclosing polyhedron, using the *gnomonic map projection* for each face.#

Fisher's polygnomonic map is the representation of the sphere on a circumscribed icosahedron.

map, polyhedral See *map, polyhedric.*

map, polyhedric #The map of an ellipsoid on an inclosing polyhedron.#

Also called a polyhedral map or map projection. Polyhedric maps were first produced systematically by the Royal Prussian Topographic Bureau (and so are sometimes called the Prussian polyhedral projection). It was intended to project the ellipsoid orthogonally onto each face, but a conical map projection was adopted instead, since this would allow matching of adjacent sheets without gaps.

map, reconnaissance #A map incorporating the information obtained in a *reconnaissance survey* with data obtained from other sources.#

A reconnaissance map differs from a map based on an *exploratory survey* in that it contains more detail. The detail is selected to serve either special or general purposes. See also *reconnaissance sketch.*

map, relief (1) #A map whose surface is shaped to represent the topography in a region.#

The most common kind is the plastic relief map. This is made by printing an ordinary topographic map on a plastic sheet, which is then placed on a plaster mold that has been carved to represent the topography. Heat and pressure are applied to fix the plastic sheet permanently into the shape of the mold. Another kind, less common and more costly but showing more detail in greater accuracy, is the solid relief map, made by carving the topography, etc., in a suitable substance such as plaster, and then painting or drawing further detail on the model. Also called a terrain model or relief model.

(2) #A map showing relief by any convention, such as by tints, hachures, contours, or shading.#

map, scale factor of See *scale factor.*

map, scale of a See *scale of a map.*

map, sketch #A map drawn freehand and greatly simplified.#

map, small-scale See *scale, fractional* and *scale, map.*

map, special-purpose #Any map designed for special rather than general use.#

Usually the information on a special-purpose map is emphasized by omitting or subordinating other information of a general character. A word or phrase, such as "geological" or "traffic flow", is usually used to describe the type of information which a special-purpose map is designed to contain.

map, State (1) #A map of one of the States of the United States of America.#

(2) #A map produced by an agency of a State (U.S.A.).#

map, State base #A *base map* of one of the States of the United States of America.#

Such maps are suitable for the overprinting of information for special purposes. The term is frequently used for State maps issued by agencies of the Federal Government and used by governmental and private agencies as bases on which special information is placed.

map, static #A map that portrays information available at a single date or time.#

Most maps are static maps. Static maps presenting comparable information valid at different dates may be combined into a single map called a dynamic map.

map, tactile (tactual) #A map on which certain symbols are raised above the surface of the map, so that they can be located and identified by touch.#

Geographic names and other information are given in Braille.

map, thematic #A map whose principal purpose is to show information other than that about the Earth's physical surface.#

Examples of the kinds of information shown on thematic maps are density of population, kind or amount of crops grown, types of soil, and amount of rainfall.

map, topographic (1) #A map showing the horizontal and vertical locations of natural and artificial features.#

It is distinguished from a planimetric map by the presence of quantitative symbols showing the relief. A topographic map usually shows the same features as a planimetric map, but uses numbered contour lines or comparable symbols to indicate elevations of mountains, valleys, and plains; in the case of hydrographic charts, symbols and numbers are used to show depths in bodies of water. A topographic map differs from a hypsographic map in that, on the latter, vertical distances are shown with respect to the geoid, while on the former, vertical distances may be shown with respect to any specified surface.

(2) #A map whose principal purpose is to portray and identify the natural or artificial features of the Earth's surface as faithfully as possible within the limitations imposed by scale.#

map, trapezoidal #A map characterized by equidistant straight lines representing parallels of latitude and convergent straight lines representing meridians.#

It is the earliest form of *polyhedric map*, having been used for star charts as early as 1426, and for maps of the world (by Nicolaus Germanus) in 1466. Also called the trapezoidal map projection.

map, uncontrolled #A map based, at least in part, on data from an original survey, but with an insufficient number of fixed points to maintain a consistent accuracy of scale and location.#

This is not the same as a sketch map.

map angle See *meridians, convergence of.*

map grid #A *grid* superposed on a map to provide a coordinate system more convenient than that provided by the *graticule.* #

mapping (1) (geodesy) #The process of making maps.#

(2) (mathematics) #A single-valued function.#

mapping, isometric #A function that preserves distances between certain points.#

Also called length-preserving mapping. See also *map projection, isometric.*

map projection (1) #A function relating coordinates of points on a curved surface (usually an ellipsoid or sphere) to coordinates of points on a plane.#

Equivalently, a relation between a coordinate system on a curved surface and a coordinate system on a plane.

(2) #A function relating coordinates of points on a curved surface to coordinates of points on a surface of different curvature.#

This is generalization of (1), and includes, e.g., the mapping of a portion of an ellipsoid onto a sphere.

(3) #A *graticule.* # A graticule is formed by the set of lines on a plane that results from applying a map projection (1) to lines of constant longitude and constant latitude on a spheroid. Also called a planisphere.

A map projection may be derived by geometrical construction or by mathematical analysis. See also *map projections, classification of.*

map projection, Adams #Any of several map projections, devised by Oscar S. Adams.#

Examples are: (a) A conformal map projection of the whole sphere within an elliptical boundary (see Adams

(1925a) for details); some of the singularities introduced by this method were removed by Lee (1965). (b) A conformal map projection of the sphere within a square, with the poles on a diagonal of the square and symmetrical about the center. (c) An equal-area map projection of the pseudo-cylindrical type, projecting the sphere onto a cylinder so that the parallels of latitude go into straight lines parallel to the x-axis and spaced at the distance $2kR_a \sin(\beta/2)$ from the origin, where R_a is the radius of the *authalic sphere, k* is a scale factor, β is the *authalic latitude;* and

$$x = R_a \lambda \cos \beta / \cos(\beta/2)$$

where λ is longitude referred to some meridian. (d) A conformal projection of the sphere within a regular hexagon.

map projection, Adams rhombic conformal #The projection of a sphere or hemisphere mapped conformally within a rhombus with one pair of opposite angles equal to 60° and the other pair equal to 120°.#

See Adams (1925). The projection was used by Cahill for one version of his butterfly map.

map projection, Airy #An *azimuthal map projection* which is approximately the arithmetic average of the *stereographic* and *azimuthal equal-area map projections.* # It is not perspective, but was intended to minimize overall scale error.

map projection, Aitoff #A map projection defined by the functions $x = 2\ z \sin \alpha$ and $y = z \cos \alpha$, where $z = \cos^{-1} [\cos \phi \cos(\lambda/2)]$ and $\alpha = \cot^{-1} [\tan \phi \csc(\lambda/2)]$. x and y are the rectangular Cartesian coordinates (easting and northing, respectively) of the point on the plane that corresponds to the point with longitude λ and latitude ϕ on the sphere.#

Invented by D. Aitoff in 1889, it is neither conformal nor equal-area. Hammer modified the map projection in 1892 to make it equal-area. Thus, the name "Aitoff map projection" is sometimes incorrectly used with reference to Hammer's modification. See *map projection, Hammer-Aitoff.*

map projection, Aitoff equal-area See *map projection, Hammer-Aitoff.*

map projection, Albers #A map projection defined by the equations:

$$n = \frac{N_1^2 \cos^2 \phi_1 - N_2^2 \cos^2 \phi_2}{2\, R_a^2 (\sin \beta_2 - \sin \beta_1)} ,$$

$$\theta = n\,(\lambda - \lambda_0) ,$$

$$r_1 = (kN_1/n) \cos \phi_1, \text{ and}$$

$$r^2 = r_1^2 + (2kR_a^2/n)(\sin \beta_1 - \sin \beta).$$

Here (r,θ) are polar coordinates of a point on the map whose geodetic latitude and longitude on the ellipsoid are (ϕ,λ); λ_o is the longitude of the central meridian; R_a is the radius of the *authalic sphere*; β is the *authalic latitude*; N is the *radius of curvature in the prime vertical*; k is a designated constant scale factor; and the subscripts 1 and 2 refer to *standard parallels* $(\phi_1 < \phi_2)$.#

The above equations can be reduced to the sphere by setting $\beta = \phi$, and $N = R_a$, where R_a is now the radius of the sphere. The origin of the polar coordinates is on the central meridian at a distance r_1 above the parallel ϕ_1.

This is an equal-area map projection on which the mapping is isometric (true) at any point on the two standard parallels. The projection also applies to the case where $\phi_1 = \phi_2$. The projection is characterized by the following properties: straight lines radiating from the origin of polar coordinates respresent meridians; arcs of concentic circles represent parallels; meridians and parallels intersect in right angles; map distortion is a function only of latitude.

This projection was devised by H. C. Albers in 1805.

map projection, American polyconic See *map projection, polyconic.*

map projection, annular equal-area See *map projection, azimuthal equal-area.*

map projection, Arrowsmith See *map projection, Nicolosi.*

map projection, aspect of a (1) #The appearance of a *graticule* that depends on whether: (a) certain meridians or parallels of latitude are mapped as lines of zero distortion (frequently called the normal aspect), (b) the line of zero distortion is perpendicular to the line that would be the line of zero distortion in the normal aspect (transverse aspect), or (c) neither relation holds (oblique aspect).#

(2) #The appearance of a graticule that depends on whether the center of the graticule represents a pole of the spheroid (polar aspect), a point on the Equator (meridional or equatorial aspect), or neither (oblique aspect).#

If the oblique aspect of a map projection is not symmetric about the central meridian, the aspect is called a skew oblique aspect.

map projection, Atlantis See *map projection, Mollweide.*

map projection, August #A *conformal map projection* of the whole sphere within a two-cusped epicycloid.#

A description was published by F. August in 1874. The sphere is first mapped conformally onto a disk. A two-cusped epicycloid is generated by rolling a circle, whose radius is 1/2 of the radius of the disk, on the circumference of the disk within which the sphere was mapped. The equation of the epicycloid is found in terms of the x,y coordinates of the circumference, thus mapping the 180° meridian onto the epicycloid. These equations therefore map the interior of the circle into the interior of the epicycloid. See Deetz and Adams (1921) and Schmid (1974) for details.

map projection, authalic See *map projection, equal-area.*

map projection, autogonal See *map projection, conformal.* The term "autogonal", meaning "conformal", is seldom used.

map projection, azimuthal #A map projection on which the azimuths or directions of all lines radiating from a central point or pole are the same as the azimuths or directions of the corresponding lines on the ellipsoid.#

Also called a zenithal map projection or central map projection. As a class, azimuthal map projections include a number of special projections which are described under their individual names. An azimuthal map projection may be constructed with two central points; such a projection is called a doubly azimuthal map projection.

map projection, azimuthal equal-area #An *azimuthal map projection* which also is an *equal-area map projection.*

On the sphere, with origin at the pole, the projection is defined by

$$r = 2R \sin(\phi/2) \text{ and } \theta = \lambda$$

where r and θ are polar coordinates on the plane, ϕ and λ are polar coordinates on the sphere, and R is the radius of the sphere.#

The projection is known both as the Lambert azimuthal and as the Lorgna.

map projection, azimuthal equidistant #*An azimuthal map projection* on which straight lines radiating from the center of projection represent geodesics in their true azimuths from the center; lengths along those lines are exact in scale.#

This map projection is neither equal-area nor conformal. Also called the Postel map projection.

map projection, Babinet See *map projection, Mollweide.*

map projection, Behrmann #A *cylindrical equal-area map projection* which maps the sphere onto a cylinder secant at latitudes 30°N and 30°S.#

The Behrmann projection is a limiting case of the Albers map projection.

map projection, bipolar oblique conformal conical #A *conformal map projection* that maps each of two subhemispheres upon a separate cone, each with its vertex centered in one of the hemispheres. The two maps are fitted together.#

The projection was described by O. M. Miller (1942) and was used for a map of the Americas.

map projection, Boggs See *map projection, eumorphic.*

map projection, Bomford See *map projection, Hammer-Aitoff.*

map projection, Bonne #An *equal-area map projection* defined by the equations

$$x = k(N \cot \phi_0 - \Delta s)\sin \theta \ ,$$

$$y = k(N \cot \phi_0(1 - \cos \theta) + \Delta s \cos \theta),$$

$$\theta = (N \cos \phi \ \Delta\lambda)/(N \cot \phi_0 - \Delta s).$$

Here x, y are the rectangular Cartesian coordinates (easting and northing, respectively) of a point whose latitude and longitude are ϕ, λ; ϕ_0, λ_0 are the coordinates of the point corresponding to $x = 0$, $y = 0$; N is the radius of curvature in the prime vertical of the ellipsoid; $\Delta s = s - s_o$, where s and s_o are meridional arc lengths corresponding to ϕ and ϕ_0, respectively; and k is the scale factor.#

The line representing the central meridian is straight and the scale along it is exact. All parallels of latitude are represented by arcs of concentric circles separated by truly scaled distances. All lines representing meridians, except for the central meridian, are curved. A particular form of this map projection is the Sanson-Flamsteed or *sinusoidal map projection,* for which the Equator serves as the parallel of origin.

map projection, Breusing #A map projection that transforms parallels of latitude into circles with radii that are the geometric means of those of the *stereographic map projection* and the *azimuthal equal-area map projection.* The radius r of the circle representing a parallel of latitude ϕ is given by

$$r = 2\ kR\ [\tan^{1/4}(\pi - 2\phi)\ \sin^{1/4}(\pi - 2\phi)]^{1/2}$$

where k is the scale factor and R is the radius of the sphere.#

A somewhat similar map projection based on the harmonic mean rather than the geometric mean of the radii, also called the Breusing map projection, was introduced by A. E. Young. In Young's variation, the scale was changed to give the least total error for a map of given radius.

map projection, Briesemeister #An oblique version of the *Hammer-Aitoff map projection* modified by a change of scale along the coordinate y-axes.#

map projection, butterfly See *map, butterfly.*

map projection, Cassini #The meridional (transverse) form of the *Plate Carrée map projection.* It plots to scale, in a rectangular Cartesian coordinate system: (a) the geodetic distance to a point on the ellipsoid from the central meridian as the x-coordinate, and (b) the distance along the central meridian from the origin to the point of intersection with the geodesic as the y-coordinate.#

This projection is not conformal but scale is exact along the line representing the central meridian and along lines representing geodesics perpendicular to the central meridian. For the sphere of radius R, the rectangular Cartesian coordinates x and y of a point corresponding to a point on the sphere whose latitude is ϕ and whose longitude is $\lambda_o + \Delta\lambda$, are given by the transcendental equations

$$\sin\ (x/kR) = \cos \phi \sin \Delta\lambda$$

$$\cot\ (\phi_o + y/kR) = \cot \phi \cos \Delta\lambda,$$

where ϕ_o is a specified latitude, λ_o is the longitude of the central meridian, and k is the scale factor.

Also called Cassini-Soldner map projection, Soldner map projection, equal-coordinate map projection, and transverse Plate Carrée map projection.

map projection, Cassini-Soldner See *map projection, Cassini.*

map projection, central See *map projection, azimuthal* and *map projection, gnomonic.*

map projection, classification of See *map projections, classification of.*

map projection, combined #A map projection derived from two or more separate projections, or from two or more different aspects of the same projection, by expressing the coordinates in the plane as some average of the corresponding coordinates given by the original projections.#

The *Breusing* and the *eumorphic map projections* are examples.

map projection, conformal #A map projection that has the property that, at any point, the scale is the same in any direction.#

Alternatively, a map projection on which the angle between any two lines on the ellipsoid is the same as the angle between the two corresponding lines on the plane. In such a projection, the *indicatrix of Tissot* is everywhere a circle. Also called an autogonal or orthomorphic map projection. Among the more important conformal map projections are the Mercator, the stereographic, the transverse Mercator, and the Lambert conformal conical.

map projection, conic See *map projection, conical.*

map projection, conical #A projection that maps the ellipsoid (or sphere) onto a tangent or secant cone.#

There are several methods of mapping from the ellipsoid to the cone. Most are analytical in character and cannot be constructed by simple graphic methods, as can a *perspective map projection* from the center of the sphere. Conical map projections may project onto a single cone tangent to the sphere, or secant to the sphere along two parallels; or they may project onto a series of tangent cones, all of which have the same axis that passes through the center of the sphere, with apices at constantly increasing (or decreasing) distances from the sphere. While a cone or cones may be used in descriptive illustrations of conical map projections, care must be taken not to consider such projections geometrical, because most are not.

map projection, cordiform #A map projection producing a *graticule* with a heart-shaped border symmetrical about the central meridian, and with parallels of latitude represented by arcs centered on the polar point.#

map projection, Craster parabolic See *map projection, parabolic.*

map projection, cylindrical #A map projection of an ellipsoid (or sphere) onto a cylinder which is either tangent or secant to the surface of the ellipsoid.#

There are several methods of projecting from the ellipsoid to the cylinder. As with *conic map projections,* some of these are purely analytical in character and do not have graphic counterparts. For example, the *Mercator map projection* is easily described algebraically but not graphically. Other methods are defined geometrically, and the projections are carried out graphically, such as for the *cylindrically equally-spaced map projection.*

map projection, cylindrical equal-area #A map projection which is both cylindrical and equal-area.#

When the ellipsoid is mapped onto a cylinder tangent at the Equator, the mapping is frequently called Lambert's cylindrical equal-area map projection.

map projection, cylindrical equidistant See *map projection, cylindrically equally-spaced.*

map projection, cylindrical perspective See *map projection, perspective.*

map projection, cylindrically equally-spaced (1) See *map projection, Plate Carrée.*

(2) #A map projection, from the ellipsoid (or sphere) to the cylinder, that maps meridians into equally spaced straight lines and parallels of latitude into equally spaced straight lines perpendicular to the first set of lines.#

The two principal forms are the Plate Carrée projection, in which spacing is the same for the two sets, and the modified Plate Carrée projection, in which different spacings are used for the two sets.

(3) #An oblique aspect of (1) or (2). See *map projection, aspect of a.* #

map projection, decumenal Mercator See *map projection, oblique Mercator.*

map projection, de Lisle See *map projection, conical.*

map projection, double #A map projection that is the product of two sequential map projections.#

An example is the version of the *transverse Mercator map projection* from ellipsoid to plane that is produced by first mapping the ellipsoid onto a sphere and then mapping that sphere onto a plane.

map projection, doubly azimuthal #An *azimuthal map projection* having two poles.#

See *map projection, two-point azimuthal.*

map projection, doubly periodic See *map projection, Guyou.*

map projection, Eckert #Any of six map projections devised by Max Eckert for mapping the entire sphere onto the plane so that the poles are represented by straight lines half the length of the Equator.#

map projection, English See *map projection, globular (2).*

map projection, equal-area #A map projection which preserves a constant ratio between the area of a region on the ellipsoid and the area of the corresponding region on the plane.#

For example, the area enclosed by any given boundary on the ellipsoid bears the same ratio to the area enclosed by that boundary on the plane as the area of the mapped portion of the ellipsoid bears to the area of the map. On an equal-area map, a definite area (such as a square centimeter) represents a constant area on the ellipsoid, no matter where the square centimeter is located on the map. Also called an equivalent map projection, authalic map projection, homalographic map projection and orthembadic map projection. The principal equal-area map projections are Albers, the azimuthal equal-area, Lambert conical equal-area, Mollweide, the Hammer-Aitoff, the sinusoidal, and Bonne.

map projection, equal-coordinate See *map projection, Cassini.*

map projection, equatorial (1) See *map projection, meridional.*

(2) See map projection, polar.

The two definitions are antithetical, but have been thus employed by various authors. Maling (1973) uses (1); Craig (1882) uses (2).

map projection, equidistant (1) #A map projection from the ellipsoid to the plane that keeps the scale exact along all lines radiating from the point at which distortion is zero, or along all lines perpendicular to the line along which distortion is zero.#

(2) #A map projection producing a *graticule* on which lines representing parallels of latitude are spaced at equal distances along the lines representing meridians, or on which lines representing meridians are equally spaced along lines representing parallels.#

Also called an equidistance map projection.

map projection, equidistant cylindrical See *map projection, cylindrically equally-spaced.*

map projection, equidistant polar See *map projection, azimuthal equidistant.*

map projection, equirectangular See *map projection, Plate Carrée.*

map projection, equivalent See *map projection, equal-area.*

map projection, eumorphic #An *equal-area map projection* for which each map rectangular coordinate is the arithmetic average of the corresponding coordinates for the *Mollweide* and *sinusoidal map projections* .#

Also called Boggs map projection and Boggs eumorphic map projection.

map projection, Flamsteed See *map projection, sinusoidal.*

map projection, Gall stereographic #A map projection defined, for mapping the sphere on the plane, by

$$x = (\sqrt{2/2})\, kR\, \lambda \text{ and } y = kR(1 + \sqrt{2/2}) \tan(\phi/2),$$

where λ and ϕ are the longitude and latitude at a point, R is the radius of the sphere, and k is the scale factor.#

This is a *cylindrical perspective projection* in which the cylinder is secant to the sphere at the parallels 45°N and 45°S. Unlike the *stereographic map projection*, it is not conformal. It resembles the stereographic only in that its perspective point is on the surface of the sphere opposite the developable surface. However, the developable surface is a plane in the case of the stereographic, but a cylinder in the case of the Gall stereographic.

map projection, Gauss See *map projection, Gauss-Krüger.*

map projection, Gauss-Boaga See *map projection, transverse Mercator.*

map projection, Gauss-Krüger #The *transverse-Mercator map projection* derived by mapping directly from the ellipsoid onto the plane.#

It is conformal and scale is exact along the line representing the central meridian.

Terminology is inconsistent. Some cartographers limit the term "Gauss-Krüger" to the transverse Mercator map projection from an ellipsoid onto a plane and limit the term "transverse Mercator" to projection from a sphere onto the plane; other usages exist. However, most American geodesists consider the terms "Gauss-Krüger" and "transverse Mercator" to be equivalent (although there is also a Gauss-Krüger stereographic map projection). Also called the Gauss map projection and the Gauss conformal map projection.

map projection, Gauss conformal See *map projection, Gauss-Krüger* and *map projection, transverse Mercator.*

map projection, Gauss conformal conical See *map projection, Lambert conformal conical.*

map projection, Gauss-Laborde See *map projection, Gauss-Schreiber.*

map projection, Gauss-Schreiber #The *transverse Mercator map projection* derived by a conformal transformation from the ellipsoid to an auxiliary sphere and thence, by another conformal transformation, to the plane.#

The procedure was originally described by Schreiber in 1866. Also called the Gauss-Laborde map projection.

map projection, geometric See *map projection, perspective.*

map projection, globular (1) #A map projection, other than the transverse aspect (see *map projection, aspect of a*) of the azimuthal map projection, of a hemisphere onto a disk.#

The earliest globular map projection appears to have been derived by G. Fourier in 1643. The Nell modified globular map projection produces a graticule in which the rectangular Cartesian coordinates of a point are the arithmetic average of those produced by the *Nicolosi map projection* and those produced by the transverse aspect of the *stereographic map projection.*

(2) See *map projection, Nicolosi.*

map projection, gnomonic #A *perspective map projection* from the ellipsoid onto a tangent plane with the point of projection at the center of the ellipsoid.

It is defined for the sphere by the equations:

$$x = kR \sin \Delta\lambda \cos\phi / D \ ,$$

$$y = kR(\cos \phi_0 \sin \phi - \sin \phi_0 \cos \phi \cos \Delta\lambda)/D \text{, and}$$

$$D = \sin \phi_0 \sin \phi + \cos \phi_0 \cos \phi \cos \Delta\lambda \ .$$

Here x and y are the rectangular Cartesian coordinates of the point on the plane corresponding to the point on the sphere at latitude ϕ and at longitude $\lambda_o + \Delta\lambda$, where λ_o is the longitude of the central meridian, ϕ_o is the latitude of the point of tangency, R is the radius of the sphere, and k is the scale factor.#

The projection is the only one representing great circles on the sphere by straight lines. Also called a central map projection. The form having the plane tangent at the Equator has been called the meridional central (map) projection.

map projection, Guyou #A *conformal map projection* of a hemisphere into a square, with the poles at the centers of opposite sides of the square. The lines representing meridians and parallels of latitude are doubly periodic elliptic integrals of the first kind.#

Also called a doubly periodic map projection. The entire world can be mapped into a 2 × 1 rectangle.

map projection, Hammer-Aitoff #A map projection that is the product of the meridional aspect of the *azimuthal equal-area map projection* and an orthogonal projection of the resulting map onto a plane tilted 60° about a line tangent to the Equator. The values of the lines representing meridians are then doubled so that they can now range over the entire ellipsoid.#

The equations for mapping from the sphere to the plane are

$$x = 2\sqrt{2}\, kR(\sin{}^{1}\!/_{2}\Delta\lambda \cos\phi)/D$$

$$y = \sqrt{2}\, kR \sin\phi/D$$

$$D = (1 + \cos\phi \cos{}^{1}\!/_{2}\Delta\lambda)^{1/2}$$

where x and y are the rectangular Cartesian coordinates of the point in the plane that corresponds to the point on the sphere at latitude ϕ and at longitude $\lambda_o + \Delta\lambda$, where λ_o is the longitude of the central meridian, R is the radius of the sphere, and k is a scale factor. The resulting map is bounded by an ellipse in which the length of the line representing the Equator (major axis) is double the length of the line representing the central meridian (minor axis).

map projection, Hatt See *map projection, azimuthal equidistant.*

map projection, homalographic (1) See *map projection, equal-area.*

(2) See *map projection, Mollweide.*

(3) See *map, Goode's homalographic.*

map projection, homalosine See *map, homalosine.*

map projection, homolographic See *map projection, equal-area.*

map projection, homolosine See *map, homalosine.*

map projection, Hotine rectified skew orthomorphic #An approximation to the *oblique Mercator map projection* based on the use of the *aposphere* as the surface onto which an ellipsoid is first projected, before final projection onto the plane.#

This projection is precisely conformal but the scale along the chosen central line is not exactly constant. However, it is sufficiently constant over a restricted area to be geodetically useful.

map projection, International Map of the World (1) #For maps prepared before 1962, a *modified polyconic map projection*, with two standard meridians along which the scale is held exact.#

Each sheet of the series depicts 4° of latitude and 6° of longitude up to latitude 60°; between latitudes 60° and 76°, the sheets are double width, so each covers 4° of latitude and 12° degrees of longitude. From 76° to 84°, the sheets are 24° wide. The scale of the map is 1: 1,000,000; thus, it is also called the millionth-scale map of the World.

(2) #In 1962, this projection was replaced by Lambert's conformal conical with two standard parallels; between 84°N and 80°S; near the poles, the polar stereographic map projection was used.#

map projection, interrupted See *map, interrupted.*

map projection, isometric #A map projection that maps a particular set of geodesics on the ellipsoid into a set of lines of length at constant ratio on the plane.#

Also called a length-preserving map projection.

map projection, isoperimetric #A map projection, from the ellipsoid to the plane, in which exact scale is maintained along the closed curve on the plane that corresponds to a given closed curve on the ellipsoid.#

map projection, James See *map projection, perspective.*

map projection, Laborde #A map projection, from the ellipsoid to the plane, approximately equivalent to an *oblique Mercator map projection* but modified so that, within the region mapped, linear distortion is minimal. The steps involved in going from the ellipsoid to the plane are as follows. (a) The ellipsoid is mapped conformally onto a sphere having the average curvature of the ellipsoid at the proposed origin and tangent to the ellipsoid at that origin. Differences in longitude and *isometric latitude* are kept proportional between the ellipsoid and the sphere. (b) The sphere is mapped conformally onto a cylinder tangent along the central meridian, using a *transverse Mercator map projection.* (c) The cylinder is mapped onto a plane on which the coordinates $x_{plane} = x_{cylinder}$ and $y_{plane} = y_{cylinder}$; the map on the plane is distorted (but keeping conformality) to reduce scale error along an axis oblique to the meridional line (the scale error along the line representing the meridian is thereby increased). The x- and y-axes at the origin are still parallel to and perpendicular to the meridian. (d) By a change of scale, the error is made zero along two oblique lines instead of along one. The linear distortion in an oblique direction is minimized.#

This map projection was first described in 1926 as applied to the mapping of Madagascar, where Laborde served as chief of the Service Géographique.

map projection, La Hire See *map projection, perspective.*

map projection, Lambert azimuthal equal-area See *map projection, azimuthal equal-area.*

map projection, Lambert azimuthal meridional equal-area See *map projection, azimuthal equal-area.*

map projection, Lambert azimuthal (polar) equal-area See *map projection, azimuthal equal-area.*

map projection, Lambert central equivalent See *map projection, azimuthal equal-area.*

map projection, Lambert conformal conic #A map projection from the hemisphere (or the half-ellipsoid) to the plane, defined, for the hemisphere, by the equations

$$r = kR\cos\phi_1[\tan{}^1\!/\!_4(\pi - 2\phi)/\tan{}^1\!/\!_4(\pi - 2\phi_1)]^n/n$$

$$\theta = n\Delta\lambda, \text{ and}$$

$$n = (\ell n \cos\phi_1 - \ell n \cos\phi_2)/[\ell n \tan{}^1\!/\!_4(\pi - 2\phi_1) - \ell n \tan{}^1\!/\!_4(\pi - 2\phi_2)] .$$

Here r and θ are the polar coordinates of the point on the plane that corresponds to the point on the sphere at latitude ϕ and longitude $\lambda_o + \Delta\lambda$, and λ_o is the longitude of the central meridian. ϕ_1 and ϕ_2 are the latitudes of two parallels for which the scale, on the corresponding lines of the graticule, is exact. R is the radius of the sphere and k is the scale factor.#

This is also called the Lambert conformal conic map projection with two standard parallels. The equations for Lambert's conformal conic map projection with one standard parallel is a special case of the above and results from the above equations by letting ϕ_2 approach ϕ_1, so that n equals sin ϕ_1. All meridians are represented by straight lines that meet in a common point outside the limits of the map, and the parallels of latitude are represented by a series of arcs of circles having the common point for a center. The mapping is uniquely defined by the property of conformality, and isometric mapping along a particular parallel. The Mercator projection can be considered a special case in which the Equator is the single standard parallel.

map projection, Lambert conformal cylindrical See *map projection, transverse Mercator.*

map projection, Lambert conical equal-area #A map projection defined, for the sphere, by the equations

$$r = 2kR \sin{}^1\!/\!_4(\pi - 2\phi)/n^{1/2},\ \theta = n\Delta\lambda,\ n = \sin^2(\phi_0/2)$$

where r and θ are the polar coordinates of a point in the plane, ϕ and $\lambda_o + \Delta\lambda$ are the latitude and longitude of the corresponding point on the sphere, λ_o is the longitude of the central meridian, R the radius of the sphere, k the scale factor, and ϕ_o is the latitude of the parallel along which scale is preserved.#

Also called Lambert isospheric stenoteric map projection.

map projection, Lambert cylindrical equal-area See *map projection, cylindrical equal-area.*

map projection, Lambert cylindrical orthomorphic See *map projection, transverse Mercator.*

map projection, Lambert equal-area meridional See *map projection, azimuthal equal-area.*

map projection, Lambert isospheric stenoteric See *map projection, Lambert conical equal-area.*

map projection, Lorgna See *map projection, azimuthal equal-area.*

map projection, Lowry See *map projection, perspective.*

map projection, Marinus See *map projection, Plate Carrée.*

map projection, Maurer orthodromic See *map projection, two-point azimuthal.*

map projection, Mecca See *map projection, retroazimuthal.*

map projection, Mercator #A map projection from the ellipsoid to the plane and defined by the equations

$$x = ka\Delta\lambda, \text{ and}$$

$$y = ka\,\ell n\left[\tan{}^1\!/\!_4(\pi + 2\phi)\left(\frac{1 - \epsilon\sin\phi}{1 + \epsilon\sin\phi}\right)^{\epsilon/2}\right]$$

in which x and y are the rectangular Cartesian coordinates of the point on the plane which corresponds to a point on the ellipsoid with latitude ϕ and longitude $\lambda_o + \Delta\lambda$, where λ_o is the longitude of the central meridian, a is the length of the semimajor axis, ϵ is the eccentricity of the ellipsoid, and k is a scale factor.#

The projection is conformal. The Equator is represented by a straight line usually true to scale (two parallels of latitude equidistant from the Equator may be made true to scale instead). The meridians are represented by parallel straight lines perpendicular to the line representing the Equator. The parallels of latitude are represented by a second system of straight lines perpendicular to the family of lines representing the meridians. Conformality is achieved by increasing the spacing between parallels with increasing distance from the Equator, to conform with the expanding scale along the parallels. The Mercator map projection is considered one of the most valuable of all map projections; its most useful feature is that a line of constant azimuth (bearing) on a sphere is represented on this projection by a straight line.

map projection, Mercator equal-area See *map projection, sinusoidal.*

map projection, Mercator-Sanson See *map projection, sinusoidal.*

map projection, meridional #A map projection producing a *graticule* with its center on the line representing the Equator.#

map projection, meridional central See *map projection, gnomonic.*

map projection, meridional orthographic See *map projection, orthographic.*

map projection, Miller cylindrical #A map projection in which meridians and parallels are straight lines, according to the formulas (defined for the sphere of radius R)

$$x = kR\lambda \text{ and } y = kR[\ell n \tan{}^1\!/\!_4(\pi + 2m\phi)]/(mn)$$

where m and n are constants (usually 0.8 and 1.0, respectively), λ and ϕ are longitude and latitude, respectively, and k is the scale factor.#

Areal distortion is less than in the Mercator map projection, but departure from conformality is larger. It is designed to decrease the areal distortions found at high latitudes of the Mercator projection by proper choices for m and n. (In the Mercator projection, $m = n = 1$.)

map projection, minimum-error #A projection producing a map for which the sums of squares of scale errors in mutually perpendicular directions integrated throughout the map are minimal.#

map projection, modified (1) #Any map projection in common use that has been changed by relocating the point or line of zero distortion and by specifying scale along different lines.#

(2) #A map projection that differs slightly from the map projection on which it is based.#

(3) #A *graticule* that is the oblique aspect of an unmodified map projection and that has been obtained by calculation.#

map projection, modified Plate Carrée See *map projection, Plate Carrée.*

map projection, modified polyconic #A map projection obtained from the regular *polyconic map projection* by altering the scale along the central meridian so it is exact along two standard meridians, one on either side of and equidistant from the central meridian.#

The term is also applied to a *rectangular polyconic map projection*. Before 1962, a modified polyconic map projection was used for the International Map of the World; the scale was exact along straight lines representing those meridians usually located 2° from the central meridian. A slightly different kind of modified polyconic map projection was also used for some State maps published by the U.S. Geological Survey. A third type is used for maps of extreme northern Canada.

map projection, Mollweide #A projection mapping the ellipsoid on the plane by the equations

$$x = (2k/\pi)a\eta^{1/2}\Delta\lambda \cos t,\ y = ka\eta^{1/2} \sin t$$

where t is a parameter defined by the implicit equation

$$2t + \sin 2t = \pi \sin \beta,$$

$$\text{and } \eta = 1 + [(1 + e^2)/2e]\ell n[(1 + e)/(1 - e)];$$

x and y are rectangular Cartesian coordinates of the point in the plane that corresponds to the point on the ellipsoid at longitude $\lambda_o + \Delta\lambda$ and authalic latitude β; λ_o is the longitude of the central meridian, a is the semimajor axis, e the eccentricity of the ellipsoid, and k is a scale factor.#

It is an equal-area projection that maps the Equator and other parallels of latitude into straight lines, and the meridians other than the central meridian into elliptical arcs. The central meridian is represented by a straight line, and the meridian 90° from the center is shown as a full circle. When this map projection is used to show the entire surface of the Earth, it is bounded by an ellipse whose major axis, representing 360° of longitude, is double the length of its minor axis, representing 180° of latitude. When it is used to map a hemisphere, the boundary of the map is a full circle.

Also called the Babinet map projection.

map projection, Nell modified globular See *map projection, globular.*

map projection, Nicolosi #A map projection from the hemisphere to a disk, in which the Equator and central meridian are mapped isometrically, the bounding meridian of the hemisphere is represented by the circumference of the disk, and the arcs of the bounding meridian and the corresponding arcs of the circumference are proportional.#

The parallels are arcs through the divisions of the central meridian passing through the corresponding divisions of the bounding meridian.

Also called the *globular projection*.

map projection, nonperspective #Any map projection that cannot be constructed by linear projection (i.e., by perspective) from a single point.#

map projection, Nordic See *map projection, Hammer-Aitoff.*

map projection, normal aspect of See *map projection, aspect of a.*

map projection, oblique aspect of See *map projection, aspect of a.*

map projection, oblique Mercator #A *conformal map projection* on which the line of isometry (i.e., on which the scale is exact) is an arbitrary geodesic.#

By the above definition the Mercator (on which the line of isometry is the Equator) and Transverse Mercator projections (where the line of isometry is a meridian) are special cases. However, the oblique Mercator projection is usually limited to exclude these two instances. If the origin is chosen at the point where the geodesic is orthogonal to a meridian, then the projection is known as the decumenal Mercator projection.

Formulas for the sphere are relatively simple; those for the ellipsoid are much more complicated. Many practical applications retain conformality but allow the scale along the central line to vary slightly. Also called the Rosenmund map projection, Hotine oblique Mercator, etc. The oblique Mercator projection has been used principally for maps of Malaya, Borneo, and Switzerland, and for the State coordinate system in Alaska. It has also been used for maps made from pictures taken from satellites.

map projection, orthembadic See *map projection, equal-area.*

map projection, orthographic #A map projection defined, from the sphere to the plane, by the equations

$$y = kR(\cos \phi_1 \sin \phi - \sin\phi_1\cos\phi \cos \Delta\lambda)$$

$$x = kR \cos \phi \sin \Delta\lambda\ ,$$

where x and y are the rectangular Cartesian coordinates of the point in the plane that corresponds to the point on the sphere at latitude ϕ and longitude $\lambda_o + \Delta\lambda$ where λ_o is the longitude of the central meridian, ϕ_1 is the latitude of the point represented by the origin of the map, R is the radius of the sphere, and k is the scale factor.#

In general, the meridians are represented by ellipses having their centers at the origin, and the parallels of latitude are represented by ellipses having their centers on the x-axis. The orthographic map projection corresponds to a *perspective map projection* with the point of projection at an infinite distance from the sphere. The above definition can be generalized to the mapping of an ellipsoid onto the plane.

map projection, orthomorphic See *map projection, conformal.* American usage seems to favor "conformal" and British usage "orthomorphic".

map projection, parabolic #An *equal-area map projection*, invented by J. E. E. Craster (1929), which represents the parallels of latitude by straight lines parallel to the Equator and the meridians by parabolas with vertices at the Equator.#

map projection, Peirce See *map projection, quincuncial.*

map projection, perspective #A projection from an ellipsoid to a developable surface in such a way that corresponding points on the two surfaces lie on a common line through a single, specified point.#

It is equivalent, geometrically, to drawing straight lines radially from the specified point (called the center of projection or perspective center) through points on the ellipsoid to the developable surface. Of the various developable surfaces, only the plane, the cylinder, and the cone are in general use. Each of these gives rise to an important family of map projections.

(1) The perspective map projection onto the plane. The plane is usually tangent to a sphere at the center of the region being mapped. The center of projection is a point on the diameter of the sphere that passes through the point of tangency (except that the point of tangency itself may not be selected). If the point of projection is at the center of the sphere, we get the gnomonic map projection; if it is at the opposite end of the diameter from the point of tangency of the plane of the map, we get a stereographic map projection; and if it is at an infinite distance, an orthographic map projection.

(2) The conical perspective map projection. The cone is tangent or secant to the sphere and the center of projection is almost always placed on the axis of the cone, usually at the center of the sphere.

(3) The cylindrical perspective map projection. This is a limiting case of (2). The cylinder is tangent to the sphere and the center of projection is usually at the center of the sphere.

Perspective map projections were developed by James, La Hire, Clarke, Lowry, Parent, and others.

map projection, plane perspective See *map projection, perspective.*

map projection, Plate Carrée #The pair of functions

$$x = kR\,\Delta\lambda \text{ and } y = kR\,\phi$$

which transform longitude $\lambda_o + \Delta\lambda$ and latitude ϕ on the sphere into rectangular coordinates x and y on the plane. Here, λ_o is the longitude of the central meridian, R is the radius of the Earth and k is a scale factor.#

This projection is also called the simple cylindrical map projection and the cylindrical equidistant map projection.

The term "modified Plate Carrée map projection" is used for one on which the spacing between lines representing parallels of latitude is constant but is different from the spacing between lines representing meridians.

map projection, polar (1) #A map projection with its center representing one of the poles.#

Also called an equatorial map projection, although the term is also used for a meridional map projection.

map projection, polar Lambert azimuthal equal-area *See map projection, Lambert azimuthal equal-area.*

map projection, polar orthographic See *map projection, orthographic.*

map projection, polar stereographic See *map projection, stereographic.*

map projection, polyconic (1) #A map projection in which the parallels of latitude are represented by nonconcentric circular (or higher degree) arcs with centers on the central meridian.#

(2) #The polyconic map projection (1) which keeps scale exact along lines representing the central meridian and parallels of latitude.#

This is the most common specific polyconic projection.

It is defined, for the mapping from the ellipsoid of revolution to the plane, by the equations

$$x = kN \cot\phi \sin(\Delta\lambda \sin\phi)$$

$$y = ks + 2kN \cot\phi \sin^2[(\Delta\lambda \sin\phi)/2]$$

where x and y are the rectangular Cartesian coordinates of the point on the plane representing a point on the ellipsoid with latitude ϕ and longitude $\lambda_o + \Delta\lambda$, where λ_o is the longitude of the central meridian, N is the radius of curvature in the prime vertical at geodetic latitude ϕ, s is the length of arc equivalent to ϕ, and k is the scale factor.

The central meridian is represented by a straight line, and the parallels of latitude by arcs of circles whose centers lie on the line representing the central meridian and whose radii are determined by the lengths of the elements of cones tangent along the parallels. All meridians except the central one are curved.

This projection is neither conformal nor equal-area, but it has been used extensively for maps of small areas because of the ease with which it can be constructed. It was the projection used until the 1950's for maps of the "Topographic Map of the United States (U.S. Geological Survey)" series and, in a modified form, for maps of larger regions. It was devised by F. R. Hassler, first superintendent of the U.S. Coast Survey. For this reason, it is sometimes called the American polyconic map projection or American ordinary polyconic map projection.

The rectangular polyconic map projection resembles the ordinary polyconic map projection defined above, but scale is exact only along one line representing a parallel of latitude. Circular arcs representing other parallels of latitude are scaled so that they intersect the meridional lines at right angles. This map is neither conformal nor equal-area. The modified polyconic map projection, also called the polyconic map projection with two standard meridians, was devised by Lallemand and is characterized by the fact that scale is exact along two meridians. There are also other equal-area polyconic map projections, e.g., the National Geographic Society's equal-area polyconic map projection.

map projection, polygonomonic See *map, polygnomonic.*

map projection, polyhedral See *map, polyhedric.*

map projection, polyhedric See *map, polyhedric.*

map projection, Postel See *map projection, azimuthal equidistant.*

map projection, pseudo-azimuthal #A class of map projections that produces *graticules* whose normal aspect (see *map projection, aspect of a*) is comprised of concentric circular lines representing parallels of latitude, and curved lines representing meridians that converge at the pole at their true angular values.#

map projection, pseudoconical #A class of map projections producing *graticules* in which principal scale is preserved along the line representing a single standard parallel and along the central meridian.#

In the normal aspect (see *map projection, aspect of a*), parallels of latitude are represented by concentric circular arcs and meridians by convergent curves. Bonne's pseudoconical map projection is the most common.

map projection, pseudocylindrical #A class of map projections producing *graticules* in which principal scale is preserved along the lines representing the Equator and the central meridian.#

In the normal aspect (see *map projection, aspect of a*), parallels of latitude are represented by a system of parallel straight lines, and the meridians by convergent curves. The sinusoidal map projection is one of the best known.

map projection, quincuncial #A *conformal map projection* of the sphere into a square using elliptical functions, with one pole at the center of the square and the other pole at the four corners.#

map projection, recentered See *map, interrupted.*

map projection, rectangular See *map projection, Plate Carrée.*

map projection, rectangular polyconic See *map projection, polyconic.*

map projection, retro-azimuthal #A map projection having the property that the azimuth or direction from any point on the map *to* a particular point specified by the projection is the same as the azimuth or direction from the first point to the second on the ellipsoid.#

This is the converse of the azimuthal map projection, which preserves azimuths *from* the point specified. The outstanding example of the retro-azimuthal map projection is the Mecca map projection, in which Mecca is the point specified. It was first described by J. I. Craig in 1909.

map projection, Rosenmund See *map projection, oblique Mercator.*

map projection, Sanson See *map projection, sinusoidal.*

map projection, Sanson-Flamsteed See *map projection, sinusoidal.*

map projection, simple cylindrical See *map projection, Plate Carrée.*

map projection, simple polyconic See *map projection, polyconic.*

map projection, sinusoidal #A map projection from an ellipsoid to a plane by the equations $x = kN\Delta\lambda\cos\phi$, and $y = ks$, where x and y are the rectangular Cartesian coordinates of the point in the plane representing a point on the sphere at longitude $\lambda_o + \Delta\lambda$ and latitude ϕ, λ_o is the longitude of the central meridian, N is the radius of curvature in the prime vertical, s is the meridional arc length corresponding to ϕ, and k is a scale factor.#

It is a particular case of the *Bonne map projection*, in which the Equator is used as the standard parallel. It is a refinement of the *Plate Carrée map projection* in that x is corrected for the convergence of the meridians. The map represents all parallels of latitude as truly spaced, parallel straight lines along which scale is preserved. An equal-area map projection, it is also known as the Mercator equal-area map projection and as the Sanson-Flamsteed map projection. It was used in the Mercator-Hondius atlases as early as 1606.

map projection, Sir Henry James See *map projection, perspective.*

map projection, skew Mercator See *map projection, oblique Mercator.*

map projection, skew orthomorphic See *map projection, oblique Mercator.*

map projection, Soldner (1) See *map projection, Cassini.*

(2) #A map projection, from an ellipsoid of revolution to a plane, so constructed that the x-coordinate of a point P' in the plane is the scaled distance of the corresponding point P on the ellipsoid from the central meridian measured along a parallel of latitude. The y-coordinate of P' is the same scale distance as a parallel of latitude through P from the Equator measured along the central meridian.# This is not the same as Cassini's map projection; the latter is more common.

map projection, space-oblique Mercator #A variant of the oblique Mercator map projection used for maps made from pictures taken by Landsat satellites.#

The central line of the projection is the subpoint track of the satellite rather than an ellipse or great circle.

map projection, Stab-Werner See *map projection, Werner.*

map projection, stereographic #A *conformal map projection* that has a single point of isometry.#

For the sphere, the stereographic is a perspective projection with the point of projection at the opposite end of the diameter of the sphere from the point of tangency of the plane of the projection. For the ellipsoid, the projection is not quite perspective, if conformality is to be preserved. The equations for the sphere are

$$x = kR(\cos\phi_1 \sin\phi - \sin\phi_1 \cos\phi \cos\Delta\lambda)/D ,$$

$$y = kR(\cos\phi \sin\Delta\lambda)/D ,$$

$$D = [1 + \sin\phi_1 \sin\phi + \cos\phi_1 \cos\phi \cos\Delta\lambda]/2 .$$

Here, x and y are the rectangular Cartesian coordinates of the point on the plane corresponding to the point on the sphere at longitude $\lambda_o + \Delta\lambda$ and latitude ϕ, λ_o is the longitude of the central meridian, ϕ_1 is the latitude of the point on the sphere corresponding to the point of isometry, R is the radius of the sphere, and k is the scale factor.#

It is one of the most widely known of all map projections, and has been in general use for maps of an entire hemisphere. When the center of projection is located at one of the poles of the sphere, it is called a polar stereographic map projection; when the center is on the Equator, it is called a meridional stereographic map projection, and when the center is on some other selected parallel of latitude, it is called an oblique or horizon stereographic map projection.

map projection, transverse Mercator #A *conformal map projection* which maps a meridian isometrically.#

On the ellipsoid, the projection is derived either as a direct mapping from ellipsoid to plane (often called the Gauss-Krüger map projection), or as the mapping from ellipsoid to sphere followed by mapping from sphere to plane (when it is known as either the Gauss-Schreiber or the Gauss-Laborde map projection).

On the map, the meridian, mapped exactly, is represented as a straight line. No other meridians or parallels of latitude are represented by straight lines.

The theory for the sphere was developed by J.H. Lambert in 1772 and an analytical theory for the ellipsoid was derived by Gauss in 1825. It was described by L. Krüger in two publications dating from 1912 and 1919 and was adopted by Germany in 1927 for its maps under the name Gauss-Krüger map projection.

map projection, transverse polyconic #A *polyconic map projection* obtained by substituting for the central meridian a great circle perpendicular to that meridian.#

This is done to provide an axis along which will lie the centers of the circular arcs representing lines of tangency of cones with the surface of the sphere. Although this is a complicated map projection and the *graticule* is difficult to construct, it is useful for mapping, with comparatively little distortion, a narrow area that extends long distances eastward and westward.

map projection, trimetric #A projection that maps, as straight lines on the plane, the three great arcs of a spherical triangle; then the true distances of points on the sphere are laid off from the vertices of the plane triangle.#

For each point on the sphere there is then a corresponding small, plane triangle on the plane formed by the intersecting arcs of the true distances. The center of each small triangle is taken as the representation of the corresponding point on the sphere. This projection has been used for a number of maps published by the National Geographic Society.

map projection, two-point azimuthal #A map projection consisting of the expansion or compression of the features in a *gnomonic map projection* in any direction so that the coordinates in that direction are changed in a constant ratio.#

There are two points on the map through which straight lines represent great circles and at which azimuths to all other points are correct.

map projection, two-point equidistant #A map projection with the property that the two distances of any point on the map from two fixed points are true to scale.#

map projection, Universal Transverse Mercator See *grid, Universal Transverse Mercator.*

map projection, van der Grinten #A projection mapping the sphere onto a disk so that the central meridian and the Equator are represented by perpendicular straight lines, while the other meridians and the parallels of latitude are represented by arcs of nonconcentric circles with their centers on the x-axis and the y-axis, respectively. It was patented by A. van der Grinten in 1904.#

Van der Grinten devised the projection by geometric construction and gave it as a transformation from geodetic coordinates to bipolar coordinates. The projection is neither conformal nor equal-area. Scale is exact along the line representing the Equator, but there is great areal exaggeration in polar regions.

map projection, Werner #A special case of the *Bonne map projection*, with the standard parallel at the pole and the tangent cone becoming a plane tangent at the pole.#

Also called the Stab-Werner map projection.

map projection, zenithal (1) See *map projection, azimuthal.*

(2) #A projection from an ellipsoid to a plane with all points at the same distance from a specified point on the ellipsoid mapped into a circle on the plane.#

map projections, classification of Map projections are classified in a variety of ways. The most common are the following.

(a) A map projection cannot preserve all geometric relationships on the curved surface, but it can preserve one or more of them. A conformal map projection preserves angles; an equal-area map projection preserves areas, an azimuthal map projection preserves azimuths from a point; and an equidistant map projection preserves distances from a particular point or a particular line.

(b) Map projections often map the ellipsoid onto the plane by using a developable surface as intermediary. In a cylindrical map projection the ellipsoid is first mapped onto a cylinder; in a conical map projection the ellipsoid is first mapped onto a cone. Projections directly onto a plane are not designated as such, but are classified according to the location of the center of projection, location of the plane, etc.

Many other schemes of classification exist; the most used are those of Maurer (1935) and Tobler (1962), but the schemes of Wray (1974) and Chovitz (1952) also have many merits.

map revision #The process of making changes to an existing map to improve its accuracy.#

map scale See *scale of a map.*

map scale, equivalent See *scale, equivalent.*

map scale, fractional See *scale, fractional.*

map scale, graphic See *scale, map.*

map scale number See *scale number.*

map series #A set of maps planned to represent a specified region and produced at a uniform scale in a common style.#

map sheet #A map, usually one of a series.#

Marek method of resection #The three-point method of resection.# See *resection.*

mareograph See *marigraph.*

margin (1) #The line or edge along which the surface of a body of water meets the land.#

(2) #The center of the stream forming a boundary of the land.# This is applied in legal usage to the boundary of a piece of land bounded by a stream.

margin, continental #A zone separating a continent from the deep-sea bottom.#

It generally consists of the *continental shelf*, the *continental slope*, and the *continental rise*.

marigraph (1) #An instrument for measuring and recording tides.#

Also called a mareograph.

mark (1) #A dot, the intersection of a pair of crossed lines, or any other physical point corresponding to a point in a survey. It is the physical point to which distances, elevations, heights or other coordinates refer.#

(2) #The object (such as an incised or stamped metallic disk) on which the mark (1) is placed.#

(3) #The entire *monument*, consisting of the mark (1), the object on which it occurs (2) and the structure to which the object is fastened.#

(4) #In hydrography, the term is sometimes used for *water mark.* #

mark, azimuth See *azimuth mark.*

mark, bench See *bench mark.*

mark, contact #A permanent mark at a tide gauge from which the level of the water inside the float well can be measured directly.#

This mark is used to check the accuracy of the heights displayed on the recorder and is located, preferably, on the frame that supports the recorder. The zero mark of the permanent tide scale or the fiducial mark of a sounding probe is established by reference to this mark. The elevation assigned to a particular contact mark is referred to as *tide gauge datum* and may be adjusted according to the results of periodic leveling from the tide gauge bench mark.

mark, fiducial (1) (photogrammetry) #The image of a *fiducial marker.* #

(2) (surveying) #A point or line used as a reference or origin.#

mark, floating #A mark that appears to occupy a position in the apparently three-dimensional space perceived by stereoscopic fusion of a pair of photographs; used as a reference when examining or measuring the stereoscopic model.#

mark, index #A real mark, such as a cross or dot, lying in the plane or the object space of a photograph and used alone as a reference in certain types of monocular instruments, or as one of a pair forming a *floating mark* in certain types of stereoscopes.#

In stereoscopic plotting instruments having pairs of index marks, each mark is called a half-mark.

mark, reference #A mark of permanent character close to a survey station, to which it is related by an accurately measured distance and azimuth (or bearing).#

The connection between a survey station and its reference mark(s) should be sufficiently precise and accurate so the station can be reestablished on the ground should its own marks be destroyed, or to permit use of the reference mark in place of the survey station for extending surveys. Reference marks are used to define positions of boundary corners that may be situated in places (as in water) where permanent marks cannot be placed. See *corner, witness.*

marker #An object identifying the location of a station.# See *marker, survey.*

marker, fiducial #One of a set of (usually four) small objects rigidly fastened to the interior of a camera's body so that they are photographed along with the scene during picture taking.#

The two lines joining images of diametrically opposite fiducial markers intersect at or near the principal point of the photograph; the orientation of the photograph is frequently referred to them. Also called *fiducial mark*, although this term is better applied to the image of the fiducial marker.

marker, geodetic See *marker, survey.*

marker, survey #An object placed at the site of a station to identify the surveyed location of that station.#

In particular, an object whose coordinates are used for control in a geodetic network. Also called marker, geodetic marker, and monument. The characteristics of a station having a survey marker are prominence, permanence, stability, and definite location.

marksetter #A person whose principal responsibility is the emplacement of survey markers.#

marsh #A region of low-lying, wet ground subject to frequent or regular flooding or such a region that is ordinarily covered by shallow water.#

The vegetation of a marsh consists chiefly of reeds, grasses, and grasslike plants. In cadastral surveying, "marsh" has usually been used to refer to *coastal salt marshes.*

marsh, coastal salt #A marsh located along or near the coast with its surface below the elevation of *mean high water.*#

marsh, salt #A region of low-lying, wet ground containing a high proportion of salt or alkali.# It is generally found in arid regions. See *marsh; marsh, coastal salt; and swamp.*

mascon #A hypothetical concentration of mass as the explanation of a large *gravity anomaly*.#

The term, first introduced to account for variations observed in the trajectory of a spacecraft moving around the Moon, is a contraction of "mass concentration".

maser #An instrument which uses the monochromatic emission from a narrow band in the spectrum of a suitable molecule (e.g., ammonia or methane) or atom to control the frequency of a radio-resonant circuit.#

The principal geodetic application has been to the generation of precise frequencies for clocks. The earliest masers used to govern clocks depended on ammonia for control of frequency. At present, the most accurate control is obtained by using masers depending on rubidium, cesium, or hydrogen gas.

mass, topographic #Solid or liquid matter between the *geoid* and the lower boundary of the *atmosphere.*#

matrix (1) (mathematics) #A rectangular array of elements which can be combined with other matrices and with individual elements according to specific mathematical rules.#

In most applications, the elements are usually real numbers, and the array is usually square.

(2) #The more or less homogeneous material in rock in which large grains or crystals of mineral are embedded.#

matrix, conditional inverse See *matrix, generalized inverse of.*

matrix, covariance See *covariance matrix.*

matrix, design See *matrix, observation.*

matrix, generalized inverse of (1) #G is a generalized inverse of the matrix M, if $MGM = M$.#

Also called a rectangular inverse matrix (Bjerhammar 1951). There are numerous other definitions of generalized inverse matrices as well as special varieties such as the pseudo-inverse matrix. See Bjerhammar (1958).

(2) See *matrix, pseudo-inverse.*

matrix, identity See *matrix, unit.*

matrix, inverse #A matrix M^{-1} is called the inverse of a matrix M if and only if $M^{-1}M = MM^{-1} = I$, where I is a unit matrix.#

matrix, observation #A matrix A whose elements are the coefficients of the unknowns in a set of linear equations of the form $\vec{y} = A\vec{x}$, where $\vec{y}$ is the vector of measured values.#

Also called a design matrix or an adjustment matrix.

matrix, pseudo-inverse #A matrix G satisfying the four conditions:

(1) $MGM = M$, (2) $GMG = G$, (3) $(MG)^T = MG$, and (4) $(GM)^T = GM$.

It is called the pseudo-inverse of M.#

Also called, by Penrose, the generalized inverse matrix.

matrix, rectangular inverse See *matrix, generalized inverse.*

matrix, transposed #A matrix A^T derived from a matrix A by interchanging the rows and columns of A.#

Also called transpose matrix, matrix transpose, or transpose.

matrix, unit #A matrix all elements of which are zero except those which have the same index for row as for column; these are identically 1.#

Also called the identity matrix.

matrix, weight See *weight matrix.*

maximum entropy, method of See *entropy, method of maximum.*

Mayer's formula #The formula

$$T_{true} = T_{obs} + a \sin(\phi' - \delta) \sec \delta + b \cos(\phi' - \delta) \sec \delta + c^* \sec \delta$$

which relates the true time, T_{true}, of the passage of a star through the meridian to the observed time, T_{obs}, to the declination δ of the star, to the latitude ϕ' of the station, and to the azimuth error a, the level error b, and the *collimation error* c^* of the instrument.#

This formula applies to observations at upper *culmination.* For use on observations at lower culminations, the sign of δ is changed. Bessel's formula and Mayer's formula are equally suitably for computing when, as is almost always the case, the azimuth, level, and collimation errors are small. When these errors are large, *Bessel's formula* should be used.

mean, standard error of the See *error of the mean, standard.*

meander (1) #To survey a *meander line.*#

(2) #A turn or winding, as of a stream.#

meander line #A *traverse* of the margin of a body of water.#

Meander lines are not surveyed as boundary lines, but are surveyed to determine the sinuosities of the bank or shore line and the quantity of land not under water. Practice of the U.S. Bureau of Land Management is to *meander* (1) only permanent natural bodies of water.

mean high water See *water, mean high.*

mean low water See *water, mean low.*

mean of the errors See *error.*

mean-square error See *error.*

measurement, double-proportionate #A procedure for restoring a lost corner of four townships or four internal sections by using the rule that the measured distance from a known corner to the restored corner shall have the same ratio to the distance given in the original record, as the measured distance between known corners has to the distance given in the original record.#

measurement, indirect #A value derived by computation from measured quantities.#

An indirect measurement is *not* a measurement and the term is best not used. In the U.S. Bureau of Land Management, the term is used with the particular meaning, "A distance determined by computation from measured distances and angles".

measurement, intermediary #The measurement of a quantity other than that desired, but of which the desired quantity is a function.# Thus, the desired quantity can be calculated from the intermediary measurement.

measurement, mark-to-mark #A measurement from the marker identifying one control point on the ground to the marker identifying another control point on the ground.#

measurement, single-proportionate #A procedure for restoring a lost corner by reference to two known corners (either east and west or north and south of the lost corner) and an alignment in the transverse direction, by using the rule that the measured distance from a known corner to the restored corner shall have the same ratio to the corresponding recorded distance (to the original corner) as the total measured distance between known corners has to the distance given in the original record, and that the alignment be preserved.#

measuring engine #An instrument for measuring distances between points on a photograph or other flat surface. It consists either of a microscope that is moved, in accurately measured increments, with respect to the surface on which measurements are made, or of a carriage that moves the surface in accurately measured increments under the microscope.#

The movable member is usually connected mechanically to two very precisely machined, mutually perpendicular screws so that each screw can move the member independently. A single-screw engine has a rotatable platform to which the object being measured can be attached; rotating the object through 90° and remeasuring gives the same results as measurement on a two-axis engine.

Also called *comparator* or coordinatograph. When the microscope is replaced by a pen, the engine becomes a *plotter*.

mechanics, celestial #The part of astronomy concerned with describing (and predicting) the motions of celestial bodies.#

For geodetic purposes, the celestial mechanics of artificial satellites and space probes is of major interest. Sometimes called dynamical astronomy or astrodynamics.

median #The middle number, in a set of numbers arranged in order of size, if the set contains an odd number of numbers; the average of the two middle numbers if the set contains an even number of numbers.#

memorial #A durable article deposited in the ground at the position of a corner, to perpetuate that position should the *monument* be removed or destroyed.#

The memorial is usually deposited at the base of the monument and may consist of anything durable, such as glass or stoneware, a marked stone, charred stake, or quantity of charcoal.

Mendenhall pendulum See *pendulum.*

Mercator bearing See *bearing.*

Mercator track #A *rhumb line* on a *Mercator map projection.* #

mere #A *boundary* or *boundary monument* or a wall marking a boundary.#

mere stone #A *boundary monument* of stone.#

meridian (1) #A north-south line from which differences of longitude (or *departures*) and azimuths are reckoned.#

(2) #A plane perpendicular to an ellipsoid and defining a north-south line from which differences of longitude and azimuths can be reckoned.#

(3) #A curve, all points of which have the same longitude.#

meridian, American See *meridian, Washington.*

meridian, astronomic (1) #A line, on the surface of the Earth, having the same *astronomic longitude* at all points.#

Because of the *deflection of the vertical,* an astronomic meridian does not necessarily lie in a single plane. The astronomic meridian and the line whose *astronomic azimuth* at every point is due south or due north (0° or 180°) are not necessarily coincident, although in land surveying the term "astronomic meridian" is sometimes used for the north-south line that has its starting point on a prescribed astronomic meridian.

(2) #A plane parallel to the Earth's axis of rotation and passing through the vertical at a given point.#

Also called the plane of the astronomic meridian.

(3) #The great circle on the celestial sphere lying on the plane parallel to the Earth's axis of rotation and passing through the vertical at a given point.#

(4) #The curve on the celestial sphere defined by the zeniths of all points with the same astronomic longitude.#

meridian, auxiliary guide #A *guide meridian* established for control purposes where the original guide meridians were placed farther apart than 24 miles.#

Auxiliary guide meridians were needed to limit errors of old surveys or to control new surveys, and were established by surveying in the same way as regular guide meridians.

meridian, basis See *meridian, principal.*

meridian, celestial #The *hour circle* which contains the zenith, or the *vertical circle* which contains the celestial pole.#

The two definitions are equivalent. The plane of the celestial meridian is parallel to the Earth's axis of rotation but, because of the *deflection of the vertical,* usually does not contain it. Its intersection with the plane of the horizon is the meridian line used in plane surveying.

meridian, central (1) #The line of constant longitude at the center of a *graticule.* #

The central meridian is usually used as a base for constructing the other lines of the graticule.

(2) #The meridian used as y-axis in computing tables for a State plane coordinate system.#

The central meridian of the coordinate system usually passes close to the geometric center of the region or zone for which the tables are computed but, to avoid the use of negative values, is given a large positive value which must be added to all x-coordinates.

(3) #A line that represents a meridian on a graticule and that is an axis of symmetry for the geometric properties of the graticule.#

meridian, ephemeris #A meridian 15.″04107 *T* east of the meridian of Greenwich, where *T* is the difference, in seconds of time, between *ephemeris time* and *universal time.* #

Meridian, Ferro #A meridian 17°37′45″ west of Greenwich; it was originally chosen to be exactly 20° west of the Paris Meridian.#

Many European geographers reckoned longitude from this meridian, which was taken as the dividing line between the Eastern and Western Hemispheres. It was established in 1634 (by order of Louis XIII) as a basis for maps and surveys of France. It was used in France until about 1800, and outside of France for a longer period. The Ferro Meridian does not pass through the nearby island of the same name.

meridian, fictitious #A line on the ellipsoid other than a meridian and used as reference for measuring angles analogous to longitudes.#

meridian, geodetic #The curve in which a plane through the shortest axis of an ellipsoid intersects the ellipsoid.#

It has the same *geodetic longitude* at every point. Meridians on a biaxial or triaxial ellipsoid are ellipses; meridians on a sphere are great circles.

meridian, geographic #A general term for either an astronomic or a geodetic meridian.#

meridian, geomagnetic #A line of a geomagnetic coordinate system which has an approximately north and south direction at the Equator.# Not to be confused with *magnetic meridian.*

Meridian, Greenwich (1) #The *astronomic meridian* through the center of the Airy transit instrument of the Greenwich Observatory, Greenwich, England.#

(2) #A meridian, chosen as close as possible to (1), which corrects for the variability of (1) due to polar motion and irregularities in Earth rotation and now accepted as the *prime meridian*.#

See Bomford (1980: pp. 103-4) for a precise definition. It is also known as the Greenwich mean astronomic meridian, or astronomic meridian of the mean observatory.

meridian, grid #A line of a map grid parallel to the line representing the *central meridian.* #

meridian, guide #A line projected north along an *astronomical meridian,* from a point established on the base line or on a standard parallel, on which township, section, and quarter-section corners are established.#

Guide meridians are usually spaced at intervals of 24 miles east or west of the principal meridian.

Meridian, Hierro See *Meridian, Ferro.*

meridian, magnetic (1) #The vertical plane in which a freely suspended, symmetrically magnetized needle, influenced by no transient artificial magnetic disturbance, will come to rest.#

(2) #A curve on the Earth's surface at all points of which the vertical plane specified in (1) above is tangent.#

meridian, null See *meridian, prime.*

Meridian, Paris #The meridian through the axis of the south front of the central pavilion of the Observatory of Paris.#

This meridian was used as the zero meridian by many countries before the Greenwich Meridian was adopted internationally as the zero meridian. The Paris Meridian is 2°20′13.″95 east of Greenwich.

meridian, photograph #The image, on a photograph, of any horizontal line in *object space* which is parallel to the *principal plane.* #

Since all such lines meet at infinity, the image of their point of intersection is at the intersection of the principal line and the horizon trace and all photograph meridians pass through that point.

meridian, prime #A meridian from which the longitudes of other meridians are reckoned.#

At the International Meridian Conference held in Washington, DC, in 1884, the adoption of the *Greenwich Meridian* as the prime meridian for the Earth was approved by the representatives of 22 governments. Also called the null or zero meridian. See *Meridian, Washington.*

meridian, prime grid #The line on a map grid that represents the central meridian.#

meridian, principal #A line extending north and south along the *astronomic meridian* passing through the initial point, and along which township, section, and quarter-section corners are established.#

The principal meridian is the line from which the survey of the township boundaries along the parallels is started. See *meridian, guide.*

meridian, radius of curvature in the See *radius of curvature in the meridian.*

meridian, terrestrial See *meridian, astronomic.*

For particular use, the term "astronomic meridian" is preferred over "terrestrial meridian". For general use, the preferred term is "geographic meridian", which applies alike to astronomic and geodetic meridians.

Meridian, Washington (1) #The *astronomic meridian* through the center of the dome of the old Naval Observatory in Washington, DC.#

The Washington Meridian was used in defining the meridional boundaries of several western States. An Act of Congress September 28, 1850, provided that "hereafter the meridian of the observatory at Washington shall be adopted and used as the American meridian for astronomic purposes and Greenwich for nautical purposes". This Act was repealed August 22, 1912 and the Greenwich Meridian adopted. Many early surveys in individual states are referred to the Washington Meridian, which is 77° 03′ 06.″276 west of the *Greenwich Meridian* on the *North American Datum of 1927.*

(2) #The *principal meridian*, adopted in 1803, which governs surveys in the southwestern portion of Mississippi.#

meridian, zero (1) #The plane which is parallel to the smallest axis of an ellipsoid or a specified axis of a sphere or rectangular Cartesian coordinate system, and from which angles to all similarly parallel planes are reckoned.#

(2) #The meridian assigned the number zero; i.e., the meridian whose longitude is zero.# See *meridian, prime.*

meridian distance (1) (plane surveying) #The perpendicular distance in a horizontal plane of a point from a reference meridian.#

The difference of the meridian distances of the ends of a line is called the *departure* of the line.

(2) (astronomy) #The *hour angle* of a celestial body when close to but not exactly on the *astronomic meridian*.#

This term was used to designate the hour angle of a star observed slightly off the meridian when making latitude observations by the zenith telescope method.

meridian distance, double #The sum of the *meridian distances* (1) of the ends of a survey line.#

meridian line #The line of intersection of the plane of the *celestial meridian* and the plane of the horizon.#

The meridian line is used in surveying; its astronomical azimuth is 0° or 180°.

meridian plane #A plane defined by a meridian; the plane is usually parallel to the Earth's axis of rotation or to the minor axis of an ellipsoid.#

meridian plane, astronomic #A plane parallel to the axis of rotation of the Earth and containing the vector in the direction of the vertical at the observer.#

meridian plane, Greenwich mean astronomic #A plane parallel to an average position of the Earth's axis of rotation and distant from the plane of the *Greenwich Meridian* by an amount defined by the *Bureau International de l'Heure* (B.I.H.) in such a way that time reckoned from this plane agrees with the *universal time* determined by the B.I.H.#

The plane is close to the Greenwich Meridian but moves slightly from year to year.

meridian plane, mean astronomic (1) #A plane parallel to the average position of the Earth's axis of rotation and containing the vector in the average direction of the vertical at the observer.#

(2) #A plane parallel to the average position of the Earth's axis of rotation and containing the tangent to the plumb line of the observer at its intersection with the geoid.#

meridian ring #A graduated ring fitted to a globe so its plane contains the poles of the globe and so that it can be adjusted into the plane of any given meridian on the globe.#

A meridian ring is used for measuring angles along a meridian.

meridians, convergence of (1) #On a curved surface (globular body) the mutual approach of the meridians in passing from the Equator to the poles.#

At the Equator, all meridians are parallel. Extending poleward from the Equator, they draw together until they meet at the poles, intersecting in angles equal to their differences of longitude.

(2) #On a curved surface (globular body) and for a given pair of meridians and a given geodesic, the difference between the two angles formed by the intersection of the geodesic with the two meridians.#

Thus the azimuth at one end of the geodesic differs from the azimuth at the other end by 180° plus or minus the amount of the convergence of the meridians at the end-points.

(3) #On a map, at a given point, the angle measured clockwise from the tangent to the projection of the meridian to the northing coordinate line (grid north)#. Also called map angle or mapping angle.

meridional (cartography) #Having the center of the map on the Equator.#

meridional parts #The length of the arc, expressed in units of 1 minute of longitude at the Equator, of a meridian between the Equator and any parallel of latitude on the *graticule* of the *Mercator map projection.*#

meridional parts, table of #A table listing distances along the *geodetic meridian* from the Equator to various latitudes and the ratio, for each of the latitudes, of the length of 1 minute of latitude to the length of 1 minute of longitude at the Equator.#

On a sphere, at the Equator, the length of a minute of longitude is equal to the length of a minute of latitude, but on approaching the poles the length of a minute of longitude steadily decreases.

Because the Earth is usually represented by an ellipsoid rather than by a sphere, the above conditions do not exactly fit. However, in the *graticule* of the *Mercator map projection,* the minutes of longitude are made to appear of the same length for all latitudes, so it becomes necessary, in order to preserve existing proportions between lengths of the parallel and of the meridian at various latitudes, to increase the distances between latitudes along the meridian; such increases are greater and greater, the higher the latitude. The length of the meridian, thus increased, constitutes the number of the meridional part corresponding to that latitude.

A table of meridional parts found in books on navigation can be used for constructing a Mercator map projection, and for solving problems in sailing. A close approximation to the value of a meridional part on an ellipsoid at a given latitude is obtained by computing the meridional part of the corresponding *geocentric latitude.*

mesosphere #An atmospheric layer, in which temperature decreases with increasing height, extending from about 50 to 85 km, where the temperature, about −90°C, is lower on the average than anywhere else in the atmosphere.#

meter (1) #A unit of length originally intended (in 1791) to be 1 part in 10^7 of the distance from Equator to pole.#

As more accurate measurements of length became possible the definition was changed.

(2) #A length equal to 443.44 *lignes* of the Toise de Peru, an iron bar made by La Condamine in 1735.#

This was realized in a brass standard produced in 1793.

(3) #A length equal to exactly 443.296 lignes of the Toise de Peru.#

It was decreed in 1799, and realized in four end-standards of platinum, of which one, the Metre des Archives, was deposited in the state archives of France.

(4) #The distance between centers of two marks on a platinum-iridium bar designated by the First General Conference on Weights and Measures in 1875 as the Prototype Metre and located at Breteuil. It was specified that the bar had to be at 0°C, under 1 standard atmosphere pressure, and resting horizontally and symmetrically on rollers 571 mm apart and at least 10 mm in diameter. Formulas were derived for the distance under other conditions of temperature, pressure and orientation.#

This definition was in effect from 1875 to 1960. In 1889, 30 copies of the platinum bar were completed and distributed to members of the International Conference on Weights and Measures. The United States of America received copies numbers 21 and 27. Copy number 27 was adopted as the primary standard, number 21 as a secondary or working standard.

(5) #The length equal to 1,650,763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels $2p_{10}$ and $5d_5$ of the krypton-86 atom.

This definition was adopted in 1960. In 1927, the value 643.846 96 × 10^{-9} m was adopted for the wavelength of the red line of cadmium as a secondary standard of length.#

Meter, Committee #An iron bar of 1 meter length, which was brought to America in 1805 by Ferdinand R. Hassler, the first superintendent of the U.S. Coast Survey, for use as a standard of length.#

It was one of sixteen such bars calibrated by the Committee on Weights and Measures in Paris in 1799 against the Metre des Archives. It served as the standard of length for geodetic surveys in this country until 1889 or 1890, when it was replaced by the National Prototype Meter. The Committee Meter was presented by Hassler to the American Philosophical Society in Philadelphia.

meter, dynamic See *dynamic meter.*

meter, French legal #The unit of length defined by the *Metre des Archives.*#

See *meter* and *toise.*

meter, international #A unit of length defined as a meter by international agreement. In particular, the unit of length defined by the *Metre des Archives.*#

Meter, International Prototype See *meter (4).*

Meter, National Prototype #Copy number 27, given to the United States of America in 1889, of the *International Prototype Meter.*#

meter, square See *area.*

metes and bounds (1) #Those characteristics of a piece of land that are used in defining its boundary.#

The metes and bounds include measurements as well as monuments, etc. A "metes and bounds description" of a piece of land is a complete description of its boundary, in which the distances (metes) and directions are given sequentially around the perimeter (bounds) of the piece of land.

(2) #The boundary lines or limits of a tract of land.#

metes and bounds, true #A description that contains full information on the vicinity of a piece of land, a call for each tie and monument that determines the boundaries, all references to adjoining lands by name and record, and a full recital of distances and directions of all courses on the external boundary of the land.#

method of repetition for azimuth determination See *azimuth determination by the method of repetitions.*

Metre des Archives See *meter* (3). It is an end standard of platinum that was used in determining a length for the International Prototype Meter. It is now preserved as a museum piece in the International Bureau of Weights and Measures at Sevres, France.

metric system #The system of units based on the meter as the unit of length, the gram as the unit of mass, and the second as the unit of time.#

The definitions of these units have changed frequently since their adoption internationally, so measurements given in terms of these units can be compared with other measurements in the same units or at different times only by using the definitions formally adopted at those times. The SI (*Système International d'Unités*) is a modification of the metric system in which the *kilogram* is substituted for the gram.

An international conference was called by France in 1870 to work out an internationally acceptable metric system. The results were: a set of official definitions incorporated in the Treaty of the Metre of Paris in 1875, the establishment of an International Bureau of Weights and Measures for preserving the standards, and the establishment of a General Conference on Weight and Measures to act on changes as the need arose. The General Conference in 1960 adopted the SI as an improved version of the previous metric system. It added to the fundamental units of length, mass and time, units of temperature, electric current, and luminous intensity.

microdensitometer See *densitometer.*

micrometer (1) (general) #Any instrument for measuring small distances very accurately.#

(2) (astronomy and geodesy) #A device for attachment to a telescope or microscope that consists of a fine line (hair, spider-web filament, or wire) that can be translated

across the field of view by a screw connected to a graduated drum and vernier.#

The screw has a fine, accurately cut thread and the amount of rotation of the screw is indicated by graduations on the head of the screw or by other means.

The screws used in micrometers for geodetic instruments are graduated in angular measure (seconds of arc). One turn of the screw moves the filament a distance corresponding to the angle, at the instrument, between two objects bisected by the wire in its two positions. Any small angle may be measured by multiplying, by the value of one turn, the whole and fractional number of turns of the screw made in moving the wire from one bisection to another.

Also called a filar micrometer.

(3) #One-millionth of a meter.#

Prior to the adoption of the SI, this unit of measurement was known as a *micron*. The standard abbreviation for the micrometer is μm.

micrometer, automatic #A *micrometer* (2) that keeps the moving line on a star or other object being observed and records the time and corresponding position of the line, all without intervention by the operator of the instrument.#

micrometer, contact correction for #A quantity applied to the chronographic record of a stellar transit observed using an electrically recording, *impersonal micrometer*. The correction is intended to produce the time that would have been recorded if the electrical signal had occurred only when the contact spring crossed the middle of the contact strip.#

micrometer, correction for run of See *micrometer, run of*.

micrometer, eyepiece See *micrometer, ocular*.

micrometer, filar See *micrometer* (2).

micrometer, impersonal #A *micrometer* (2) that sends signals to a recorder indicating the position of the moving line. The line is moved at a constant but controllable rate by a motor.#

micrometer, ocular #A *micrometer* (2) placed so that its moving line moves in the principal focal plane of a telescope.#

Also called an eyepiece micrometer, the ocular micrometer is used in surveying and astronomic work for making accurate and precise measures of small angles between lines to objects viewed with the telescope.

micrometer, run of #The difference, in seconds of arc, between the nominal value of one complete turn of the screw in a micrometer and its actual value as determined by measuring, with a *micrometer microscope*, the distance between two adjacent graduation marks on an accurate scale such as a graduated circle.#

This quantity is sometimes called the error of run, but run of micrometer is more generally used and preferred. The error is kept quite small by adjusting the instrument, and its effect on observed values is minimized by well-designed methods of observing. A correction for this error was applied in the past to readings of the horizontal or vertical circle of a theodolite, when such theodolites were equipped with micrometer microscopes to make such readings. However, the correction was later made unnecessary by requiring prior adjustment of the instrument and by adopting better methods of observation.

micrometer, transit #An *impersonal micrometer* with its moving line placed in the focal plane of an astronomic transit and at right angles to the direction of motion of the image of a star (which is observed at or near culmination).#

micrometer method of azimuth determination See *azimuth determination by the micrometer method*.

micrometer microscope #A *micrometer* (2) placed so its moving line moves in the focal plane of a microscope.#

micrometer screw, reversing point of #The setting of the head of the screw in a *micrometer* (2) on a spirit level at which the bubble remains in the center of the leveling vial when the instrument is level and is rotated about its axis.#

micron #One-millionth of a meter.# See *micrometer* (3).

Properly called a micrometer. The term "micron" is not approved for the SI.

microscope, blink See *comparator, blink*.

microtriangulation #Triangulation in which the sides of triangles are from a few meters to a few hundreds of meters long.#

microwave #Radiation with a wavelength in the range from (approximately) 1 millimeter to 1 meter.#

The limiting values between microwaves and longer or shorter radiations are indefinite.

Mie scattering See *scattering, Mie*.

mil (1) #1/6400 of the circumference of a circle.#

Approximately 1/1000 radian. See *angle*.

(2) #1/1000 of an inch.#

mil, circular See *area*.

mile #A unit of distance, variously defined.# See *mile, nautical* and *mile, statute*.

The word *mile* is derived from the Latin "mille" (one thousand), and meant one thousand paces of about 5 feet each. The mile of the Romans thus was about 5,000 feet long, a value that suffered many changes as the mile came into use among the other western nations. In general usage, "mile" means the statute mile of 5,280 feet. The nautical mile is almost never referred to simply as a "mile" unless the meaning is obvious from context.

mile, geographical See *mile, nautical*.

mile, international nautical #The *nautical mile* defined as exactly 1,852 m in length.#

It was proposed in 1929 by the International Hydrographic Bureau because of the variety of nautical miles then in use. It has since been adopted by most maritime nations, and, on July 1, 1954, by the U.S. Department of Commerce and the U.S. Department of Defense.

mile, nautical #The United States nautical mile is defined as equal to the length of one-sixtieth of a degree of a great circle on a sphere having an area equal to the area of an ellipsoid representing the Earth's surface.#

Its value, calculated for the Clarke spheroid of 1866, is 1,853.248 m (6,080.2 ft); (compare with the international nautical mile of 1,852 m (6,076.1 ft)). The United States nautical mile is also called a sea mile, a geographical mile, and a geographic mile. It may be taken as equal to the length of a minute of arc along the Equator or a minute of latitude anywhere on a map. The nautical mile is used principally for stating distances over water. It is the unit of length used for defining the knot, a unit of speed defined as 1 nautical mile per hour.

mile, sea See *mile, nautical.*

mile, square #The area of a flat surface enclosed by a square with 1 *mile* sides.#

This unit is now used almost exclusively within the United States of America. In using it, care must be taken to specify whether the statute mile or the nautical mile is meant. A square mile (statute mile) is equal to approximately 2.589 988 square kilometers, 258.9988 hectares, 240 acres, or 27,878,400 square feet.

mile, statute #A unit of length defined to be exactly 5,280 feet.#

It is used principally in stating distances on land.

milligal See *gal.*

minus sight See *foresight.*

minute (1) #An angle that is exactly 1/60 of a *degree* or, equivalently, contains exactly 60 *seconds* of arc.#

The symbol for a minute of arc is ($'$); it is placed after the last integral digit, e.g., $10'$ or $35.'599$.

(2) #An interval of time containing exactly 60 *seconds* of time or, equivalently, 1/60 of an hour.#

The minute is not a fundamental unit and therefore it has always been defined in terms of the second, the hour, or the day (which contains 1,440 minutes). The symbol for minute of time is (^{m}) and is placed as a superscript to the last integral digit: e.g., 10^m; $35.^m999$.

misclosure #The amount by which a value of a quantity obtained by surveying fails to agree with a value (of the same quantity) determined, e.g., by an earlier survey, an arbitrarily assigned starting value, or a value determined from theory.# It is also called closure or error of closure.

(a) (leveling) #The amount by which two values for the elevation of the same bench mark, derived by different surveys, by the same survey made along two different routes, or by independent observations, fail to exactly equal each other.#

The misclosure may occur in a line of leveling that begins and ends on different bench marks whose elevations are held fixed, or that begins and ends on the same bench mark.

(b) (traverse) #The amount by which a value of the location of a traverse station obtained by computation fails to agree with another value for the location as determined by a different set of observations, or a different route of the traverse.#

The traverse may run between two stations whose locations are held fixed, or it may begin and end at the same station. In either case, there are two values for the location of the final station; one known before the traverse was computed, the other obtained by computation using the observations made on the traverse. The difference between these is the misclosure. It may be resolved into misclosure in latitude, in longitude (departure), or in both. The total misclosure is also called a misclosure in position.

misclosure, angular #The amount by which the actual sum of a series of angles fails to equal the theoretical value of that sum.# See *misclosure of horizon* and *misclosure of triangle.*

misclosure, linear #The distance between the beginning and final points of a closed traverse, as calculated from the observations.#

misclosure in azimuth #The amount by which two values of the azimuth of a line, derived by different surveys or along different routes, differ.#

Generally, one value is derived by computations using the observations made during the survey (triangulation, trilateration, or traverse); the other is an adjusted or fixed value determined by an earlier or more precise survey or by independent astronomical observations.

misclosure of horizon #The amount by which the sum of a series of horizontal angles measured between adjacent lines in a complete circuit of the horizon fails to equal exactly 360°.#

See *horizon, closing the.*

misclosure of triangle #The amount by which the sum of three observed angles of a triangle fails to equal exactly 180° plus the spherical excess of the triangle.#

See *equation, angle.*

m.k.s. system of units #A system of units in which the units are the *kilogram* for mass, the *meter* for length, and the *second* for time. To this is added an electromagnetic unit; the one most often used is the coulomb, for charge.

In an m.k.s. system, the volt and ampere are also units. The m.k.s. system is the forerunner and prototype of the *Système International d'Unités* (SI).

mode #The number, in a set of numbers, that occurs with the greatest frequency.#

model (1) #The copy of an object, on a reduced scale, or, occasionally, on an enlarged scale.#

(2) (photogrammetry) #The visual or optical image produced by optically combining light transmitted through a stereoscopic pair of photographs, or by use of a hologram.#

A stereoscopic model, in the strict sense, is not a material object but an image or pair of images that give the same visual effect as would a material model.

(3) (photogrammetry) #The set of points that would constitute a stereoscopic model in the above sense (2), if one were formed.#

A good deal of photogrammetry formerly done by direct measurement on stereoscopic models is now done by measurement on the photographs themselves, and the stereoscopic model as such is never actually formed. But the set of spatial coordinates or points determined by calculation from measurements on photographs is still referred to as "the model", regardless of the method used.

(4) (mathematics) #A set of mathematical objects that satisfies a particular abstract theory.#

model, flat #Any *stereoscopic model* that can be positioned so that the z-axis is parallel to the direction in which heights are measured in the model.#

Differences of z-coordinates are then the same as differences of height in the stereoscopic model and are proportional to differences of height in the original. The model is then said to be "level". A model that cannot be made level is said to be "warped".

model, gross #The entire *overlap* of a stereoscopic pair of photographs.#

See *model, neat.*

model, neat #The portion of the overlap of a pair of photographs that is actually used in a photogrammetric mapping project.#

model, stereoscopic (1) #An image, either actual or visual, formed by passing light through a stereoscopic pair of photographs and combining the light in a suitable optical system.#

(2) #The points of an image so formed, or the points that would exist if such an image were formed.#

(3) #By extension, those portions of a stereoscopic pair of photographs that are used in creating a stereoscopic model (definitions 1 or 2).#

While this definition, (3), is sometimes used, it is technically incorrect. See *model, gross* and *model, neat.*

model, warped #A *stereoscopic model* so distorted that distances measured parallel to the z-axis are not everywhere parallel to lines along which heights in the model should be measured.#

Some points on the model will be given erroneous scale-heights, so the elevations computed for corresponding points on the ground will be incorrect.

Model Earth #A hypothetical body whose shape is derived from that of the Earth by shifting the Earth's topography so that the average slope of the surface is not greater than 1 part in 100.#

The term was originated by J. de Graaff-Hunter.

Moho See *discontinuity, Mohorovičić.*

Mohorovičić discontinuity See *discontinuity, Mohorovičić.*

Moiré fringe #One of the lines in a *Moiré pattern.* #

Generally used in the plural as a synonym for *Moiré pattern.*

Moiré pattern #The pattern formed by transmitting light through two separate, overlapping families of parallel lines.#

As one family is translated or rotated with respect to the other, the pattern shifts or otherwise changes. Because a small change in relative position of the two families can cause a large apparent change in the pattern, the principle has been used extensively in measuring-engines.

Also called Moiré fringes.

mole #An amount of substance, by weight in grams, equal numerically to the molecular weight of that substance.#

Also called a mol.

Molitor leveling rod See *leveling rod, Molitor precise.*

Molodensky correction (1) #The difference between the length of a specific geodesic between two points on the representing ellipsoid and the length of the geodesic between the corresponding points on the geoid as calculated using *Molodensky's formula.* #

In older methods of calculating coordinates in triangulation networks, the length of the measured base line on the ground was reduced to its equivalent length on the geoid, but this length was then assumed to be the length of the corresponding geodesic on the ellipsoid. The Molodensky correction eliminates this error.

(2) #The difference $(h - h_c)$ between the actual geoidal height and the assumed geoidal height, as given by *Molodensky's formula.* #

Molodensky's formula #The formulas

$$h = h_c + RA \sin \theta + B \cos \theta,$$

and

$$\zeta = \zeta_c + A \cos \theta - (B/R) \sin \theta$$

in which h is the height of geoid above the ellipsoid and ζ is the deflection of the vertical in the direction of the chain of triangulation. h_c and ζ_c are the corresponding assumed height and deflection, θ is the angular distance along the chain, and R is the radius, at the midpoint of the chain, of the ellipsoid representing the Earth. A and B are constants given by

$$A = \zeta_0 - \zeta_{c0} - (1/R)\int h_c \cos \theta \, d\theta$$

and

$$B = h_0 - h_{c0} + \int h_c \sin \theta \, d\theta$$

where the subscript 0 denotes the value at $\theta = 0$.#

monocomparator #A *measuring engine* that measures distances between points, or determines plane coordinates of individual points, on one photograph at a time.#

(The *sterocomparator* measures distances on a stereoscopic model formed from two photographs simultaneously). Although a monocomparator may have a binocular microscope for viewing single photographs, it cannot be used as a stereocomparator.

month (1) #A general term for the period of revolution of the Moon around the Earth.#

A more precise definition depends on an exact definition of revolution. See *month, anomalistic; month, sidereal; month, synodical*; and *month, nodical.*

(2) #A period of time approximating the month as defined in (1) but containing an integral number of days

whose number is fixed by law or custom.# See *month, calendar*.

month, anomalistic #The interval of time between two successive passages of the Moon in its orbit through *perigee*.#

The length of the anomalistic month is 27.554 551 mean solar days.

month, calendar #An interval of time, approximately one-twelfth of a year in length, as specified in a calendar.#

While arbitrary in length, the calendar month is based roughly on the *synodical month*. For example, the Gregorian calendar month ranges in length from 28 to 31 mean solar days.

month, draconic See *month nodical*.

month, lunar See *month, synodical*.

month, nodical #The interval of time between two successive passages of the Moon through the same node of its orbit.#

Also called a draconic month. The length of the nodical month averages 27.212 220 mean solar days.

month, ordinary See *month, synodical*.

month, sidereal #The interval of time it takes the Moon to make its revolution from the meridian through a specific star back to the same meridian.#

The sidereal month may be measured by the length of time it takes the Moon to revolve from a given celestial longitude back to the same longitude, reckoned from a fixed equinox. The length of the sidereal month averages 27.321 661 mean solar days; because of perturbations, the actual length varies some 7 hours. The difference between the lengths of the sidereal and tropical months is caused by the precession of the equinoxes.

month, synodical (1) #The interval of time between two successive conjunctions (new moons) or oppositions (full moons) of the Moon.#

Also called a lunation, a lunar month, an ordinary month, or a synodic month. The average length of the synodical month is 29.530 589 mean solar days. It is the month meant when a lunar month is specified.

month, tropical #The interval of time between two successive passes of the Moon through the same equinox.#

The tropical month may be measured by the interval of time it takes the Moon to revolve from a given celestial longitude back to the same longitude, reckoned from an equinox affected by precession. The length of the tropical month averages 27.321 582 mean solar days; because of perturbations, the actual length varies by about 7 hours. The difference between the lengths of the sidereal and tropical months is caused by the precession of the equinoxes.

monument (1) #A structure that marks the location of a *corner* or point determined by surveying.#

"Monument" and "corner" are not synonymous, although they often are used as if they were.

(2) #Generally, any material, object, or collection of objects which indicates the location, on the ground, of a survey station or corner.#

The term monument may be used for the *mark* at the station or corner, and for all marks directly related to it by surveying as aids in its recovery and identification. In land surveying, the term may also include objects such as roads, ditches, fences, etc., that form a boundary for the land. It is advisable, therefore, in writing about survey stations, to use the designations station mark or center mark, reference mark, and witness mark for the separate marks. In land surveying, unless monument is used in a general sense, one should use the terms corner or corner mark, reference mark, and witness mark. Note: A witness mark has more authority in land surveying than in control surveying.

monument, boundary See *boundary monument*.

monument, judicial #A *monument*, set by order of a court, at a location determined by that court as a boundary *corner*.#

monument, location #Monuments established to supplement the monuments of the U.S. Public Land Survey.#

They are established in connection with the official patent survey of mining claims in regions where subdivision surveys have not been made or where monumentation is inadequate and where there is no *corner* of the public land survey within 2 miles of the claim. They were formerly called mineral monuments.

monument, record #An *adjoining* property, such as a street or particular parcel of land, called for in a deed.#

Frequently, the boundary line of the adjoining property is referred to as the record monument; actually the entire property, rather than the line, is the record monument.

moon #(1) A satellite of a planet.# The word is not capitalized when used in this sense—e.g., "a moon of Mars".

(2) #The Earth's only natural satellite.#

The word *is* capitalized when used in this sense. The Moon has been used considerably by geodesists for occultation surveying, eclipse surveying, surveying with the dual-rate moon-camera, and for measuring distances to corner-cube reflectors on the Moon. The Moon's principal physical characteristics are as follows:

mass	7.35×10^{22} kg
radius (average)	1,738 km
distance from Earth (average)	384,400 km
gravity (acceleration) at surface	1.62 m/s^2
period (synodic)	$29^d\ 12^h\ 44^m\ 2.^s9$
period (sidereal)	$27^d\ 7^h\ 43^m\ 11.^s5$
eccentricity of orbit	0.0549

more or less #Words used in legal descriptions of property to indicate that the actual distance, direction, or area may not be exactly that given in the description.#

This description is used when it would be impractical to determine the exact value and when the exact value is not important.

mosaic See *photomosaic*.

mosaic, controlled #A *photomosaic* oriented and scaled to horizontal ground control (usually assembled from rectified photographs).#

mosaic, map-controlled #A *photomosaic* constructed by using topographic maps to provide control and orientation.#

Both controlled and, especially, semicontrolled mosaics may be map-controlled mosaics.

mosaic, semicontrolled #A *photomosaic* composed of photographs that have been mutually oriented by reference to some coordinate system other than that determined by ground control.#

motion, absolute proper #*Proper motion* in a well-defined coordinate system that does not depend on the relationships among the stars themselves, e.g., that associated with a meridian circle.#

motion, proper (1) #The part of the apparent angular motion of a star, with respect to the observer, which is not caused by the movement of the coordinate system, i.e., the movement is not caused by precession and nutation or by revolution of the Earth.#

In star catalogs, listed positions do not include proper motion, although tabular corrections may be given separately. Corrections for precession, nutation, and proper motion must be applied to obtain coordinates at different epochs.

(2) #The changes in location of a star caused by the star's motion with respect to an inertial coordinate system with its origin at the barycenter of the solar system, and *not* caused by motion of the coordinate system itself.#

motion, reduced proper #*Proper motion*, reduced to *absolute proper motion* and expressed in kilometers per second (of time).#

mount See *mounting*.

mounting #A mechanical structure which serves to connect a detachable instrument to a base.#

The term is applied, in geodesy, primarily to the device to which a telescope or a distance-measuring instrument can be attached and which is itself attached to a tripod. Mountings for cameras are generally attached either to the fuselage of an airplane or, in the case of terrestrial photogrammetry, to a tripod. If the mounting is attached to a vehicle or airplane, shock absorbers are usually interposed between the mounting and the camera. Mountings for telescopes are classified by the kind of motion required for the telescope (altazimuth, right-ascension/declination, triaxial) or by the particular design (equatorial, yoke, Springfield, English, etc.).

mounting, altazimuth #A *mounting* which permits rotation of the instrument (telescope, antenna, or distance-measuring instrument) either through azimuth angles or in angular elevation.#

The mount for a theodolite is of the altazimuth variety with graduated circles to indicate the amounts of rotation in both the vertical and the horizontal directions. Some astronomical telescopes are supported by altazimuth mountings. With such a mounting, the telescope motion is controlled by eye and hand if the telescope is small, or automatically under computer control if the telescope is large.

mounting, equatorial #A *mounting* which permits rotation of the instrument about two axes, one parallel to and one perpendicular to the Earth's axis of rotation.#

The first axis is called the right-ascension axis; the second is called the declination axis.

mounting, inertial #A *mounting* whose orientation is held fixed with respect to a nonrotating coordinate system.#

The mounting should, in theory, be one which is not rotating with respect to the totality of mass in the universe or with respect to the very distant galaxies. In practice, the requirement is often weakened to mean "fixed with respect to bodies known to be rotating". The usual way of fixing the mounting's orientation is to attach to it at least two gyroscopes with nonparallel axes of rotation.

mounting, right-ascension/declination #A *mounting* that allows rotation of an instrument either in right ascension, in declination, or in both simultaneously.# This kind of mounting is almost always equatorial.

mounting, triaxial #A *mounting* which allows rotation of the instrument independently about any one of three axes.#

multiplex (photogrammetry) #A stereoscopic plotter consisting of two or more projectors that can be translated or rotated independently, each of which projects an image in either red or blue-green light.#

The images are projected from small transparencies (diapositives) reduced from the original photographic negatives, and the resulting pair of differently colored images is called an *anaglyph*.

N

nadir #The point where the direction of the plumb line extended below the horizon meets the celestial sphere.#

The nadir is directly opposite the *zenith.*

nadir, ground #The point on the ground which is vertically underneath the perspective center of an airborne-camera lens system.#

nadir, map #The point on a map corresponding to the *ground nadir.* #

nadir, photograph #The point at which a vertical line through the perspective center of the camera's lens system pierces the plane of the photograph.#

Also called nadir point.

National Geodetic Vertical Datum See *Datum, National Geodetic Vertical.*

National Tidal Datum Control Network #Those *tide stations* of the U.S. National Ocean Service that provide the basic *tidal datums* for coastal boundaries and for chart datums of the United States of America.#

National Tidal Datum Convention of 1980 #A convention, adopted by the United States and effective November 28, 1980, that made changes (a) through (g), below, to the previously established rules governing *tidal datums.*

(a) Establishment of one uniform, continuous tidal datum for all tidal waters of the United States (including commonwealths, territories, and United Nations trust territories under jurisdiction of the U.S.A.); (b) a tidal datum independent of computations based on the type of tide provided; (c) chart datums lowered from *mean low water* to *mean lower low water* along the Atlantic coast of the United States; (d) the *National Tidal Datum Epoch* from the epoch 1941 through 1959 changed to the epoch 1960 to 1978; (e) the name "Gulf Coast Low Water Datum" changed to "mean lower low water"; (f) the tidal datum of *mean higher high water* introduced in regions of predominately diurnal tides; (g) *mean high water* lowered in regions of predominately diurnal tides.#

National Tidal Datum Epoch #A period of 19 years adopted by the National Ocean Service as the period over which observations of tides are to be taken and reduced to average values for *tidal datums.* #

The epoch is designated by the years the period began and ended, e.g., National Tidal Datum Epoch of 1941 through 1959. Note that the word "Epoch" as used here is at variance with the astronomic and geodetic conventions.

navigation #The determination of the course and position of a vehicle, vessel, or aircraft over an interval of time.#

Determination of where the vehicle is at a particular instant is called *positioning.* A set of equipment and techniques used for navigation is called a *navigation system*; a set of equipment used for positioning is called a *positioning system.*

navigation, arc #Navigation in which the course is maintained along a circular arc by reference to radio signals from a transmitter at the center of the arc.#

navigation, Doppler #(1) Navigation using the shift in frequency (*Doppler shift*) of sound waves reflected from the ocean bottom to determine the velocity of the vessel.#

(2) #Navigation using the Doppler shift in frequency of radio waves reflected from the ground to determine the velocity of the aircraft.#

(3) #Navigation using the shift in frequency of radio waves from an orbiting radio transmitter to determine the location of the vessel or aircraft.#

navigation, hyperbolic See *navigation system, hyperbolic.*

navigation, radio #Any method of navigation in which location or velocity is inferred from measurements on radio waves.#

The term is generally applied only to one of the following methods of navigation: (a) measuring direction or distance to two or more radio transmitters, (b) measuring differences of distance to two or more pairs of radio transmitters, (c) measuring the Doppler shift in frequency of a signal from an orbiting beacon or beacons.

navigation system #A set of equipment and techniques by which the location of a moving vehicle, vessel, or aircraft can be determined and made known sufficiently quickly so the information can be used for navigation.#

navigation system, Doppler #In general, any navigation system which makes use of the measured shift in frequency of a signal of known frequency to determine the velocity of the receiving system relative to the signal source and, from these measurements, the location of the receiver.#

Two different kinds of Doppler navigation system are used at present: that in which the system itself is both source and receiver of the signal, and the velocity is with respect to the surface producing the echo; and that in which the system receives a signal from a beacon.

Systems of the first kind take two forms which are very different instrumentally but share much the same mathematics. These forms are systems in which the signal consists of sound waves reflected from the ocean bottom, and those in which the signal consists of radio waves reflected from the ground. The first is used almost exclusively by ships or water craft, the second almost exclusively by aircraft. Because neither the ocean bottom nor the ground is simple in shape nor accurately known, velocities inferred from the reflected signals are degraded by lack of complete knowledge of these shapes.

Most systems of the second kind have the beacon in orbit about the Earth. The orbit of the beacon is determined by measuring the beacon's radial velocity with respect to a small number of receivers at fixed locations and solving the resulting observation equations for the parameters of the orbit. Navigating systems then use this known orbit, together with the frequency shift they measure, to determine the location of the receiver with respect to the orbit.

navigation system, hyperbolic #A navigation system using the differences in distance (measured in wavelengths) of a mobile unit from three or more fixed stations to determine location.#

The locus of points all of which have the same difference of distance is a hyperbola. If the difference in distance from two pairs of fixed points (one point of which may be common to the two) is determined, two intersecting hyperbolas result and the mobile unit is located at one of those intersections.

Only the fractional part of one wavelength is actually measured. Most hyperbolic navigation systems keep count of the changes of difference by a whole wavelength, so that once the entire distance is known, the system continues to indicate the total difference, regardless of the motion of the mobile unit.

navigation system, inertial #Any navigation system in which gyroscopes or accelerometers are used to provide a coordinate system which has a fixed orientation with respect to the distant galaxies.#

A gyroscopic compass is a particularly simple form of inertial navigation system. A more complicated form, called SINS (Ship's Inertial Navigation System), gives not only orientation but location. It is used for ship navigation.

navigation system, rho-rho #A navigation system which determines the distances of a mobile unit from two or more fixed stations by measuring the time needed for a signal to travel between the mobile unit and each of the fixed stations.#

A measured distance locates the mobile unit on the circle with radius ρ (rho, whence the name), equal to the distance. The two distances from the two fixed stations locate the mobile unit at one of the two intersections of the two circles.

navigation system, rho-theta #A navigation system that determines the distance ρ of a mobile unit from a single, fixed station and the direction θ of the unit from each of a pair of fixed stations (one of which may be at the same point as the first, distance-determining station).#

The mobile unit determines its distance from the single station by measuring the time of travel of a signal between it and that station. This locates the mobile unit somewhere on a circle whose radius ρ is the distance determined. It determines the difference in distances from the pair of stations in the same way. However, because the two stations of the pair are very close together, this difference in distance can be converted into an approximate direction to the midpoint of the pair. The combination of distance and direction gives the location of the mobile unit.

navigation system, satellite (1) #A navigation system used for the navigation of satellites.#

(2) #A navigation system having beacons or transponders placed on satellites rather than at fixed points on land.#

The most successful satellite navigation system to date has been the TRANSIT system (also called NNSS or Navy Navigation Satellite System) in which the mobile unit determines its location by measuring the Doppler shift in the frequency of the radio waves from one or more satellites. The location of the satellite must, of course, be known. That information is usually available in the form of an orbit ephemeris, but it is also broadcast together with the fixed-frequency radiation from the satellite.

Another system under development (1986) is the Global Positioning System in which the mobile unit determines its location by measuring, almost simultaneously, the times of travel of signals from several satellites whose locations are known, and converting this to distances from the satellites. The plan for this system calls for eighteen satellites in orbit at all times; at least three or four of them will be visible simultaneously from any point on Earth. See also *positioning system, satellite* and *Global Positioning System.*

Navy Navigation Satellite System #A set of satellites developed and operated by the U.S. Navy for *Doppler navigation* and positioning.#

Support for this system by the U.S. Navy is scheduled to cease soon after the *Global Positioning System* becomes operational. This system is popularly known by the term Transit.

neap See *tide, neap.*

neap range, mean #The average, semidiurnal difference in height of water occurring at the time of *quadrature.* #

neap rise #The height of *mean high water neaps* above the chart datum.#

negative (photography) #A photograph which is dark where the original scene was light and light where the original scene was dark, etc., or whose colors are the complements of those in the original scene.#

neat line #One of the lines that bounds a map.#

net See *network.* The term net has been used extensively, but is gradually being replaced by network.

net, base See *triangulation network, base-extension.*

network #A set consisting of: (a) stations for which geometric relationships have been determined and which are so related that removal of one station from the set will affect the relationships (distances, directions, coordinates, etc.) between the other stations; and (b) lines connecting the stations to show this interdependence.#

The lines represent adjusted distances, directions, or angles or the sequence in which measurements were carried out. For example, a triangulation network consists of stations whose horizontal coordinates with respect to each other have been determined, and lines representing distances, directions, or angles between the stations. A level network consists of a network of level lines. A gravity network consists of gravity stations occupied in sequence, together with lines connecting them in the sequence in which they were occupied.

Networks contain only closed circuits; all lines connect at least two different points, and each point lies on at least two different lines. This follows from the condition that the values for each station are interdependent.

network, base See *triangulation network, base-extension.*

network, control #A *survey network* in which the stations are *control stations.* #

network, densification #A *survey network* connected to and contained within a survey network of the same or higher order.#

The distances between stations in a densification network are usually much shorter than distances between stations in the surrounding network.

network, extension See *triangulation network, base-extension.*

network, free #A network whose position is not specified.#

Angles and distances between points are known, but neither coordinates nor directions are known.

network, geodetic #A network in the geodetic sense: i.e., a network whose nodes are survey stations or gravity stations.#

network, gravity See *gravity network.*

network, horizontal-control extension See *triangulation network, base-extension.*

network, level (1) #A network lying on an equipotential surface or on a flat surface of limited horizontal extent.#

(2) See *leveling network.*

network, leveling See *leveling network.*

Network, National Tidal Datum Control See *National Tidal Datum Control Network.*

network, survey See *survey network.*

network, traverse See *traverse network.*

network, triangulation See *triangulation network.*

newton #A unit of force defined as that necessary to give a mass of 1 kilogram an acceleration of 1 meter per second per second.#

It is equal to 10^5 dynes and is the standard unit in SI.

Newtonian constant of gravitation See *gravitational constant.*

nodal point See *lens system, nodal point of.*

node (1) (general) #The intersection of two or more lines.#

(2) (astronomy) #One of the two points of intersection of two great circles on the celestial sphere.#

In geodesy, the most important node is the *First Point of Aries*, which is the intersection of the ecliptic and the Equator where the Sun apparently moves from south to north.

(3) #One of the two points of intersection of the celestial sphere with the line in which the plane of the osculating orbit of a satellite intersects the reference plane through the focus.#

(4) #One of the points, on the orbit of a satellite, in which the osculating orbit intersects the plane of reference through the focus.#

(5) (optics) See *lens system, nodal point of.*

node, ascending (1) #The point on the celestial sphere at which a celestial body apparently crosses the celestial Equator from south to north.#

(2) #The point in which the radius vector from the focus through a satellite intersects the celestial sphere at the instant the satellite is passing through the reference plane in what is defined as the upward direction.#

(3) #The point on the orbit of a satellite occupied by the satellite at the instant it is passing through the reference plane in an upward direction.#

node, descending #The same as the *ascending node* except that passages are from north to south or downward.#

In an elliptical orbit, the ascending and descending nodes are on the same straight line through the foci of the ellipse.

node cycle #The time required for the nodes of the Moon's orbit to regress through 360° of longitude, a period of about 18.6 years.#

node factor #A factor whose value depends on the longitude of the node of the Moon's orbit and, when applied to the average value of the coefficient of a tidal *constituent*, will make that coefficient usable for the prediction of tides for a particular year.#

nodes, line of #The line connecting the ascending and descending nodes.#

noise (1) #The part of any radiation that does not convey intelligible or wanted information to the recipient.#

The term is commonly used in this sense by electronic engineers to denote the randomly varying portion of radio waves, voltages, etc.

(2) #The random portion of any varying quantity.#

noise, background #Noise received from sources other than that emitting the desired signal while that signal is being received.#

nomogram #A diagram relating the values on two scales so that a line drawn from a point (value) on one scale through a known second point intersects the other scale at the corresponding point (value).#

Nomograms are used for solving equations graphically. The accuracy is generally less than that obtainable by numerical computation.

nomograph See *nomogram.*

nonius #A disc having concentric, graduated circles drawn or engraved on it, and used for determining angles.#

It is named for the Portuguese mathematician and geographer, Nunez (1492 - 1577). The nonius was later replaced by the *vernier.*

noon, apparent #The instant at a point on the Earth when the apparent Sun—i.e., the true or actual Sun—is over the upper branch of the local meridian.#

Normaal Amsterdams Peil #The mean sea level at the tide gauge in the harbor of Amsterdam which provides a vertical datum for the Netherlands and for the European combined leveling network.#

The vertical datum for the leveling adjustment of 1970 is designated NAP-REUN-1970.

normal (adjective) (gravimetric geodesy) #Standard, when part of a name. e.g., normal gravity formula, normal height, etc.#

Normal gravity means standard value of gravity when used in gravimetric geodesy, and average gravity when used in astronomy.

normal (noun) (1) (general) #A straight line perpendicular to a surface or to another line. Also, the condition of being perpendicular to a surface or line.#

(2) (geodesy) #A straight line perpendicular to the surface of a particular spheroid or ellipsoid.#

While it is correct to use the term normal to designate a line perpendicular to the surface of the geoid, use of the term vertical is preferred.

Normal Amsterdams Peil See *Normaal Amsterdams Peil.*

normal equation See *equation.*

normal section #The curve in which a plane through the perpendicular at a given point of a surface intersects that surface.#

In general, for each pair of points there are two normal sections, because the plane through the perpendicular at one of the points will not, in general, also contain the perpendicular at the other point. On a sphere, there is only one normal section through such a pair.

normal section azimuth See *azimuth, normal section.*

normal section line #A line connecting two points on an ellipsoid and lying in the plane through the perpendicular at one of the points.#

It differs from the *normal section* in being terminated by the two points.

north (1) #The positive direction of a line lying in a plane through the Earth's axis of rotation and tangent to the geoid or to an equipotential (gravity) surface at a point.#

(2) #The positive direction of a line lying in a plane through the minor axis of an ellipsoid and perpendicular to the normal to that ellipsoid at a point.#

(3) #The direction indicated by the positive end of a magnetic needle suspended so as to rotate freely.# See *north, magnetic.*

north, astronomic #A direction perpendicularly to the left of an observer facing in the direction of the Earth's rotation.#

In particular, (a) the positive direction of that line parallel to the Earth's axis of rotation and perpendicularly to the left of an observer facing in the direction of the Earth's rotation, or (b) the positive direction of a similar line tangent to the (gravity) equipotential surface at the observer.

north, compass #The direction indicated by the north-seeking end of the needle or other magnetic component of a magnetic compass.#

It differs from *magnetic north*, the direction of a magnetic line through the point of observation, by the amount that the supports and housing of the magnetic compass affect the needle's movement.

north, magnetic #The direction indicated by the north-seeking end of an unconstrained, magnetized needle.# See *north, compass.*

north, true See *north, astronomic.*

northeasterly #A direction within 22.5° of northeast.#

northerly #A direction within 22.5° of north.#

northing (1) #A linear distance, in the coordinate system of a map grid, northwards from the east-west line through the origin (or false origin).#

(2) See *latitude, difference of.*

northing, false #A value assigned the east-west line through the origin on a map grid to avoid the inconvenience of negative northings at some points.#

Equivalently, a constant value added to the northing of points on a map grid with origin at (0,0).

north point (1) #The northern intersection of the celestial meridian with the horizon.#

If the observer is close enough to the North Pole that the Pole is included within his horizon, the north point is the intersection closest to the Pole.

(2) #An arrow-like symbol indicating the direction *north* on a map or chart.#

North Star See *Polaris.*

northwesterly #A direction within 22.5° of northwest.#

number, dynamic See *dynamic number.*

number, geopotential See *geopotential number.*

number, normal dynamic See *dynamic number, normal.*

nutation #A quasiperiodic motion of the Earth's instantaneous axis of rotation about an average position, i.e., about the position corrected for *precession*. The period of the major component is approximately 18.6 years.#

Nutation moves the equinox by as much as 17″ ahead of or behind its average position. Astronomers conventionally distinguish between nutation as the periodic movement of the instantaneous axis of rotation, and the Eulerian nutation which consists of the long-period oscillation of the axis of figure about the instantaneous axis plus a very small diurnal oscillation.

nutation, constant of #The value adopted by the International Astronomical Union in 1976 is 9.″2109 at epoch 2000.#

This is the amplitude of the longest term in the Fourier-series representation of nutation and depends on the longitude of the node of the Moon's orbit.

nutation, Eulerian See *nutation.*

nutation in right ascension The *right ascension* of the mean equinox referred to the *true Equator* and *equinox*. #

It is the difference between mean and apparent sidereal time. Since 1960, this has been called the equation of the equinoxes.

O

objective (optical system) #The *lens* or assemblage of lenses that focuses light from the object to form the primary image.#

In optical instruments such as telescopes and microscopes, the image formed by the objective is magnified by a second lens system called the eyepiece. In cameras, the image formed by the objective is the final image. Objectives in astronomical telescopes generally consist of only one or two elements (separate lenses). Objectives in surveyors' telescopes and in cameras generally contain several elements.

object space #The space of all points from which light or other electromagnetic radiation can enter an imaging system.#

Often limited to that part of space from which rays can enter and pass entirely through an imaging system. See also *image space*.

object observed, eccentric See *signal, eccentric*.

oblateness (1) #A real *eccentricity* of an ellipsoid.#

An ellipsoid with imaginary eccentricity is a prolate ellipsoid and the absolute value of the eccentricity is called the prolateness.

(2) #The deviation from sphericity of a spheroid or ellipsoid.#

This is a general meaning which could refer to either the *eccentricity* or *flattening*.

oblatum #An oblate ellipsoid of revolution.#

oblique ascension #The arc of the celestial Equator or the angle at the celestial pole, between the hour circle of the vernal equinox and the hour circle through the intersection of the celestial Equator and the eastern horizon at the instant a point on the celestial sphere rises above the horizon. This angle is measured eastward from the hour circle of the vernal equinox through 24 hours.#

obliquity #The angle between a planet's or satellite's axis of rotation and its axis of revolution.#

obliquity factor #A factor, in the expression for a constituent tide (or tidal current), involving the angle of inclination of the plane of the Moon's orbit to the plane of the Earth's equator.#

obliquity of the ecliptic See *ecliptic*.

observability condition #A set of linear equations between two vectors $\vec{x}$ and $\vec{y}$,

$$\vec{y} = A\,\vec{x} + \vec{b},$$

which is solvable for $\vec{x}$ in terms of $\vec{y}$, the constant vector $\vec{b}$ and the constant matrix A.#

Like *observable* (definition 3 below), this appears to be limited in use.

observable (1) #Any phenomenon that is or can be made the object of an *observation*, i.e., deliberately sensed and noted.#

(2) In common usage, #any phenomenon that can be made the object of a measurement.#

(3) #A quantity that can be solved for in an equation.# This usage is limited. See also *observability condition*.

observation (1) #The act of deliberately sensing an event or object and noting the circumstances.#

Observation is distinguished from sensing by (a) being deliberate and (b) involving the noting (e.g., by recording) of the circumstances. It differs from measurement by not requiring that the circumstances be noted as quantities. That is, a measurement is an observation for which a quantitative value is noted.

(2) #The notes or records produced by an observation as defined above.#

observation, direct #An observation in which the event or object itself is observed.#

It is the antithesis of an *indirect observation*, in which an image or other surrogate for the event or object is actually observed.

observation, indirect #An observation made of a particular effect or aspect of an event or thing, rather than of the event or object itself.#

See also *measurement, indirect*.

observation, intermediary See *measurement, intermediary*.

observation, reciprocal #One of two observations made as a pair to reduce the size of some systematic error.#

In particular, one of a pair of observations taken forward and backward at the ends of a line. For example, in trigonometric leveling, the angle measured between the top of some feature and the horizontal plane at the observer is generally paired with the angle (the reciprocal observation) measured from the horizontal plane at the top of the feature to the point from which the first angle was measured.

The term should be applied only to observations made either simultaneously or nearly simultaneously, since only then will conditions permit cancellation of systematic errors.

observation equation See *equation*.

occultation #The disappearance of one celestial body behind another body larger in apparent size.#

When the Moon passes between the observer and a star, the star is said to be occulted (unless the star is the Sun, in which case the Sun is said to be eclipsed). The three associated terms—*occultation, eclipse,* and *transit*—are exemplified by the motions of the satellites of Jupiter. An *eclipse* occurs when a satellite passes into the shadow cast by the planet; an *occultation* occurs when a satellite passes directly behind the planet, so that it could not be seen even if it were illuminated; and a *transit* occurs when a satellite passes between the observer and the planet, and is visible against the disk of the planet. The occultation of stars by the Moon furnished a method used in early surveys for determining position. See also *Besselian elements*.

ocean (1) #One of three large bodies of water—the Atlantic Ocean, the Pacific Ocean and the Indian Ocean. The Arctic Ocean is sometimes named as a fourth ocean.#

(2) #The union of the Arctic, Atlantic, Pacific, and Indian Oceans.#

There are no easily and universally recognized boundaries between the four oceans, since they form a continuous body of water. This continuity is often recognized by referring to the three oceans together as "the ocean" or "the world ocean". A number of smaller but still large bodies of water adjacent to and connected to the oceans are distinguished from the oceans proper and are called seas or gulfs, e.g., the Mediterranean Sea, the Black Sea, the Persian Gulf, and the Gulf of Mexico. As with the boundaries between oceans, the boundaries between seas, gulfs, and oceans are usually more a matter of arbitrary definition or convention than of physical difference.

oceanography #The study of the oceans and seas in all their aspects—their extent, their dimensions, their composition, their movements (tides, current, waves, etc.), the plant and animal life in them, etc.#

Study of the crust under the oceans and seas is considered by some a part of oceanography, by others a part of geology or geophysics, and is commonly called marine geology or marine geophysics. Oceanography is otherwise divided into two main disciplines: physical oceanography, which is concerned with the movement and constitution of the waters of the oceans and seas, and biological oceanography or marine biology, which is concerned with life in the oceans and seas.

The term *oceanology* is sometimes used as a synonym for oceanography.

oceanology (1) #The study of oceans and seas and their relation to the rest of the world and the life on it.#

Thus *oceanology* is a more comprehensive term than *oceanography*, since it includes additional topics such as navigation, the technology involved in exploiting the oceans, etc.

(2) #*Oceanography*.#

odometer #A revolution-counter attached to the wheel of a vehicle to register the number of turns made by the wheel in traveling over the ground.#

Most odometers indicate the distance traveled by the vehicle. See also *passometer*.

offset (surveying) (1) #A short line perpendicular to a surveyed line, measured to a line or point for which data are desired, thus locating that line or point with respect to the surveyed line.#

Offsets may be measured from surveyed lines to the edges of an irregular-shaped body of water, or to any irregular line whose position is wanted.

(2) #A short line segment in a surveyed or other line at the start of which the original line makes an abrupt change of direction and at the end of which it returns to its original direction.#

(3) #The perpendicular distance measured from a great circle line to a parallel of latitude, to locate a section corner on that parallel.# See also *secant method* and *tangent method*.

offset line (surveying) #A supplementary line close to and roughly parallel with a main line, to which it is referred by measured *offsets*.#

Where the line which is to be measured is relatively inaccessible, the required data are obtained by running an offset line in a convenient location and measuring offsets from it to salient points on the other line.

offset, swing (surveying) #The perpendicular distance from a given point to a transit line, which is found by holding the zero point of a tape at the given point and swinging the tape in an arc until the shortest (horizontal) distance is obtained.#

offshore (1) #The zone extending from a specified shoreline seaward for an indefinite distance.#

On the Atlantic and Gulf coasts of the United States, the shoreline specified is the line of *mean low water;* on the Pacific coast, it is the line of *mean lower low water*.

(2) #The comparatively flat region (of variable width) that extends from the outer margin of the rather steeply sloping *shoreface* to the edge of the continental shelf.#

omega #A *hyperbolic navigation system* operating at VLF (between 10 and 14 kHz).#

The rms error of location is between 1 and 3 km; the lower values occur during daylight when the ionosphere is lower and denser. The phase of the signal received from a first pair of stations is determined by the receiver, and is used to locate the receiver on a hyperbola whose position is known with respect to the two stations. Signals received from a second pair of stations determine a second hyperbola whose intersections with the first hyperbola fix, with an easily resolved ambiguity, the location of the receiver.

The range of the system is about 9,000 km. By 1978 there were enough omega stations in the world to make navigation by this means possible anywhere at sea.

one-body problem #The problem of determining the location of a body as a function of time, when the field of force in which the body moves and the initial location and velocity of the body are known.#

Determining the orbit of an artificial satellite is a one-body problem, because the motion of the primary is not affected by that of the satellite.

opposition (astronomy) #The configuration taken by the Sun, a planet, and the Earth when apparent geocentric (celestial) longitude of planet and Sun differ by 180°, i.e., the planet, the Earth, and the Sun lie on the same line with the Sun on one side of the Earth and the planet on the other side.#

In such a configuration, the planet is said to be in opposition.

optical system #Any assemblage of *optical elements* used to direct light rays along a specified path for a specific purpose.#

See also *aperture, focal length, lens, nodal point, stop,* and *window*.

See also *camera, leveling instrument, telescope, theodolite,* and *transit*.

optical system, angle of view See *field of view*.

optical system, catadioptric #An optical system containing both refracting and reflecting elements.#

optical system, catoptric #An optical system containing only reflecting elements.#

optical system, curvature of field of #An *aberration* affecting the longitudinal position of images off the axis so that objects in a plane perpendicular to the axis are imaged in a curved surface.#

optical system, diffraction-limited #An optical system free from *aberrations;* thus the quality of resulting images is determined by diffraction only.#

No real optical system is solely diffraction-limited, but many systems come close to this ideal within a narrow field of view and a limited range of wavelengths.

optical system, dioptric #An optical system containing only lenses and flat mirrors.#

Usually called a lens system.

optical system, pancratic See *optical system, zoom.*

optical system, zoom #An optical system with variable power of magnification.#

Also called a pancratic optical system, it is widely used on television cameras, on copying cameras, and in some kinds of steroscopic plotting instruments.

optical wedge #A refracting prism of very small deviation, e.g., those used in the eyepieces of some stereoscopes.#

orbit (1) #The path followed by the center of mass of a body moving in response to the force of gravitation and other natural forces, together with the times at which the points in the path were occupied.#

An orbit can also be defined as the function that gives the location of such a body, with time used as the independent variable. Forces other than gravitation that may affect orbital motion are air drag, radiation pressure, and magnetic or electrical fields.

(2) #The path followed by the center of mass of a body moving in response to the force of gravitation and other natural forces.#

If the set of points forms an arc continuous except at the ends, the orbit (in sense of the second definition) is also called the path of the body.

Both meanings are commonly used for the word. (Note: *orbit* and *trajectory* are not synonyms.)

orbit, element of an See *element, orbital.*

orbit, Keplerian #An orbit followed by a body obeying *Kepler's laws* of motion.#

By extension, therefore, any body following an elliptical orbit.

orbit, lunisolar perturbation of an #Perturbations of the orbit of a body in the Solar System caused by the attraction of the Moon and Sun.#

In particular, in geodetic usage, such perturbations in the orbit of an artificial satellite of the Earth. See also *orbit, perturbed.*

orbit, normal See *orbit, Keplerian.*

orbit, osculating #The orbit that a satellite moving under the influence of several forces would follow if all forces other than the gravitational attraction of the primary were suddenly removed.#

The body would then follow an elliptical (Keplerian) orbit about the primary; this orbit would be tangent to the actual orbit at the point where the perturbing forces were removed. Because most satellites follow orbits that are approximately Keplerian for short time intervals, it is mathematically and practically convenient and physically meaningful to describe an actual orbit in terms of an osculating orbit whose elements (size, shape, and orientation) are slowly changing.

orbit, perturbed #An orbit that differs from another orbit considered standard for the same body.#

The perturbations are the differences between the actual orbit and the standard orbit. A commonly used standard orbit is an osculating orbit selected at some particular time. Another is a Keplerian orbit chosen so that the average values of the perturbations are small.

orbital mode of reduction #A method of solving for the location of a survey station by: first deriving the orbit of a satellite; then using observations of the satellite from the station and locations of the satellite obtained from the orbit, to derive the location of the station.#

The satellite orbit is computed from observations of the satellite from a number of known stations. The location of the satellite is then calculated for the times at which observations were made of it from the station whose location is to be determined. The location of this station is computed from the computed locations of the satellite and from the observations made at the station. Two variants of this method are in common use: the *short-arc method* and the *long-arc method.*

The orbital mode is distinguished from the simultaneous mode of reduction by not requiring simultaneous or nearly simultaneous observations of the satellite from all stations.

ordinary (adjective) #Equivalent legally to average, when used in connection with terms such as low water, high water, etc.#

ordinate #In a plane Cartesian coordinate system, the distance measured from the horizontal axis along a line parallel to the vertical axis, to the point in question. Commonly, the y-coordinate.#

ordinate, middle #The distance from the midpoint of a chord to the midpoint of the corresponding circular arc.#

orientation (1) #The rotation or set of rotations needed to make the axes of one rectangular Cartesian coordinate system parallel to the axes of another.# Equivalently, the set of direction angles made by the axes of one coordinate system with the axes of the other.

(2) In photogrammetry, #the set of angles and coordinates defining the geometric relationship between a photograph and the corresponding object space.#

This usage differs from that given in (1) above, which is nearly universal, by including the location of the photograph in the definition.

(3) #The act or process of rotating one coordinate system into coincidence with or parallel to another.#

In particular, in photogrammetry, the process by which the coordinate system of a photograph is brought into proper relationship with an object space coordinate system. In surveying, it is the act of seeing that an instrument is properly aligned with respect to the points of the compass.

orientation, absolute #The process of fixing the scale, location, and orientation with respect to an object space coordinate system of a stereoscopic model formed by using a pair of photographs in correct *relative orientation.* #

orientation, analytical (1) #The computational steps required to determine the location and orientation of the camera's coordinate system in the coordinate system used for object space.#

(2) #The computational steps required to determine tilt, direction of the principal line, flight height, preparation of templets at the scale used in rectification, distances and angles, and preparing aerial photographs for rectification.#

The resulting values are set on the circles and scales of a rectifier or transforming printer.

orientation, basal #The establishment of the locations of both ends of an *air base* with respect to a system of coordinates on the ground.#

Six quantities—the three coordinates of each end of the air base (or their equivalent)—are required. In practice, these quantities may also be expressed as (a) the coordinates of one end of the air base and the three differences between these and the coordinates of the other end or (b) the coordinates of one end of the air base, the length of the air base, and the direction (two angles) of the air base.

orientation, empirical #The quantities of magnification, swing, tilt of easel, x-displacement, and y-displacement used to adjust a rectifier to correctly recreate in the projected image the exact conditions that existed in the negative at the instant of exposure.#

orientation, exterior (1) #Determining, analytically or in a photogrammetric instrument, the location of the camera station and the orientation of the camera at the instant of exposure.#

Exterior orientation, in a stereoscopic plotting instrument, is divided into two parts, relative and absolute. Also called outer orientation.

(2) #The set of quantities that fixes the location of the camera station and the orientation of the camera at the instant of taking the photograph.#

The set of quantities consists of three coordinates (location) and three angles (orientation).

orientation, inner See *orientation, interior.*

orientation, interior #The determination of the position of the coordinate system of a photograph with respect to the coordinate system of the camera used to take the photograph, or with respect to the coordinate system of the photogrammetric plotter in which the photograph is used.#

At least three constants, called the elements of interior orientation, specify the position of the photograph's coordinate system. These are (a) the distance (principal distance) along the perpendicular from the center of perspective to the plane of the photograph, and (b) the coordinates of the foot of the perpendicular in the coordinate system of the photograph. This definition implies that the plane of the photograph is perpendicular to the optical axis of the camera or projector and that the axes of the two coordinate systems are parallel. Where this assumption is unsatisfactory, one or more additional constants are introduced.

Many American photogrammetrists consider that the corrections for radial and tangential distortion are part of interior orientation, and the corresponding constants are among the elements of interior orientation. In this case, the calibrated focal length, rather than the principal distance, (a), is specified.

orientation, one-swing method of relative #The technique, used for *relative orientation,* that eliminates y-parallax by keeping one projector of a pair in a fixed position and making all adjustments with the second projector.#

Also called one-projector method, y-swing method, and single-projector method.

orientation, outer See *orientation, exterior.*

orientation, rationalization method of relative #The technique of relative orientation of successive stereoscopic models that takes into consideration the limiting factors of the equipment used and the nature and variations of tilt and crab at successive camera stations, and provides approximate adjustments of the projectors so the final adjustment can be reached in a shorter time.#

orientation, relative #The reconstruction (mathematically or instrumentally) of the same geometric relationships (except for scale) that existed between a pair of photographs when the photographs were taken.#

In the instrument, this is achieved by a systematic sequence of rotational or translational movements of the projectors. This procedure is sometimes called clearing y-parallax.

If the two photographs have enough image points in common (at least five), one photograph can be visually oriented with respect to the other.

orientation, swing-swing method of relative #The technique of achieving relative orientation of two projectors merely by rotating the projectors.#

Identical rotations applied about the z-axes (swings) have the same effect as translation of one projector in the y-direction; identical tilts about the y-axes have the same effect as translating one projector in the z-direction. Hence, y-parallax can be eliminated by this method without translations.

orientation of a rectifier, analytical See *rectifier, analytical orientation of a.*

orientation of a rectifier, empirical See *rectifier, empirical orientation of a.*

origin, false #A point chosen as origin on a map grid so that all points on the map have positive easting and positive northing.#

origin of a datum See *datum, origin of.*

orthodrome #An obsolete term for a *great circle* or, on the ellipsoid, a *geodesic.* #

orthometric correction See *leveling correction, orthometric.*

orthomorphism See *conformality.*

orthophotograph #A photograph prepared from a perspective photograph by removing displacements of points caused by tilt, relief, and perspective.#

orthophotomap #A map made by assembling a number of orthophotographs into a single, composite picture.#

A grid is usually added. The map may be further improved, cartographically, by photographically bringing edges out sharply in the picture, or by adding color or symbols.

orthophotoquad #An *orthophotograph* or mosaic of orthophotographs at the size of a standard quandrangle (a scale of 1:24,000), with little or no cartographic work added to it.#

orthophotoscope #An instrument used to produce *orthophotographs* from ordinary photographs.#

orthostereoscopy #A condition, in stereoscopic viewing, that causes the horizontal and vertical distances in a stereoscopic model to appear to be at the same scale.#

oscillation #In general, the repeated movement of an object, at equal time intervals, from one point to another and back again.#

In particular the two motions, one in each direction, of a pendulum is defined as an oscillation. Because dissipative forces affect most motions, the oscillation of real bodies is between points which gradually approach each other, i.e., the oscillations die down. If the mechanism is very carefully constructed and dissipative forces made small, the oscillations can continue undisturbed for long periods. The pendulums of clocks are usually kept oscillating by the periodic addition of a small amount of energy just sufficient to overcome the energy dissipated.

Each movement from one point to the other is called a *vibration;* the oscillation defined above is thus double vibration.

oscillation, forced #An oscillation maintained by the continued application of force.#

oscillation, free #An oscillation unaffected by a dissipative force.#

out (surveying) #A term used in some field notes and deeds in the early 1800's in America for a distance the equivalent of 5 chains.#

outboundary #A township line or range line forming part of the perimeter of a surveyed region. In particular, the controlling lines around the perimeter of an independent resurvey.#

outcrop #The exposed portion of a stratum of rock or of a vein at the surface of the Earth.#

In describing a survey station, the exposed portion of a large boulder is sometimes mistaken for an outcrop.

outkeeper (surveying) #On older-style surveyors' compasses, a scale numbered 1 to 16, with a pointer that was turned by a milled knob to keep track of the *outs.* #

outlier (1) #A value of a randomly varying quantity that lies outside certain arbitrary limits.#

(2) #Any value of a randomly varying quantity that is larger in absolute value than expected and that is suspected to be a *blunder.* #

overlap (1) #The parts of two separate photographs that show the same part of object space.#

Also called "stereoscopic overlap".

(2) #A measure of the area in two photographs that shows the same part of object space.#

It is customarily expressed as a percentage of the total amount of area of one photograph. For example, 60 percent overlap means that 60 percent of the area of one photograph shows the same part of object space as a second photograph. See also forward lap and side lap under *lap.*

(3) #The region on a map or chart that shows the same geographical region as an adjoining map or chart.#

(4) #A region of land common to two titles; a piece of land lying within the boundaries claimed by two distinct titles.#

overlay #A collection of symbols on a transparent sheet that is to be laid over another collection of symbols so that the two collections appear as one.#

overtide #A tidal or tidal-current *constituent* that is an exact multiple of the speed of one of the fundamental constituents.#

The presence of overtides is usually attributed to conditions in shallow water. See *speed* (2).

P

pace (1) #A *step.*#
(2) #The distance from where the heel of one foot strikes the ground to where the same heel next strikes the ground.#
Also referred to as a "Roman pace". Definition (2) is equivalent to about 5 feet and is twice the length of definition (1), which appears to represent the preferred usage.

pace, Roman See *pace* (2).

pair, stereoscopic #Two images of the same scene either perceived or photographed from two directions chosen so that when one eye views one image and the other eye views the other, a visual impression of depth is obtained.#

parallax (1) #The apparent displacement of the position of an object with respect to a reference system, or to a set of points or objects, because of a shift in the location of the observer.#
(2) #The difference in direction of an object as seen from two different points.#
(3) #The angle, at one point, between lines to two other distinct points such as the two ends of a base line.#
Parallax enters into many problems of astronomy, surveying, and mapping. It is used in many ways, and wherever clarity is essential, the term should be accompanied by a defining adjective.
See *parallax, annual; parallax, diurnal; parallax, instrumental; parallax, optical; parallax, personal*, and *parallax, secular*.
Parallax is also a basic term used in photogrammetry, where it is identified as linear, stereoscopic, etc.

parallax, absolute See *parallax, absolute stereoscopic.*

parallax, absolute stereoscopic #The algebraic difference of the distances of two images of a point from the respective photograph nadirs, measured in a horizontal plane and parallel to the air base.#
The term is generally shortened to parallax. It is also called absolute parallax, horizontal parallax, linear parallax, stereoscopic parallax, and x-parallax.

parallax, annual #The angle subtended at a celestial body by the average or specified radius of the Earth's orbit, the radius forming one side of a right triangle of which the line from the center of the Sun to the celestial body is the hypotenuse.#

parallax, diurnal (1) #The difference between the direction from a point on the surface of the Earth to a celestial object and the direction from the center of the Earth to the same object.#
(2) #The same as the preceding definition, but with "reference ellipsoid" substituted for "Earth".#
(3) #The angle subtended, at a celestial object, by the line from a specified point on the Earth (or on a specified reference ellipsoid) to the center of the Earth (or to the center of the ellipsoid).#
Diurnal parallax is equal to the horizontal parallax when the celestial object is on a horizontal plane through the observer, and to the equatorial horizontal parallax when the observer is also on the Equator.

parallax, equatorial horizontal See *parallax, diurnal.*

parallax, geocentric See *parallax, diurnal (1)* and *(2).*

parallax, heliocentric See *parallax, annual.*

parallax, horizontal #The angle subtended, at a celestial body, by a radius of the Earth (or of an ellipsoid representing the Earth), the radius forming one side of a right triangle and the line from the center of the Earth to the body forming the hypotenuse.#
See *parallax, diurnal (3).*

parallax, instrumental #A change in the apparent position of an object, with respect to reference marks on an instrument, caused by imperfect adjustment of the instrument or by a change in the position of the observer.#
When a telescope is so poorly focused that the image of the object does not lie in the plane of the reticle (cross hairs), a movement of the eye transverse to the line of collimation will cause an apparent movement of the image with respect to the cross hairs. This is a common form of instrumental parallax, and is usually called optical parallax. Instrumental parallax may also result if an observer reads a vernier or marks the end of a tape from an incorrect position. This kind of instrumental parallax is often called personal parallax.

parallax, lunar #The *geocentric parallax* of the Moon.#

parallax, optical See *parallax, instrumental.*

parallax, personal See *parallax, instrumental.*

parallax, secular #The apparent secular change in direction of distant stars caused by movement of the Solar System with respect to the rest of the Galaxy.#

parallax, solar #The *equatorial horizontal parallax* of the Sun.#
Solar parallax, an angular measure, is the basis for the determination of the astronomical unit (the length of the semimajor axis of the Earth's orbit). Its adopted value, 8."794 148, is often used in astronomical calculations instead of the astronomical unit for expressing distances to stars.

parallax, stellar See *parallax, annual.*

parallax, stereoscopic (1) #The apparent shift in direction of a point when viewed first by one eye and then by the other.#
(2) See *parallax, absolute stereoscopic.*

parallax bar #A graduated bar carrying two coplanar glass plates, each engraved with a dot, cross, or other mark, and each movable along the bar.#
The parallax bar is used to determine the height of an object from a pair of overlapping photographs. One of the glass plates can be slid freely along the bar and is used for coarse adjustment of the distance between the pair of photographs; the other plate can be moved precisely along the bar and is used for fine adjustment of the distance. Also called a *stereometer*, although this term is used for a larger class of instruments than the parallax bar.

parallel (geodesy) #A *geographic parallel.*#

By implication, therefore, a geodetic parallel or an astronomic parallel. The term parallel should be used alone only where there is no possible doubt as to what kind of parallel is meant. The term is also used instead of geodetic parallel or astronomic parallel.

parallel, astronomic #A line on the surface of the Earth that has the same *astronomic latitude* at every point.#

Because the *deflection of the vertical* is not the same at all points on the Earth, an astronomic parallel is an irregular line not lying in a single plane. The astronomic parallel of 0° astronomic latitude is called the astronomic or terrestrial Equator.

parallel, auxiliary standard #A new *standard parallel* established for control where the original standard parallels were placed at intervals of 30 or 36 miles.#

Auxiliary standard parallels are used for the extension of old surveys or the control of new surveys. Such a line may be given a local name, such as "Cedar Creek Correction Line" or "Fifth Auxiliary Standard Parallel North".

parallel, geodetic #A line on an ellipsoid which has the same *geodetic latitude* at every point.#

parallel, geographic #A line on the Earth, or a representation thereof, which represents the same latitude at every point.#

The term is applicable alike to an astronomic or a geodetic parallel.

Also called a parallel of latitude or, when no misunderstanding is possible, a parallel.

parallel, ground #The line in which the plane of a photograph intersects the plane of reference on the ground.#

See *axis of homology*.

parallel, isometric #A line on a photograph that passes through the *isocenter* and is the image of a horizontal line in object space perpendicular to the *principal plane* of the photograph.#

parallel, photographic #The image on a photograph of any horizontal line in object space which is perpendicular to the *principal plane*. #

All photographic parallels are perpendicular to the *principal line*.

parallel, standard (1) #A *geodetic parallel* used as a control line in the computation of a map projection.#

In pictures of *graticules* made by conic map projections, a standard parallel usually represents a line of tangency or of intersection of a cone with the surface of the ellipsoid. Such pictures are not exact.

(2) #An auxiliary governing line, established along the *astronomic parallel*, starting at a selected township corner on a principal meridian, and usually spaced at intervals of 24 miles from the base line, on which standard township, section, and quarter-section corners are established.#

Also called a correction line. Standard parallels, or correction lines, are established to limit the convergence of *range lines* from the south.

parallel determination, tangent method of #A method of determining the *geographic parallel*, for survey of a base line or *standard parallel*, by offsets from a great-circle line started at an established township corner and tangent to the base line or standard parallel at that corner.#

The tangent great circle is projected at an angle of 90° from the meridian at the township corner from which it starts, and offsets are measured north from the tangent to the parallel upon which the corners are established.

parallel of altitude See *almucantar*.

parallel of latitude See *parallel, geographic*.

parallelogram of Zeiss #The parallelogram formed by (a) the line joining the perspective centers of the projectors in a stereoscopic plotting instrument, and (b) the line joining one perspective center to a projected point, together with (c) the sides parallel to these two lines.#

In stereoscopic plotting instruments with mechanical or optical trains, the parallelogram is frequently realized mechanically or optically to increase the range of scales that can be handled by the instrument.

parameter (1) #A quantity that appears as a constant in an equation containing variables, but whose value may be assigned arbitrarily.#

If the equation represents a line or surface, then to each value of the parameter there corresponds a different line or surface. For example, in the equation $y = ax + b$ for a straight line, a and b can be considered parameters. To each value of a, there corresponds a line of different slope through the point $(0,b)$. To each value of b, there corresponds a line passing through $(0,b)$ parallel to a line of slope a through the origin (0,0).

(2) #An independent variable in terms of which the coordinates of points on a line or surface are given.#

In general, one of M independent variables in terms of which the N coordinates ($N > M$) of points of an M-dimensional surface in N-space are given. For example, the N-dimensional vectorial equation

$$\vec{x} = \vec{a}t + \vec{b}$$

defines a straight line (1 dimension) in N-space, with t as parameter and $\vec{a}$ and $\vec{b}$ as constants.

(3) #In statistical terminology, any numerical constant derived from a population or from a probability distribution.#

Specifically, it is an arbitrary constant in the mathematical expression of a probability distribution.

parameter, geostrophic See *geostrophic parameter*.

parcel #A single region of land described in a single description in a deed, or as one of a number of lots on a plat, separately owned, either publicly or privately, and transferable separately.#

parsec #The distance at which the angle (*annual parallax*) subtended by the average radius of the Earth's orbit is 1 second of arc (1").#

It is approximately 3.26 light-years or 30.9×10^{12} km.

partial See *divergence*.

pascal #A unit of pressure defined as the pressure exerted by a force of 1 *newton* on an area of 1 square meter.#

The pascal (symbol Pa) is therefore equal to 10 *dynes* per cm^2, or to 10^{-5} bar. It is an SI derived unit.

pass (1) (photogrammetry) #One complete set of measurements on a specific photograph.#

(2) (satellite geodesy) #The period of time, or the path traversed by a satellite in that period, during which a ground station is within signal range of the satellite.#

(3) #One revolution of a satellite.#

passometer #A pocket-sized instrument which registers the number of *steps* or *Roman paces* taken by the pedestrian carrying it.#

See *pedometer*.

pass point See *point, pass*.

pedometer #A pocket-sized instrument which registers the distance in linear units traversed by the pedestrian carrying it.#

The term pedometer was formerly used to refer to an instrument that registered the number of steps or Roman paces taken; that instrument is now called a passometer.

peg adjustment See *leveling instrument, peg adjustment of a*.

Peil, Normaal Amsterdams See *Normaal Amsterdams Peil*.

pel See *pixel*.

Pemberton leveling rod See *leveling rod*.

pendulum #In general, a body suspended so it can swing freely back and forth under the influence of gravity.#

See *pendulum, simple* and *pendulum, compound*.

pendulum, Besselian #A pendulum consisting of a heavy sphere suspended by a very long wire.#

Also called a filar pendulum. This kind of pendulum was used by Bessel in Konigsberg in 1826. Wires 200 m long have been used.

pendulum, bronze #A *quarter-meter pendulum*, used by the U.S. Coast and Geodetic Survey, made of aluminum-bronze consisting of one part of aluminum and nine parts of copper.#

Beginning in 1920, bronze pendulums were replaced by invar pendulums in the gravity work of the U.S. Coast and Geodetic Survey.

pendulum, center of oscillation of #The point in an actual pendulum that lies on the line joining the *point of suspension of the pendulum* and the center of mass, and is at a distance ℓ_0 from the point of suspension, where ℓ_0 is the length of a *simple pendulum* having the same frequency of oscillation as the actual physical pendulum.#

If ℓ is the distance from the point of suspension to the center of mass and k is the *radius of gyration* of the physical pendulum, then $\ell_0 = (\ell^2 + k^2)/\ell$.

pendulum, center of suspension of #The fixed point about which an *ideal pendulum* oscillates.#

See *pendulum, point of suspension of*.

pendulum, compound #A pendulum that does not have its entire mass concentrated at one point.#

Thus, any actual pendulum is a compound pendulum. A compound pendulum may be considered to be composed of a large number of material particles, each at a different distance from the center of suspension and each constituting a *simple pendulum*. The period of oscillation of the compound pendulum is the resultant of the periods of the simple pendulums of which it is composed.

pendulum, dummy #A pendulum similar in structure to *working pendulums*, but equipped with a thermometer and fastened rigidly in its container so that it cannot swing during observations.#

The dummy pendulum is subjected to the same environmental temperatures as the working pendulums, and is used to determine their temperatures while in use.

pendulum, Eötvös See *torsion balance*.

pendulum, filar #A pendulum in which the mass is hung at the end of a very thin, light wire.#

Such a pendulum comes close to being a *simple pendulum*. Unfortunately, the elasticity of the wire introduces other problems that have so far been more severe than the problems associated with using compound pendulums.

Also called a *Besselian pendulum*.

pendulum, flash apparatus for See *flash apparatus*.

pendulum, flexure of #The bending of a swinging pendulum because it is not perfectly rigid.#

The effect of the bending is to increase the period of oscillation; that is, a flexible pendulum swings less rapidly than a rigid pendulum. In determining relative gravity, account is not taken of the bending of the pendulum. Flexure is then taken to mean the movement of the supports of the pendulum that is caused by the swinging pendulum.

pendulum, Foucault #A *filar pendulum* consisting of a very heavy, spherical mass suspended by a very long thread or wire; it is set to oscillating in a plane.#

If the site for the pendulum is carefully chosen to be free from microseisms and air currents, the pendulum will keep its plane of oscillation fixed in space while the Earth rotates under it. The plane of oscillation then appears to rotate about the point of lowest descent, with an angular velocity ψ, given by $\psi = \omega \sin \phi'$, where ϕ' is the geocentric latitude and ω is the Earth's rate of rotation.

pendulum, free-swinging #A pendulum moving wholly under the influence of gravity with its initial momentum imparted by mechanical or other means.#

In measuring gravity, the initial momentum may be imparted by drawing the pendulum slightly out of plumb and then releasing it.

pendulum, horizontal #A horizontal rod resting at one end on the side of a rigid, vertical bar and attached at the other end by a long wire to the top of the bar, so that the rod is the base of a right-angled triangle of which the wire is the hypotenuse and the upright side is part of the vertical support bar.#

A heavy mass is suspended from the horizontal rod just beyond the end of the wire.

pendulum, ideal #A *simple pendulum* subject to no forces other than its weight and the tension in the connecting rod.# For example, the resistance of the atmosphere is neglected.

pendulum, idle #A *working pendulum* placed in its container well before use, so that it will assume the same temperature as the *dummy pendulum.* #

pendulum, invar #A *quarter-meter pendulum,* made of invar, which was used by the U.S. Coast and Geodetic Survey.#

See *pendulum, bronze* and *pendulum, quarter-meter.*

pendulum, invariable #A pendulum designed and supported in such a way that it can be used only in one position.#

The centers of suspension and of oscillation of an invariable pendulum are not interchangeable.

pendulum, inverted #A pendulum in which the point of support is below the center of mass.#

In this position, the pendulum is in unstable equilibrium and is extremely sensitive to changes in the position of the point of support or to changes in gravity. If k is a constant expressing the elasticity of the strip supporting the pendulum mass, M the mass of the pendulum, and I its moment of inertia about the point of support, then the period t of the pendulum depends on the value g of gravity and on the length L of the pendulum according to the formula

$$t = \pi\ [I/(kMgL)]^{1/2}.$$

pendulum, Mendenhall #An *invariable pendulum*, one-quarter meter in length, with a vibration period of one-half second; it is composed of a lenticular bob on a thin stem, and is swung in near-vacuum in an airtight case.#

This pendulum was designed in 1890 by Superintendent Mendenhall (and assistants) of the U.S. Coast and Geodetic Survey.

pendulum, minimum #A pendulum constructed in such a way that a change of temperature causes a minimal change in the length of the pendulum.#

pendulum, oscillation of a (1) #The total motion of a pendulum from the time it passes through a specified position in a specified direction until it again passes through the same position moving in the same direction.#

(2) #The total motion of a pendulum between its passing from one extreme position to its next passage in the same direction through an extreme position.#

pendulum, period of a See *period of a pendulum* and *pendulum period*. Note: These two terms have different meanings.

pendulum, point of suspension of #The point, in a moving pendulum, at which it is supported by its fixed support.#

All pendulums are supported along a surface, not at a point. The surface is usually so narrow that it can be considered a line and, because of the pendulum symmetry with respect to the plane of oscillation, also can be considered a point. For an *ideal pendulum,* this point is fixed, but in actuality, it will oscillate slightly as the pendulum oscillates.

pendulum, quarter-meter #A pendulum about 25 cm long with a period of 1 second.#

It is often called a "half-second pendulum".

pendulum, receiver for a #A heavy box of cast metal, within which the pendulum is suspended and some auxiliary equipment is placed, when measurements of gravity are being made.#

pendulum, reversible #A pendulum designed and supported in such a way that it may be used with either end up.#

The centers of suspension and of oscillation of a reversible pendulum are interchangeable. Pendulums of this type were constructed by Kater, Peirce, and Repsold. Formerly used for absolute measurements of the intensity of gravity at base stations. See *pendulum, invariable.*

pendulum, Schuler #A hypothetical *simple pendulum* with its point of support at the Earth's center of mass and a length equal to a defined radius of the Earth.#

A Schuler pendulum with a length of 6,378 km has a period of about 84.6 minutes.

pendulum, simple #A hypothetical pendulum consisting of a point mass attached to one end of a massless, rigid rod of zero cross section, the other end of which pivots without friction on a horizontal axle of zero radius so that the point-mass is free to oscillate in a vertical plane about the horizontal axis.#

An actual pendulum differs from a simple pendulum as follows. First, its mass is not concentrated at a point (a real pendulum with distributed mass is called a *compound pendulum*). Second, the rod is flexible rather than rigid and has a finite cross section, so its motion is resisted by the medium in which the pendulum swings. Third, its pivot is not frictionless. Fourth, the pivot is not an ideal line; the pendulum and pivot are in contact along a surface, and the shape of this surface changes with the position of the pendulum. Lastly, the support for the pivot itself flexes and sways. Each of these differences requires a correction to the equation representing the motion of a simple pendulum.

pendulum, Sterneck #A pendulum (made using the original design by Sterneck) in which the disk-shaped mass is at the end of a cylindrical rod.#

pendulum, swing of a #The total motion of a pendulum between its passage from one end of its arc to the other, or from the point of maximum velocity in one direction to the point of maximum velocity in the other.#

Also called a vibration. Two successive swings or vibrations make up one oscillation.

pendulum, working #A pendulum whose period of oscillation is measured to determine the intensity of gravity.#

pendulum apparatus #An instrument, consisting of one or more pendulums and accessories, used for the determination of gravity.#

The usual accessories are (a) a mechanism for lifting the pendulum from its support, releasing it into motion, and replacing it on its support; (b) a device for recording the period of oscillation or positions of the pendulums as a function of time, (c) a clock, (d) thermometers, and (e) a barometer. As many as four pendulums have been used in a single pendulum apparatus to compensate for flexure of the supports or for the motion of the apparatus as a whole, or simply to provide several independent measurements that can be averaged to get a more precise value for gravity.

pendulum apparatus, Besselian #A pair of specially suspended *filar pendulums*, differing in length by an accurately known amount (1 toise), in Bessel's pendulum apparatus of 1826-1827.#

pendulum apparatus, Brown #A pendulum apparatus made up of the *Mendenhall pendulum*, a special kind of clamp for holding the pendulum in the receiver while the apparatus is being transported, and an electrical detecting and amplifying device for measuring and recording the oscillations of the pendulum on a chronograph.#

The apparatus was designed by E. J. Brown of the U.S. Coast and Geodetic Survey and was first used in the field in 1932.

pendulum apparatus, Lejay-Holweck #An *inverted pendulum* contained in an evacuated glass tube, with a period of 6 to 7 seconds.#

Forty to sixty minutes of observation gives gravity measurements with precision better than 1 mgal.

pendulum apparatus, Vening-Meinesz #A pendulum apparatus with five pendulums; designed by Vening-Meinesz for measuring gravity at sea.#

Essentially of the Sterneck type, it had three half-second brass pendulums swinging in the same plane. This permitted making a correction for the motion of the ship. Two of the pendulums were highly damped and were used as references for the motions of the other three pendulums.

pendulum period #The interval of time required for one swing of a pendulum.# The period of an *ideal pendulum* is a function only of its length and of the local value of gravity; it is otherwise constant. The period of an actual pendulum depends also on the amplitude of swing and on the density of the surrounding air. The pendulum period decreases with time. See *pendulum, swing of a*.

pendulum period, arc correction to #The quantity added to a pendulum period to account for pendulum departure from simple harmonic motion.#

By limiting the amplitude of oscillation, the correction is kept small.

pendulum period, coincidence method of determining #A method of determining the pendulum period of a free-swinging pendulum by observing the interval of time between coincidences of position with a pendulum clock.#

pendulum period, creep in #A gradual change in the pendulum period.#

Synonymous with "drift".

pendulum period, dynamic temperature correction to #The correction to an observed pendulum period to compensate for changes associated with the observed rate of change of temperature of the pendulum.#

The dynamic temperature correction is related to the type of pendulum apparatus used, and depends especially on the way the thermometer is mounted and on the shape of the pendulum. It may vary not only in magnitude but even in sign depending on the type of apparatus used.

pendulum period, pressure correction to #A correction added to the pendulum period to account for the buoyant effect of the environmental medium on the pendulum and the resistance of the medium to the pendulum motion.#

Changes in atmospheric pressure produce changes in both the buoyancy and resistance of the air to the motion of the pendulum.

pendulum period, temperature correction to #The quantity added to the pendulum period to allow for the difference in length of the pendulum at the temperature during the current observation and its length at the temperature at which it was calibrated or at which other observations were made.#

pentaprism See *prism, right-angle* and *prism, pentagonal*.

perch #An obsolete unit of length equivalent to the *rod* and the *pole*.#

peri- #A prefix, meaning "the point in an orbit closest to", used with the name of the body (or point) of reference. Examples: *perigee, perihelion*, and *pericenter*.#

Note: If a satellite has appreciable mass compared to the parent body, the center of mass of the two-body system is meant, e.g., lunar perigee refers to that point in the Moon's orbit closest to the center of mass of the Earth-Moon pair.

periapsis #The point in the orbit of a satellite at which the satellite is closest to its *primary*.# Sometimes incorrectly called the pericenter.

pericenter #The point in the orbit of one component of a binary system at which that component is closest to the center of mass of the system.#

This is a more general term than *periapsis*, since periapsis is equivalent to pericenter only when the second component is a point with much greater mass than the first component. Unfortunately, pericenter is sometimes used to denote the two points in an orbit at which the satellite is closest to the center of the orbit.

perigee #The point in the orbit of a satellite of the Earth at which the satellite is closest to the Earth's center of mass.#

perihelion #The point in the orbit of an object revolving about the Sun at which the object is closest to the Sun's center of mass.#

Passage of the Earth through its perihelion is the starting point for the *anomalistic year*.

period #The interval between two events in a sequence of recurring events.#

period, anomalistic #The interval of time between two successive passages through *perigee* or, in general, *pericenter*.#

period, Eulerian free #The period of *nutation* of a rotating, rigid body not under the influence of external forces.#

The term is applied, in particular, to the period of nutation that a rigid Earth would have if it were not affected by external forces. The Eulerian free period is 305 sidereal days, or about 304 mean solar days.

period of a pendulum #The interval of time required for one oscillation of a pendulum.#

This term must not be confused with *pendulum period*, which is the interval of time required for one *swing*. Because a real pendulum oscillates in an arc whose amplitude is steadily decreasing, the period required for the first swing of an oscillation is slightly more than half the period of the oscillation containing that swing. See *pendulum, swing of a.*

periscope, solar #A device that can be attached to an aerial camera so that the camera orientation with respect to the Sun can be determined at the moment of exposure.#

It was invented by E. Santoni.

perpendicular (1) #A straight line which intersects another line, not necessarily straight itself, at right angles.#

(2) By extension, #a straight line which intersects a surface at right angles to all lines in the surface that pass through the point of intersection.#

In Euclidean space, the perpendicular from a line or surface to a point is also, at least locally, the shortest line from that line or surface to that point.

perpendicular, photograph #The perpendicular from the interior *perspective center* to the plane of the photograph.#

See *distance, principal.*

perspective (1) #Two sets of points, each on a different surface, are said to be "in perspective" from a given point if corresponding points in the two sets lie on a straight line that passes through the given point.#

(2) #A *projection* (also called a perspective transformation or perspective projection) that relates points on two surfaces by drawing straight lines from a given point through points on the one surface to the points of intersection with the second surface.#

The given point is called the perspective center or center of perspective.

(3) #The set of points, on a surface, that consists of the intersections with that surface of straight lines from a given point through points on another surface.#

perspective, central See *projection.*

perspective, orthogonal See *perspective.*

perspective center See *center, perspective.*

perspective ray See *ray, perspective.*

perturbation (celestial mechanics) #Any deviation in the path of an object in motion within an orbit or within a standard trajectory.#

In celestial mechanics, a perturbation is usually the deviation along the path of an actual orbit from a Keplerian orbit. The forces causing these deviations are called perturbing forces. The principal perturbations of the orbit of a satellite of the Earth are caused by the noncentral part of the Earth's gravitational field, atmospheric drag, the gravitational attraction of the Moon and the Sun (lunisolar perturbation), radiation pressure from the Sun, and the action of the geomagnetic field (electromagnetic drag perturbation). Note: The perturbation is the effect on the orbit, not the force which causes the effect.

perturbation, lunisolar #An orbital perturbation of a satellite of the Earth caused by the attractions of the Sun and Moon.#

perturbation, orbital See *perturbation.*

perturbation, periodic #An orbital *perturbation* that increases and decreases periodically; in the absence of other perturbations a satellite subjected to a periodic perturbation returns to the same point at the end of each period.#

Perturbations of many different periods may be present simultaneously. Those with periods on the order of the period of the unperturbed orbit are called short-period perturbations; those with much longer periods are called long-period perturbations.

perturbation, radiation pressure #A *perturbation* caused by the pressure of electromagnetic radiation on a satellite.#

The principal cause of radiation pressure perturbations in the orbits of artificial satellites in the Solar System is solar (electromagnetic) radiation which can be exerted either directly on the satellite or indirectly after reflection and scattering from the Earth.

perturbation, secular #An orbital *perturbation* that increases monotonically with time.#

This is in contrast to a periodic perturbation, which increases and decreases with time. The terms "secular" and "periodic" are also used in a relative sense. A perturbation may be secular over a specified time interval, but periodic if the time interval is extended.

Petzval condition #The condition that an anastigmatic system of lenses must satisfy to produce a planar image; expressed by the equation $\Sigma(f_i n_i)^{-1} = 0$, where f_i is the focal length and n_i the refractive index of the i-th lens.#

phase (1) #The visible aspect of an object.#

(a) In astronomy, the phase is a stage in a cycle of recurring aspects, caused by a systematic variation of the illumination of an object. The Moon, for example, passes through its phases (new moon, first quarter, full moon, last quarter, and back to new moon) as its position relative to the Sun and Earth changes. (b) In surveying, the term is applied to the aspect of a signal which presents regions of varying brightness to the observer: a round pole, illuminated from the side; a square pole, of which the observer sees two sides, one more strongly illuminated than the other. The pointing error caused by phase is of the same character and requires the same treatment as an error caused by observing an eccentric object. Phase may be closely associated with asymmetry of object (target), but the two terms are not synonymous.

(2) #A particular stage in the history of a phenomenon which goes through a cyclic sequence of stages.#

Examples are the phases of the Moon, the phase of an alternating current, and the phase of a variable star.

phase space #The collection of all sets of six coordinates specifying the location and momentum of a body.#

Philadelphia leveling rod See *leveling rod, Philadelphia.*

photobase See *base length, photographic.*

photo contour process #A process that combines, in a photo contour map, the information otherwise portrayed separately on a topographic map and an aerial photograph.#

The process consists of drawing the contours with a conventional stereoscopic plotting instrument, rectifying the photographs to remove the effect of tilt, and removing the effects of relief displacement by a zone printer or similar instrument. The contours are then superposed on the photographs.

photogram #A photograph, in particular, one used in photogrammetry.# The word is not widely used.

photogrammetry #The science of deducing the physical dimensions of objects from measurements on images (usually photographs) of the objects.#

Properly, the term should be used only when photographic images are used, since photogrammetry is a subdivision of *ikonogrammetry*. This latter term is infrequently used, as most people consider the two terms equivalent. A modifier is used with the term to indicate the kind of radiation responsible for the image, e.g., X-ray photogrammetry, infrared photogrammetry, and acoustic photogrammetry. The principal application of photogrammetry is to the mapping of the Earth's surface, but it is also used for mapping the surfaces of other bodies in the Solar System, for determining the geometry of architectural and archaeological objects, for measuring the human body, and for other purposes in many sciences and technologies.

photogrammetry, aerial #Photogrammetry in which photographs or other images of the Earth taken from aircraft or satellites are used.#

photogrammetry, analytical #Photogrammetry in which the shape and size of an object are determined mathematically from measurements directly on the images, rather than mechanically from measurements on the stereoscopic model.#

photogrammetry, cantilever method of See *extension, cantilever.*

photogrammetry, geodetic #Photogrammetry used for geodetic applications.#

The term usually means aerotriangulation, aerial mapping, and terrestrial photogrammetry. It also includes the photogrammetric practices associated with the use of artificial satellites for geodetic purposes.

photogrammetry, grid method of See *grid method, perspective.*

photogrammetry, ground See *photogrammetry, terrestrial.*

photogrammetry, perspective #Photogrammetry using only a single photograph, as opposed to using a stereoscopic pair.#

Also called monoscopic photogrammetry.

photogrammetry, stereo See *stereophotogrammetry.*

photogrammetry, terrestrial #Photogrammetry using photographs taken at, and of the Earth's surface.#

Also called ground photogrammetry and phototopography.

photogrammetry, topographic #Photogrammetry used for determining the geometry of surfaces, as distinguished from photogrammmetry for determining the geometry of figures *on* surfaces.#

In geodesy, topographic photogrammetry is used to determine all three coordinates of points on the Earth's surface, while planimetric photogrammetry is used to determine only horizontal coordinates. See *planimetry.*

photograph #An image created by the action of eletromagnetic radiation or high energy particles on an emulsion containing radiation-sensitive substances such as silver bromide.#

The term is properly applied only to images created by the action of visible light.

photograph, aerial #A photograph taken from an aircraft.#

photograph, center of #The center of a photograph as indicated by the images of the fiducial mark or marks of the camera.#

In a perfectly adjusted camera, the center of photograph and the *principal point* are identical. Also called photograph center.

photograph, equivalent vertical #A hypothetical photograph, theoretically vertical, taken at the same camera station as the actual photograph.#

photograph, horizon See *horizon photograph.*

photograph, oblique #An aerial photograph taken with the optical axis of the camera deliberately pointed away from the vertical.#

Usually, in vertical photography, the optical axis of the camera lies within 5° of the vertical. Oblique photographs could therefore be defined as photographs taken with the optical axis more than 5° from the vertical. There are two kinds of oblique photographs: high-oblique, which show the horizon, and low-oblique, which do not.

photograph, vertical #An aerial photograph taken with the axis of the camera as nearly vertical as possible, so that the resultant photograph is an approximately horizontal representation.# See *photograph, oblique.*

photograph, wing #A photograph taken through one of the side (wing) lenses of a multi-lens camera.#

photograph perpendicular See *perpendicular, photograph.*

photographs, stereoscopic pair of See *pair, stereoscopic.*

photography (1) #The process or technique of taking photographs.#

(2) #The science concerned with the chemical and optical processes involved in taking photographs and transforming them in various ways.#

photography, aerial #Photography from an aircraft.#

photography, convergent #*Oblique photography*, usually with an assembly of two cameras, in which one photograph is taken looking forward along the line of flight and the succeeding, overlapping photograph is taken looking back along the line of flight.#

Convergent photography can provide a much larger *base-height ratio*, but is much more difficult to use than vertical photography.

photography, convergent low-oblique See *photography, twin low-oblique.*

photography, cross-flight #Aerial photographs taken in strips that overlap between exposures and in a direction at right angles to that of other existing strips of photographs.#

photography, divergent low-oblique See *photography, twin low-oblique.*

photography, horizontally controlled #Aerial photography in which distances between the taking camera and each of two or more points (whose geodetic coordinates are known) are determined simultaneously with the taking of the pictures.#

The distances are usually measured with shoran, hiran, or shiran.

photography, oblique #The taking of *oblique photographs.*#

photography, process #The preparation of line- and halftone photographs for subsequent use in the preparation of plates for printing.#

photography, satellite #Photography from an artificial Earth satellite.#

photography, strip #Photography using a *strip camera.*#

photography, terrain-profile #Aerial photography in which data on the elevation of the terrain along the ground track of the aircraft are obtained at the same time as the photographs.#

The terrain-profile recorder is normally used as the elevation measuring device.

photography, terrestrial #Photography from the Earth's surface.#

In particular, in photogrammetry, the term means photography on and of the Earth's surface.

photography, tricamera #Aerial photography using three cameras arranged at fixed angles to each other in such a way that adjacent photographs overlap.#

Usually the cameras are arranged so that a vertical photograph is obtained by the central camera and high-oblique photographs are obtained by the other two. This assembly is often referred to as a "trimetrogon camera assembly" because of the wide use of metrogon lens systems in early tricamera photography.

photography, trimetrogon #*Tricamera photography* in which high-oblique photographs are taken in a direction at right angles to the line of flight.#

The oblique photographs, taken at angles of 60° from the vertical, together with the vertical photograph, produce a continuous picture from horizon to horizon. Exposures usually are made at short intervals so that successive picture triplets overlap along the line of flight.

photography, twin low-oblique #Aerial photography using two cameras with their optical axes inclined at small angles (typically, about 20°) to the vertical.#

There are two kinds: convergent low-oblique photography, using a pair of cameras whose optical axes point downwards and towards each other along the line of flight to give greater base-height ratio, and divergent low-oblique photography, using a pair of cameras whose optical axes point downwards and away from each other at right angles to the line of flight to give increased angular coverage.

photography, vertical See *photograph, vertical.*

photo interpretation #The science or process of inferring the nature (other than geometric) of an object from photographs or other recorded images of the object.#

Geometric inferences are made by *photogrammetry*; inferences about the purpose, use, origin, or identity of objects are made by photo interpretation. The images may be made by radar, acoustic systems, or imaging devices other than cameras.

photomap #An assemblage of aerial photographs that, wholly or partially, substitutes for or supplements a map.#

The photographs may or may not be rectified or restituted. A grid, marginal information, contours, place names, boundaries, and other data may be added.

photomosaic (1) #An assemblage of photographs, each of which shows part of a region, put together in such a way that each point in the region appears once and only once in the assemblage, and scale variation is minimized.#

A photomosaic is assembled by trimming, warping, and fitting together the individual photographs. If the photographs were taken at different heights, the individual photographs must be enlarged or reduced to a common scale.

(2) #An assemblage of parts of aerial photographs joined together to leave as few variations of scale as possible.#

It may be uncontrolled or may be controlled by adjusting distortions to ground measurements. See *mosaic, controlled; mosaic, map-controlled;* and *mosaic, semicontrolled.*

photopolygonometry #*Aerotriangulation* in which the length of the *air base* is derived from the altitude at which the photographs were taken, as measured by an altimeter (typically, a radar altimeter). Otherwise similar to *radial aerotriangulation.*#

photo pyramid See *pyramid, photograph.*

phototheodolite #A *theodolite* in which a camera replaces or is affixed to the telescope.#

In newer models, the vertical and horizontal circles and the object under observation may be photographed simultaneously. The phototheodolite differs from the cinetheodolite principally in that the latter takes photographs through the telescope with a moving-picture camera and generally tracks a moving object.

phototopography See *photogrammetry, terrestrial.*

phototriangulation (1) #The determination of horizontal or vertical coordinates from measurements of angle, distance, or coordinates of points on overlapping photographs.#

Phototriangulation is classified as terrestrial or aerial, depending on whether the photographs were taken on the ground or from the air. Aerial phototriangulation is usually called "aerotriangulation".

(2) #The method by which horizontal or vertical control is determined from measurements of angle, direction, or coordinates of points on overlapping photographs.#

phototriangulation, analog #Phototriangulation using stereoscopic plotting instruments.#

phototriangulation, analytical #Phototriangulation in which the coordinates of ground points are derived from the measured coordinates of image points.#

phototriangulation, block method of #Phototriangulation in which measurements of coordinates of points on a large number of photographs are converted to the corresponding coordinates of the ground points for all the points at one time rather than individually for selected subsets of the points.#

See *phototriangulation, strip method of*. Also called block phototriangulation and phototriangulation by blocks.

phototriangulation, mechanical #The mechanical determination of coordinates of points on an object from stereoscopic photographs of the object.#

The term may be used whether or not the photographs are stereoscopic, but general usage is as given above.

phototriangulation, principal-point method of See *aerotriangulation, radial.*

phototriangulation, radial See *aerotriangulation, radial.*

phototriangulation, strip method of #Phototriangulation carried out on a whole strip of photographs at one time.#

If the region is pictured on several overlapping strips of photographs, the strip method is first applied to each strip individually. The results are then adjusted to give unique values for control points within the overlapping regions.

phototriangulation, terrestrial #Phototriangulation using photographs taken on the Earth's surface.#

In its original form, the method was developed from *plane-table surveying*. The pictures were set up vertically on a drafting table in their proper directions from a point taken as the camera station and then viewed through a special telescope similar to that used in plane-table surveying and using a similar procedure for drawing the map. More recent procedures involve the mathematical treatment of measurements made directly on the photographs.

phototriangulation adjustment #Determination of corrections to assumed or approximate coordinates of objects using phototriangulation.#

phototriangulation adjustment, radial #An analytical or mechanical phototriangulation adjustment in which photographs are fitted together so that *radials* are deformed as little as possible.#

phototrig #A method of determining elevations or heights from vertical angles measured on the ground and from horizontal distances measured on a map constructed by *stereocompilation*. #

physical constant #A constant quantity or value that has physical significance.#

Those physical constants that occur frequently in the equations of physics and from which all other physical constants can be derived are called "fundamental physical constants". The following are part of a set of consistent values recommended by the American Institute of Physics (Anderson 1981). Standard deviations (not cited) are attached to these numbers, so they should not be considered as necessarily accurate to the number of significant figures listed.

c	speed of light (in vacuum)	299,792,458 km/s
G	gravitational constant	6.6720×10^{-11} m^3 kg^{-1} s^{-2}
e	element of electrical charge	$1.602\ 189\ 2 \times 10^{-19}$ C
N_A	Avogadro's constant	$6.022\ 045 \times 10^{23}$ mol^{-1}
m_e	mass of electron	$9.109\ 534 \times 10^{-31}$ kg
		$5.485\ 802\ 6 \times 10^{-4}$ atomic mass unit
F	Faraday's constant ($=N_A\, e$)	$9.648\ 456 \times 10^4$ C mol^{-1}
h	Planck's constant	$6.626\ 176 \times 10^{-34}$ J Hz^{-1}
k	Boltzmann constant	$1.380\ 662 \times 10^{-23}$ J K^{-1}
R	gas constant	8.314 41 J mol^{-1} K^{-1}
V_o	standard volume of ideal gas	$22.413\ 83 \times 10^{-3}$ m^3 mol^{-1}

physiographic feature #A prominent or conspicuous physiographic form or a salient part thereof.#

physiographic form #A land form identified with respect to its origin, cause, or history.#

physiography See *geomorphology*.

pin (1) (leveling) #A stake of wood or metal on which the leveling rod rests when in use.#

Also called a turning-point pin.

(2) (distance measurement) #A short rod of metal, of which one end is pointed for driving into the ground and the other is bent into a round loop to make it easy to pull the pin out.#

Also called a taping pin, it is used for marking the ends of taped (measured) intervals on the ground. A complete set consists of 11 pins, allowing the laying down of a tape end-to-end 10 successive times before the set is exhausted.

pin, taping See *pin* (2).

pin, turning-point See *pin* (1).

pitch (1) #The angle, measured in a vertical plane, between the longitudinal axis of a vehicle and a horizontal plane.#

(2) #By extension, the angle between the axis, in a rotated body, that is called the longitudinal (roll) axis and the plane through the original, unrotated positions of the so-called longitudinal and transverse (pitch) axes.# See *rotation* (photogrammetry).

During flight, pitch is the rotation of an aircraft about the horizontal axis normal to its line of flight (longitudinal axis). The pitch is positive if it causes the aircraft's front end to rise. In aerial photography, the term is applied to a rotation of the camera, or of the coordinate system of the photograph, about either the y-axis of the photograph's coordinate system, or about the y-axis of the ground coordinate system. It is also called tip, longitudinal tilt, or y-tilt.

pivot inequality #Any difference in the diameters or any irregularities in the form of the pivots of the horizontal axis of a surveying or astronomical instrument (theodolite, transit, etc).#

In the past, corrections for pivot inequality were made to astronomical observations taken for geodetic surveys. Such corrections are unnecessary for observations made with precise modern instruments.

pixel (1) #An element of surface resulting from subdividing an image into the smallest identically shaped figures that give information about the location, intensity and perhaps color of the source, but such that no smaller subdivision will provide more information.#

The concept of "pixel" (diminutive of "picture element") is valid only for images made up of discrete patches. It is not valid for continuous images.

The term is sometimes assumed to be the equivalent of *resolution* expressed in terms of area. However, it is not exactly equivalent, because resolution can be defined for pictures which do not contain pixels. The size of a pixel is set principally by the size of the smallest individual radiation-sensitive element in the instrument creating the image. For example, in the human eye, the pixel is the region occupied on the retina by a cone.

(2) #The geometric region on the object that corresponds to a pixel (as defined above) on the picture.#

place (astronomy) #The angular coordinates of a celestial body. The location of a celestial body on the celestial sphere.#

place, apparent #The angular coordinates, referred to the true equinox and Equator of date, that a celestial body would have if it were seen from the center of the Earth.#

Apparent place is computed from *topocentric place* with the same equinox and equator by correcting for atmospheric refraction, diurnal aberration, and geocentric parallax. If more accuracy is wanted, corrections may also be made for the variation of latitude.

Apparent place is calculated from true place by transferring the origin of the coordinate system from the center of the Solar System to the center of the Earth and adding the effects of aberration—stellar, if only distant objects are involved, or planetary, if bodies inside the Solar System are involved. See *place, true.*

place, mean #The angular coordinates of a celestial body in a heliocentric coordinate system referred to mean Equator and equinox of date.#

place, normal #A single direction or position that is the weighted average of a number of observed directions or positions.#

place, observed #The angular coordinates in a topocentric coordinate system of a celestial body determined by direct observations from the the Earth's surface and corrected only for errors in the instrument used and in the method of observation (errors of collimation, leveling error, index error, dip of horizon, and so on).#

place, topocentric #The angular coordinates of a celestial body referred to a coordinate system with its origin at the observer.#

place, true #The angular coordinates of a celestial body in a heliocentric coordinate system referred to the true equinox and true Equator of date.#

True place is computed from observations in a topocentric coordinate system by (a) removing the effects of refraction, diurnal aberration, and distance of the observer from the center of the Earth; (b) removing the effects of annual aberration and the distance of the center of the Earth from the center of the Sun.

plane (1) (mathematics) (a) #Geometrically, a surface on which a straight line connecting any two points on the surface lies entirely on that surface.#

(b) #Algebraically, the surface defined in 3-space by all values of x, y, and z that satisfy the equation $ax + by + cz = d$, where a, b, c, and d are constants.#

(2) (geodesy) #A small region on a level surface.# See *plane, tidal.*

plane, azimuth See *azimuth, grid.*

plane, datum See *datum, tidal.*

plane, epipolar #Any plane containing the *epipoles;* therefore, any plane containing the *air base.* #

Also called basal plane.

plane, equatorial (1) (sphere) #The plane determined by a specified great circle or, if a diameter of the sphere is specified instead, the plane through the center of the sphere perpendicular to the specified diameter.#

(2) (ellipsoid of revolution) #The plane through the center of the ellipsoid containing the two axes of equal length.#

For an oblate ellipsoid, this corresponds to the plane through the circle of maximum radius; for a prolate ellipsoid, it is the plane through the circle of minimum radius.

(3) (triaxial ellipsoid) #The plane through a specified pair of axes.#

In geodesy, this is usually the plane through the longest and next longest axes.

plane, focal See *focal plane.*

plane, fundamental See *Besselian elements.*

plane, galactic #A plane placed with respect to the stars of the Galaxy so that half the stars are on one side of the plane and half on the other.#

plane, ground #The horizontal plane passing through the ground nadir of a camera station.#

plane, hill #A plane containing three ground marks that are control points.#

This may be, but rarely is, a horizontal plane.

plane, horizon See *horizon, plane of the.*

plane, horizontal #A plane at a given point which is perpendicular to the direction of gravity at that point; also called the horizontal plane at that point.#

In general, the plane is perpendicular to gravity only at the point under consideration. The term is not synonymous with *plane of the horizon*, which is defined in terms of the celestial circle called the horizon.

plane, image (1) #The plane on which an image is assumed to lie.# See *plane, photograph.*

(2) #The plane, in a camera, which provides the best average focus over the area of the photographic plate or film.#

The image plane in a camera is fixed in position with respect to the body of the camera.

plane, meridian See *meridian plane.*

plane, meridional See *meridian plane.*

plane, photograph #The plane in a camera in which the plate or film is held or is assumed to lie while a picture is being taken.#

It is not exactly at the primary focal plane of the lens, but is placed so as to secure the best balance of points that are out of focus on either side of the plane over all parts of the plate or film.

plane, principal (1) (optics) #The portion of the *principal surface* which lies sufficiently close to the optical axis to be considered planar.#

(2) (photogrammetry) #The vertical plane through the internal perspective center containing the photograph perpendicular of a tilted photograph.#

In the case of a truly vertical photograph, the principal plane is indeterminate.

plane, tangent #A plane P is said to be tangent to a surface C at a common point p if and only if all lines in P passing through p are tangent to C.#

A plane tangent to the ellipsoid at any point is perpendicular to the normal at that point. A small region of an ellipsoid may be conveniently projected onto a plane tangent near the center of the region.

plane, tidal #*Mean sea level* in the immediate vicinity of a tide gauge.#

plane, vertical #Any plane passing through a point on the Earth and containing the zenith (and nadir) of that point.#

A vertical plane that contains the zenith must also contain the nadir. The planes of the celestial meridian and of the prime vertical are vertical planes.

plane coordinate system, State See *coordinate system, State plane.*

plane of the horizon See *horizon, plane of the.*

plane rectangular coordinate See *coordinate, plane rectangular.*

plane surveying See *surveying, plane.*

plane table #A drawing board on a tripod plus a ruler which can be pointed at the observed object by means of a telescope or other sighting device attached to it.#

It is used for plotting an observed direction directly on a sheet. The name, plane table, may be used to designate the drawing board itself, the drawing board and tripod, or the assemblage of drawing board, tripod, and *alidade.*

plane table, traverse #A *plane table* consisting of a small drawing board mounted on a light tripod in such a way that the board can be rotated and clamped in any position. A compass is recessed in the board.#

planimeter #A mechanical integrator for measuring the area of a planar figure.#

By using a planimeter, the area within a given closed curve on a map can be measured; by applying a factor derived from the map scale, the area on the map can be transformed into the corresponding area on the Earth.

planimetry (1) #The theory and practice of measuring areas on planes.#

(2) #The determination of horizontal distances, angles, and areas from measurements on a map.#

(3) (photogrammetry) #The determination of horizontal distances, angles, coordinates, or areas by photogrammetric measurements.#

(4) (photogrammetry) #The information on horizontal distances and angles contained in a map.#

planisphere #A representation (mapping) on a plane of a family of circles (parallels, meridians, etc.) on a sphere.#

One particular form of planisphere is a device carrying a map obtained by polar projection of the celestial sphere; it has movable parts that can be adjusted to show the visible aspect of the heavens at any given time, and can be used for the selection and identification of stars for various purposes. This form of planisphere is the basis of the planispheric astrolabe.

planisphere, Aitoff's See *map projection, Aitoff's.*

planisphere, Hammer's See *map projection, Hammer-Aitoff.*

plat (1) #A diagram or map, drawn to scale, showing all essential data pertaining to the boundaries and subdivisions of a tract of land; the data used are determined by survey or *protraction.* #

A plat should show all data required for a complete and accurate description of the land it delineates, including the bearings and lengths of the boundaries of each subdivision. This is, in fact, the distinguishing characteristic of a plat as compared to other kinds of maps. A plat may constitute a legal description of the land and thus may be used instead of a written description.

(2) #A map that shows accurately the boundaries and dimensions of land and contains the essential data of a *cadastral survey.* #

(3) #A map or drawing that represents the region, such as a township, a private land claim, or a mineral claim included in a specific survey, and its relation to adjoining official surveys. It shows the lines surveyed, established, retraced, or resurveyed, the direction and length of each such line, the boundaries, descriptions, and areas of each subdivided land parcel, and, when practical, a representation of the relief and man-made improvements within the survey area.#

plat, abstractor #A plat carrying a compilation of all descriptions of land within a given region, showing controlling measurements and other data.#

Not all dimensions in a deed are shown; controlling dimensions are emphasized.

plat, base #A plat showing only those details essential to the identification of the legal subdivision shown on it.#
It may also show cultural and topographic features as considered desirable. However, it is now usual to show culture, topography, etc., by transparent overlays to the base plat.

plat, master title (1) #The plat on which is shown survey data necessary to identify and describe lands in the public domain, and on which are indicated those actions which currently limit or restrict the use or availability of public lands and resources.#
(2) #A composite of the plats of a township on which is shown the ownership and legal status of the land.#

plat, use #A copy of the *master title plat* and any supplemental plats of a U.S. township showing additional information about land use, as indicated by applicatons, leases, permits, and so on.#

plate (photography) #A thick, rigid piece of material, usually glass, that supports light-sensitive material used for taking photographs.#

plate, calibration #A photographic negative on glass; during calibration it is exposed with its emulsion side in the same position in the camera as the emulsion side of a film in normal use.#
The plate provides a record of the distances between the fiducial marks of the camera. It is also called a master glass negative or a flash plate.

plate, compensation See *compensation plate.*

plate, foot See *foot plate.*

plate, pressure #A flat plate that presses the film in a camera into contact with the focal plane.#

plate, turning See *foot plate.*

plate reduction #The process of deriving the astronomical coordinates of a celestial object, whose image appears on one or more photographs, by measuring on each photograph the plane coordinates of that image and of the images of neighboring stars.#

plate tectonics #A geophysical theory which ascribes large-scale crustal changes, such as folding and faulting, to the movement of large, continent-sized crustal segments (called "plates") and explains such changes in terms of the relative movements of the plates and the consequent pressures of plate upon plate.#

plateau, continental #A large, elevated mass of the crust coinciding approximately with a continent.#

platform #A flat, stable support or base.#

platform, inertial (1) #A support (for an instrument) whose orientation with respect to an *inertial coordinate system* is either known or is held fixed.#
Orientation is usually fixed by coupling the support to two or more gyroscopes.

platting See *description, plat.*

plot (1) #To place data from a survey upon a map or plat.#
(2) #A *plat.* #
It is suggested that "plot" be used only as described in (1), and that "plat" be used for the graphical representation itself.
(3) #A small parcel of land.#
(4) See *aerotriangulation, graphic radial.*

plotter (1) #An instrument that converts data into their graphical equivalent.#
Most plotters draw lines on a sheet according to instructions given by a computer or as forced by mechanical or optical linkages to a stylus that moves about over a photograph. Some plotters create the plot by focusing a directed beam of light on a photographic emulsion.
(2) #A technically trained person who develops graphical representations of data sets.#
(3) See *plotting instrument.*

plotter, analytical #A photogrammetric instrument consisting of a *stereoscopic comparator* connected to a computer which in turn is connected to and controls a plotter; the combination generates a topographic map of the region viewed in the comparator.#

plotter, photogrammetric See *plotting instrument, photogrammetric.*

plotter, radial See *plotting instrument, radial.*

plotter, stereoscopic See *plotting instrument, stereoscopic.*

plotting instrument #A plotter connected to and controlled by a machine that converts measurements on a photograph or stereoscopic image into data for use in drawing lines.#
Most plotting instruments are designed for photogrammetric applications. They are classified either as analog plotting instruments or as analytical plotters, depending on whether the connection between the measuring instrument and the plotting instrument is direct (through mechanical and optical linkages) or indirect (through a computer).

plotting instrument, analytical See *plotter, analytical.*

plotting instrument, photogrammetric #A plotting instrument designed for use in photogrammetry.#

plotting instrument, radial #A *stereoscopic plotting instrument* in which a pair of photographs is viewed stereoscopically and the planimetric details within the common area of the photographs are drawn on a map or base sheet through a mechanical linkage embodying the *radial line* principle.#
Also called a radial line plotter.

plotting instrument, stereoscopic #A plotting instrument in which measurements are made on a stereoscopic model and are then transferred by mechanical or optical linkages to the plotter.#
Most modern stereoscopic plotting instruments not only direct the motion of the plotter but also display or record the measurements numerically.
Also called stereo plotter, stereoplotter, and stereoscopic plotter.

plumb line (1) #A line perpendicular to all equipotential surfaces of the Earth's gravity field that intersect with it.#
It is a line of force in the Earth's gravity field, and thus is curved rather than straight.

(2) #A length of string or wire to one end of which a pointed weight is attached; the point lies on an extension of the direction of the string when the weight is suspended by the string.#

A plumb line indicates the average direction of the force of gravity between the point of suspension and the point of the weight. The weight is usually called a plumb bob or plummet.

(3) #The direction of gravity at a point, as indicated by a plumb line (sense 2 above) of infinitesimal length.#

The distinction between (1) in which the term is a curved line of force and (3) in which it is a tangent to that curved line of force at a given point is quite sharp. The term "vertical" commonly is contrasted with "plumb line" so that if the latter is taken in one sense, then the former is taken in the other. See *vertical.*

The term plumb line should be used in sense (1) only. Otherwise there usually will be some doubt as to which of the other meanings is intended.

plumb line, normal #A plumb line (1) in a *normal* (instead of the actual) *gravity field.* #

plumb point of a photograph See *nadir, photograph.*

plummet See *plumb line.*

point (geodesy) #A geometric point or a pointlike physical mark whose location on the Earth has been determined by surveying.#

Also called fix and station.

point, angle (1) #A *monument* marking a change in azimuth on an irregular boundary line, reservation line, boundary of a private claim, or a re-established, nonriparian meander line.#

(2) #A stake driven at a point to indicate a change in direction of the *traverse* at that point.#

(3) #A point, in a survey, where the alignment or boundary deflects from its previous course.#

point, cardinal (1) #One of the four directions—north, east, south, and west—on a compass.#

(2) #One of the four geographic directions: north, east, south, and west.#

(3) #One of a set of points used in tracing the paths of rays through an optical system.#

The cardinal points defined here are usually used for establishing the principal points, the nodal points, and the focal points. These points are useful in designing a lens system and in predicting the performance of an ideal optical system.

point, control See *control point.*

point, detail (1) #A *ground control point* established by a subsidiary survey (not a survey for establishing geodetic control), placed at or near an important cultural or other feature to be included in the final map, and identifiable on photographs.#

The number of detail points selected will vary with the nature of the terrain and the amount of detail required on the map. Ten detail points per photograph are usually sufficient.

(2) #A selected identifiable point used, particularly on oblique photographs, to assist in correctly locating other features displaced because of elevation.#

point, focal See *focal point.*

point, ground control #A point on the ground, established by survey, and used to determine scale, orientation, etc., for aerial photographs.#

point, horizontal control #A control point whose longitude and latitude (but not necessarily its elevation or height) have been defined or determined.#

point, initial #The starting point of the survey of the principal meridian and base line controlling the survey of the public lands within a given region.#

For a list of initial points, principal meridians, and base lines, and the regions to which they pertain, see *Manual of Instructions for the Survey of the Public Lands of the United States* (Bureau of Land Management 1947: sec. 139).

point, middle #The point on a circular curve which is at the same distance from both ends of the curve.#

Abbreviated as M.P.

point, pass #A point whose horizontal or vertical position is determined from photographs by photogrammetric methods; intended for use (in the manner of a supplemental control point) in the absolute orientation of other photographs.#

Also called a photogrammetric point.

(2)#A point used in determining the relative orientation of two adjacent photographs in a strip of photographs.#

point, peripheral #A point in the vicinity of a control point, intended for use with the control point but which is not itself a control point.# Reference marks and azimuth marks are examples.

point, picture #A point on a map corresponding to an identifiable point in a picture.#

point, principal (1) (optics) #The intersection of a *principal surface* with the optical axis of an optical system.#

(2) (photogrammetry) #(a) The foot of the perpendicular from the interior perspective center to the plane of the photograph. (b) The point at which lines through corresponding fiducial marks on a photograph intersect, or the point taken as the average location of such points of intersection. This is an approximation to definition (a). The difference can be determined by calibration. (c) The point at which the optical axis of the projector's lens system intersects the plane of the image being projected.#

point, singular See *coordinate system.*

point, subsatellite (1) #The point at the foot of a perpendicular from a satellite to an ellipsoid used to represent the Earth.#

(2) #A point vertically below a satellite and on the Earth's surface.#

point, tie #One of a set of points used to link photogrammetric models from two adjacent strips of photographs.#

point, turning #A point in a line of levels on which a leveling rod is held and to which a foresight is taken from one instrument station and a backsight is taken from the next instrument station. It is established so the leveling instrument can be moved forward along the level line without a break in the sequence of measured differences of elevation.#

A turning point may be a steel pin driven in the ground, the head of a spike on a railroad track, a nail driven in a tie of a railroad track, a ball bearing set in a small dent in a concrete pavement, etc.

point, vanishing #The point, in *image space*, at which the images of a family of parallel lines in *object space* converge.#

point base #A manuscript which contains radial centers, picture points, pass points, control points, and tie points from the photographs used in the radial triangulation method.#

Pointers #The second-magnitude stars, Alpha and Beta in Ursa Major (the Big Dipper).#

A line drawn through these two stars points to Polaris. They are on the side of the bowl of the Big Dipper away from the handle.

point-matching method of rectification See *rectification*.

point of beginning #In metes and bounds descriptions of a survey, the first point mentioned on the boundary of the property being described.#

After passing through the successive courses, the description returns to the point of beginning. When descriptions start at a reference point not contiguous to the property being described, the starting point is called the point of commencement; in this case, the description starts from the point of commencement and ends at the point of beginning.

Point of Beginning, the #The point on the west boundary of the State of Pennsylvania at the north bank of the Ohio River, which is the point of beginning for the survey of the public lands of the United States of America.#

The point was established on August 20, 1785, and was marked by a stake.

point of certainty #In a simple, two-point intersection problem, the point where the two intersecting rays cross; the location of the point is confirmed by the intersection of a third (check) ray.#

point of commencement #In the description, by *metes and bounds*, of the boundary of a property, the point with which the description starts if that point is not part of the boundary.#

point of commencing See *point of commencement*.

point of compound curvature #The point, on a line, where a circular curve of one radius is tangent to a circular curve of a different radius and both curves lie on the same side of their common tangent.#

Also called the PCC.

point of curvature #The point, on a line, where a tangent ends and a circular curve begins.#

Also called point of curve (PC) and beginning of curve (BC). It is the point where a straight line in a survey changes to a circular curve. See also *curve, point of tangency of.*

point of curve See *point of curvature*.

point of intersection #The point where the two tangents at the extremities of a circular arc meet.#

Also called the vertex of curve, or the PI.

point of reverse curvature #The point, on a line, where two circular curves lying on opposite sides of the line are tangent.#

Also called the PRC.

point of tangency #The point of a line where a circular curve ends and a tangent begins.#

Also called point of tangent or PT. The point of tangency and *point of curvature* are both points of tangency to a curve, their different designations being determined by the direction of progress along the line.

point of tangent See *point of tangency*.

point of the compass #One of 32 equally spaced marks on a compass that indicate directions.#

The points are 11.25° apart. The four points labeled N(orth), E(ast), S(outh) and W(est), called the *cardinal points*, are 90° apart.

point of zero distortion #The point(s), on a map, where the principal scale is preserved.#

Poisson ratio #The ratio of the transverse (contracting) strain to the longitudinal (stretching) strain when a rod (or an isotropic solid, in general) is stretched by forces applied at its ends and parallel to its axis.#

Poisson's equation #The second-order, partial-differential equation

$$(\partial^2 V/\partial x^2) + (\partial^2 V/\partial y^2) + (\partial^2 V/\partial z^2) = -4\pi\rho(x,y,z)$$

where x, y, z are rectangular Cartesian coordinates, V is a scalar function of the coordinates and $\rho(x,y,z)$ is the density function. Also, any equation into which the above equation is transformed by a change of coordinate systems. In vectorial notation, Poisson's equation is

$$\nabla^2 V = -4\pi\rho(x,y,z).$$

Poisson's equation is a generalization of *Laplace's equation* (2). Its solution gives the potential V determined from the distribution of mass (or electrical charge). In geodesy, V is usually the gravitational potential of a body. If the coordinate system is considered to be rotating with respect to a stationary coordinate system, the right-hand side is augmented by terms representing the effects of centrifugal force, Coriolis force, etc.

polar (cartography) #Having the center of the map at one of the poles.#

Polaris #The second-magnitude star, Alpha, in the constellation Ursa Minor (the Little Dipper).#

Also known as the Pole Star, or the North Star, because of its proximity to the North Pole of the celestial sphere. Polaris is well situated for determining astronomical azimuth, and the direction of the celestial meridian. It is at the extreme outer end of the handle of the Little Dipper. See *Pointers*.

polar motion #The movement of the Earth's instantaneous axis of rotation with respect to the axis of figure (the axis about which the moment of inertia is a maximum).#

It is sometimes called Chandlerian motion, although this term properly refers only to the part of the polar motion that has a period of about 1.2 years. Other terms are variation of latitude, variation of the pole, wobble, and wander.

Extended to the celestial sphere, the poles of the axis of figure describe a path about each pole of the axis of rotation—a path which is irregular, although annual and 14 month periodicities are detectable. The greatest variation of the axis of figure with respect to the axis of rotation ranges between 0."1 and 0."3. Polar motion affects the determination of astronomic latitude, longitude, azimuth, and time. Compensation for the variation is important only in first-order surveying work and geophysical applications.

Polar motion was first definitely detected by Chandler in the late 1800's. The International Latitude Service, created in 1899 to measure polar motion, has been active until recently, using observations from zenith telescopes. The International Polar Motion Service and the Bureau International de l'Heure currently determine polar motion by the same means. Modern methods of determination are by satellite Doppler and laser observations, and by radio interferometry.

Polastrodial #A mechanical device, developed by the U.S. Geological Survey, for graphically determining the angle between Polaris and the observer's meridian at any hour angle anywhere in the Northern Hemisphere.#

pole (1) #One of the two points in which an axis of a figure intersects that figure.#

The following definitions for poles are frequently used:

#(a) In spherical geometry, either of two points equidistant from a given great circle on the sphere.

(b) In geography, either of the two points (North Pole and South Pole) where the Earth's axis of rotation intersects the Earth's surface.

(c) In geodesy, either of the two points where the minor axis of an ellipsoid of revolution (representing the Earth) intersects the surface.

(d) In astronomy, either of two points equidistant from the celestial Equator. In particular, either of the two points in which the Earth's axis of rotation intersects the celestial sphere.#

(2) #A unit of length in English measure, legally equal to 5 1/2 yards.#

The pole, no longer used as a unit of length, was commonly used in the original thirteen colonies (of the U.S.A.) and in England in descriptions in deeds. In the nineteenth century, public land surveyors were required to use chains 2 poles long in surveying. Synonymous with *perch* and *rod.*

pole, geomagnetic #Either of two points marking the intersection of the Earth's surface with the extended axis of a powerful bar-magnet assumed to be located at the center of the Earth and with a field approximating the actual magnetic field of the Earth.#

The geomagnetic pole is based on a hypothetical magnet and should not be confused with the magnetic pole, which relates to the actual magnetic field of the Earth. The Earth's geomagnetic poles are located approximately at 78.5° N, 69.0° W and at 78.5° S, 111.0° E.

pole, lining See *range pole.*

pole, sounding See *sounding pole.*

pole, variation of the See *polar motion.*

pole of figure #One of the points in which the axis of figure of a celestial body intersects the celestial sphere.#

See *axis* (2).

pole of rotation #One of the points in which the axis of rotation of a celestial body intersects the celestial sphere.#

See *axis* (3).

Pole star See *Polaris.*

polygon #A geometric plane figure consisting of *N* line segments having *N* points of intersection, with each segment lying on and terminated by exactly 2 points of intersection.#

The segments are called sides, the points of intersection are called vertices. A polygon divides a surface into a region internal to the polygon and a region external to the polygon. Angles within the figure are called interior angles, angles outside of the figure are called exterior angles. A polygon in a plane is convex if every interior angle is less than 180°. Otherwise the polygon is concave or re-entrant.

polygon, convex See *polygon.*

polygon, directed #A polygon each of whose sides has a direction associated with it.#

Equivalently, a polygon whose vertices are numbered and always taken in a specified order.

Also called a *traverse.*

polygonization #The process of making a *traverse*.#

See *survey, polygonometric.*

Porro-Koppe principle #The principle, used in some photogrammetric plotting instruments, that the effects of lens distortion can be minimized by using lenses in the plotting instrument that have the same distortion as the lenses in the camera used for taking the original photographs.#

The plotting instrument then, in effect, reverses the optical and geometric relationships that existed when the picture was taken and creates, according to the law of reversibility of light paths, a distortion-free image of the photographed scene.

position (1) #A numerical or other description of the *location* and *orientation (attitude)* of an object.#

(2) #A numerical or other description of the location of a point or object.#

In particular, in geodesy and navigation, (a) data which give the location of a point in a specific coordinate system, (b) the place occupied by a point on the Earth, (c) the coordinates giving the location of a point on the geoid or ellipsoid.

(3) #A prescribed setting (reading) of the horizontal circle of a direction theodolite, when the line of sight is

directed at the initial station of a series of stations to which observations are to be made.#

Position, as defined in (3), indicates a definite point on the horizontal circle. For example, in first-order triangulation, when a two-micrometer direction theodolite is used, in Position Number 1 the circle is set to read 0°00′40″ when observing the initial station; in Position Number 2 the circle is set to read 11°01′50″ when the initial station is observed and so on.

position, adjusted #An adjusted value of the coordinates giving the location of a point on the Earth.#

In the adjustment of a horizontal control survey, discrepancies arising from errors in the observational data are removed to give adjusted coordinates in an adopted coordinate system (geodetic datum or plane coordinate system). The coordinates obtained by the adjustment are called adjusted positions; when used as control for other work they are referred to as fixed positions. In the adjustment of data from a vertical control survey, the values obtained are called adjusted elevations. When used to control other surveys, they are called fixed elevations.

position, apparent See *place, apparent.*

position, astronomic #The location of a celestial body on the celestial sphere, corrected for diurnal and annual aberrations but not for planetary aberration.#

position, field #A location computed during field work to determine the acceptability of the observations or to provide a preliminary location for other purposes.#

position, fixed See *position, adjusted.*

position, geodetic #The location of a point on the surface of the Earth expressed in terms of geodetic latitude and longitude.#

A geodetic position implies that a particular geodetic datum was adopted. In the complete record of a geodetic position, the datum adopted must be stated.

position, geographic #The location of a point on the surface of the Earth, expressed in terms of either geodetic or astronomic latitude and longitude.#

position, relative #The location of a point with respect to other points.#

The relative positions of two points whose locations are given in the same coordinate system are expressed as the differences of their coordinates or by the direction and distance from one point to the other.

position computation, direct #On an ellipsoid, given the geodetic coordinates of a point P_1 and the azimuth and the length of the geodesic from it to a point P_2, the geodetic coordinates of P_2 and the azimuth from P_2 to P_1 can be computed.#

position computation, inverse #On an ellipsoid computation of the length, the forward azimuth, and the backward azimuth of a geodesic between two points whose geodetic coordinates are known.#

position determination, Doellen's method of See *Doellen's method.*

position determination, position-line method of #The zenith distance of a star of known declination is observed and the time of observation noted. The observer is then located on the circumference of a circle (for a spherical Earth) whose center is directly under the star and whose radius is proportional to the zenith distance of the star. Observations on two or more stars give two or more intersecting circles and the observer is located at one of the intersections.#

The observer generally knows his location well enough so that he can determine which of the well-separated intersections corresponds to his location; he can approximate the intersecting arcs by short segments of straight lines called position lines, *lines of position*, and *Sumner lines.* Also called the Sumner method of position determination. *St. Hilaire's method* is a simplification of the position-line method.

position determination, St. Hilaire's method of See *St. Hilaire's method.*

position determination, Sumner method of See *position determination, position-line method of.*

positioning (1) #Placing an object in a required location and orientation.#

The term is also used in the more limited sense of placing an object in a required location without regard to orientation.

(2) #Determining the location and orientation of an object.#

The term is also used to mean determining only the location of an object.

positioning, acoustic #Determining the location of a ship by using the difference in times of reception of acoustic signals emitted from sources of known location.#

The most common and accurate method involves sending sonic pulses from a ship to transponders on the bottom and measuring the time needed for the pulses to travel from the emitter to the transponder and back. This is multiplied by the speed of sound in water to get the corresponding distances. The ship's location is found by resection. The error in location is strongly affected not only by the errors in the locations of the transponders but also by the errors in the assumed paths of the sonic pulses. A less common method uses the pulses for mapping the bottom in the vicinity of the ship. By comparing this map with an accurate, known map of the bottom in the region in which the ship is traveling, the location of the ship can be determined.

positioning, astronomic #Determining location by observations on celestial bodies such as stars, the Sun, etc.#

positioning, hypervisual #Navigating a vessel along a hyperbolic line of position while observing, with a sextant, the angle between two objects (such as hydrographic signals) on the beach.#

The objects must straddle (lie on opposite sides of) the hyperbolic line.

positioning system #Generally, a system (equipment, procedures, and personnel) used for locating a vehicle or, less frequently, an instrument.#

A navigation system can also be used for positioning, but a system designed specifically for positioning generally gives more accurate locations. Positioning systems are classified either according to the nature of the equipment, as, e.g., radio, inertial, optical, and acoustic, or according to the geometric relationship between the vehicle and the rest of the positioning system (see *range-range* and *hyperbolic positioning systems*).

positioning system, acoustic #A positioning system that determines the location of a point by measuring the time of travel of sonic pulses from that point to two or more points of known location, or from two or more points of known location to the unknown point. More generally, any method of location depending on acoustic equipment.#

The most common type consists of a sonic-pulse generator on a moving ship or boat, transponders on the bottom, and receiving and measuring equipment on the craft. See also *positioning, acoustic.*

positioning system, circular See *positioning system, range-range.*

positioning system, Doppler #A positioning system consisting of a radio receiver at the point whose coordinates are to be determined, one or more beacons in orbit about the Earth, and a computing system for determining the orbits of the beacons.#

The difference between the frequency of a radio wave as received and its frequency as transmitted from the beacon is a function of the radial velocity of the source with respect to the receiver. Given the ephemeris of the beacon, the coordinates of the receiver can be calculated from measurements of the difference in frequencies.

positioning system, hyperbolic #A positioning system in which the observer measures the difference in time of reception of signals from two stations whose coordinates are known.#

The difference in time is converted to a difference in distance. The locus of all points lying at a fixed difference in distance from two points are the two branches of a hyperbola. There is usually a third station operating in conjunction with one of the other two to provide the observer with another difference in distance and another pair of hyperbola branches. The observer is at one of the intersections of the branches.

positioning system, inertial #A positioning system consisting of a computer and an assemblage of three accelerometers and two or three gyroscopes. The gyroscopes are fastened together in such a way that they define the orientation of the accelerometers with respect to nonrotating coordinates and the accelerometers measure the components of acceleration of the positioning system along the directions defined by the gyroscopes. The computer and associated equipment integrate the components of acceleration to give the three components of displacement of the positioning system.#

positioning system, radio #A positioning system in which the travel time or phase shift of radio waves is measured.#

The most common radio positioning systems at present measure the difference in time of travel of radio pulses from three or more known points.

positioning system, range-range #A positioning system for determining the horizontal location of a vehicle (airplane, ship, etc.) by measuring, as nearly simultaneously as possible, the time needed for a signal to travel from the vehicle to each of two points of known location and back again.#

Also called a rho-rho or circular positioning system. See *navigation system, rho-rho.*

positioning system, rho-rho See *positioning system, range-range.*

positioning system, rho-theta #A positioning system containing at least two fixed radio stations and one mobile radio station. The moving station determines distance (rho) to one of the fixed stations and direction (theta) to the other.#

See *navigation system, rho-theta.*

positioning system, satellite #A positioning system consisting of a radio receiver, or a receiver and transmitter, at the point whose location is to be determined, one or more beacons or transponders in orbit about the Earth, and a computing system for determining and predicting the orbits.#

The satellites can be considered points of known location. The radio receiver may measure times of travel of radio pulses, directions to the satellites, or the Doppler shift in the frequency of the radio waves emitted by the satellites. See *navigation system, satellite.*

position line See *line of position.*

position-line method of determining position See *position determination, position-line method of.*

positive (photography) #A photographic image that has approximately the same gradation of tones or the same colors as the original subject.#

See *diapositive.*

post, corner #A post set as a monument to mark the *corner* of a section, quarter-section, township, etc.#

post, identification #A post of wood or other durable material, appropriately marked and inscribed, and placed near a survey station to aid in recovering and identifying the station.#

Identification posts may also serve as guard posts, calling attention to the stations they serve, and may also protect the stations against accidental destruction.

potential #A function $V(P)$ of position P, in a force field $\vec{f}(P)$, given by the line integral of $\vec{f}$ over a path from a reference point Q to point P,

$$V(P) = \int_Q^P \vec{f} \cdot d\vec{s}$$

under the condition that $V(P)$ be independent of the path taken in going from Q to P.#

The force field is said to be conservative. For most force fields, $\vec{f}$ is zero at infinity; Q is then conveniently placed at infinity also.

(2) #A function $V(P)$ that is a function of location only and whose gradient at a point P in a force field is the negative of the force at P.#

(3) #Any scalar function of location, in a vector field, whose gradient at a point is the negative of the vector at that point.#

This definition is a generalization of (2) above and is particularly useful in describing velocity fields.

potential, centrifugal See potential, rotational.

potential, disturbing #The difference between the actual value of the potential at a point and the value predicted by theory or used for reference.#

Also called the potential disturbance or, particularly in orbital theory, the perturbing potential. In particular, in the theory of the *geopotential*, it is the difference between the actual value of the gravity potential at a point and the value calculated from a standard formula for the gravity potential. See *potential, perturbing*.

potential, gravitational #The potential attributable to the presence of a gravitational field.#

From the definition of a field and from Newton's law of gravitation, it follows that the potential $V(P)$, at a point P, attributable to the attraction of a body of total mass M is

$$V(P) = \int_M dM/r$$

where the integral is taken over the entire mass M, and r is the distance between P and an element dM of the mass of the body. It can be shown that this is equivalent to any one of the following definitions (except for arbitrariness of sign).

(a) The potential at a point P is the amount of work done by a conservative field in carrying a unit mass to P from infinity.

(b) The difference in potential between points P and Q is the amount of work done by a conservative field in carrying a unit mass from P to Q.

(c) A scalar function of location is a potential if its gradient is force (or acceleration).

potential, gravity #The potential attributable to the Earth's gravitational field and centrifugal force.#

It is equivalent to the work done in bringing a body of unit mass from infinity to a point attached to or rotating with the Earth. The term is also used for the potential attributable to the gravitational field and rotation of any other body.

potential, perturbing #In the theory of orbits, any potential affecting the motion of the body but not included in the formulas used in computing the reference orbit.#

The potentials of the gravitational fields of the Sun and the Moon would be considered perturbing potentials for any orbit taking account only of the Earth's gravitational potential. The term is also sometimes used to mean that part of the potential over and above a potential adopted as standard. For example, if the potential corresponding to that of a solid, homogeneous oblate ellipsoid of known mass is adopted as a standard for computing the orbit of a satellite of the Earth, then any potential differing from this would be considered a perturbing potential.

Also called a disturbing potential or a potential disturbance.

potential, rotational #The quantity V_c, at a point which is revolving at a rate ω about an axis at a distance p, given by the formula

$$V_c = {}^1\!/\!_2\, \omega^2 p^2.\#$$

Also called the centrifugal potential.

potential disturbance See *potential, disturbing*.

potential energy See *energy, potential*.

potential function #The function: potential energy per unit mass.#

The term is used in this sense in this glossary. However, it is often equated with potential energy (also called potential).

Pothenot-Snellius problem See *three-point problem*.

Pothenot's problem See *three-point problem*.

Potsdam standard of gravity See *gravity, Potsdam standard of*.

power spectrum #The square of the amplitude of the complex Fourier coefficients of the Fourier series representing a given periodic function.#

Thus, if the function $f(t)$ is periodic with period T, its Fourier series coefficients are

$$F(n) = (1/T) \int_0^T f(t)\, e^{-in\omega t}\, dt$$

where ω is $2\pi/T$, and the power spectrum of $f(t)$ is the set $|F(n)|^2$. Here, n takes integral values and the spectrum is discrete. The term "power spectrum" originated in electrical theory, and $F(n)$ did have the dimensions of power. However, the term is now applied to many other functions and often has no relation to power whatsoever.

Pratt's hypothesis See *isostasy, Pratt's hypothesis of*.

Pratt's theory of isostasy See *isostasy, Pratt's hypothesis of*.

precession #In general, the motion of the instantaneous axis of rotation of a body about a line whose direction is fixed in space.#

It is customary to limit the meaning of the term to secular motions and to denote by *nutation* the smaller, periodic excursions of the axis of rotation from its average position.

In astronomy, precession in its limited sense is called general precession. This is of two kinds: lunisolar, which results from the gravitational attraction of the Moon and Sun on the Earth, and planetary, which results from the gravitational attractions of the other members of the Solar System. The rate of general precession per century, is, as given by Newcomb (1906), 5025."64 + 0."0222 T, where T is time in *tropical years* since 1900.0. The value adopted by the International Astronomical Union in 1976 is 5029."0966 per Julian century (36,525 days) at epoch

2000. The value of the coefficient of T was not specified. See *American Ephemeris and Nautical Almanac*, U.S. Naval Observatory (current year).

precession, general #The motion of the equinoxes westward along the ecliptic, at the rate of about 50."3 per year.#

This precession causes the difference between the lengths of the sidereal and tropical years.

precession, lunisolar #The part of *general precession* caused by the attraction of the Moon and Sun.#

precession, planetary #The part of *general precession* caused by planetary perturbations of the plane of the ecliptic.#

It amounts to about 0."13 per year.

precession of the equinoxes See *precession, general.*

precision (1) #In statistics, a measure of the tendency of a set of random numbers to cluster about a number determined by the set.#

The usual measure is either the standard deviation with respect to the average, or the reciprocal of this quantity. It is distinguished from *accuracy* by the fact that the latter is a measure of the tendency to cluster about a number not determined by the set but specified in some other manner.

(2) #In physics (in metrology and in the art of measuring generally), precision relates to the quality of the method by which the measurements were made, and is distinguished from *accuracy* which relates to the quality of the result. The term "precision" not only applies to the fidelity with which required operations are performed, but, by custom, has been applied to methods and instruments employed in obtaining results of a high order of precision. Precision is exemplified by the number of decimal places to which a computation is carried and a result stated.

(3) #The quantity $1/(\sigma\sqrt{2})$, where σ is the standard deviation of the random variable involved.# Also called a precision index or index of precision.

prediction (statistics) #The process of obtaining an estimate of the value of a quantity at a specified time t from data available before t.#

preliminary (adjective) #Adopted for temporary use with the understanding that it may be changed later.#

In the adjustment of triangulation, the term preliminary is applied to triangles and geographic coordinates derived from selected observations.

pressure, solar radiation See *perturbation, radiation pressure.*

pressure plate See *plate, pressure.*

Prey reduction See *gravity reduction, Prey's.*

primary (noun) #The more massive of two mutually attracted celestial bodies.# For example, the Sun is a primary with respect to the Earth.

prime vertical, radius of curvature in the See *radius of curvature in the prime vertical.*

principal axis See *lens, principal axis of.*

principal direction See *curvature, radius of normal.*

principal distance See *distance, principal.*

principal-distance error #In a stereoscopic plotting instrument, an instrumental error resulting from improper calibration of the camera, the diapositive printer, or the projector.#

The error is of little importance in a model of a flat surface, but is increasingly important in proportion to the relief in the model.

principal point See *point, principal.*

principal-point assumption #The assumption that radial directions are correct if measured at the principal point.#

This assumption is satisfactory only for nearly vertical photographs.

principal-point error #A *personal error* committed by improperly orienting a diapositive in the printer or in the projector of a stereoscopic plotting instrument; the result of either (or of both) is unequal displacement of the principal points in the stereoscopic plotting instrument and errors in the vertical distances.#

principle of radial displacement #The photogrammetric principle that, if the point N' (the nadir point) on the photograph is vertically above the point N on the ground, and if point P' on the photograph corresponds to point P on the ground, then the distance of P' from N' depends not only on the horizontal distance of P from N and on the tilt of the photograph, but also on the relative heights of P and N.#

print #A photographic copy on an opaque base, made by projection or by contact printing from a negative or transparency.#

printer, rectifying See *rectifier.*

prism (1) (mathematics) #A polyhedron with two congruent and parallel faces, whose other faces are parallelograms.#

(2) (optics) #Any transparent solid, usually shaped as in the definition above, and used for deviating a ray of light by refraction or internal reflection.#

The term is often used in optics for any transparent solid used for deviating rays by internal reflection, regardless of its shape. There are three common uses for prisms: (a) A prism can be used for dispersing light into its spectral components. (b) Prisms are useful as reflectors because very little light is lost in internal reflection and the angles of reflection can be accurately machined. (c) An isotropic material can be used to polarize light or to separate it into components polarized in different planes. Prisms are used in geodesy principally to deviate rays of light by internal reflection through 90° or 180°, and to invert or revert images.

prism, Amici #A prism that deviates rays of light through 90° and inverts the image.#

An Amici prism is a type of *roof prism.*

prism, Bauernfeind See *prism, Baurenfeind four-sided* and *prism, three-sided.*

prism, Bauernfeind four-sided #A four-sided prism containing two right angles, one 45° angle and one 135° angle, and used in surveying to establish a right angle.#

prism, deflecting (1) See *prism, reflecting.*

(2) See *prism, deviating.*

prism, deviating #A prism with two intersecting flat surfaces that changes the direction of light by refraction.#
Sometimes called a deflecting prism.

prism, Dove #A prism that reverts an image without deviating or displacing the beam of rays.#
A given angular rotation of the prism about its longitudinal axis causes the image to rotate through twice the angle. Also called a rotating prism.

prism, Goulier See *prism, pentagonal.*

prism, index #A prism in a sextant that can be rotated to any angle (within established limits) corresponding to angular elevation.#
It is the counterpart, in the bubble or pendulum sextant, of the index mirror of a marine sextant.

prism, Nicol #A rhombic prism of natural calcite which is cut into two equal parts along a diagonal plane; the two parts are then cemented together with Canada balsam. The dihedral angles opposite the cemented faces are then ground to 68°.#
Light incident on the small (end) face of the rhombus parallel to the long edge is split into two rays, one of which is linearly polarized and passes straight through the prism while the other is lost to total reflection. The Nicol prism is therefore extensively used to produce linearly polarized light in a specified direction and to filter out light linearly polarized in other directions.

prism, objective #A thin, wedge-shaped prism placed in front of the objective lens of a telescope to produce the spectra of starlight for photography.#

prism, pentagonal #A prism having five sides (faces).#
Pentagonal prisms are used in surveying for establishing right angles. They occur in two forms: (a) one is a prism with an approximately regular pentagon as cross section (four angles of 112.°5 and one angle of 90°); (b) the other has a more irregular pentagon as a cross section (three angles of 135° and two angles of 67.°5). The first is called a Goulier prism, the second is a Wollaston prism.

prism, Porro #A prism that inverts an image and deviates the axis of the beam through 180°.#
It may be described as two right angle prisms cemented together.

prism, reflecting #A prism that changes the direction of light by internal reflection.#
Also called a deflecting prism, although this term is also used in the special sense of a reflecting prism that can be rotated about an axis to deflect light in various directions.

prism, right angle #A prism that turns a beam of incident light through 90°.#
Depending on the orientation of the prism with respect to the object, it may invert or revert the image. The pentagonal prism is the most common right angle prism used in surveying.

prism, Roelof #A prism, made for attachment in front of the objective lens of the telescope on a theodolite, that permits precise pointing at the Sun's center by creating four overlapping images of the Sun. The images overlap in such a way that all four images intersect at a common point on the optical axis when the telescope is pointed at the Sun's center.#

prism, roof #A prism in which the image is reverted by two surfaces set at a right angle to each other.#

prism, three-sided #A flat prism with a three-sided cross section).#
The type used in surveying for establishing right angles has a right-angled isosceles triangle as cross section. It is also called the Bauernfeind prism or the Bauernfeind three-sided prism (to distinguish it from the four-sided Bauernfeind prism.

prism, Wollaston See *prism, pentagonal.*

problem, Hansen's See *two-point problem.*

problem, Snellius See *three-point problem.*

problem, three-point See *three-point problem.*

profile #A representation of the intersection between a moving vertical or normal straight line and a portion of the surface of the Earth or of an underlying stratum.#
Alternatively, a representation of the intersection of a developable surface with the Earth's surface.

profile leveling #Determining elevations at closely spaced points along a survey line to determine the profile of the ground along that line.#
In the United States the points are marked by stakes 25, 50, or 100 feet apart. The points at 100-foot intervals, starting from the beginning of the line, are called full stations; all other points are called *plus stations.*

progress sketch #A map or sketch showing the current state of a survey.#
In triangulation and traversing, each point established, lines observed over, and base lines measured are shown on the progress sketch. In leveling, the progress sketch shows the route followed and the towns passed through, but not necessarily the locations of the bench marks.

projection (1) #A function relating points on one surface to points on another surface so that for every point on the first surface there corresponds exactly one point on the second surface.#
A map projection is a special case in requiring that one of the surfaces be a spheroid and the other be a developable surface.
(2) #The extension of a line segment beyond the points that determine its position.#
(3) #The transfer of a series of surveyed lines to a single theoretical line by a series of lines perpendicular to the theoretical line.#
In making a traverse, a series of short measured lines may be projected onto a single long line, connecting two main stations of the traverse, and the long line then treated as a measured line of the traverse.

projection, conformal double #A method for mapping the ellipsoid onto the plane by first mapping conformally onto a sphere and then mapping conformally onto a plane.#

projection, double See *map projection, double.*

projection, map See *map projection.*

projection, orthographic #The projection defined by a set of parallel straight lines through corresponding points.#

Equivalently, a *perspective projection* in which the perspective center is placed at infinity.

projection, perspective #The projection defined by a set of straight lines passing through corresponding points on the two surfaces and through one point common to all the lines.#

The common point is called the perspective center or the center of perspective. One of the two surfaces is usually a plane or other developable surface.

projection cross #A small cross, on a map, indicating a point at which lines through two pairs of *projection ticks* would intersect within the map.#

Projection de la Carte de France See *map projection, Bonne.*

Projection du Depot de la Guerre See *map projection, Bonne.*

projection tick #A very short line (tick) drawn perpendicular to the *neat lines* of a map, to indicate a point through which a line representing a meridian or a parallel would pass if it had been shown on the map.#

projector #An optical instrument that projects an image onto a surface where it may be viewed or photographed.#

It generally consists of a lamp and an optical system for projecting the image.

In particular, in photography and photogrammetry, a projector having the lamp and optical system connected to a flat surface onto which the image is projected in such a way that the relative positions of the three components can be adjusted precisely and maintained rigidly.

projector, reflecting #A projector that uses mirrors as part of the optical system.#

The advantage of a reflecting projector is that images on an opaque medium can be projected. Most projectors are designed for use with images on transparent media.

projector, rotational movements of a #The set of rotational adjustments that can be made to orient the projector of a photogrammetric instrument with respect to a three dimensional coordinate system.#

The projector in a photogrammetric instrument is usually supported in an assembly of nested gimbals (Cardan suspension) or its equivalent.

prolongation (1) #The extension beyond one endpoint of a directed straight line.#

(2) #If applied to a line composed of segments of straight lines in a traverse, the extension of the segment ending at the last-mentioned intersection, geodetic marker, or monument.#

(3) #If applied to a directed, curved segment, the extension of the tangent to the endpoint of the curve beyond the endpoint.#

proof-mass See *test-mass.*

proportioning deficiency, principle of See *proportioning excess or deficiency, principle of.*

proportioning excess or deficiency, principle of #A principle, governed by several rules, for distributing excess or deficiency of a measurement over or under what is required.#

For example, the frontage of 10 lots in a city block may total 330 m by deed or plan. The measured length of the block is 332.42 m . Where the principle applies, the excess, 2.42 m, must be distributed or prorated among the 10 lots.

proration (1) #A method of distributing an excess or deficiency of land, as discovered by a survey, between parties having equal rights or proportionate rights to the excess or deficiency.#

(2) #A method of calibrating the tape used in a recent survey against the tape used by the original surveyor, by distributing the excess or deficiency of the recently used tape proportionately along the one used earlier.#

prototype #An international or national standard of length or mass in the metric system of units.#

For example, a prototype meter or a prototype of mass. The term is no longer used in this sense.

protraction (1) #Extension or prolongation.#

(2) #A *plat* or the process of making a plat.#

(3) #In land and cadastral surveying, the subdivision of land by drawing or extending lines on maps or plats of the region being subdivided. The lines are drawn before surveying and monumenting the subdivisions and are therefore indicated by dashed, straight lines.#

Protraction has been used to subdivide a large area in Alaska.

protractor #A plate marked with units of circular measure and having a single point (the center) as the vertex of the angles.#

A protractor is used for laying out on a flat or curved surface an angle of desired magnitude, or for determining the magnitude of the angle made by two intersecting lines on a flat surface. See *protractor, three-arm* and *protractor, coordinate.*

protractor, coordinate #A square protractor with graduations on two adjacent edges, and the center at one corner. Mounted on it is a movable arm turning about the center and graduated in centimeters or other linear units. The protractor is ruled with a grid of the same scale and units as the arm.#

In using the protractor, the arm is set to a given angle, azimuth, or bearing, and the length of a line is marked on the arm; a reading of the grid at this point will give the latitude and departure of that line.

protractor, three-arm #A circular protractor equipped with three arms whose fiducial edges, extended, pass through the center of the circle. The middle arm is fixed, and reads 0° on the graduated circle. The other arms are movable, and their positions on the circle are read using verniers.#

It is also called a station pointer. The two movable arms may be set to two angles observed between three fixed points (signals) of known location. The three arms are made to pass through the charted locations of the three points. The observer is then located, on the chart, at the center of the protractor. This is a graphical solution of the *three-point problem.*

pseudo-gravimetric anomaly #A quantity, $\Delta g(x,z,M)$, introduced by Baranov in 1957 to take into account not only the variation of gravitational attraction with horizontal and vertical distances x and z, respectively, but also the variation of magnetization M.#

pseudo-inverse See *matrix, pseudo-inverse.*

pseudoscopy #The sensing, when viewing an image, of relief contrary in direction to the natural relief, e.g., hills seen as valleys, valleys as hills, etc.#

The most common cause of pseudoscopy is illumination of the images from the wrong direction. When a pair of stereoscopic images is used, another cause can be the interchange of the images from their correct positions. This is also called pseudoscopic stereo.

psychrometer #An assemblage of two ventilated thermometers, the bulb of one being moistened by a bit of damp fabric.#

The difference of temperature of the two thermometers is an indication of relative humidity of the air. The thermometers are usually attached to a chain or pivoted arm so that they can be swung about rapidly for ventilation, or are ventilated with an electric or hand-rotated fan.

public domain #In the United States of America, the territory ceded to the Federal Government by the original thirteen States, together with certain subsequent additions by cession, treaty, and purchase.#

At its greatest extent, the public domain contained over 1,820,000,000 acres and included the present States of Alabama, Alaska, Arizona, Arkansas, California, Colorado, Florida, Idaho, Illinois, Indiana, Iowa, Kansas, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Mexico, North Dakota, Ohio, Oklahoma, Oregon, South Dakota, Utah, Washington, Wisconsin, and Wyoming. As of 1979 it had diminished to 677,800,000 acres administered by U.S. Federal agencies.

public land #In the United States of America, that portion of the public domain still held by the Federal Government.#

public-land State #A State or Territory created out of the public domain.#

A list of public-land States is given under *public domain.*

Puissant's formula #The formula, developed by L. Puissant in 1842, for *direct position computation* on the ellipsoid of revolution.#

The formula was once used extensively by the U.S. Coast and Geodetic Survey.

pulsar #A star that periodically emits radio pulses.#

The periodicity of a pulsar ranges from 0.03 to more than 3 seconds. Pulsars, believed to be rotating, magnetic, neutron stars, are very useful as sources of signals for radio interferometry.

pupil, entrance #The image (real or virtual) of the aperture stop formed by all the elements of the optical system on the *object space* side of the *aperture stop.* #

pupil, exit #The image of the aperture stop formed by all elements of the optical system on the *image space* side of the *aperture stop.* #

The ratio of the diameters of the *entrance pupil* to the exit pupil is equal to the magnifying power of the optical system.

pyramid, ground #A geometric figure (pyramid) whose base is the triangle formed from three control points on the ground and whose apex is the perspective center of the camera at the instant the photograph showing the control points was taken.#

pyramid, photograph #A geometric figure (pyramid) whose base is the triangle formed by three points on a photograph and whose apex is the perspective center of the photograph.#

pyramid, photogrammetric #The double pyramid formed by the combination, at their vertices, of a ground pyramid with the corresponding photograph pyramid.#

Q

quad (1) See *quadrangle.*

(2) #A region, on the ellipsoid, bounded by two meridional arcs and two parallels of latitude all of the same angular extent.#

For example, a 1° × 1° quad is a region bounded by two meridians 1° apart and by two parallels of latitude 1° apart.

quadrangle #A map or plat of a rectangular or nearly rectangular area usually bounded by given meridians of longitude and parallels of latitude.#

Sometimes called a quad or a quadrangle map.

quadrant (1) (mathematics) #A region on a plane bounded by two mutually perpendicular half lines.#

Two full lines intersecting at right angles define four quadrants. The quadrants are customarily numbered counterclockwise about the point of intersection, the first being to the quadrant at the upper right.

(2) (surveying) #A surveying or astronomical instrument composed of a graduated arc, usually a 90° segment, and a sighting device (alidade) that pivots about the center of the circle of which the arc is a segment.#

The quadrant may be considered a particular form of the *sector*. Some quadrants combine both surveying and astronomical functions, and have both a horizontal and a vertical arc.

(3) #A (1/4)° × (1/4)° *quad* included within a 1° × 1° quad.#

(4) #A map of the region referred to in (3).#

quadrature (1) #The evaluation of a definite integral.#

(2) #The determination of the length of the side of a square having the same area as the area within a given closed curve.#

This is the original meaning of the term.

(3) #In general, the relationship between two periodic quantities whose relative phase differs by a quarter of a cycle.#

(4) #In particular, in astronomy, the configuration in which lines drawn from the Earth to the two principal tide-producing bodies (Moon and Sun) are nearly at right angles.#

Thus, the Moon is in quadrature in its first quarter or last quarter.

quadribrach #The four-armed base of a surveying instrument that has foot screws for use in leveling the instrument.#

Quadribrachs are unsuitable for use in establishing third-order or higher control because only three screws are needed for leveling an instrument. Adding a fourth screw constrains the motion and may introduce strains into the base of the instrument. This in turn may affect the direction in which the instrument is pointed during observation.

quadrillage #A *grid* composed of two families of equally spaced, parallel straight lines intersecting at right angles, so that the plane is divided into squares or rectangles.#

quasar #A starlike object at an extremely great distance from the Galaxy.#

Quasars are the most usual source of radiation which *radio interferometers* observe for geodetic purposes.

quasigeoid #The locus of points whose distances (if positive, measured downwards) from the Earth's surface are equal to the *normal heights* of the corresponding points on the surface.#

See *height, normal*. The quasigeoid is not an equipotential surface, but approximates the geoid closely. Its distance from the *normal ellipsoid* is given by the *height anomaly.*

quasileveling See *leveling, geostrophic.*

quasinivellement See *leveling, geostrophic.*

quintant #A sextant type of instrument with an arc of 72° (one-fifth of a circle); i.e., with a range of 144°.#

R

radar #An instrument for determining the distance and direction to an object by measuring the time needed for radio signals to travel from the instrument to the object and back, and by measuring the angle through which the instrument's antenna has traveled.#

It is an acronyn for "RAdio Detection And Ranging". The usual radar consists of a radio transmitter sending a narrow beam of radio pulses in a determined direction, a receiver which amplifies the returned signal, and a clock and resolver which measure the travel time and direction of pointing, respectively. Some radars also determine the radial velocity of moving objects by measuring the shift in frequency of the reflected waves (see *radar, Doppler).* Continuous wave (CW) radars emit continuous radiation rather than pulses and measure velocity and direction rather than distance and direction. The direction is usually determined from accurately divided circles or angular resolvers that tell the direction in which the beam is pointed. A similar instrument, the *lidar,* uses optical rather than radio wavelengths.

Radar scopes can show maps of terrain, cloud formations and rain patterns, positions of aircraft, etc., depending on the radio waves generated by the transmitter; the radar scope used for these displays is the ppi (plan position indicator). Radar scopes can also be used to scan vertically in one direction at a time to show heights of terrain, heights of clouds, the altitudes of aircraft, etc. The latter radar scope is known as the rhi (range height indicator).

radar, Doppler #A radar which detects and interprets the Doppler effect on a signal in terms of the radial velocity of a target.#

The frequency of the signal received by a radar from a moving target differs slightly from that of the transmitted wave.

radar, side-looking #A form of radar, mounted on aircraft, in which the beam is pointed, either by scanning or by shaping, in a direction perpendicular to the longitudinal axis of the aircraft so that the returned signals come from a long, narrow strip of ground approximately perpendicular to the airplane's line of flight.#

The ground is mapped as a set of adjacent, overlapping strips.

radar, synthetic-aperture #A radar containing a moving or scanning antenna; the signals received are combined to produce a signal equivalent to that which would have been received by a larger, stationary antenna.#

The amplitudes and phases of the signals received at the antenna are stored for each position the antenna occupies. These quantities are subsequently combined to yield a signal with the angular resolution of a standard stationary antenna.

radargrammetry #A method of radar surveying in which pulses returned from a scanned region are converted to a picture of the region; measurements are made on the picture to determine horizontal and vertical distances between points.#

It is the analog, at radio frequencies, of photogrammetry in the visible wavelengths.

radial #A line or direction from the *radial center* of a photograph to a point on the photograph.#

Unless otherwise specified, the radial center is assumed to be the principal point of the photograph.

radial assumption #The assumption that angles between lines drawn from a particular point (the radial center) on a photograph to other points on the photograph are equal to the angles between corresponding lines drawn on the ground.#

This assumption is usually not correct, since the requirements for its correctness—orthogonality of the camera's optical axis to the horizontal plane, lack of distortion in the photograph, absence of relief, etc.—are usually not met. In an aerial photograph taken from well off the vertical, of ground with considerable relief, neither the nadir point nor the *isocenter* is the theoretically correct radial center. The photographic nadir point should be used as the radial center if relief is the major contributor to distortion, and the isocenter should be used if tilt is the major contributor. See *principal-point assumption*, and *nadir, photograph.*

radial center #The point on a photograph selected as the origin of radials, that is, as the point from which lines (directions) to various other points are drawn or measured.#

The radial center is either the *principal point*, the *nadir* point, the *isocenter*, or some other point that is a reasonable approximation to one of these. The radial center is also called the center of radiation and the center point.

radian #A unit of angular measure equal to the angle subtended at the center of a circle by an arc equal in length to that of the radius of the circle.#

The circumference of a circle encompasses 2π radians (360°), so one radian is (to 10 significant figures) 57.°295 779 51 or 206,264.″8062. The milliradian, a commonly used unit, is approximately 3.′5.

radiation (surveying) #A method of surveying in which a theodolite is placed at any convenient point from which the observer can see all points whose locations are wanted. Directions and distances are measured from the point of observation to the other points.#

radiosonde See *sonde.*

radio source (astronomy) #Any celestial object, such as the Sun, Jupiter, certain stars, nebulae, galaxies and clouds of gas, that is a source of detectable *radio waves.* #

Radio sources were originally called radio stars, when only stars were thought to be the sources of the detected waves.

radio star See *radio source.*

radio waves #Electromagnetic waves (radiation) with wavelengths longer than 1 mm (or, according to some classifications, longer than 0.3 mm).#

Radiation shorter than 0.3 mm is generally considered to be infrared radiation. The region between 0.3 mm and

1 mm may be considered to belong to either radio waves or infrared radiation.

radio waves, classification of Radio waves are conventionally classified according to their frequencies or wavelengths. Each category contains radio waves having frequencies between 3×10^n and $3 \times 10^{n-1}$ Hertz, or wavelengths between 10^m and 10^{m-1} meters. n begins at 11 and continues indefinitely downwards; m begins at -3 and increases indefinitely upwards. The factor 3 was introduced to make it easy to convert between categories based on frequency and categories based on wavelength, since the two are related by the velocity of light, which is about 300,000 km/s. The following table gives the names and limits of the categories.

CLASSIFICATION

Class designation	*Wavelength*		*Frequency*	
	From	*To*	*From*	*To*
Audio frequency	10^4 km	>30 km	<30 Hz	<10 kHz
VLF	30 km	10 km	10 kHz	30 kHz
LF	10 km	1 km	30 kHz	300 kHz
MF	1 km	0.1 km	300 kHz	3000 kHz
HF	100 m	10 m	3 MHz	30 MHz
VHF	10 m	1 m	30 MHz	300 MHz
UHF	1 m	0.1 m	300 MHz	3000 MHz
SHF	100 mm	10 mm	3 GHz	30 GHz
EHF	10 mm	1 mm	30 GHz	300 GHz

Radar was an important field of investigation during World War II. To preserve secrecy, the Allies gave arbitrary literal designations to the bands of frequencies at which research was being done. The following designations are still in use.

SPECIAL CATEGORIES
(used for radar)

Designation	*Frequency (GHz)*		
UHF-band	from 0.3	to	3.0
I-band	0.1	to	0.15
G-band	0.15	to	0.225
P-band	0.225	to	0.390
L-band	0.390	to	1.55
S-band	1.55	to	5.2
C-band	3.9	to	6.2
X-band	5.2	to	10.9
Ku-band	12.5	to	18.0
K-band	18.0	to	26.5
Ka-band	26.5	to	40.0
Q-band	36.0	to	46.0
V-band	46.0	to	56.0
W-band	56.0	to	100.0

radius #The line segment from the center of a figure to a point on the boundary of the figure.#

The radius of a circle and the radius of an n-dimensional sphere are constant. In the theory of orbits, the vector from the focus to the body is often referred to as the "radius vector". This is not the same as the radius of the orbit.

radius of curvature See *curvature, radius of.*

radius of curvature in the meridian #The *radius of curvature* at a point on an ellipsoid with respect to the *meridian* through that point.#

radius of curvature in the prime vertical #The *radius of curvature* at a point on an ellipsoid with respect to the *prime vertical* through that point.#

radius of gyration #The distance from a specified line to a point such that, if the entire mass of the body were concentrated at that point, the moment of inertia of the concentrated mass would be the same as the moment of inertia of the body (with respect to the specified line).#

The point of concentration is called the "center of gyration".

radius of the Earth See *Earth, effective radius of the.*

random #Nonsystematic; unpredictable by nature.#

See *variable, random.*

random walk #The path taken by a point which moves with a velocity (speed and direction) that is constant within discrete intervals of time but changes randomly from interval to interval.#

The sequence of errors in leveling networks and traverses displays some of the characteristics of a random walk.

range (1) #In general, in surveying, two points in line with the point of observation.#

The following are practical exemplifications of range:

(a) The line defined by the side of a building or by a fence may be extended visually to its intersection with a surveyed line; the point of intersection thus determined is said to be in range with the side of the building or with the fence.

(b) In hydrographic surveying, a range formed by two objects on the shore aids in keeping a boat moving in a straight line, i.e., the line defined by the range.

(c) In navigation, specially placed structures or objects mark ranges delimiting channels which are to be followed by vessels so as to be clear of dangers.

(d) Boundaries across water and boundary corners in water-covered regions where permanent markers cannot be established are sometimes delimited by intersections of lines through ranges or by one such line and a distance from a marker; such lines are marked by permanent monuments on land.

(2) #The distance between two points, at one of which is a target and at the other the measuring device.#

(3) #Any series of contiguous *townships*, or sections within a township, situated north and south of each other.#

Ranges of townships are numbered consecutively east and west from a *principal meridian.* Thus, "range 3 east" indicates the third range or column of townships east of a principal meridian. The word "range" is used together with the appropriate designation of a township to indicate the township's location. Thus, "township 14 north, range 3 east" indicates the township which is the 14th township north of the base line and the 3rd township east of the principal meridian.#

range finder #An instrument for finding the distance from a single point of observation to other points at which no instruments are placed.#

In general, a range finder contains a very short, fixed-length base line, which is part of the instrument. It is used according to the principle of triangulation. The precision of the optical and other parts of the instrument is high, but because of the small magnitude of the angle of intersection of the lines of sight at the object observed, the distances obtained are not very precise. See *tachymeter.*

range line (1) #An external boundary of a *township,* extending in a north-south direction.#

(2) #The line determined by a *range* (1).#

range pole See *range rod.*

range rate See *velocity, radial.*

The term is also used to mean, in particular, the rate of change of measured distance (range).

range rod #A simple wood or metal 6- to 8-foot-long rod, 1 inch or less in diameter, fitted with a sharp-pointed steel shoe, and usually painted alternately red and white at 1-foot intervals.#

Range rods are used to line up points of a survey or to show the observer at the theodolite the location of a point on the ground.

Also called a lining pole.

ray #A line perpendicular to the sequence of surfaces identifying a propagating wave.#

The rays considered in geodesy are principally those of light.

ray, chief #A ray directed toward the center of the entrance pupil of an optical system.#

Sometimes called a principal ray.

ray, epipolar (1) #The line, on the plane of a photograph, joining the *epipole* to the image of any point.#

(2) #The intersection of an *epipolar plane* with the plane of the photograph.#

ray, paraxial #A light ray so close to the optical axis of an optical system that *Gauss' equation* (optics) can be used without significant error.#

ray, perspective (1) #A straight line joining a point in *object space* or *image space* to a *perspective center.* #

(2) #The broken line consisting of (a) the line joining a point in object space to the front *nodal point* of an optical system, (b) the line joining the front nodal point to the rear nodal point, and (c) the line joining the rear nodal point to the corresponding image point.#

ray, principal (1) #A ray directed toward the first *principal point* of an optical system.#

(2) #A ray directed toward the optical center of an optical system.#

(3) See *ray, chief.*

Rayleigh scattering See *scattering, Rayleigh.*

reading (1) #The act of noting or recording the numbers that indicate the result of measurement by an instrument.#

(2) #The numbers (measurements) obtained by "reading" in the above sense.#

Reaumur scale See *temperature scale, Reaumur.*

rebar #A section of concrete-reinforcing rod.#

Rebars are used by surveyors as monuments or parts of monuments.

recession (of water) (law) #The gradual, natural and more or less permanent lowering of the elevation of a lake's surface, or the complete disappearance of that surface, when referred to what was regarded as the normal (average) elevation at the date of an established survey.#

reconnaissance (geodesy) #An investigation of a region where a survey is to be made, to determine the best locations for observing stations, geodetic markers, etc.#

Usually, the reconnaissance includes making arrangements for permission to enter and use land, etc.

reconnaissance sketch #A drawing used for reconnaissance but lacking sufficient information to make it usable as a map of the region depicted.#

recovery of station #The finding and identification of the geodetic marker of a previously established survey station, and the making of a record attesting to the fact that the marker was found, identified, and proven to be authentic and in its original location.#

Recovery of station is tested by checking the measurements of distance and azimuth (or bearing) from the station to a *reference mark. Witness marks* are aids to the recovery, but afford only secondary evidence of the position of the recovered station. Sometimes, exact recovery requires that the original, surveyed connections between the station and at least two adjacent stations of the same survey and class be tested and found unchanged.

rectification #The process of producing, from a tilted or oblique photograph, a photograph from which displacement caused by tilt has been removed.#

It is usually done optically, by projecting the photograph on the same orientation with respect to an unexposed film or plate as the ground plane had to the photograph when the picture was taken. The image on the photograph is then projected onto the emulsion to reverse, in effect, the original picture-taking process.

Rectification by this method cannot compensate for radial displacement caused by relief. Mathematical or analytical rectification is done by coupling, through a computer, a pair of scanning beams in such a manner that the motion of the beam scanning the original picture moves the second beam (which is scanning and exposing a fresh emulsion) to produce the same effect as rectification by projection.

rectification, optical #*Rectification* by projecting the image from the original photograph onto an unexposed film or plate held at a suitable angle with respect to the original.#

rectifier #A projection printer specially designed so that the geometric relationship between original image, center of projection, and the copy can be varied to eliminate the effect of tilt on an aerial photograph.#

There are two basic types: those in which the optical axis of the rectifier lens is the common reference or base direction of the instrument, and those in which the line between the principal point of the negative and the rectifier lens is the common reference.

Also called a rectifying camera.

rectifier, analytical orientation of a #Adjustment of a rectifier by setting on the rectifier controls the precise values needed for orientation, these values being calculated beforehand.#

rectifier, autofocus #A precise, vertical rectifier that connects lens system, original negative, and enlargement by a linkage that automatically keeps the projected image in sharp focus.#

The linkage is usually motor-driven. See *inversor.*

rectifier, automatic #Any rectifier in which a mechanism is used to ensure that the *lens law* and the *Scheimpflug condition* are automatically satisfied.#

These mechanisms, called *inversors,* provide a mechanical solution for the linear and angular elements of *rectification.*

rectifier, empirical orientation of a #Adjustment of a rectifier, usually by matching certain elements of the projected image with corresponding, controlling elements on a map or template.#

Unlike analytical orientation of a rectifier, the empirical procedure does not require exact computation of tilt, direction of principal line, flight altitude, etc.

red shift #The ratio $(\lambda - \lambda_0)/\lambda_0$, where λ is the observed wavelength of an identified line in a spectrum and λ_0 is the wavelength of the same line when the source is stationary (e.g., in the laboratory).#

Red shift is an indication of the radial velocity of stars, galaxies, and other celestial bodies with respect to the Earth. Increasing values of λ (and the ratio) indicate the source is receding from the observer; negative values indicate approach. Red shift is related to the Doppler effect.

reduction (1) #The calculation of theoretical values from observational data.#

(2) #A theoretical value added (algebraically) to a measured value of gravity to get closer agreement between the theoretical value of gravity at a point and the measured value there.#

Reduction is distinguished from *correction*, in gravimetric theory, by being the sum of individual corrections.

(3) #Any computational process involving a reduction in sense (2) above.#

See *gravity reduction.*

reduction, eccentric See *eccentric reduction.*

reduction, lunar #A correction to the Moon's orbit calculated from the difference between the true longitude of the Moon and its tabulated longitude.#

reduction to center See *center, reduction to.*

reduction to mean sea level See *reduction to the geoid.*

reduction to sea level See *reduction to the geoid.*

reduction to the ellipsoid #Calculation of the length of a line lying on an ellipsoid of reference with the same longitudes and latitudes at its end points as those of a given line lying on or at an average elevation above the geoid.#

The calculation is essentially a change of scale to the given length by the factor $h/(R + h)$, where R is approximately the radius of the Earth, and h is the average elevation of the given line above the ellipsoid.

reduction to the geoid #Calculation of the length of a line, all points of which are at zero elevation and which has the same longitudes and latitudes for its end points as does a corresponding line that lies at a constant, nonzero elevation.#

The calculation is based on the assumption that the line being reduced lies in a plane or is subdivided into planar segments.

reduction to the spheroid See *reduction to the ellipsoid.*

reference frame #A coordinate system associated with a physical system.#

reference mark See *mark, reference.*

referencing #The process of measuring and recording the horizontal distances and directions (azimuths or bearings) from a survey station to nearby landmarks, reference marks, or other objects for use in the recovery of the station.#

reflection #The reversal, at a surface or combination of surfaces, of at least one component of the direction of propagation of sonic or electromagnetic energy incident on the surface(s).#

Reflection is commonly classified as specular (the angle between normal to the surface and the incident beam of energy is equal to angle between the normal and the reflected beam); diffuse (energy leaves the surface at all angles, regardless of the direction of the incoming energy, although not with the same intensity in all directions), and mixed (some of the energy undergoes specular reflection and some undergoes diffuse reflection). Mixed reflection is commonly referred to as *scattering.*

reflector (1) #A surface, or combination of surfaces, that reverses a substantial portion of at least one component of the direction of propagation of incident sonic or electromagnetic radiation.#

The qualification "a substantial portion" is needed because all surfaces reverse the direction of propagation of some portion of the incident radiation. Some physicists therefore prefer to consider all surfaces as reflectors, classifying them as poor or good reflectors depending on whether they reverse the direction of a small or a large portion of the incident radiation. General usage, however, refers to good reflectors.

(2) See *telescope, reflecting.*

reflector, corner-cube See *reflector, cube-corner.*

reflector, cube-corner #An arrangement of three flat, reflecting surfaces that form a tetrahedron with 90° dihedral angles at the apex.#

Geometrically, the figure can be obtained from a cube by cutting off a corner along a plane passing through the three corners that have edges in common with the selected corner. The cube-corner reflector is useful because it reflects incoming rays in the direction from which they came, regardless of the angle of entry. There are two forms of cube-corner reflector. One, in common use for all wavelengths shorter than X-rays, consists of three flat, mutually perpendicular mirrors. The second, useful only from the infrared through the ultraviolet (including the visible range), consists of a solid prism with three mutually perpendicular faces. In this form, the radiation undergoes total internal reflection unless the faces are given a reflecting metallic coating.

reflector, retrodirective #A reflector that turns the direction of propagation through 180° so that radiation returns in the direction of its source.#

Cube-corner reflectors are the most common type of retrodirective reflector for electromagnetic and sonic radiation.

Also called a retroreflector.

refraction #The bending of sonic or electromagnetic rays by the medium through which the rays pass.#

The amount and direction of bending are determined by the refractive index of the medium.

refraction, angle of #The difference between the direction to a source of radiation and the direction from which the radiation arrives at the observer.#

In particular, the difference between the zenith distance at which a source of radiation would be observed in the absence of the atmosphere, and the zenith distance at which it actually is observed.

Also called refraction angle.

refraction, astronomical #Refraction by the Earth's atmosphere of light from a source outside the atmosphere.#

Light from a star or planet passes entirely through the atmosphere before reaching the Earth's surface; a ray follows a curved path concave toward the Earth's surface. The angle between the direction of the ray where it enters the atmosphere and the direction at the point of observation is called astronomical or celestial refraction. The amount of this refraction is greatest when the source is near the horizon and decreases to a minimum when the source is near the zenith. It reaches zero when the ray is perpendicular to the surfaces of the atmospheric layers. See *refraction of light.*

refraction, atmospheric #The bending of electromagnetic radiation by the atmosphere.#

Light and infrared radiation are refracted principally by temperature inversions in the troposphere. The stratosphere and ionosphere have little effect, being too rarified. Radio waves longer than about 30 cm are refracted more by ionized layers than by the troposphere.

refraction, coefficient of (1) #The ratio of the angle of refraction at the point of observation, to the angle at the center of the Earth subtended between the point of observation and the point observed.#

(2) #The ratio of the average radius of curvature of the Earth to the average radius of curvature of the path of the electromagnetic ray.#

(3) #Half the quantity specified in definition (2).#

refraction, horizontal #The bending in a horizontal plane of light rays during passage from a source to an observing instrument.#

Also called lateral refraction, it is caused by the differences in density of the air along the path of the rays. See *refraction, terrestrial.*

refraction, index of #The ratio of the sine of the angle of incidence, at the boundary between two media, to the sine of the angle of refraction.#

When a ray of light passes from a vacuum into some medium or from some medium into a vacuum, the index of refraction is the absolute index of refraction of that medium. The index of refraction is slightly different for light of different wavelengths. This deviation, by refraction, at different wavelengths is known as "dispersion" and, for any given medium, the amount of the deviation is a measure of the dispersive power of the medium.

refraction, lateral See *refraction, horizontal.*

refraction, photogrammetric #The refraction of light, by the atmosphere, as it affects aerial photographs.#

refraction, terrestrial (geodetic observation) #Refraction by the Earth's atmosphere of electromagnetic radiation from a terrestrial source.#

The term is commonly understood to apply to the refraction of light. In geodetic applications, the path of light from a terrestrial source is usually almost horizontal; it passes only through the lower strata of the atmosphere. The light is often subject to refraction throughout its path. The *angle of refraction* (or simply the refraction) of a surveyed line is the angle, at the point of observation, between the true direction of the observed object and the direction from which the light comes to the observer. Because microlayers within the air are not exactly symmetrical in either form or density the path of a ray of light through the atmosphere is a complex curve that does not lie completely in a plane. Its curvature is greatest, however, in or close to a horizontal plane, where its magnitude is important for observations referred to the plane of the horizon. Its effect is usually to make the apparent angular elevation of an object greater than the true angular elevation (although under special atmospheric conditions, this effect may be reversed).

In triangulation, a station which is normally just below the apparent horizon may, because of refraction under certain conditions of the atmosphere, become visible for a short period of time. A line on which the signal is visible only because of the bending of the light rays by refraction is called a refraction line.

refraction angle See *refraction, angle of.*

refraction line #A *line of sight* to a survey signal that becomes visible only because of atmospheric refraction.#

See *refraction, terrestrial.*

refraction of light #The change in direction of a ray of light passing from a medium in which its speed has one value to a medium where the speed has a different value.#

A ray of light before refraction is called the incident ray; after refraction, the refracted ray. The angle between the incident ray and the normal to the surface separating the two regions at the point of refraction is the angle of incidence; the corresponding angle between refracted ray and normal is the angle of refraction.

refraction of radio waves #The change in direction of a ray of radio waves passing from a region in which its speed has one value to a region where its speed has a different value.#

Short radio waves (30 cm or less) are refracted principally by subsidence layers or temperature inversions in the troposphere; longer radio waves are refracted mainly by ionized layers.

refractive index of the atmosphere See *atmosphere, refractive index of.*

region, intertidal #The region on a shore between the lowest and highest levels reached by the tides.#

reglette #The graduated scale fastened to the end of a surveyor's wire.#

In particular, the form of scale used on wires designed for measurement of base lines.

regression (1) #A backward motion.#

(2) #A function expressing the systematic component of the variation of a random variable as a function of one or more nonrandom variables.#

The term is much used in the biological and social sciences but is seldom used in geodesy, where the terms "function" and "relationship" are preferred. "Linear regression" denotes a linear function, "nonlinear regression" a nonlinear function.

regression of the nodes #The motion of the line in which the plane of an orbit intersects a reference plane.#

In particular, for the Moon, the westward displacement of the nodes along their points of intersection with the ecliptic.

regularization #Calculation of those corrections to the measured value of gravity that must be made to convert it to the value it would have on the equipotential surface resulting from transferring matter outside the geoid to inside the geoid in a particular manner.#

The new surface is called the regularized geoid.

reliability #The probability that an instrument will work satisfactorily for a specified length of time.#

A formula often used is

$$\text{reliability} = e^{-kt},$$

where t is the length of time an instrument is to be used and k is the average rate of deterioration of the instrument.

reliction #The gradual recession of water resulting in an uncovering of land once submerged.#

See *accretion* and *dereliction.*

relief (1) See *topography.*

(2) #The deviation of a surface, or portions thereof, from some surface used as reference.#

For example, geoidal relief is the deviation of the geoid from a reference ellipsoid.

relief displacement See *displacement, relief.*

remote sensing See *sensing, remote.*

repeatability (1) #Any measure of the closeness of the values in a set of measurements to a particular value which may or may not be a member of the set.#

In particular, (2) #the standard deviation of the measurements with respect to the average.# See *precision.*

repetition of angle See *angle, repetition of.*

repetition method of azimuth determination See *azimuth determination by the method of repetitions.*

Repsold apparatus See *base line apparatus.*

reseau (1) #A rectangular grid.#

(2) (photogrammetry) #A rectangular grid on glass, placed against the film in a camera so it is photographed together with the object; or a rectangular grid formed by holes in the platen illuminated from the back.#

Changes in the film after exposure distort the image of the reseau as well as the image of the object. Distortion can be minimized by restoring the image of the reseau to its correct shape and size.

resection #Determination of the horizontal location of a survey station by using observed directions from the station to points of known location.# See *intersection.*

While many methods have been devised for computing the location of one unknown point from observations on three points of known location, only three methods are frequently used, those of Cassini, Collins, and Kaestner. Cassini's method introduces two auxiliary points; Collins' method uses only one auxiliary point and reduces the problem to one involving two intersections; and Kaestner's method does not involve any auxiliary points.

The most usual problem in resection is the determination of a point of observation by measuring two angles between three fixed points; this is known as the *three-point problem*. It is solved by computation (in triangulation), by mechanical means (with a three-arm protractor in hydrographic work), or graphically (on a plane-table survey). Its solution gives what is often called a fix (a location for the point of observation). As used in photogrammetry, the term refers to determining locations from measurements on photographs.

resection, Italian #A method of resection in which the direction to one far-distant known point is determined by measurement of the angle between two other known points.#

resection, three-point-problem of See *three-point problem.*

resection, two-point problem of See *two-point problem.*

residual #The difference between an observed value and a computed value.#

See *error, residual.*

resolution (1) #In general, a measure of the finest detail distinguishable in in an object or phenomenon.#

(2) #In particular, and usually, a measure of the finest detail distinguishable in an image.#

Resolution usually varies from point to point of an image, so an average value (area-weighted average resolution), is often used as the resolution of the entire image.

(3) #A measure of the shortest distance over which differences of gravity can be distinguished.#

In particular, the length of arc along a great circle of a sphere representing the Earth corresponding to the term of highest degree present in a representation of the gravity potential by spherical harmonics.

(4) #The reciprocal of the width of the beam from a unidirectional antenna, measured in degrees.#

(5) #The separation of a vector into its components.#

(6) See *resolving power.*

"Resolution" and "resolving power" are often used as if they were synonymous. However, it is better to use resolution when referring to details of the object (image) and resolving power when referring to capability of the instrument used for observing.

resolution, area-weighted average #A measure of the resolution over the field of view of an optical instrument, computed as a weighted average of the measured resolutions in regions of the field, the weighting factors being the areas of the regions.#

It is usually used only as the acronym "AWAR". See *resolution.*

resolution, ground #The size, in length or area, of the smallest pattern or region on the ground which can be distinguished on an image.#

See *pixel.*

resolving power (1) #In optical systems, the angular distance, measured at the center of perspective, between two point-sources of equal brightness when their images are so close together that the brightness at a point between the two images is half the greatest intensity.#

If photographic images are involved, the above definition applies if "photographic density" is substituted for "brightness".

(2) #In photography, the closest spacing, expressed as number of lines per millimeter or per inch, of equally spaced, equally wide alternately black and white lines that allows individual lines to be distinguished.#

This is not a precise measure, since it depends on the method used for distinguishing between lines, e.g., visually or by a microdensitometer.

resonance #A phenomenon occurring in a satellite orbit whereby the satellite, due to a particular juxtaposition of values of its orbital elements, is subject to significant perturbations, which would be relatively small otherwise.#

The most common example is geopotential resonance, where the satellite's mean motion is commensurable with the Earth's rotation rate. Magnification of these perturbations enables the generating components in the gravitational field to be more easily obtained.

restitution #Determination of the correct (mapped) position of an object whose image appears distorted or displaced on an aerial photograph.#

Restitution corrects for distortion introduced both by tilt of the photograph and by relief displacement.

restitution instrument See *plotting instrument, stereoscopic.*

restoration (1) #The replacing of a survey monument that has disappeared or been destroyed, or the substantial renewal of an existing survey monument by a satisfactory equivalent.#

In particular, the replacement or substantial renewal of one or more lost corners or obliterated monuments for the purposes of a new survey.

(2) #The recovery of one or more lines or corner locations of a previously approved survey.#

resurvey #A retracing, on the ground, of the lines of an earlier survey when all recovered points of the earlier survey are held fixed and used as control.#

If too few points of the earlier survey are recovered to satisfy the requirements for control of the resurvey, a new survey may be made. A resurvey is related directly to an original survey, although there may have been several previous resurveys. The terms "original survey, resurvey", and "new survey" each have a different significance in land surveying.

resurvey, dependent (1) #A resurvey for restoring a missing corner, based on the original recorded conditions.#

The dependent resurvey is made by first identifying existing corners and other recognized and acceptable control points of the original survey, and then by restoring the required corners by proportionate measurement in agreement with the original survey.

(2) #A *retracement* and reestablishment of the lines of an original survey in their true, original locations according to the best available evidence of the locations of the original corners. It includes the restoration of lost corners in accordance with the procedures set by the Bureau of Land Management.#

resurvey, independent #A resurvey which is intended to supersede the original survey and to establish new boundaries and subdivisions.#

It is generally made in regions where the evidence on the ground of the original survey has become lost or the descriptions of the earlier survey are irreconcilable. The area to be resurveyed may contain both public and private lands.

retardation, lunar #The approximately 50 minutes needed for a particular meridian on the Earth to catch up with the Moon one 24-hour day after the meridian first passes the Moon.#

Retardation occurs because the Moon revolves about the Earth in the direction of the rotation of the Earth.

reticle #An assembly of wires, hairs, threads, etched lines, or the like, placed in a plane perpendicular to the optical axis at the principal focus of an optical instrument.#

Also called a reticule.

reticle, wedge #A *reticle* carrying a pattern in which one arm of the simple cross (+) shape is evenly split longitudinally and the halves spread apart to form a wedge (V) with its apex at the center of the cross.#

This reticle pattern is common in leveling instruments, since it permits a more precise setting of the horizontal line on the center of a graduation.

reticle ring #The ring across which the filaments of a *reticle* are stretched, or the ring that supports the disk of a reticle that consists of lines etched on glass or other transparent material.#

reticule See *reticle.*

retracement #A survey made to verify the direction and length of lines and to identify monuments and marks of an earlier, established survey.#

Recovered corners are repaired, but lost corners are not restored nor are lines through timber reblazed.

retracing #The process of making a *retracement.*#

retroreflector See *reflector, retrodirective.*

reversing point, micrometer screw See *micrometer.*

reversion See *image, reverted.*

revolution (1) #The turning of a body about an external point or axis.#

See *rotation.*

(2) #The turning of a body through 360° about an external point or axis.#

(3) #The turning of a geometrical figure about an axis.# We say that the Earth rotates on its axis and revolves around the Sun. However, such a clear distinction between the two terms is not always made consistently. For example, in geodesy, we often speak of an "ellipsoid of revolution", though according to exact terminology it is an ellipsoid developed by the *rotation* of an ellipse around its minor axis.

(4) #A turning through 360°.# The number of revolutions is usually specified, e.g., one revolution, ten revolutions.

rhumb line #A line that crosses successive meridians at a constant angle.#

The Mercator map projection is the only map projection on which a rhumb line is represented by a straight line. Other names for rhumb line are loxodrome, loxodromic curve, equiangular spiral, and Mercator track.

rhumb line, fictitious #A line making the same oblique angle with all *fictitious meridians.*#

It may be called a transverse, oblique, or grid rhumb line, according to the type of fictitious meridian.

rhumb line, grid #A line making the same oblique angle with all meridian-representing lines of a grid.#

rhumb line, oblique (1) #A line making the same oblique angle with all *fictitious meridians* of an oblique Mercator map projection.#

(2) #Any rhumb line, real or fictitious, making an oblique angle with meridians.#

In this sense the term is used to distinguish a rhumb line from parallels and meridians, real or fictitious, which are included in the term "rhumb line". See *rhumb line, fictitious.*

rhumb line, transverse #A line making the same oblique angle with all fictitious meridians of a transverse Mercator projection.#

Also called "inverse rhumb line".

ridge line (topography) (1) #A graphic representation of a major ridge in a region.#

Ridge lines are used particularly on maps of regions in which radar stations are located to show those places where the radar beam is partially or totally blocked at low angular elevations.

(2) #A line through points of maximum elevation along a ridge.#

right ascension #The angle between the plane of the *hour circle* passing through a celestial body and the plane of the hour circle passing through the vernal equinox; it is measured eastward from the *vernal equinox* through 24 hours (360°).#

Right ascension may be measured at the celestial pole by the angle between the tangents to the hour circles of the celestial body and of the vernal equinox, or by the arc of the Equator intercepted by those hour circles. Right ascension and *declination* are the coordinates usually used to specify the location of a body on the celestial sphere.

ring, meridian See *meridian ring.*

riparian #Connected with, or adjacent to, the banks of a stream or other body of water.#

riparian rights #The legal right which assures the owner of land abutting a stream or other body of water the use of such waters.#

rise, continental #A gentle slope with a generally smooth surface, rising toward the foot of the continental slope.#

See *slope, continental.*

rise, mean #The elevation of *mean high water* above *chart datum.*#

river bed See *bed, stream.*

river crossing See *water crossing.*

river level #*Water level* of a river; the elevation of the surface of the river above a reference surface.#

river level, mean #The average elevation of the surface of a river at any point for all stages of the tide observed over a 19-year period.#

It is usually determined from hourly readings of the height of the surface at a graduated staff or other device. Unusual variations of river level caused by abnormally large runoff or discharge are excluded from the computation.

rod (1) #A unit of length, in the English system, legally equal to 5-1/2 yards, 198 inches, or 25 links.#

It is equivalent to 5.0292 m. It was established as a unit of length, by the 1303 ordinance of Edward I, as equal exactly to 5-1/2 ulnae (the ulna was the length of a standard iron bar which was the the prototype of the yard).

Also called a perch or pole. Rods were commonly used as length units in deeds written in the time of the 13 American colonies to describe boundaries of parcels of land. The public-land surveyor, in the early 1800's, was required to use two-pole (or two-rod) chains in surveying.

(2) #A leveling rod.#

rod, leveling See *leveling rod.*

rod, range See *range rod.*

rod, speaking See *leveling rod.*

rod, stadia See *stadia rod.*

rod, target See *leveling rod.*

rod, wading See *wading rod.*

rod constant See *leveling-rod constant.*

rod correction See *leveling correction, rod.*

rodman #The person responsible for moving a *leveling rod* from point to point during a survey, for ensuring that it is held perpendicularly while being sighted on, and for other associated duties, such as moving the target, etc.#

rod stop See *leveling-rod stop.*

rod unit #The smallest interval into which the scale of a *leveling rod* is divided.#

roll (1) #Angular motion of a craft about its longitudinal axis; also the angular deviation from the horizontal about the longitudinal axis.#

(2) #By extension, motion or angular deviation of an aerial camera or coordinate system of a photograph about either the photograph's x-axis or about the x-axis in object space.# See *rotation, pitch*, and *yaw.*

rose #A set of lines radiating from a point on a map and marked to indicate velocity or some other quantity as a function of direction.#

See *compass rose, current rose*, and *wind rose.*

rotation (1) #A turning of a body about an internal axis.#

See *revolution*. For example, the Earth rotates on its axis (and revolves around the Sun), the alidade of a theodolite rotates about a vertical axis.

(2) #The angle through which a point is revolved or a body is rotated.#

Three different kinds of rotation are considered in photogrammetry: These refer to the orientation of a photograph with respect to the camera (interior orientation); the orientation of the camera with respect to the object (exterior orientation); and the orientation of the photograph emplaced in a measuring engine with respect to the horizontal axes of the engine. See *orientation.*

rotation, anticyclonic See *rotation, clockwise.*

rotation, clockwise #A direction of rotation that, when viewed from a specified direction, is the same as the direction in which the hands of a clock rotate.#

Clockwise rotation is also called anticyclonic rotation or rotation cum sole.

rotation, counterclockwise #A direction of rotation that, when viewed from a specified direction, is in the opposite direction from that in which the hands of a clock rotate.#

Also called cyclonic rotation or rotation contra sole.

rotation, cyclonic See *rotation, counterclockwise.*

rotation contra sole See *rotation, counterclockwise.*

rotation cum sole See *rotation, clockwise.*

round See *rounds, method of.*

rounds, method of #A procedure for making angular observations, in which the theodolite is pointed sucessively at each of the targets involved in order of azimuth. Starting with a particular target (called the initial target), the reading of the horizontal circle is recorded for each pointing, up to and including pointing at the initial target again.#

The succession of pointings and the ordered set of recordings is called a "round".

Rudoe's formula #A set of formulas developed by Rudoe for direct position computation (Bomford: 1971, pp. 131-133) and inverse position computation (Bomford, 1971, p. 136).# See *position computation, direct* and *position computation, inverse.*

Rudzki inversion method #A method, developed by Rudzki in 1911, for mathematically converting masses outside the geoid to equivalent masses inside the geoid without changing its shape (although the gravity field outside the Earth is changed). The procedure is applicable only if the geoid in the vicinity of the place where the reduction is applied can be considered a sphere. The reduction consists of replacing an element dm_1 of mass outside the sphere, and at a distance r_1 from the center, by an element dm_2 of mass on the same radius but at a distance r_2 from the center. The mass dm_2 and the distance r_2 are related to dm_1 and r_1 by the equations $dm_2 = Rdm_1/r_1$ and $r_2 = R^2/r_1$, where R is the radius of the sphere.#

rule, semicircular #A geometric method using the pattern of a semicircle to determine when an indentation of a coast should be regarded as part of the inland waters of a country and when it should be regarded as part of the open sea.# See *waters, inland.*

rule of the tidemark #The rule that, where a coastline is relatively straight, or where only slight curvatures exist, the *base line* follows the sinuosities of the coast as defined by a tidal plane.#

See *base line (5).*

running (1) #A sequence of differences of elevation, measured set up by set up in one direction along a section of a *line of levels.* #

This results in a determination of the difference of elevation between the bench marks or other points, either temporary or permanent, at the ends of the section.

(2) #The set of elevation differences determined by leveling in one direction between the two ends of a *level line.* #

(3) #The chain of small difference of elevation measured between the ends of a *section.* #

(4) #The surveying done in going from beginning to end of a section of a level line.#

(5) #The survey of a traverse, or a segment of a traverse, in one direction only.#

run of micrometer See *micrometer.*

S

saddle #A smooth, curved, portable device used to support a surveying tape at intermediate points.#

sag #The vertical distance between the lowest point of a surveyor's tape suspended between two points and the straight line joining those points.#

The amount of sag in a surveyor's tape is approximately *WL/8T*, where *W* is the weight of the tape between the supports, *L* is the length of the tape between the supports, and *T* is the tension on the tape.

sag correction See *taped length, sag correction to* or *wire, surveyor's.*

St. Hilaire method #An adaptation of the *Sumner method* for determining location. This method uses assumed values of angular elevations (vertical angles) in the computation of astronomical coordinates and applies a simple correction for the differences between the observed and assumed values of the angular elevations.#

This method, invented in 1874 by Marcq de St. Hilaire, a French naval officer, simplifies the usual method of computing a location from Sumner lines; it is especially effective and easy to use near the geographic poles.

salinity #The total amount of solid matter, in parts per thousand (o/oo) per unit weight of sea water, when all the carbonate has been converted to oxide, all the bromine and iodine to chloride, and all organic matter has been completely oxidized.#

Saros #A time cycle, corresponding to the recurrence of eclipses, with a period of 223 *synodical months* (6,585.32 days or approximately 18.03 *Julian years*).#

In a cycle of 6,585.78 days, or 0.46 days more than in a Saros cycle, the Sun passes through a particular node of the Moon's orbit a total of 19 times; thus each eclipse of a new Saros falls about 120° west of the corresponding eclipse of the previous Saros.

satellite #Any body that revolves about another body.#

The body about which a satellite revolves is called its *primary*. All systems of two or more attracting and revolving bodies actually revolve about the center of gravitational attraction of the system—a point that may lie far from either body. However, one body, because of its mass or charge, usually exerts so much more powerful an attraction than the other that the center of attraction lies within it. For example, the center of attraction for the Earth and its Moon lies within the Earth. The planets, meteorites, and comets in the solar system are satellites of the Sun; the Moon is the satellite of the Earth, and the moons of Mars are satellites of Mars.

satellite, active #An *artificial satellite* observable by means of the radiation it generates.# Contrasted to *passive satellite*.

satellite, artificial #A man-made satellite, as distinguished from natural satellites such as the planets and their moons.#

The most important artificial satellites so far have been those that have been put into orbit about the Earth: a few have been put into orbits about the Moon and Sun. Spacecraft deliberately placed in temporary orbits or in trajectories that include only a short segment of an orbit are usually called space probes.

satellite, geosynchronous See *satellite, synchronous.*

satellite, natural #Any natural body revolving more or less permanently about another.#

The Moon, as far as we know, is the only natural satellite of the Earth.

satellite, passive #Any artificial satellite that does not emit signals.#

satellite, synchronous #A satellite whose period and direction of revolution is the same as that of some motion of the body about which it is in orbit.#

In particular, a satellite of the Earth with a period of 24 hours. The orbit of such a satellite has an average radius of about 42,240 km. A synchronous satellite revolving in the same direction as the Earth rotates is called a geosynchronous or geostationary satellite. Both environmental observation and communications satellites have been placed into geostationary orbits.

satellite, Sun-synchronous #A satellite in such an orbit that local solar time at the subsatellite point remains constant.#

Examples of Sun-synchronous orbits are those of the early Tiros weather satellites.

satellite geodesy #The process of obtaining geodetic information by the observation of artificial satellites.#

By definition, geodetic information obtained by lunar, solar, planetary, or stellar observations is excluded.

satellite geodesy, dynamic #Satellite geodesy in which the forces acting on the satellite must be taken into account in order to determine the satellite's orbit.#

The most important of these forces is the gravitational field of the Earth.

satellite geodesy, geometric #Satellite geodesy in which the geometric relationship between observation stations and satellite yields geodetic information; the orbit of the satellite plays little or no part in these determinations.#

satellite geodesy, simultaneous mode of #Determining the coordinates of a point by measuring directions or distances to a satellite simultaneously from that point and from points whose coordinates are known.#

The orbit of the satellite is then irrelevant. The term also covers the case when the observations are not simultaneous but are made so close to simultaneity that a simple correction can be made for the nonsimultaneity.

scale (noun) (1) #The ratio of two numbers *a* and *b*, where *b* is the length of a characteristic dimension of some object and *a* is the length of the corresponding dimension in a representation (model or map) of that object.#

See *scale, map* and *scale of a map.*

(2) #A set of marks placed at uniform intervals along a straight line and numbered to indicate the distance of each mark from the first.#

See *scale, map (2).*

scale (verb) (1) #To measure lengths, or distances between points on an object.#

(2) #To make a model of an object.#

For example, to scale down is to make the model at a smaller scale than the original. When a map is prepared from photographs, it is usually scaled down.

scale, bar See *scale, map (2).*

scale, compilation #The scale at which a map is compiled, as distinct from the expressed scale of the map.#

scale, equivalent #The relationship between a small distance on a map and the corresponding actual distance expressed verbally as an equivalence, such as, "1 cm (on the map) equals 25 km (on the ground)".#

This also appears in abbreviated forms such as "inch to the mile" and "mile to the inch"; the former is preferred. Infrequently called verbal map-scale or verbal scale.

scale, fractional #The ratio between any small distance on a map and the corresponding actual distance.#

Sometimes called the numerical scale or the natural scale. The term "representative fraction" is used to indicate a fractional scale whose numerator is unity, e.g., 1/10, 1/50, etc.

scale, graphic See *scale, map* and *scale of a map.*

scale, gray See *gray scale.*

scale, linear See *scale, map (2).*

scale, map (1) See *scale of a map.*

(2) #A line on a map with numbered graduations that represent actual distances.#

Also called graphic scale, bar scale, or linear scale.

scale, particular #The ratio between an infinitesimal linear distance in any direction at any point on a map and the corresponding actual distance.#

Also called relative scale.

scale, relative See *scale, particular.*

scale, temperature See *temperature scale.*

scale factor (1) #A number by which a distance obtained from a map by computation or measurement is multiplied to obtain the actual distance on the datum of the map.#

(2) #A number by which a length calculated in the State plane coordinate system is multiplied to obtain the length of the geodesic; also used conversely.#

Lengths calculated on the State plane coordinate system are affected by any distortions of the map projection.

scale height #The quantity RT/gM, where g is the acceleration of gravity, M is the mass of the atmosphere below the height where the temperature is T, and R is the gas constant 8.3143×10^3 J/(kmol · K).#

Also called "pressure scale height" to distinguish it from "density scale height", which is derived from it by using the equation of state of the atmosphere.

The term "scale height" derives from the formula

$$\rho = \rho_0 \, exp[-(h - h_0)/H]$$

where H is the scale height, and serves to scale a difference in height h from a given height h_0 in order to determine the density ρ at h from the given density ρ_0 at h_0.

scale number #The denominator of a fractional *map scale*.# For example, if the fractional scale is 1/50,000, the scale number is 50,000.

scale of a map #A number, constant for a given map, which is representative of the ratios of small distances on the map to the corresponding actual distances.#

These ratios vary from point to point on the map. The scale of a map is customarily chosen to correspond to the ratio at a given point or along a given line (if constant along that line) multiplied by a suitable factor (usually close to unity). It is expressed as a common fraction having 1 as the numerator, and the integer closest to the correct value as denominator.

Maps are commonly categorized as large scale, medium scale, or small scale. There is no general agreement on the values to be associated with these categories. A fairly common practice is to call maps with scales equal to or larger than 1/50,000, large-scale maps; maps with scales between 1/50,000 and 1/500,000, medium-scale maps; and maps with scales smaller than 1/500,000, small-scale maps.

scale point #A point on a photograph at which the *scale* is known.#

A scale point is considered an infinitesimal segment of a line whose scale can be determined.

scattering #The random redistribution of the direction of propagation of light incident upon a small area, from a single direction into a cone of directions.#

Scattering may occur because the surface is composed of many small, randomly oriented, reflecting facets, or because the surface absorbs and then reemits light. Opaque surfaces scatter light only into one hemisphere; the portion radiated in the direction of the source is called backscatter. Translucent materials redistribute the light into both hemispheres; the portion scattered into the hemisphere opposite to that containing the incident light is called forward scatter.

scattering, Mie #The scattering of electromagnetic radiation by particles whose characteristic size is of the same order of magnitude as the wavelength of the radiation.#

scattering, Rayleigh #The scattering of electromagnetic radiation by particles whose characteristic dimension is considerably smaller than the wavelength of the radiation.#

For example, the scattering of light by molecules is a form of Rayleigh scattering and is responsible for the blue color of the sky. Radar beams undergo Rayleigh scattering by minute particles in the air.

Scheimpflug condition #The requirement that object plane, image plane, and plane of the lens (the plane through the center of perspective and perpendicular to the optical axis) intersect in the same line so that a direct-focusing projector will focus sharply.#

Schreiber's method #A procedure for observing angles in triangulation under which independent angles between each pair of stations, rather than rounds of directions, are observed.#

Each angle is observed once clockwise and once counterclockwise or, depending on the rule used for observation, each angle and its supplement is observed.

scintillation #Irregular changes in brightness of an image caused by inhomogeneities of refractive index in the air between the object and the image.#

Many different names, such as "twinkle" and "glitter", are used in popular literature for this phenomenon. Contrast with *shimmer.*

sea (1) #A body of water of considerable extent (but smaller than an ocean) which resembles an ocean in its physical and chemical characteristics but is sufficiently enclosed by land to make it geographically distinguishable from an ocean to which it may be connected.#

Two types of sea are distinguished, depending on the extent of inclosure: Mediterranean seas (the Mediterranean Sea is the archetype), which are almost entirely inclosed; and marginal seas, like the Japan Sea and the English Channel, which are much more open.

(2) #An *ocean.* #

sea, marginal #The waters bordering a nation and over which the nation has exclusive jurisdiction, except for the right of innocent passage of foreign vessels.#

Also called a territorial sea, an adjacent sea, a marine belt, or a maritime belt.

sea, territorial See *sea, marginal.*

seafloor spreading #The hypothesis that the oceanic basins have been formed by the forcing apart of the tectonic plates forming the ocean bottom by exudation of magma at the crests of midocean ridges.#

The hypothesis provides a mechanism for plate motion as well as for the formation of the basins.

sea level (1) #In general, the reference elevation of the surface of the sea from which elevations are measured.#

In surveying and mapping, this term is used as a curtailed form of "mean sea level".

Also called "physical sea level", when the sea level is to be explicitly distinguished from a theoretical quantity. See *sea level, mean.*

(2) #The *elevation* of the surface of the sea or a portion thereof.#

sea level, derived mean #The average of elevations of water level measured at a particular place over a specified period; these measurements are referred to the elevation of a specified bench mark.#

sea level, ideal An oceanographic term for the *geoid.*

sea level, instantaneous #The free surface of the sea at a particular instant.#

sea level, mean (1) #The average location of the interface between ocean and atmosphere, over a period of time sufficiently long so that all random and periodic variations of short duration average to zero.#

The U.S. National Ocean Service has set 19 years as the period suitable for measurement of mean sea level (in the sense described in (2) below) at tide gauges. If an average over a shorter period is meant, this period should be stated. See (3) below.

(2) #The arithmetic mean of elevations (heights) of the water's surface observed hourly over a specific 19 year cycle.#

This quantity is not suitable for most oceanographic or geodetic work, because such a mean sea level exists only at places where measurements have actually been made.

(3) #The same as definition (2), except that the 19 year period is not required.#

When the 19 year period is not used, the period used should be specified. For example, specify that monthly mean sea level or annual mean sea level is the basis for this mean sea level value.

The adjective "mean" in all three definitions refers to an average over time, not over an area.

The geoid has been defined by some geodesists as the equipotential surface that best fits mean sea level (with all random and periodic variations removed). There can be only *one* mean sea level for the entire globe if this definition is to be usable. Definition (1) must be clearly distinguished from definition (2), which not only differs from place to place but from time to time.

sea level, mean instantaneous #The average elevation of the water surface at a specified instant over a specified region.#

sea level, physical See *sea level.*

sea level, steric #Sea level determined by *hydrostatic leveling*—i.e., by considering the differences in density of sea water at different points.#

sea level datum See *datum.*

seamount #An upward projection of the seafloor having a nearly equidimensional extent less than 60 nautical miles across its summit.#

This definition was adopted by the Board of Geographic Names in 1960.

seas, high #Waters, beyond and adjacent to the marginal sea, which are not subject to the exclusive jurisdiction of any one nation.#

secant method #A method of determining the parallel of latitude for the survey of a base line or standard parallel by offsets from a great circle line which cuts the parallel at the first- and fifth-mile corners of the township boundary.#

In the secant method (a modification of the tangent method) the lengths of offsets made from the projected great circle line to the parallel are minimal; at the first- and fifth-mile stations on the secant, the offsets are zero; between those stations, the offsets are measured to the south; before and after those stations, the offsets are measured to the north.

second #A unit of time, variously defined.#

Until 1960, the second was based on the length of the day, and was defined as 1/86,400 of the length of the *mean solar day*. In 1960, the General Conference on Weights and Measures adopted the ephemeris second as the standard definition of the second. See *second, ephemeris*. In 1967 the conference abandoned this definition and adopted, instead, a definition, in terms of atomic time, called the atomic second. See *second, atomic.*

second, atomic #The duration of 9,129,631,770 periods of the radiation corresponding to the transition, unperturbed by external fields, between two hyperfine levels (F = 4, M_F = 0 and F = 3, M_F = 0) of the ground state of the cesium-133 atom.#

This is based on a resolution adopted by the General Conference on Weights and Measures in 1967, replacing the ephemeris second by the atomic second.

By this definition, each cesium clock in the national time services became a primary standard for time. This situation was clarified by the decision, adopted by the 1972 General Conference on Weights and Measures, that the atomic second should be that defined by the Bureau International de l'Heure as the average given by a number of clocks whose times were monitored by the Bureau.

second, ephemeris #1/31,556,925.974 7 part of the *tropical year* for 1900 January 0 at 12 hours *ephemeris time*. #

It is theoretically equivalent to the system of time used by Simon Newcomb in his theory of the motions of the Solar System.

second-order work See *survey, second-order*.

section (1) #The portion of a level line that is recorded and abstracted as a unit, and constitutes a self-consistent and self-sufficient set of measurements of differences of elevation.#

A section always begins and ends on either a temporary or permanent bench mark, whether the mark is part of the main level line or is on a spur from a level line. In the case of a spur to a point whose elevation is determined by taking an additional foresight, the section must begin on a temporary or permanent bench mark and end at the point on which the leveling rod was held when the additional foresight was taken.

(2) #The segment of a leveling line consisting of two neighboring markers connected by a *running*.#

(3) #The unit of subdivision of a township, normally a quadrangle 1 mile square, with boundaries conforming to meridians and parallels within established limits, and containing, as nearly as possible, 640 acres.#

A township is normally divided into 36 sections by lines 1 mile apart measured from the southern and eastern boundaries; any excess or deficiency created by the measurements is placed in the northern *tier* or western *range* of sections. The sections within a township are numbered consecutively commencing with number 1 in the northeastern section, and progressing west and east alternately within each tier, to number 36 in the southeastern section.

section, fractional (1) #A *section* containing appreciably less than 640 acres, usually because it has been invaded by a segregated body of water, or by other land which cannot properly be surveyed or disposed of as part of that section.#

(2) #A section which in its original form contained one or more subdivisions of less than 40 acres because of irregular exterior boundaries or because a meandered body of water encroached upon it, or by extension into it of boundaries of other land which could not be properly surveyed or disposed of as an aliquot part of that section.#

Sections are also frequently turned into fractional sections in closing the surveys on the northern and western boundaries of the township, because deficiencies in measurement caused by errors of survey or convergence of meridians are placed in the half-mile closing against these boundaries.

section, half #One-half of a *section* formed by dividing a section into two parts by a line connecting two corners each placed midway on opposite sides of the section, and containing, as nearly as possible, 320 acres.#

The half section is a unit used in identifying public lands; thus, the "east half, section 10" is the legal identification of that portion of section 10 of a given township lying east of the north-south central line of the section. See *section, quarter*.

section, normal (1) #The intersection of a surface with a plane through a perpendicular to that surface.#

(2) #The intersection of a solid with a plane through a perpendicular to the surface of the solid.#

section, one-sixteenth See *section, quarter-quarter*.

section, quarter #One-fourth of a *section* formed by dividing a section into four parts by lines connecting four corners each placed midway on separate sides of the section, and containing, as nearly as possible, 160 acres.#

The quarter section is a unit used for identifying public lands; thus, the "northeast quarter, section 10" is the legal identification (description) of that portion of section 10, of a given township, lying east of the north-south central line and north of the east-west central line of that section.

section, quarter-quarter #One-sixteenth of a *section* formed by dividing a *quarter section* into four parts by lines connecting the midpoints of opposite sides, and containing, as nearly as possible, 40 acres.#

The quarter-quarter section is a unit used in identifying public lands; thus, the "northeast quarter of the northeast quarter, section 10" is the legal identification (description) of that portion of section 10, of a given township, lying east of the north-south central line and north of the east-west central line of the northeast quarter of that section.

sector (1) #A geometrical figure bounded by a circular arc and the two radii to the ends of that arc.#

(2) #An instrument composed of a graduated arc to which is fastened a sighting device (*alidade*) so that the angle between two directions of sighting can be measured.#

sector, zenith #An astronomical instrument for measuring zenith distances, in which a plumb line is read against a short vertical arc.#

In its early form, before the invention of the telescope, the zenith sector consisted of a quadrant and a plumb line. With the introduction of the telescope, zenith sectors used in astronomical geodesy became short vertical arcs attached to telescopes up to 1.5 to 2 m long; the vertical angle was read by means of the plumb line suspended from the horizontal axis of the instrument. A later form of zenith sector, incorporating spirit levels and an ocular micrometer, is a precise instrument. Such instruments were used in measuring zenith distances and differences of zenith distances of stars close to the zenith. The zenith sector has been superseded by the zenith telescope for determining astronomic latitude.

seeing See *shimmer*.

The term seeing is used primarily by astronomers.

selenotrope #An instrument similar to the heliotrope, but adapted to act as a geodetic signal by reflecting moonlight rather than sunlight.#

The selenotrope differs from the *heliotrope* only in the greater size of the mirror used. It is operated in exactly the same way. In tests made in 1883 and 1887, selenotropes furnished satisfactory lights on which to observe at distances up to 70 miles. The instrument is no longer in use.

sensing, remote (1) #The response of an instrument or organism to stimuli from a distant source.#

(2) #The response of an instrument to electromagnetic radiation from a distant source.#

These definitions can be expanded to include the theory and procedures by which inferences are drawn about the nature of the source.

sensor #An instrument or organism that responds perceptibly to a stimulus.#

sensor, remote #An instrument that responds perceptibly to any stimulus without being in close contact with the source of the stimulus.#

servitude See *easement*.

setback #The horizontal distance from the fiducial mark on the front end of a tape, or on the part of the tape that is in use at the time, back to the point on the mark or monument to which the particular measure is being made.#

If portable supports, such as *bucks (saddles)*, are used, there will seldom be need for measuring setbacks. Setbacks are minus corrections to measured distances. The U.S. National Geodetic Survey avoids the use of setbacks. See *setup*.

setup (1) #In general, the adjustment of a surveying instrument so that it is in proper position at a point from which observations are to be made.#

In particular, the actual physical placement of a leveling instrument over an instrument station, or the situation resulting from such placement.

(2) #The horizontal distance from the fiducial mark on the front end of a tape, or on the end of the tape which is in use at the time, measured forward to the point on the mark or monument to which the particular measure is being made.#

If portable supports, such as bucks, are used, there will seldom be need for measuring setups. Setups are positive corrections to tape distances. See *setback*.

(3) #The positions of those parts of a stereoscopic plotting instrument that are adjustable but remain fixed while the instrument is in use.#

sextant #A hand-held surveying instrument for measuring the angle, at the observer, between a celestial object and the horizon or between two objects.#

It is based on the principle that if a ray of light undergoes two successive reflections in the same plane, the angle between the first and second directions of the ray will be twice the angle between the plane mirrors.

The sextant has a graduated arc, on which the angle is measured, that usually covers one-sixth of a full circle. However, the name "sextant" is often applied to instruments constructed on the same principle, even though the arc may be longer or shorter.

The instrument is used in navigation for measuring angular elevations of celestial bodies. It is used in hydrographic surveying for measuring horizontal angles between shore objects from a point in a moving boat and wherever instability of support makes it impossible to use a theodolite or transit.

The sextant has been in use since around 1730.

sextant, box #A cylindrical box containing two vertical mirrors, one of which can be rotated as much as 60° about a vertical axis. The movable mirror is turned by a knob at the top of the box; as the knob is turned, an external pointer indicates the angle turned on a metallic, graduated arc.#

The largest angle that can be measured is 120°. The instrument is best used for quickly obtaining approximate measurements of horizontal angles in reconnaissance surveys.

sextant, bubble #A *sextant* in which the bubble of a spirit level serves as the horizon.#

shape of the Earth (1) #The geometric surface which coincides on land with the topographic surface of the *lithosphere* and, where the land is covered by water, with a suitably averaged surface of the *hydrosphere*.#

(2) #The *flattening* of the Earth.#

(3) #The *curvature* of the geoid.#

sheet (1) #In hydrography, the material surface upon which the details of a survey are drawn.#

See *sheet, base* and *sheet, boat*.

(2) #In photogrammetry, a material surface on which detail is plotted.#

See *sheet, base*.

sheet, base #A sheet of dimensionally stable material upon which the map graticule and ground control are plotted, and upon which aerotriangulation or compilation is done.#

sheet, boat #The sheet, used in the field, on which are plotted the details of a hydrographic survey during that survey.#

sheet, circle #A *boat sheet* or *smooth sheet* on which intersecting families of curves are shown, each curve corresponding to the locus of points at which some constant angle exists between two stations.#

sheet, fair See *sheet, smooth*.

sheet, smooth #A sheet on which field control and hydrographic data such as soundings, depth curves, and regions surveyed with a wire drag are finally plotted before being used in making a final chart.#

Also called a smooth chart (U.S.A.) or a fair chart (British).

shelf, continental There are two different definitions of the continental shelf: the geological and the legal.

(1) There is no standard geological definition, but one commonly used is:

#The region of the oceanic bottom that extends outward from the shoreline with an average slope of less than 1:100, to a line where the gradient begins to exceed 1:40 (the continental slope).#

Since this line is difficult to determine accurately, oceanographers use the practical criterion that the shelf is that part of the bottom that extends outward from the shoreline with a gentle slope to the line where the slope changes abruptly to a much more vertical gradient.

(2) In the international law of the sea, the continental shelf was once defined legally as #extending from land out to a depth of 200 m.#

At the United Nations Conference on the Law of the Sea (UNCLOS III) begun in 1973, the legal continental shelf is #the entire continental margin consisting of shelf, slope, and rise, or the oceanic bottom within the 200-n.mi. economic zone, whichever is greater.#

shelf, insular #The part of an island or archipelago extending from the shore outward to the line where the bottom begins to slope rapidly down to the oceanic depths.#

shelf, outer continental #The part of the *continental shelf* that is seaward of States' boundaries as defined in the Submerged Lands Act (43 U.S.C.A sect. 1301 et seq.)#

Shida number #The ratio between a horizontal tidal displacement at the Earth's surface and the horizontal tidal displacement in the corresponding static, oceanic tide.#

The number was introduced by T. Shida in 1912.

shimmer #The apparently irregular motion of the image of an object which is caused by moving irregularities in the refractive index of the atmosphere through which the light from the object passes.#

Shimmer can cause the apparent location of a object to change by several seconds of arc over a period of a few minutes. It is also called "seeing", particularly by astronomers. It is not the same as *scintillation*, the irregular variation in brightness of the image, even though the basic cause is the same.

shiran #A continuous wave, electronic, distance-measuring system developed from hiran by translation of the frequency to S-band (about 3 GHz).#

Shiran is no longer in use; it has been replaced by methods using artificial satellites.

shoe See *tripod*.

shoran #A pulse-emitting, electronic-ranging system originally designed for navigation of bombing aircraft and later adapted for navigation of airplanes taking photographs for geophysical exploration, for hydrography, and for geodetic surveying over long distances.#

Fundamentally, the system consists of a mobile transmitter-receiver-indicator unit and fixed receiver-transmitter units (transponders). Pulses are sent from the mobile unit and returned to it by the transponder. The indicator measures the time required for a pulse to make the round trip and converts this information into one-way distance to the nearest thousandth of a mile. The mobile unit and transponder must be practically intervisible, since at the frequencies used (between 200 and 300 MHz), radio waves travel practically in a straight line. In a large project for establishing control in Canada (1949-1957), the average length of a line was about 350 km, and a relative distance error of 1:56,000 was achieved. Shoran is no longer used for geodetic applications.

shore (1) #Land which is covered and uncovered by the rise and fall of the normal tide.#

(2) (of a sea) #The strip of land in immediate contact with the sea and lying between the high water line and the low water line.# In its strictest use, the term applies only to land along tidal waters.

(3) (of a stream) #The region between the bank of a stream and its low water line.#

shoreface #The narrow zone, seaward or lakeward from the *shoreline* at low water, that is permanently covered by water and over which the sands and gravel actively move with the action of the waves.#

shoreline (1) #The boundary line between a body of water and the land, in particular, the boundary line between the water and the line marking the extent of *high water* or *mean high water*.#

(2) The intersection of the surface of the land with the surface of a body of water.#

The shoreline shown on hydrographic charts represents the line of contact between the land and a water surface at a specified elevation. In regions affected by tidal fluctuations, this line of contact is usually the line of mean high water. In confined coastal waters of diminished tidal range, the mean water level may be used instead.

shoreline, apparent #The outer edge of marine vegetation (marsh, mangrove, cypress) delineated on aerial photographs where the actual shoreline is obscured.#

shoreline, ocean #The intersection of the ocean surface in some specified aspect with the shore or beach.#

For example, the high water shoreline would be the intersection of the surface, at *mean high water*, with the shore or beach.

The line delineating the shoreline on nautical charts of the National Ocean Service approximates the line of mean high water.

shoreline, river #A line that lies along the bank at the average level attained by the waters of a river wherever they reach the bank without overflowing it.#

short-arc method #The approximation of short segments of an orbit by using arcs of a curve that is simple compared to the curve used to approximate a whole or several whole revolutions.#

The short-arc method is used to determine coordinates of an unknown station from its observations and from observations made at known stations so close to it that orbital perturbations can be ignored over the observed arc.

shot (1) #A sighting or measurement from one point to another.#

(2) #A weight used in measuring depths of water.#

shot, side #A sighting or measurement from a survey station to locate a point which is not intended for use as a base for the extension of the survey.#

A side shot is often made to determine the location of an inaccessible object to be shown on a map.

shutter #The part of a camera that controls the admission of light to the photographic emulsion.#

shutter, between-the-lens #A shutter that is located between the elements of a camera's lens system.#

There are several varieties. The butterfly shutter has approximately the shape of a figure 8; it rotates about an axis that passes through the waist of the 8 and is parallel to the optical axis of the lens system. The disk of the rotating-disk shutter contains one or more radial slots and rotates like the butterfly shutter.

shutter, capping #A shutter mounted in front of the lens system of a camera.#

shutter, focal-plane #A shutter located just in front of the focal plane of a camera; it consists of a curtain containing a slit that is drawn from one side of the focal plane to the other.#

shutter, Kerr-cell #A shutter consisting of a *Kerr cell* and one or two polarizing plates arranged so that light passes first through one of the polarizers, then through the Kerr cell, and finally, if the light is properly polarized, through the second polarizer.#

shutter, louvre #A shutter consisting of a number of thin, parallel, and overlapping metallic strips that individually pivot simultaneously about their longitudinal axes to form either an opaque metallic screen (closed) or to let light pass between them (open).#

SI See *Système International d'Unités, le*

sidelobe See *lobe*.

sight (1) #The act of looking through an instrument (such as a telescope) at a distant mark and recording the reading of the instrument.#

(2) #The act of looking through an instrument at a distant mark.#

(3) #The measurement made as a result of looking through the instrument.#

sight, closing #The observation or measurement made to the last point of a survey when that point is also the first point of the survey, or is a point whose coordinates were established previously.#

sighting #Changing the orientation of an optical system until the *line of sight* is directed at a specified object or at a specified point on that object.#

sighting, double See *double-sighting*.

signal (1) #The component of an event that is itself, or which conveys, information.#

Noise is the accompanying component that does not convey information. What part of an event is signal and what part noise does not necessarily depend on the event itself but on the purpose for which the event is being observed. For example, to someone determining latitude by measuring the azimuth and zenith distance of a star, the direction that would be observed in absence of an atmosphere is signal, and the shifting of this direction, caused by anomalous refraction, is noise. To someone using the same star to determine anomalous refraction, the actual direction of the star is irrelevant and the shifting is the signal.

In short, a *signal* is any desired component of a transmitted or received message or wave, while noise is the accompanying, undesired component.

(2) #A natural or artifical object toward which a line of sight is directed for making a measurement.#

See *signal, triangulation* and *signal, survey*.

signal, eccentric #A *survey signal* that is not vertically above the point whose direction is desired.#

A computed correction is applied to an observed direction to convert it to what the direction would be if the survey signal were vertically above the point it represents.

The eccentric signal is called the eccentric object observed. See *center, reduction to*.

signal, hydrographic #A natural or artificial object that can be observed from a vessel or from land for use in determining the location of a vessel that is making soundings.#

signal, longitude #A signal made at a particular time, observable at different stations, and used in comparing local times at those stations to determine the differences of longitude.#

See *longitude determination*.

signal, survey #A natural or artificial object or structure whose horizontal (and sometimes vertical) location is determined by surveying; it is constructed so it can be observed easily and precisely.#

Survey signals are given special names to identify them with the kind of survey for which they are used.

signal, triangulation #A rigid structure erected over or close to a triangulation station and used for supporting instrument and observer, or target, or all three, in triangulation. Also any object, natural or artificial, whose location is determined in triangulation.#

A structure whose location is determined by triangulation, but whose primary purpose is to serve later in a hydrographic or topographic survey, is called a hydrographic or topographic signal.

signal-to-noise ratio #The quantitative ratio between the part of an event that is considered *signal* to the part that is considered *noise*.#

The measure most commonly used is power, but energy or amplitude may also be used.

sketch, progress See *progress sketch*.

sketch, reconnaissance See *reconnaissance sketch*.

SLAR See *radar, side-looking*.

slope, continental #A sharp seaward drop from the edge of a *continental shelf* to a greater depth.#

slope correction See *taped length, grade correction to*.

slope stake #A stake set on the line where a finished side slope of an excavation (cut) or embankment meets the original surface of the ground.#

smoothing (1) #The representation of a function, given by *N* terms of a series, by fewer than *N* terms of the series.#

The shorter series is usually obtained by dropping all terms of degree or frequency higher than a selected number less than *N*.

(2) #Using a function with fewer than *N* adjustable parameters to represent a set of *N* points.#

(3) #The process of obtaining an estimate of the value of a quantity at a specified time *t*, given that the data for obtaining the estimate are available for times both before and after *t*.#

This definition is equivalent to interpolation.

smooth sheet See *sheet, smooth.*

solar attachment #A device that may be attached to an engineer's transit or other kind of theodolite, to permit use of the instrument as a *solar compass.*#

solar constant (1) #The amount of energy received, over a unit area per unit of time, from the Sun at the average distance of a planet or satellite from the Sun.#

(2) In particular, #the amount of energy received per unit area per unit time from the Sun at the average distance of the Earth from the Sun (i.e., at the distance of 1 astronomical unit).#

This quantity is expressed as units of energy per unit area per unit of time. A well-accepted value, determined in 1972, for the solar constant of the Earth is 1,355 watts per square meter or 1.943 calories per square centimeter per minute.

solar wind #The flux of particles emitted by the Sun and sweeping through interplanetary space.#

This wind travels as a thin cloud (about five particles per cm^3 at the distance of Earth) at a velocity of about 400 km per second. The part of the solar wind reaching the Earth is deflected to form a many-layered sheath that bends the lines of the Earth's magnetic field. It also causes auroras and magnetic storms.

solar radiation pressure See *perturbation, radiation pressure.*

solstice #A point on the ecliptic midway between (90° from) the equinoxes.# See *solstice, summer; solstice, winter*; and *equinox.*

solstice, summer #The point on the ecliptic, north of the Equator, that is midway between (90° from) the equinoxes.#

The Sun attains its greatest northerly declination at the summer solstice; the corresponding time marks the beginning of summer in the Northern Hemisphere.

solstice, winter #The point on the ecliptic, south of the Equator, that is midway between (90° from) the equinoxes.#

The Sun attains its greatest southerly declination at the winter solstice; the corresponding time marks the beginning of winter in the Northern Hemisphere.

sonar (1) #An apparatus that detects the presence of, or determines the distance or direction of, an object underwater by receiving and interpreting sound from the object.#

The term is applied principally to apparatus that itself generates the sound; the object then reflects or scatters the sound back to the apparatus. It is also applied to apparatus that makes use of sound emitted by the object. Such apparatus is more usually called asdic.

sonde #An instrument, carried by aircraft, rocket, balloon or parachute, that measures atmospheric characteristics such as pressure, density, humidity, and temperature.#

Sondes may also be used to determine chemical composition or to bring back samples of the air. Balloon-borne sondes equipped with radio and radar reflectors are also tracked to determine wind velocity.

sounding (1) #A measurement of depth in water—usually a measurement of the distance of the bottom below the boat or ship from which the measurement is taken.#

(2) #The process of making measurements of depth in water.#

The usual method is to transmit a sonic pulse downwards and to measure the the time required for the pulse to travel to the bottom and back. Since the path of the pulse is considerably bent by refraction and the pulse itself also penetrates some distance into the bottom, both factors must be accounted for in depth calculations. In shallow water, greater accuracy often can be obtained by using weighted, graduated plumb lines, or by using graduated staves.

(3) #Depth of water referred to the datum (usually tidal) shown in the legend of a hydrographic chart.#

sounding, echo #A method of determining depths by measuring the interval of time it takes a sonic pulse to go from its source near the surface to the bottom and back again and then using the the velocity of sound in water and the elapsed time to calculate the depth.#

sounding, off #Any region where the depth cannot be measured by a *sounding line*; generally considered to be beyond the 100-fathom (200-meter) line.#

sounding, on #Any region where the depth of water can be measured by using a sounding line; generally considered to be within the 100-fathom (200-meter) line.#

sounding line #A graduated cord with a lead weight on one end; used for measuring depths in water.#

sounding pole #A 15-ft long round, wooden pole used for sounding in shallow water. It is graduated in feet and half-feet from the center towards both ends and numbered consecutively from the ends toward the center.#

southeasterly #A direction within 22.°5 of southeast.#

southerly #A direction within 22.°5 of south.#

southing See *latitude, difference of.*

southwesterly #A direction within 22.°5 of southwest.#

specific-volume anomaly See *steric anomaly.*

specifications (geodesy) #Those elements of a survey that are considered essential for the survey to meet the standards of accuracy for a particular category.#

In the practice of the U.S. National Geodetic Survey, the scheme of classification is based on specified standards of accuracy and not on the procedures needed to attain these accuracies. However, in practice, the criteria used for classification appear to be discretionary, and certain specifications may be used as criteria. See *classification.*

Among the elements specified are the number of observations to be made, the length of time and sequence of observations, the quality of the instruments used, the greatest or least distance permitted between observer and observed object, the shapes of the geometric figures involved, and the spacing of control points.

spectrum level #The level of that part of a signal contained within a band 1 cycle per second wide, centered at a particular frequency.#

speed (1) (mechanics) #Magnitude of *velocity*.#

It is the rate of change of the distance of a moving point or body from a fixed point; the distance is measured along the path taken by the moving point or body. Speed should not be confused with *velocity*, which is a vector and gives the direction as well as the rate of motion.

(2) (oceanography) #The rate of change of phase of a harmonic of the tides.#

(3) (photography) #A measure of the sensitivity of photographic emulsion to light.#

Roughly, the lower the speed of a film, the longer the film must be exposed to light of a given intensity to provide an image of given darkness (density). Speed is often expressed numerically according to one of several systems such as, e.g., H&D, DIN, ASA, and Scheiner.

speed, aerial film #A speed, for aerial film, that is defined as $3/(2H)$, where H is the exposure time in microseconds at the point on the characteristic curve where the density is 0.3 above base-plus-fog density on black-and-white film.#

The quantity replaces the aerial exposure index, now obsolete.

sphere (1) #Geometrically, the locus of all points equidistant from a given point.#

"Sphere" is also used for ball, although this is not good usage mathematically.

(2) #A unit of solid angle equal to the solid angle subtended, at a point, by an entire sphere having that point as center.#

The practical unit is the "centisphere", equal to 0.01 sphere or approximately 0.1257 *steradians*. The unit is used principally in calculations of illumination.

sphere, authalic #A sphere whose area is equal to that of a specified ellipsoid of revolution.#

If the length of the semimajor axis and the eccentricity of the ellipsoid are a and e, respectively, then the radius, r, of the authalic sphere is given by

$$r^2 = (1/2)a^2\,(1 - e^2)\{[1/(1 - e^2)] + (1/2e)\ell n[(1 + e)/(1 - e)]\}.$$

sphere, celestial #A sphere of indefinitely large radius described around a specified center upon which locations of celestial bodies are shown as points obtained by projecting the centers of the bodies onto the sphere along radii from the center of the sphere.#

In surveys involving observations on a celestial body, the direction, but not the distance, of the celestial body from the point of observation is important. For observations on bodies within the limits of the Solar System, the center of the celestial sphere is placed at the center of the Earth. For bodies outside those limits, the diurnal and annual parallax are negligible in surveying operations, and the center of the celestial sphere may be taken as being at the point of observation.

A number of points or great circles on the celestial sphere are used as referents for the establishment of coordinate systems. The most important of these are the poles (celestial and ecliptical), the equinoxes, and the solstices. The important great circles are the meridians, the Equator, and the ecliptic.

sphere, conformal #A sphere which is related to a specified ellipsoid of revolution by the formula

$$R = (N \cos \phi\; ds_1)/(\cos \chi\; ds_2)$$

where R is the radius of the sphere, N the radius of curvature in the prime vertical of the ellipsoid, ds_1 and ds_2 the elements of length on the sphere and ellipsoid, respectively, ϕ, the geodetic latitude, and χ the *conformal latitude*.#

See Thomas (1952: p. 86). See also *latitude, isometric.*

spherical excess #The amount by which the sum of the three angles of a spherical triangle exceeds 180°.#

In geodesy, in the computation of triangles, the difference between spherical angles and spheroidal angles is generally neglected, and spherical angles are used. Legendre's theorem is applied to the distribution of the spherical excess, i.e., approximately one-third of the spherical excess of a given spherical triangle is subtracted from each angle of the triangle.

spheroid (1) #Any surface differing but little from a sphere.#

(2) #An *ellipsoid of revolution.*#

(3) #A surface derived, by use of a standard formula for the Earth's potential, by giving the potential one specific value.#

Such a surface is intended to be an approximation to the geoid.

(4) #By extension, a surface close to the geoid or approximating the geoid.#

Although sense (2) has been widely used in geodetic literature, modern practice is to employ "ellipsoid of revolution" as a specific figure, and "spheroid" in sense (1) as a general term. Many reference ellipsoids of older vintage have been called spheroids (e.g., Bessel spheroid) and are so listed in this glossary.

spheroid, Airy 1830 #A reference ellipsoid used in adjustments of horizontal control in Great Britain. For the new (1936-1950) triangulation the dimensions were taken to be:

semimajor axis	20,923,713 ft	(6,377,563.541 m)
semiminor axis	20,853,810 ft	(6,356,257.053 m)
flattening (derived)		1/293.325#

The metric values were computed using for the ratio of the foot to the meter 0.304 800 756.

Also called Airy's Figure of the Earth.

spheroid, Australian National #A reference ellipsoid with the dimensions:

semimajor axis	6,378,160 m
flattening	1/298.25#

This is based on the *Geodetic Reference System 1967.*

spheroid, Bessel 1841 #A reference ellipsoid with the dimensions

semimajor axis	3,272,077.14 *toise*	(6,377,397.2 m)
semiminor axis	3,261,139.33 toise	(6,356,079.0 m)
flattening (derived)		1/299.152 8#

This is usually the ellipsoid meant when the "Bessel spheroid" is mentioned. It was used extensively for computation of triangulation in many parts of Europe. The metric values were computed using 1.949 036 31 meters per toise.

spheroid, Clarke 1858 #A reference ellipsoid with the dimensions:

semimajor axis	20,926,348 ft	(6,378,361 m)
semiminor axis	20,855,233 ft	(6,356,685 m)
flattening (derived)		1/294.26#

This is usually the ellipsoid referred to as the "Clarke 1858 spheroid". It was used in the triangulation of many British Crown colonies in Africa. The metric values were calculated using 0.304 800 47 to convert the foot to the meter.

Two other ellipsoids are also designated Clarke 1858. See Strasser (1957: pp. 42-43.)

spheroid, Clarke 1866 #A reference ellipsoid with the dimensions:

semimajor axis	20,926,062 ft	(6,378,206.4 m)
semiminor axis	20,855,121 ft	(6,356,583.8 m)
flattening (derived)		1/294.978#

This ellipsoid has been in use since 1880 in the United States of America for computing triangulation. The metric values were calculated using 0.304 797 26 to convert the foot to the meter.

spheroid, Clarke 1880 #A reference ellipsoid with the following dimensions:

semimajor axis	20,926,202 ft	(6,378,316 m)
semiminor axis	20,854,895 ft	(6,356,582 m)
flattening (derived)		1/293.465#

Metric values were calculated using 0.304 800 47 to convert the foot to the meter.

spheroid, eccentricity of See *eccentricity* (1).

spheroid, ellipticity of See *flattening.*

spheroid, Everest 1830 #A reference ellipsoid with the dimensions:

semimajor axis	20,922,931.80 ft	(6,377,276.345 m)
semiminor axis	20,853,374.584 ft	(6,356,075.416 m)
flattening (derived)		1/300.80#

The above values are in Indian feet, derived from the Indian 10-foot Standard Bar. A. G. Bomford used the ratio: 1 Indian foot equals 0.304 798 41 meters to get the above value for the semimajor axis. However, the value 6,377,301.243 m is also used in India and Pakistan. There is also an Everest spheroid of 1847 which was never used in triangulation.

spheroid, Fischer 1960 (1) #A reference ellipsoid with the dimensions:

semimajor axis	6,378,166.0 m
flattening	1/298.3#

It is used for the *Mercury 1960 datum.*

(2) #A reference ellipsoid with the dimensions:

semimajor axis	6,278,155.0 m
flattening	1/298.3#

It is used for the South Asia datum. Both were calculated by I. Fischer.

spheroid, flattening of See *flattening.*

spheroid, Hayford #A reference ellipsoid with the dimensions:

semimajor axis	6,378,388 ± 18 m
flattening	1/(297.0 ± 0.5)#

The ellipsoid was derived by Hayford (1909) using the theory of *isostasy* to determine the geoid to which the ellipsoid was fitted. Hayford's values for the length of the semimajor axis and flattening, but without the probable errors, were adopted by the International Association of Geodesy at its General Congress in Madrid in 1924, as the defining values of the *International Ellipsoid.*

spheroid, Krassovski #A reference ellipsoid used for horizontal control in the U.S.S.R. Its dimensions are:

semimajor axis	6,378,245 m
flattening	1/298.3#

It is derived from the *Krassovski ellipsoid* (1), which has axes of three different lengths.

spheroid, level (1) #A spheroid which is also an equipotential surface, i.e., a surface on which the gravity potential is constant.#

spheroid, Maclaurin #One of a series of stable, biaxial figures that a homogeneous, rotating, completely deformable body can assume.#

The other series consists of triaxial figures, known as *Jacobi ellipsoids*. The two series merge at a particular value of the product of density and rate of rotation; the Maclaurin spheroids are stable at higher values.

spheroid, Mercury 1960 See *spheroid, Fischer 1960* (1).

spheroid, reference See *ellipsoid, reference*.

spheroid, Schott 1900 #A reference ellipsoid developed by C. A. Schott as best fitting the region traversed by the Eastern Oblique Arc. Its dimensions are:

semimajor axis	6,378,157 ± 90 m
flattening	1/(304.5 ± 1.9)#

The Eastern Oblique Arc is a chain of triangulation that extends from Calais, Maine, to New Orleans, Louisiana.

spheroid, South American 1969 #A reference ellipsoid used in the *South American datum 1969*. Its dimensions are:

semimajor axis	6,378,160 m
flattening	1/298.25#

This reference ellipsoid is based on the Geodetic Reference System 1967.

spheroidal excess #The amount by which the sum of the three angles of a spheroidal triangle exceeds 180°.#

In geodesy, spherical rather than spheroidal angles are used, since the difference between the two kinds of angles is quite small even for the largest triangles and so is considered negligible for ordinary triangulation. See *spherical excess*.

spherop (1) #An equipotential surface in a *normal gravity field* of the Earth.#

Also called a *spheropotential* surface.

(2) #The surface defined by assigning a constant value to the potential in some series expansion of the Earth's gravity potential and taking only the first few terms of that series.#

spherop, Earth #A *spherop* containing a volume equal to the Earth's.#

Since the Earth's volume is not directly measurable but is calculated from radii of regular bodies representing the Earth and from elevations, the Earth spherop is known only approximately.

spherop, mareograph #A *spherop* that passes through a point at mean sea level at a specified tide gauge.#

spheropotential #The potential calculated from the *spheropotential function*.#

Also called normal potential, potential of the normal Earth, etc. Not to be confused with *spherop*, which is a surface defined by a particular value of the spheropotential in the spheropotential function.

spheropotential function (1) #The function yielding the *potential* of the *normal gravity field* given by

$$U = (GM/r)\,[1 + (C - A)\,(1 - 3\sin^2\phi')/(2Mr^2)] + (\omega^2 r^2 \cos^2\phi')/2$$

where M is the total mass of the Earth, C and A are moments of inertia about the axis of rotation and about an axis perpendicular to it, ω is the rate of rotation of the Earth, G is the gravitational constant, and the point at which U is to be calculated is at a distance r from the origin of the coordinate system and at an angle $(90° - \phi')$ to the axis of rotation.#

(2) #The function

$$U = (GM/r) \sum_{n=0}^{N} [(A_n/r^n)P_n(\phi') + \omega^2 r^2 \cos^2\phi'/2]$$

where P_n is an n-th degree *Legendre function*, and the constants A_n are n-th degree moments of inertia. The series is usually truncated at a small value of N (see *spherop* (2)).#

spheropotential number #The difference between the *spheropotential* on a *mareograph spherop* and the spheropotential on a *spherop* through a given point.#

It is calculated by integrating the normal value of the acceleration of gravity between the two points in increments in the direction of the *normal plumb line*.

Also called normal geopotential number.

spin #A rapid rotation.#

Sometimes used instead of rotation, for example, for the rotation of the Earth.

spiral #Any plane curve whose radius of curvature increases or decreases monotonically with distance along the curve.#

It can also be defined as a curve of the term $r = f(\phi)$, where r and ϕ are polar coordinates.

The spiral most used in surveying is the *clothoid* (Cornu spiral).

spiral, Archimedes #A curve for points on which the distance r from a fixed point is proportional to the angle ϕ of rotation about that point:

$$r = k\phi,$$

where k is a constant.#

spiral, Cornu See *clothoid*.

spiral, Ekman #In general, a polar diagram (i.e., in polar coordinates) showing how rotational velocity in a fluid varies with depth.#

In particular, a polar diagram showing the variation of wind-driven, oceanic currents with depth. It is often represented as a three-dimensional model (a helix); arrows representing the speeds and directions of the current at different depths are attached horizontally to a vertical rod on which depths are shown.

spiral, equiangular See *spiral, logarithmic.*

spiral, Euler #A curve along which the curvature at every point is proportional to the distance of that point from the start of the curve.#

spiral, logarithmic #A curve whose equation in polar coordinates (r, ϕ) is

$$\ln (r/K') = K\,\phi,$$

where K, K' are constants.#

Also called the equiangular spiral and the Bernoulli spiral.

spirit level See *level, spirit.*

spirit level instrument (1) #An instrument with an attached spirit level or the spirit level itself.#

(2) #A leveling instrument carrying a spirit level.#

(3) #An instrument for testing spirit levels.#

This is often called a level trier.

spring range, mean #The average semidiurnal range of tide at time of *syzygy.*# Also called spring range.

spring rise, mean #Elevation of *mean high water springs* measured above the basic surface of reference (chart datum).

Also called spring rise.

springs #The tides that occur when the Moon's phase is either full or new.#

Also called spring tides. These high tides are higher than when the Moon is in other phases. The term "spring" has nothing to do with the seasons; it denotes the rapid rise, or "springing" of the waters.

springs, high water See *water springs, mean high.*

square See *block.*

square, optical #A small, hand-held instrument that deflects a beam of light through 90°.#

Used to set up right angles in the field. See *sextant, box.*

stadia (1) #The plural of *stadium*.#

(2) #A *stadia rod.*#

(3) (adjective) #Involving a stadia rod or part of an instrument used in surveying with a stadia rod.#

stadia arc #A graduated, vertical arc on which graduations correspond to those vertical angles for which the difference in height is a simple multiple of the *stadia rod* interval.#

The graduations may be on the vertical circle of the surveying instrument or on an auxiliary arc. Also called a stadia circle. The original design of the stadia arc was by W. M. Beaman of the U.S. Geological Survey.

stadia circle See *stadia arc.*

stadia constant (1) #The sum of the focal length of a telescope and the distance from the vertical axis of the instrument to the center of the objective lens.#

Also called anallactic (or anallatic) constant.

(2) See *stadia factor.*

stadia factor (1) #The constant that is multiplied by the *stadia interval* to obtain the distance from the leveling or stadia rod to the front focal point of a surveying instrument (*tachymeter*).#

(2) #The constant by which the sum of the stadia intervals for all sights of a running is multiplied to convert to the length of the running.#

Also called a stadia ratio.

Either constant, (1) or (2), is also called a stadia constant. However, *stadia constant* is better reserved for the distance from the vertical axis of a transit or leveling instrument to the front focal point of the objective lens.

stadia intercept See *stadia interval.*

stadia interval #The length of graduated rod seen between the upper and lower cross hairs in a telescope.#

Also called stadia intercept.

stadia ratio See *stadia factor.*

stadia rod #A graduated rod used to determine distance by observing the amount of rod that subtends a small, known angle at the point of observation.#

In practice, the angle is usually fixed by two lines in the reticle of a telescope on a theodolite or on a telescopic alidade.

stadimeter #An instrument for determining the distance to an object of known height by measuring the angle subtended at the observer by the object.#

The instrument is graduated directly in units of distance. See *range finder* and *tachymeter.*

stadium #An ancient length measure based on the length of the field in an architectural structure (called a stadium) in which races and other spectacles were held.#

The Greek stadium (measure) was 600 Greek feet long, but the length of the Greek foot varied according to the length of the stadium (structure) involved. The Olympic stadium (measure) was equal to 192.3 meters. The Roman stadium (measure) was equal to 625 Roman feet or 184.8 meters.

staff gauge #The simplest form of tide gauge or *stream gauge,* consisting of a graduated staff securely fastened to a pole or other suitable support.#

It is so designed that part of the staff will be below lowest *low water* when mounted and the above-water remainder will be in position for direct observation from the shore or other vantage point. See *tide gauge.*

stake, slope See *slope stake.*

Stampfer level See *leveling instrument, Stampfer.*

stand #The condition, at either high or low water, when there is no change in the height of the water level.#

Also called stand of tide.

standard (1) #An object, force, or other physical entity that, under specified conditions, defines, represents, or records the magnitude of a unit of measurement.#

For example, the meter bar at Sevres was at one time a standard of length. It has on it two marks; the distance between these is defined to have the value "1 meter". All distances expressed in the metric system were given as a multiple or submultiple of this distance. The standard of length is now the wavelength of a particular kind of electromagnetic radiation. See *length, standard of.*

(2) #An agreed-upon procedure within a particular industry or profession, that is to be followed in producing a particular product or result.#

(3) #A set of characteristics, such as dimensions or color, that must, by agreement within a profession or industry, be possessed by a product of that profession or industry.#

Such a standard, usually called an industrial standard in the United States, is established to ensure that the products are more or less interchangeable in use, or to promote efficiency in manufacturing, e.g., standards for the dimensions and material of screws, nuts, and bolts.

(4) #A number, or set of numbers, established within an industry, a science, or a technology, setting limits on precision or accuracy with which operations, measurements, or products are to be made.#

In manufacturing, these standards are sometimes referred to as "standard tolerances".

standard, laboratory #A measuring device that has been calibrated by direct comparison of its scale or measurements with the scale or measurements of a *primary standard,* and that has been calibrated with sufficient accuracy to permit its use for calibrating other, similar measuring devices.#

Also called a secondary standard.

standard, primary #A standard that is correct by definition, and to which other measuring devices are referred for calibration.#

A primary standard is often referred to simply as *the* standard.

standard, working #A measuring device, calibrated with a *laboratory standard,* that is used for calibrating other measuring devices which may *not* be used for calibration.#

A working standard is usually the last and least accurate of the measuring devices in the chain: primary standard, laboratory standard, and working standard.

standard deviation (1) #The quantity, s_x, of a set $\{x_n\}$ of N random numbers with an average value $\bar{x}$, and a proportional weight (w_n) for each x_n, given by

$$s_x = \left[\sum_{n=1}^{N} (x_n - \bar{x})^2 \, w_n/(N-1)\right]^{1/2}.\#$$

(2) #If x is a continuous, random variable with probability density $p(x)$, the quantity, σ_x, given by

$$\sigma_x = +\left[\int_{-\infty}^{+\infty} (x - \bar{x})^2 \, p(x)dx\right]^{1/2}$$

in which $\bar{x}$ is the average value of x.#

Other terms for standard deviation are standard error, mean error, and dispersion. These terms have unfortunately acquired a multiplicity of meanings and should not be used when clarity is desired.

Standard deviation is sometimes restricted for use with populations with a *Gaussian distribution*, while root-mean-square (rms) error is used with populations with any kind of *distribution.*

standardization (1) #The establishment and mandatory use of standards.#

(2) #The physical correction or adjustment of a measuring device to make its units of measurement correspond to those of a standard.#

(3) See *calibration.*

standards of accuracy #Numbers used for classifying control or surveys into categories according to their average accuracy or precision.#

The national geodetic organizations of most countries have established categories for classification of geodetic control and surveys. The classification used by the U.S. National Geodetic Survey contains three major categories (orders), some of which are divided into two subcategories (classes).

See *classification* and *control, classification of.*

standpoint #The point from which an observation is taken in surveying.#

star #Any continuous, self-luminous celestial body such as the Sun.#

Stars are approximately spherical, gaseous bodies that obtain their energy by one of several different processes of atomic fission and fusion.

star, circumpolar (1) #A star whose apparent path in the sky does not pass below the horizon of an observer.#

The latitude of the observer as well as the declination of the star determines whether the star is circumpolar or not.

(2) #A star whose declination is equal to or greater than 90° minus the latitude of observer.#

star, equatorial #A star whose declination is close to 0°.#

Because of their greater angular rate of motion in azimuth or angular elevation, such stars are preferred over stars with greater declination for determining time and longitude.

star catalog (1) #A compilation of coordinates (positions) of stars.#

Star catalogs generally give for each star: an identifying number or name; its photovisual, apparent magnitude; its coordinates (right ascension and declination); the epoch to which the coordinates refer; and its proper motion. A number of different types of star catalogs are recognized; the type depends on the nature or source of the coordinates.

(2) #A star catalog, in the sense of the preceding definition, except that the coordinates have been fully reduced.#

Star catalogs of measured coordinates, such as annual star catalogs are not star catalogs in this sense.

star catalog, absolute (1) #A star catalog containing an extensive list of coordinates referred to a coordinate system associated directly with the observing instrument.#

For example, a star catalog containing right ascensions all of which have been determined by using a meridian circle would be an absolute star catalog.

(2) #A star catalog in which the stars' coordinates are in a system that does not depend on previously known stellar coordinates; e.g., the coordinates are found by observation of the asteroids, other planets, etc.#

star catalog, annual #A list of measured, but not fully reduced, stellar coordinates.#

star catalog, Boss See *star catalog, compilation.*

star catalog, compilation #A star catalog prepared by combining coordinates given in more than one independent catalog.#

The most important compilation catalogs for geodetic purposes, have been: (a) the *General Catalog of 33342 Stars for the Epoch 1950,* by Benjamin Boss and six collaborators (1937), and (b) the Smithsonian Astrophysical Observatory's (1966) *Star Catalog: Position and Proper Motions of 258,997 Stars for the Epoch and Equinox of 1950.* The (Boss) General Catalog is a *fundamental star catalog,* but by 1981 the coordinates obtained from it contained rather large errors because of uncertain proper motions. The Smithsonian Astrophysical Observatory's catalog is a compilation but not a fundamental star catalog.

star catalog, fundamental #A *compilation star catalog* in which the coordinates have been adjusted (by analyzing differences between positions given in the various catalogs) to give positions as precisely and accurately as possible.#

For the geodesist, the most important fundamental star catalogs are the ones designated as FK3, FK4 and FK5, which contain the mean right ascensions and declinations for 1535 stars for epoch and equinox 1950.0, and the annually published star catalogs *Apparent Places of Fundamental Stars* which contain positions derived from those in FK3 and its successors.

star catalog, independent #A star catalog that gives coordinates which were measured and reduced solely for that catalog and which are not based on previously published and fully reduced coordinates.#

Also called an observation star catalog.

star catalog, observation See *star catalog, independent.*

star catalog, relative #A star catalog that gives the star coordinates in a coordinate system defined by previously determined coordinates of certain reference stars.# Thus the coordinates in a relative star catalog are with respect to the coordinates of the reference stars.

star catalog, zone #A star catalog devoted to stars within a narrow band of declinations.#

It is usually referred to simply as a zone catalog. The *Yale Zone Catalogs* and the *Astrographic Catalogs* are outstanding examples.

star factor #One of the coefficients in *Bessel's formula* (for difference of observed and calculated times of transit) as used in astronomic geodesy, i.e., a factor accounting either for errors in azimuth, or inclination of axis, or for error in collimation of the telescope.#

star number, Besselian See *day number, Besselian.*

State, public-land See *public-land State.*

State coordinate system See *coordinate system, State plane.*

state vector (1) #A vector, in six-dimensional space, from the origin to a point whose coordinates are the three coordinates of location and the three components of velocity.#

An example in Cartesian coordinates is a vector with the components $(x, y, z, \dot{x}, \dot{y}, \dot{z})$.

(2) #A vector whose components describe the state of a physical system at a particular instant.#

station (1) #A physical location or site at which, from which, or to which observations have been made.#

(2) #A point representing the physical location or site at which, from which, or to which observations have been made.#

The principal kinds of station, named for the kind of observations made there, are: air station, gravity station, magnetic station, survey station (including bench marks and triangulation stations), and tide gauge or tidal station. Stations are also classified according to their order of importance: base station, principal station, supplementary station, etc.

(a) In particular, in oceanography, it represents the place at which a ship makes an observation. A station is usually identified by the name of the vessel involved, the longitude and latitude of the station, the time, and an identifying numerical or alphanumerical code, such as, BROWN BEAR M-1035 180° E, 0° N, 1977 Nov 12, 1200 GCT.

(b) In photogrammetry, the term is used to denote a point (also called common station) at which a photograph has been taken. The point is generally at the camera's center of perspective. If the photograph was taken from an aircraft, the station is referred to as an air station.

station, A- See *A-station.*

station, air See *air station.*

station, astronomic #A point whose location on the Earth has been determined by observations on celestial bodies.#

Usually, therefore, a point with known astronomic longitude and latitude.

station, B- See *B-station.*

station, base (1) #A station on a base line.#

(2) #A station at which a sufficiently large number of accurate measurements have been made, so that instruments can be calibrated there or measurements made elsewhere can be referred to the value at the base station.#

For example, a point at which gravity has been measured is a base station if gravity can be found accurately at other points by measuring the difference between gravity at these other points and the gravity at the base station.

(3) #An electrical instrument that transmits or receives radio signals used for navigation, location, or positioning.#

If the instrument is kept at a fixed place of known location, it is called a fixed station; if it is moved from place to place, it is called a mobile station. When one instrument controls the transmission or reception of others, that instrument is called the master station and the other instruments slave stations. The kind of instrument is often shown by a prefix, e.g., *hiran* station or *loran* station.

station, control (1) #A point on the ground whose horizontal or vertical location is used as a basis for obtaining locations of other points.#

(2) #A *survey station* whose coordinates are accepted as being sufficiently accurate so that the coordinates of other survey stations can be determined by reference to it.#

station, drift #The particular *navigation station*, of a pair, from which a craft doing a hydrographic survey tries to maintain a fixed distance.#

The second station of the pair is then called the *rate station*.

station, eccentric (1) #A point over which a surveying instrument is centered and observations are made, but which is not in the same vertical line with the station that it represents and to which the observations will be reduced before being combined with observations at other stations.#

In general, an eccentric station is established and occupied when it is impracticable to occupy the intended station or when points to which observations must be made are not visible from the intended station. Because the data resulting from the occupation of an eccentric station are referred to the intended station (which should be marked with a permanent geodetic marker) the mark at an eccentric station is usually temporary. See *center, reduction to*.

(2) #A station, located above or below the observing instrument, whose elevation difference is measured and is used to compute the elevation of the station.#

station, full See *profile leveling*.

station, gravity #A point at which gravity has been measured.#

station, ground #A monumented *survey station* at which is placed equipment for use in obtaining locations of an aircraft taking photographs.#

station, hiran See *station* (2), and *hiran*.

station, instrument #The point over which a leveling instrument is placed for taking a backsight, a foresight, and such other sightings as may be necessary from that point.#

Except in rare instances, instrument stations in a level line are not marked points. See *setup*.

station, intersection #An object or point whose horizontal location is determined by observations from other survey stations; no observations are made at the object or point itself.#

If the object is observed from only two stations, the location is called a no-check position, as there is no proof that such observations were free from blunders. Intersection stations either are at places which would be difficult to occupy, or are survey signals whose locations can be determined with sufficient accuracy without being occupied.

station, Laplace #A triangulation or traverse station at which a *Laplace azimuth* is observed.#

At a Laplace station, both astronomic longitude and astronomic azimuth are observed.

station, loran See *station, base* (3), and *loran*.

station, magnetic #A monumented station at which measurements of the Earth's magnetic field have been made.#

It usually consists of a bronze marker, set in stone or concrete, on which the magnetic intensity at the marker is added to the normal markings.

station, master #The station, in a group of *navigation stations*, that controls the transmissions or reception of the other (slave) stations.#

If pulses are transmitted, the master station controls the timing between the pulses sent out by all stations.

station, navigation #An instrument, more or less permanently emplaced at a known location, to assist in navigation.#

station, occupied #A station, in a particular survey, at, or from which, observations have been made that can be used in that survey.#

An unoccupied station is a station at, or from which, such observations have not been made.

station, plus #An intermediate point on a surveyed line that is not at an integral number of tape lengths from the initial point.#

See *distance, plus*.

station, principal #A *survey station* used in the extension of a survey network or part of the original network to which the new network is connected.#

Also called a main-scheme station. A principal station serves primarily for the continued extension of a survey; this purpose requires that its location be determined with higher accuracy and precision than if the station were to be used only to control local surveys or to help establish supplementary stations.

station, projection #The position of a projector, in a stereoscopic plotting instrument, when absolute orientation has been completed.#

This position reproduces the geometric conditions existing at the corresponding camera station at the instant of exposure.

station, rate See *station, drift*.

station, recovered #A *survey station* which, upon being revisited, is identified as authentic and is proved to be occupying its original site.#

See *recovery of station*.

station, recovery of See *recovery of station*.

station, slave #Any instrument, in a group of instruments, whose transmission or reception is controlled by another instrument (the master station) in the group.#

Often shortened to "slave".

Also called a remote station or a remote.

station, subsidiary #A station established to overcome some local obstacle to the progress of a survey, and not primarily to determine a point in the survey.#

The term subsidiary station is often used to indicate *A-stations* of a traverse. A subsidiary station usually is temporary and so is not permanently marked. If it serves the additional purpose of supplying control for a local survey, such a station may be permanently marked; it is then called a supplementary station.

station, supplementary #A *survey station* established either to increase the number of control stations in a given area, or to mark a desired location where it is impracticable or unnecessary to establish a *principal station.* #

A supplementary station is permanently marked and is established at an accuracy and precision somewhat lower than that required for a principal station, since extensive surveys are not made from it.

See *station, subsidiary.*

station, survey See *survey station.*

station, total See *total station.*

station, tracking #Any complete set of equipment for observing a moving object such as an airplane, a satellite, a meteor, or a ship.#

In particular, a set of equipment which can also measure one or more components of the object's location or velocity in a local coordinate system.

station, traverse #A point which has had its location determined by *traverse.* #

station, triangulation #A point which has had its location determined by *triangulation.* #

station, unoccupied See *station, occupied.*

station adjustment See *triangulation adjustment, local.*

station error *#Deflection of the vertical.* #

station pointer See *protractor, three-arm.*

statoscope #A sensitive *barometer* used in aerial photography for measuring small differences in altitude between succesive *air stations.* #

A differential *altimeter.*

step #The distance, in the normal way of walking on level ground, between the point at which the heel of the left foot first touches the ground and the succeeding point at which the heel of the right foot first touches the ground.#

It is half the length of a *Roman pace.*

Stephenson leveling rod See *leveling rod, Stephenson.*

step wedge See *gray scale.*

steradian #The solid angle subtended, at the center of a sphere, by a region on the surface of the sphere with an area equal to that of a square whose sides are equal in length to the radius of the sphere.#

The total surface of a sphere subtends 4 π steradians.

stere #One cubic meter.#

stereo, pseudoscopic #The three-dimensional impression of relief opposite to that actually existing; such an impression is obtained when the photographs of a stereoscopic pair are interchanged.#

Also called false stereo, inverted stereo, and reverse stereo. See *pseudoscopy*.

stereocomparagraph #A simple stereoscopic plotting instrument in which each photograph is viewed separately by reflection from a pair of mirrors. The mirrors are mounted on a base with a parallax bar, a drawing attachment, and a parallel-motion mechanism.#

stereocomparator (1) #A stereoscopic instrument for measuring parallax on a pair of photographs.#

(2) #A stereoscopic instrument for measuring simultaneously the coordinates of corresponding images in a stereoscopic pair of photographs.#

See *comparator, stereoscopic.*

stereocompilation See *compilation* (2).

stereogram #A *stereoscopic pair* of photographs or drawings correctly oriented and mounted (or projected) for stereoscopic viewing.#

stereograph (1) #A *stereometer* used to plot topographic detail from a *stereogram* by means of an attached marker.#

steromate #One picture of a *stereoscopic pair.* #

stereometer #A *stereoscope* containing a micrometer by means of which the separation of two index marks can be changed to measure parallax difference on a *stereoscopic pair* of photographs.#

Also called a parallax bar.

stereophotogrammetry #Determination of the geometric characteristics of an object by measurements on images of the object as seen from different points.#

In particular, determination by measurements on photographs taken from two different points in such a way that the same region is shown on both photographs. Much of photogrammetry is stereophotogrammetry. Hence, it is customary to omit the prefix "stereo" and to speak merely of *photogrammetry*; the meaning is usually clear from the context.

stereoplotter See *plotting instrument, stereoscopic.*

stereoplotting #Photogrammetry done with a *stereoscopic plotting instrument.* #

stereoscope #An optical device that gives an observer the impression of viewing a three-dimensional object when one is actually viewing two two-dimensional images placed side by side.#

The general principle is to two views of a single scene photographed from two different points sufficiently close together so that, by using a stereoscope, the separate images, viewed together, appear to be a single three-dimensional image.

See *anaglyph.*

stereoscopic pair #A pair of photographs each showing the same object from a different but nearby point so that, when the two are placed close together, one eye looks at a part of one photograph and the other eye looks at the corresponding part of the other photograph. The result is an apparent three-dimensional effect.#

stereotemplet #A composite, from a pair of *slotted templets*, adjustable in scale and representing the horizontal plot of a stereoscopic model.#

An assemblage of stereotemplets provides a means of doing aerotriangulation with a stereoscopic plotter not designed for stereotriangulation.

stereotriangulation *#Phototriangulation* using a *stereoscopic plotting instrument.* #

Also called bridging, instrument phototriangulation, multiplex triangulation, triangulation, and stereotriangulation.

Because most stereotriangulation is done using aerial photographs, the above definition is often thought of as applying to *aerotriangulation* in particular rather than to *phototriangulation* in general.

steric anomaly #The difference between the reciprocal of the actual density of a sample of sea water and the reciprocal of the density of sea water at 35 percent salinity, temperature at 0°C, and at the pressure measured at the sample.#

stick #A length of 2 *chains.* #
The term is used in some surveyor's field notes and deeds in the United States during the early 1800's.

stilling well #A large enclosure placed around a tide gauge to prevent waves from affecting the gauge.#
The enclosure reaches from the bottom to above the greatest expected wave heights. Small holes a short distance above the bottom let water flow slowly in or out.

Stokes' formula #The formula for the *geoidal height* N_P of a point P given by

$$N_P = \left[\iint_S F \Delta g dS\right] / 4\pi \bar{g} \bar{R}$$

where $\bar{g}$ and $\bar{R}$ are average values of gravity and radius of curvature, respectively, over the geoid; dS is an element of area on the surface S; Δg is the *gravity anomaly* at a point on the geoid at distance s from P, and F is the function

$$F = \text{cosec}\ \sigma + 1 - 5 \cos 2\sigma - 6 \sin \sigma$$

$$- 3 \cos 2\sigma\ \ell n\ [(1 + \sin \sigma) \sin \sigma]$$

where σ is $s/2\bar{R}$. #
The formula is based on the assumptions that all matter lies inside the geoid, that the ellipsoid to which the geoidal heights are referred has the same volume as the geoid with its center at the Earth's center of mass, and that Δg is known over the entire surface of the Earth. F is known as Stokes' function.

Stokes' function See *Stokes' formula*

stool, taping See *taping stool.*

stop #Any part of an optical system that limits the angular size of the bundle of rays coming from the object.#
There are four principal kinds of stops: the *aperture stop*, the *field stop, the vignetting stop* and the *glare stop.*

stop, aperture (1)#The opening in an optical system which determines the largest apex angle of a cone of rays from a point in object space, from which all rays within the cone pass entirely through the optical system.#
(2) #The opening in a lens system which limits the area of the lens through which light can pass to the field stop.#
Adjusting the size of the aperture stop of a given system regulates the brightness of the image without necessarily affecting the size of the image.
Also called stop.

stop, field #The opening in an optical system which determines the largest angle for which principal rays from points in object space will pass through the system.#
The field stop determines the field of view of the optical system.

stop, glare #Blackened elements placed to intercept unwanted light from bright, outside sources, or from light scattered or reflected inside an optical system.#

stop, vignetting #A *stop* introduced into an optical system to cut off rays passing through parts of the system that cause large aberrations.#

storage factor #The quantity 2 π (average energy stored per cycle/energy dissipated per half cycle), which characterizes the ability of a system to store energy.#
Usually denoted by Q and therefore called the Q factor of the system. Also called the specific dissipation factor by some geophysicists.

strain gauge (1) #A device for measuring small dimensional changes in an object.#
It is usually used for measuring the effect of torsion, compression, etc., on a specimen.
Also called *extensometer*, strainometer, or strainmeter.
(2) See *extensometer.*

strain meter See *extensometer.*

strainometer See *extensometer.*

stratosphere #The portion of the atmosphere, lying between the *troposphere* (which ends at about 8 to 11 km) and the *mesosphere* (which begins at about 50 km), in which the temperature remains nearly constant or increases with altitude.#
The bottom of the mesosphere, the region in which the temperature begins decreasing again, is at about the same altitude as the bottom of the *ionosphere*. The stratosphere has little geodetic significance. It is too rarified to substantially refract either light or radio waves at frequencies higher than about 1 GHz; because it is not ionized, it does not greatly affect radio waves at frequencies lower than about 1 GHz.

stream gauge #A graduated staff placed vertically on the bed of a stream or river to measure changes in the elevation of the stream surface, or to measure its elevation above a specified surface.#
Also called a river gauge.

strength of figure #The comparative precision of computed lengths in a triangulation network as determined by the sizes of the angles, the number of conditions to be satisified, and the distribution of base lines and points of fixed location.#
Strength of figure in triangulation is not based on an absolute scale but rather is an expression of relative precision. The strength of figure number is really a measure of a network's weakness, since it increases in size as the strength decreases. The strength of figure, N_F, derived from that part of the formula for probable error of a triangle's side which is independent of the accuracy of the observations, is given by

$$N_F = [N_d - N_c)/N_d]\ \Sigma(\delta_A{}^2 + \delta_A \delta_B + \delta_B{}^2)$$

in which N_d and N_c are the numbers of directions observed and of conditions to be satisified, respectively, and δ_A and δ_B are the rates of change of the sines of the *distance angles* A and B.

stride #The distance a pedestrian moves in taking two *steps*.# See *pace*.

strike #The direction of the line of intersection between a horizontal plane and the plane of a stratum, fault, etc.#

strip (1) #A set of overlapping photographs that can be arranged in sequence so that, except for the last photograph, part of the object space shown in one photograph is also shown in the succeeding photograph.#

(2) #A set of overlapping photographs obtained sequentially from a moving aircraft or satellite.#

(3) #A single, strip-like photograph, made by sequentially exposing narrow crosswise sections of film through a moving slit when photographing a fixed object, or by exposing the film through a fixed slit when photographing a moving object.# See *camera, continuous-strip*.

strip adjustment See *aerotriangulation adjustment, strip*.

summation convention #The convention that if any index (subscript or superscript) appears more than once in a product of indexed symbols, the product is to be evaluated for each value of the repeated index and the sum of all these products taken.#

For example, by this convention, the sum of

$$(x_1)^2 + (x_2)^2 + \ldots + (x_N)^2$$

can be written simply as $x_i x_i$ instead of

$$\sum_{i=1}^{N} (x_i)^2.$$

Sumner line #A short segment of a *circle of position*, represented as a straight line.#

Also called a line of position.

Sumner method #A method of obtaining location on a map by two observations of the angular elevation of a star. The observations are used to plot two points on a line of position, and a straight line (the *Sumner line*) is drawn between them.#

The line is a chord, rather than the tangent to the *circle of equal altitudes*.

The Sumner method was devised by Thomas H. Sumner in 1843. The *St. Hilaire method* is a special adaptation of the Sumner method to navigation.

Sun (1) #When written "sun", a synonym for star.#

(2) #When written "Sun", the star about which the Earth revolves.#

The prefix "helio-" is used to create terms pertaining only to the Sun, such as heliocentric coordinates, heliometer, and *heliotrope*.

The principal physical characteristics of the Sun are given by the following constants.

aberration	20."47
area	6.09 (10^{18}) m^2
rotational period (sidereal)	25.38 days
density, average	1.41 (10^3) kg/m^3
gravity at surface	274 m/s^2
magnitude (visual)	−26.8
mass	1.99 (10^{30}) kg
parallax, mean horizontal	8."8
radius	696 (10^3) km

Sun, mean #A fictitious Sun which is considered to move in the celestial Equator at a uniform speed corresponding to the average angular speed of the Sun in the ecliptic.#

Sun, true (1) #The actual or real Sun; the object on which astronomical observations are made.#

(2) #An abstract body whose center coincides with the *barycenter* of the actual Sun as observed from the Earth.#

The concept is in contrast to that of the mean Sun, whose center moves uniformly along the path of the actual Sun.

sundial #An instrument that indicates the local Sun time by using an object to cast a shadow onto a calibrated dial.#

The position of the shadow indicates the hour angle of the Sun. The object that casts the shadow is called a gnomon.

sundial, analemmatic #A *sundial* which has on it an *analemma* for converting apparent solar time (indicated by the real Sun) to the mean solar time indicated by the *mean* Sun.#

surface, Cartesian #In optics, a surface whose reflective or refractive properties are such that all rays proceeding from a point in space to that surface continue from the surface to another previously specified point.#

surface, developable #A surface that can be flattened without tearing or stretching.#

The cone and the cylinder, after cutting along a generating element, are examples of developable surfaces. The two principal geodetic applications of developable surfaces are (a) for use as intermediaries in the mapping of a spheroid onto the plane, and (b) for sectioning the Earth's surface and so creating a profile of that surface.

surface, equipotential #A surface with the same *potential* (usually of gravity or of gravitation) at every point.#

Since the potential is the same at every point, no work is done when a body (point mass) is moved about on such a surface. When bodies of the same mass are moved from one equipotential surface to another, the same amount of work is developed or expended regardless of the route followed. An equipotential surface is also referred to as a *level surface*. A particular equipotential surface may be identified by its *dynamic number*.

surface, geopotential (1) #A surface on which the Earth's gravity potential is constant.#

Equivalently, any surface along which a body can be moved at constant velocity without doing work against the Earth's gravitational and centrifugal forces.

Also called a level surface.

(2) #A surface on which the gravity potential of the Earth is defined, specified, or known.#

Because the term is ambiguous, it should not be used without first being carefully defined.

surface, isobaric #A surface over which the pressure is constant.#

The concept is primarily of meteorological and oceanographic interest. In *oceanographic leveling,* the surface needed as a referent for leveling is the one where an isobaric surface and an equipotential surface coincide over the region of interest. It is commonly identified as the level at which there is no movement of the water.

An aircraft flying at an indicated constant altitude follows an isobaric surface. This surface is *not* parallel to the geoid, in general, nor is it parallel to or related in any simple way to sea level or mean sea level. Therefore altitudes obtained by profiling from an airplane cannot be subtracted from the altitudes indicated by the airplane's barometric altimeter to obtain elevations of points on the ground.

surface, level #An *equipotential surface* of the gravity field.#

The force of gravity is everywhere perpendicular to this surface. The surface of a body of still water is a level surface. The surface of the ocean, if disturbances caused by tides, currents, winds, atmospheric pressure, and so on, are not considered, is a level surface. The surface of the geoid is a level surface. With respect to the Earth, level surfaces are approximately ellipsoidal, the distance between any two level surfaces decreasing with increase of latitude. For example, a level surface which is 1000 m above the average surface of the sea at the Equator is 995 m above that surface at the poles.

surface, principal #The locus of intersections of straight lines representing rays incident on an optical system (and parallel to the optical axis) with straight lines representing the same rays after they leave the optical system.#

In any optical system, there are two principal surfaces (which may be coincident): one is created by rays entering from the left and leaving at the right, the other by rays entering from the right and leaving at the left. The principal surface is sometimes called the *principal plane*. This term, however, should be applied only to that part of the principal surface that lies in the paraxial region. The intersection of the principal surface with the optical axis is called a *principal point.*

surface, ruled #A surface that is generated by moving a straight line through space. Alternatively, a surface through every point of which passes at least one straight line.#

surface, spheropotential See *spherop.*

surface density layer See *density layer.*

survey (1) #The orderly process of determining data relating to any physical, chemical, or geometric characteristic of the Earth.#

The list of orderly processes which may properly be called "surveys" is long. It may be divided into classes according to the type of data obtained, the methods and instruments used, the purposes to be served, etc. For example, there are geodetic, topographic, hydrographic, land, geologic, geophysical, soil, mine, and engineering surveys.

(2) #The *data* obtained by a survey as defined above.#

The data obtained in a particular project may be designated by the name of the project, such as, "The topographic survey of the District of Columbia".

(3) #An organization engaged in making a survey as defined above.#

Such an organization is often given an official name which includes the word survey; for example, "The United States Geological Survey" or "The National Geodetic Survey".

survey, ABC See *survey, Airborne Control.*

survey, aerial #A survey in which aerial photographs are the primary source of data.#

survey, Airborne Control #A method of surveying, in which distances and horizontal and vertical angles are measured from two or more known points to an aiming point on a helicopter hovering over an unknown location on the ground.#

The distance of the unknown location beneath the helicopter is determined with a graduated plumb line.

survey, balancing a See *traverse adjustment.*

survey, basic #A *hydrographic survey* so complete and thorough that it need not be supplemented by other surveys and is adequate to supersede, for charting, all earlier hydrographic surveys of the region.#

survey, boundary See *boundary survey.*

survey, cadastral #A survey, relating to boundaries and subdivisions of land, made to create regions suitable for transfer or to define the limitations of title.#

Derived from *cadastre,* meaning a register of the real property of a political subdivision with details of area, ownership, and value. The term cadastral survey is also used in the United States to designate the surveys of the public lands, and retracement surveys for the identification or restoration of property lines.

survey, Cape Canaveral #A survey made in the vicinity of Cape Canaveral, Florida, to determine the geodetic coordinates of nine ballistic cameras located there. In the adjustment, the horizontal geodetic coordinates of two points of the CENTRAL and CENTRAL S.E. bases were held fixed to their values on the North American 1927 datum. The Clarke 1866 spheroid was used, and the geoidal height at one station was set equal to zero.#

The above constants are sometimes referred to as the Cape Canaveral datum or the Cape Kennedy datum. However, the network orientation was determined using several Laplace stations, so more conditions were set on the network than can be satisfied by a datum.

survey, completion #A survey made to finish a partially subdivided township or section or to finish parts of boundaries of townships or sections that had not been surveyed previously.#

See *survey, extension*.

survey, control #A survey that provides coordinates (horizontal or vertical) of points to which supplementary surveys are adjusted.#

The fundamental control surveys of the United States of America provide the geodetic and plane coordinates of thousands of triangulation and traverse stations and the elevations of thousands of bench marks that are used in hydrographic surveys of the coastal waters, for control of the national topographic survey, and for control of surveys by State, city, and private organizations.

survey, dependent #A survey that derives the coordinates of points in the survey from the coordinates of points determined by a previous survey, accepting these earlier coordinates without change.#

The previous survey is sometimes called a higher-order survey. While the previous survey usually is of a higher order or accuracy than the dependent survey (see *control, classification of*), it need not be and sometimes is not. The terms higher-order and lower-order (for the dependent survey) should therefore not be used in this way. The term *dependent resurvey* has an entirely different meaning.

survey, detailed #A survey which takes account of the smaller features in the region surveyed.#

The term is relative, but is usually applied only to surveys concerned with distances shorter than those specified for third-order control. Control surveys are not detailed unless they are made for engineering control.

survey, engineering #A survey made to obtain information that is essential for planning an engineering project or development and for estimating its cost.#

The information obtained may, in part, be recorded in the form of a map.

survey, exploratory #A survey made to obtain general information about regions for which no such information was on record.#

survey, extension #A survey made to add to an existing, partial survey. It does not, however, complete a survey of boundaries of townships, sections, or subdivisions thereof.#

Compare with *survey, completion*.

survey, first-order (1) #A *geodetic survey* of the highest prescribed order of precision and accuracy.#

Such surveys were formerly called primary surveys; in 1921, representatives of the various map-making and map-using agencies in the United States changed the designation to "precise". In 1925, the Federal Board of Surveys and Maps adopted the designation "first-order control," established standards for the accuracy of such control, and specified essential elements of the procedures to be used in establishing such control. A geodetic survey that establishes first-order control is therefore called a first-order survey. See *control, classification of.*

survey, geodetic (1) #A survey that takes into account the size and shape of the Earth (as distinguished from a plane survey, in which the surface of the Earth is considered a plane).#

(2) #A survey for determining the size and shape of the Earth or any portion thereof.#

(3) #An organization engaged in making geodetic surveys.#

survey, geographic #A general term for a wide variety of surveys ranging from and merging into *exploratory surveys* at one extreme and basic *topographic surveys* at the other.#

Geographic surveys usually cover large areas, are based on coordinated control, and are used to record physical and statistical characteristics of the region surveyed.

survey, geologic #A survey or investigation of the character and structure of the Earth, past and current physical changes of the Earth's crust, and the causes of those changes.#

survey, geological #A general term used for an organization that does geologic surveys and investigations.#

survey, ground #A survey by ground methods as distinguished from an aerial survey.# Ground photography may be included.

survey, hydrographic (1) #A survey that has as its principal purpose the determination of geometric and dynamic characteristics of bodies of water.#

A hydrographic survey may consist of the determination of one or several of the following classes of data: depth of water and configuration of bottom; velocities of currents; heights and times of tides and water stages; location of fixed objects for purposes of surveying and navigation.

(2) #A record of a survey, at a given date, of a water-covered region, with particular reference to the relief of the bottom as shown by soundings and depth contours.#

The hydrographic survey is the authority for all data on features below the plane of *high water* (including the names of hydrographic features).

survey, inventory #A survey made to collect and correlate engineering data of particular types over a given region.#

An inventory survey may be recorded on a map.

survey, land #A survey or the results of a survey that provides as a minimum the boundaries of a particular piece of land.#

Other information such as the locations of structures, easements, and water courses, and the total area, is often included. See *surveying, land.*

survey, location #The establishment on the ground of points and lines in locations previously determined by computation or graphical methods.#

The plans for a civil engineering project are prepared in the office from survey data obtained in the field. These plans form a paper location, and are the basis for the location survey.

survey, metes and bounds #A survey that describes the boundary of a tract of land by giving the bearing and length of each successive line of the boundary.#

Much of the land in the non-public-land States of the United States has been surveyed and described by this method. This method is also used in the surveys of public lands to define the boundaries of irregular tracts, such as claims, grants, and reservations that are not easily subdivided into rectangles of uniform size.

survey, mine #A survey to determine the locations and dimensions of the underground passages of a mine, or of the natural and artificial surface and underground features of the mine and its surroundings.#

The data include both horizontal and vertical locations, lengths, and directions (slopes) of tunnels, topographic and geological characteristics of the vicinity of the mine, ownership of the land and of the mine, and any other pertinent information.

survey, photogrammetric (1) #A survey in which monuments are placed at points that have been determined photogrammetrically.#

(2) #A *geodetic survey* using either ground-based or aerial photographs.#

survey, plane See *surveying, plane.*

survey, plane-table #A topographic survey using a *plane table.* #

survey, polygonometric #A *traverse*.#

The term occurs in English surveying literature as a close transliteration from the German term.

survey, preliminary #A survey made to collect data on which to base studies for a proposed geodetic survey.#

Also called a reconnaissance survey. A reconnaissance for triangulation is a preliminary survey to obtain data on which to base plans for making the triangulation. It is usually made rapidly and at relatively low cost. The information obtained is recorded, in part, in the form of a reconnaissance map or sketch.

survey, reconnaissance See *survey, preliminary.*

survey, resurvey See *resurvey.*

survey, second-order #A *geodetic survey* of next-to-the-highest order of accuracy and precision.#

See *control, classification of.*

survey, standard #A *geodetic survey* which, in scale, accuracy, and content satisfies criteria prescribed by competent authority or by general agreement for such a survey.#

survey, topographic (1) #A survey which has, for its major purpose, the determination of the configuration (relief) of the surface of the land and the location of natural and artificial objects thereon.#

The information gathered by a topographic survey is usually published as a topographic map.

(2) #The designation of an organization making such surveys.#

survey, transit-and-stadia #A survey during which horizontal and vertical directions are observed with a transit and distances are measured with a *transit* and stadia *rods.* #

survey, windshield #A *preliminary survey.* #

survey adjustment (1) #Determining values for angles and distances in a horizontal network or traverse, or for heights in a vertical network, in such a way that the new values fit the geometric conditions on the network better than do the observed (measured) values.#

The criterion for "fitting better" is usually that the sum of the squares of the differences between the measurements and the new values shall be a minimum.

(2) #Determining values for the coordinates of points in a horizontal, vertical, or three-dimensional network in such a way that the sum of the squares of the differences between measurements of angles, distances or heights, and the values for these quantitites calculated from the new values of the coordinates shall be a minimum.#

Specific conditions are often imposed on the coordinates.

surveying #Measuring distances, angles, heights, etc., to determine the relative locations of points on the Earth.#

surveying, cadastral #The process of making a *cadastral survey.* #

surveying, geodetic #The branch of the art of surveying that takes into account the figure and size of the Earth.#

Also called geodetic engineering.

surveying, hydrographic #The process of showing upon a survey sheet the portion of the Earth's surface that lies beneath the water in a particular region.#

Hydrographic surveys include the delineation of the submerged contours of channels, banks and shoals, and the collection of bottom specimens and samples of water. Also included are consideration of tides and currents, and information on temperature and salinity of the water and their effects on the accurate measurement of depths by echo sounding.

surveying, land #The determination of boundaries and areas of tracts of land.#

Boundaries are usually determined by ownership, commencing with the earliest owners, and descending through successive ownerships and partitions. Land surveying includes the reestablishment of original boundaries, and the establishment of such new boundaries as may be required in partitioning the land. The term cadastral survey is also used to denote a land survey, but in the U.S.A.'s Bureau of Land Management it is used only to denote surveys of the public lands of the United States.

surveying, occultation #Surveying done by timing the instants of occultation of stars by the Moon.#

At the instant of occultation the observer lies on an almost (because of refraction) straight line joining his position, the star, and a point on the Moon's edge. Other points of observation can be chosen where the occultation occurs at the same place on the Moon's edge but at different times. The intervals between occultations are known functions of the Moon's apparent velocity and of the distances between points of observation. The former can be computed from astronomical data. If several sets of such observations are made from the same unknown point but from different known points in each set, the location of the unknown point with respect to the known points can be determined.

surveying, plane #Surveying done under the assumption that the surface of the Earth is flat.#

In plane surveying, the curvature of the Earth is ignored and the formulas of plane geometry and plane trigonometry are used in computations. In general, plane surveying is used where the regions are of limited extent or where the accuracy required is so low that corrections for the effect of curvature would be negligible in comparison with the errors of observation. The accuracy and precision of plane surveying decrease as the extent of the region under survey increases.

surveying, plane table #Surveying with the use of a *plane table*. #

surveying, stadia #Surveying in which angles are measured with a *transit* or *theodolite* and distances are determined by sighting on a *stadia rod*. #

Two methods of stadia surveying are common: horizontal, in which the *stadia rod* is horizontal and the lines on the *reticle* are vertical during an observation, and vertical, in which the stadia rod is vertical and the lines on the reticle horizontal.

surveying, topographic (1) #Surveying done to obtain data for mapping.#

(2) #Geodetic surveying in which data sufficient for determining both horizontal and vertical coordinates are obtained more or less simultaneously.#

Some kinds of stadia surveying, aerial phototriangulation, and photomapping are considered topographic surveying. The term is properly limited to geodetic surveying done for mapping. Surveying done merely to establish the three-dimensional coordinates of a few points as is done in satellite geodesy or very long baseline interferometry does not constitute topographic surveying. The term should not be used to mean plane table surveying.

surveying, trilinear #The determination of the location of a point from which observations are made by measuring the angles at that point between lines to three points of known location.#

This determination involves the solution of the *three-point problem*. It may be done algebraically or graphically by using a mechanical device such as the chorograph or the three-arm protractor. See *resection*.

surveying instrument #Any instrument used for measuring angles, distances, heights or elevations, or for determining geographic coordinates.#

surveying system (1) #Any complex apparatus used for geodetic surveying.#

(2) #The complete collection of equipment, materials, personnel, and procedures required for a particular type of surveying.#

survey network #A network in which the points are survey stations and the lines either represent adjusted distances and directions, or show the sequence in which elevations were measured or survey stations were occupied.#

The two principal types are the *horizontal survey network* and the *leveling network*. If the survey stations are control stations, i.e., if the network is a control network, the network is called a horizontal-control survey network or vertical-control survey network.

surveyor, land #A person whose profession is the determination, by surveying, of boundaries and areas of land.#

survey station (1) #A point at which, or from which, observations have been made for a geodetic survey.#

(2) #A definite point, on the Earth, whose location has been determined by geodetic surveying.#

(3) #A point, on a traverse, over which an instrument is placed (a setup).#

(4) #On a traverse, a length of 100 feet measured on a given broken, straight, or curved line.#

(5) #A stake indicating one end of a 100-foot-long interval on a traverse.#

The nature of a survey station is usually indicated by adding a term that describes the station's origin or purpose, for example, triangulation station, topographic station, or magnetic station. A survey station may or may not be marked on the ground. If it is, a geodetic marker (monument) of special construction, or a natural or already present artificial structure is often used to mark the station.

swamp (1) #Low-lying land saturated with moisture and overgrown with vegetation, but not covered with water.#

(2) #Land, at elevations below that of upland, too wet and unfit for agriculture without artificial drainage.#

sweep bar #A heavy section of steel rail or a steel beam suspended at a predetermined depth by two vertical cables and towed by a vessel to determine the depths of navigational obstructions.#

Often used in a hydrographic survey.

swing (1) #The angle of rotation of a photograph, about the perpendicular to the photograph from some referent direction such as the direction of flight of an airplane.#

(2) #The angle at the *principal point* of a photograph, measured clockwise from the positive y-axis to the *principal line* at the *nadir* point.#

(3) #The angle of rotation of a projector, in a stereoscopic plotter, about the z-axis of the plotter.#

(4) See *pendulum, swing of a*.

swing, relative #The angle of rotation of an oblique camera about its own optical axis and with respect to the plane of the photograph in the vertical camera, measured on the oblique photograph by the angle between the *isoline* and a line joining the fore and aft fiducial marks.#

system, imaging See *imaging system*.

Système International d'Unités (SI), le #A self-consistent system of units adopted by the General Conference on Weights and Measures in 1960 as a modification of the then existing metric system. The following units are considered fundamental in SI:

Quantity	*Base unit*	*SI symbol*
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A

Quantity	*Base unit*	*SI symbol*
temperature	kelvin	K
quantity of matter	mole	mol
luminous intensity	candela	cd #

Supplementary Units

plane angle	radian	rad
solid angle	steradian	sr

Some derived units with special names

frequency	hertz	Hz cycle/s
force	Newton	N $kg\cdot m/s^2$
work	Joule	J $N\cdot m$
pressure	pascal	Pa N/m^2

Prefixes denoting multiples, by powers of 10, of the units are the same as in the earlier (c.g.s.) metric system. A few have been added to cover the anticipated range of values for often used quantities. The added prefixes are:

SI prefix	*Power of 10*
atto-	−18
femto-	−15
pico-	−12
nano-	−9
giga-	+9
tera-	+12
peta-	+15
exa-	+18.

system uncertainty #The root-mean-square value of the systematic and random errors in a quantity inferred from a system of measurements and computations.#
Examples of such a quantity are a rate of motion inferred from measurements of distances between two points at different times, or a height of sea level inferred from measured altitudes and calculated coordinates of a satellite.

syzygy #One of the two points in the orbit of a planet or satellite where the body, the Earth, and the Sun have either the same longitude or differ in longitude by 180°.#
(2) #In particular, the position of the Moon when it is new or full.#

T

tacheometer See *tachymeter.*

tacheometry See *tachymetry.*

tachometer #An instrument for measuring rate of rotation.#

The word is sometimes used erroneously for *tachymeter.*

tachymeter #A surveying instrument for the rapid determination of distance, usually together with the measurement of direction and difference of elevation.#

A common type of tachymeter consists of a theodolite with a reticle containing two lines whose vertical separation is adjustable and known. The separation is adjusted to match a standard interval (the base line) on the image of a vertical, graduated rod at the target. The horizontal distance to the rod and the height of the target above the horizontal plane at the point of observation can then be easily determined. Another form of tachymeter is that in which the base line is contained in the instrument; the term "tachymeter" is usually used in reference to this type of instrument. In still another form of tachymeter, the time it takes electromagnetic pulses to travel from the instrument to the target and back is measured and converted to distance.

Also called tacheometer. Modern versions in the United States, usually with electronic readout, are often called *total stations.*

tachymeter, auto-reducing #A tachymeter that provides distance and height directly from readings of the intercepts of three lines on the tachymeter's reticle with the image of the *stadia rod*.#

In a common form of tachymeter, the reticle is geared to the vertical motion of the instrument telescope. The horizontal distance to the target is 100 times the distance between the intercepts of the top and bottom lines on the reticle. The vertical distance is the value at which the central line intercepts the rod, multiplied by a factor that appears in the field of view.

tachymetry #Surveying in which distance, direction, and differences of height are measured approximately simultaneously by the same instrument.# See *tachymeter.*

Talcott method of determining latitude See *latitude determination, Horrebow-Talcott method of.*

tangency, point of See *point of tangency.*

tangent (1) #A straight line which meets a given curve in one and only one point, such that if the tangent is rotated about that point by any amount, however small, it will then intersect the curve in more than one point.#

It may be defined, alternatively, as #the limiting position taken by a straight line intersecting a curve in two points, as one of the points approaches the other.#

(2) See *plane, tangent.*

(3) #The part of a traverse or alignment included between the *point of tangency* of one curve and the *point of curvature* of the next curve.#

(4) #A great-circle line tangent to a parallel of latitude at a *township corner.* #

tangent distance See *distance, tangent.*

tangent method #A method of determination of the *geographic parallel* for the survey of a *base line* or *standard parallel* by *offsets* from a great circle initiated at an established *township corner* and tangent to the base line or standard parallel at that corner.#

tangent plane See *plane, tangent.*

tape (surveying) #A ribbon, usually of metal with a low coefficient of expansion, with two marks a convenient distance (50 m or 100 ft) apart and usually having one unit at either or both ends subdivided into finer units.#

For precise surveying, 50- or 100-m tapes are most common, and the material is *invar*. In European practice (other than British), wire is used instead of ribbon.

tape, adding #A surveyor's tape which has, beyond the zero mark at the end of the tape, an additional meter (or foot) graduated in tenths or hundredths.#

See *tape, subtracting.*

tape, base #A surveyor's tape or band of metal or alloy, so designed and graduated, and of such excellent workmanship, that it is suitable for measuring the lengths of base lines for controlling triangulation, and for measuring the distances between points in first- and second-order traverses.#

In use, a base tape is subject to certain physical conditions that influence its effective length and must be taken into account when computing the length of a measured base line. These conditions include tension, temperature, method of support, sag, grade, alignment, and calibrated length. (See *tape correction*.) At one time, base tapes were made of steel, a metal with a high coefficient of thermal expansion; they are now made of invar, nilvar, or some other alloy with a very small coefficient of thermal expansion. See *invar.*

tape, breaking #The process of measuring horizontal distances on sloping terrain by holding only short lengths of tape horizontal and marking the end points of the length by placing taping pins beneath them in the ground.#

The tape is usually extended to its full length from the starting mark and successive partial lengths are measured with the tape held horizontal.

tape, catenary correction to See *taped length, sag correction to.*

tape, correction for alinement of See *taped length, alignment correction to.*

tape, correction for catenary of See *taped length, sag correction to.*

tape, correction for elasticity of See *tape length, tension correction to.*

tape, correction for sag of See *taped length, sag correction to.*

tape, correction for slope of See *taped length, grade correction to.*

tape, correction for temperature of See *tape length, temperature correction to.*

tape, correction for tension on See *tape length, tension correction to.*

tape, cut See *tape, subtracting.*

tape, grade correction to See *taped length, grade correction to.*

tape, lovar #A surveyor's tape made of the alloy lovar.# Lovar is less expensive than invar but has a larger coefficient of expansion.

tape, metallic surveyor's #A graduated, waterproof ribbon of fabric into which wires of brass or bronze are interwoven longitudinally to prevent stretching.#

tape, piano-wire #Piano wire is used instead of metallic tape, when it is advisable to control hydrography by precise traverse rather than by a weak extension of triangulation.#

tape, standard length of #The length of a surveyor's tape when the tape is supported throughout its length under a specified, standard tension.#

tape, subtracting #A surveyor's tape with the first and last meter (or foot) divided into tenths or hundredths.#

Also called a cut tape.

tape, surveyor's #A tape used for surveying.#

tape correction #A correction applied to a distance measured with a tape to eliminate error caused by differences between the conditions under which the tape was used and those under which it was calibrated.#

Tape corrections are of two kinds: corrections to *tape length*, which are needed because the distances between marks on the tape were incorrect when the tape was being used; and corrections to *taped length*, which are needed because the tape was not coincident with the length or distance being measured. Usually corrections for temperature, tension, calibration, and length variations are made to tape length; corrections to taped length usually involve alignment, grade, and sag factors. The quantity subtracted from a taped length (after the above corrections have been made) to obtain the corresponding length on the geoid or the ellipsoid is not considered a tape correction. For definitions of the various corrections, see items beginning with "tape length" and "taped length".

taped length #A length or distance which has been measured with a surveyor's tape.#

Because no measuring process is perfect, corrections are made to a taped length to get a length close to what would have been obtained if the measuring process had been perfect. (Corrections to *tape length* involve factors that influence the length of the tape, not that of the measurement.)

taped length, alignment correction to #A correction applied to the measured length of a line to allow for the tape's not being held exactly in a vertical plane containing the line.#

Though the vertical planes at the two ends of a line which contain the direction of the line at those points are not coincident, for practical purposes they are considered coincident, so any method of aligning a base between its end points will serve for determining an alignment correction.

taped length, grade correction to #A correction to a distance measured on a slope to reduce it to a horizontal distance between the vertical lines through its end points.#

Also called slope correction, or correction for inclination of tape.

As the vertical lines through the end points of a line are not parallel, the reduction should be such that the length at the average elevation is obtained. In practice this is done by considering each taped length a separate line, and reducing it individually. In base line measures, the difference in elevation of the ends of the tape, rather than the grade or inclination of the line expressed in angular form, is used in computing the grade correction. In effect, this treatment applies the grade correction to the nominal length of the tape in determining its effective length in measuring a distance.

taped length, sag correction to #The difference between the effective length of a tape (or part of a tape) when supported continuously throughout its length and the length of the tape when supported at only a limited number of independent points.#

Base tapes are usually supported at 3 or 5 points, and hang in curves (catenaries) between adjacent supports. Correction for sag is not required when the method of support during field use is the same as that which was used for calibrating the tape. A base tape may also be supported throughout, such as on a rail, or at 4 points. The formula used by the U.S. C.&G.S. (Gossett 1950) for this correction ΔL to a tape of total length L can be expressed as

$$\Delta L = -L(W/nT)^2/24$$

where W is the total weight of the tape, T the tension, and n the number of sections into which the tape is divided by equally-spaced, frictionless supports. If the amount of sag d is used instead of the tension, the formula is

$$\Delta L = 8d^2\, n/(3L).$$

taped length, slope correction to See *taped length, grade correction to.*

tape length #The nominal, assumed, or exact length of a surveyor's tape.#

This should not be confused with "taped length", which is the distance measured with a tape. Corrections are usually applied to the nominal or assumed lengths between graduations on the tape to arrive at the actual lengths at the times and under the conditions under which the tape was used.

tape length, calibration correction to #The correction to the nominal length between two graduations on a tape needed to account for the difference (calibrated minus nominal) between the nominal length and the length found by calibration.#

When the graduations mark the full length of the tape, the calibration and length corrections to tape length have the same value. See *tape length, length correction to.*

tape length, gravity correction for #A correction applied to the nominal length of a surveyor's tape to compensate for the tape's use under a gravity different from that under which the tape was calibrated.#

The sag correction for tape length is not affected by a change in gravity, but the tension correction is, in the ratio $\Delta g/g$, where g is the value of gravity at the place of calibration and Δg is the change in that value.

tape length, length correction to #The difference between the nominal length of a tape and its effective length as determined by calibration.#

The standard (calibrated) length of a tape is usually expressed by a number of whole units (the nominal length) plus or minus a small distance which is the length correction defined above (calibrated minus nominal).

"Length correction" and "calibration correction" are not synonymous. See *tape length, calibration correction to.*

tape length, temperature correction to #The quantity applied to the nominal length of a tape to allow for a change in its effective length if the tape is used at a temperature other than that under which it was calibrated.

If the coefficient of expansion is k_T, and the tape was calibrated at temperature T_o, the expansion or contraction ΔL caused by measurement at a temperature T is

$$\Delta L = k_T L\,(T - T_o).\#$$

tape length, tension correction to #The correction applied to the nominal length of a tape to allow for a change in effective length when used at a tension other than that at which it was calibrated.#

A tape L meters long, with coefficient of elasticity k_e and cross-sectional area a, and under an increase ΔT over the tension at which it was calibrated experiences a change ΔL in length given by

$$\Delta L = \Delta T\, L / (a\, k_e).$$

tapeman #A person who assists in measuring distances with a surveyor's tape by carrying one end of the tape and inserting or removing *taping pins* to mark the distance measured.#

There are usually two tapemen—a rear tapeman and a head tapeman. The rear tapeman places the zero mark on the tape at the proper mark or pin on the ground and aligns the head tapeman, carrying the other end of the tape, with the following mark or pin. The head tapeman pulls the tape taut and inserts a pin at the last graduation on the tape. The rear tapeman removes the rear pin after every measurement and keeps count of the number of measurements made. (In some cases the head tapeman carries the end with the zero mark). Other terms are chainman and contactman.

tape stretcher #A mechanical device for holding a tape at a prescribed tension and in a prescribed position.#

It generally consists of a spring balance to which the tape or wire is attached, and a lever for applying tension to the tape (wire) through the spring balance.

taping #The operation of measuring a distance on the Earth by use of a surveyor's tape.#

See *chaining.*

The term taping is used in this sense in all surveys except those of the public lands of the United States of America where, for historical and legal reasons, the term chaining is preferred.

taping, slope #*Taping* during which the tape (or chain) is held as required to match the slope of the ground, the slope of the tape is measured, and the horizontal distance is calculated.#

Also called slope chaining.

taping stool #A stool, usually of metal, placed under the graduated end of a surveyor's tape, with a surface on which the position of the graduation can be marked.#

Also called tape tripod, or tripod support.

tare (gravimetry) #An abrupt change in the measurements made with a *gravimeter* that is the equivalent of a shift in the value of gravity taken as standard at a base (base datum).#

target (1) #Any object at which a telescope is pointed while obtaining a measurement of angle, direction, distance, or height.#

The salient feature of a target is its marked visibility; targets are selected or constructed so as to be clearly visible even under poor lighting conditions. See *asymmetry of object.*

(2) #A brightly painted, round disk that can be moved up and down a leveling rod until a mark on the disk is on the line of sight of a leveling instrument.#

(3) #An artificial or natural mark or feature on the ground, identifiable on an aerial photograph, that indicates the location of a control point.#

Targets for aerial photography made by assembling large strips of cloth or plastic into a geometric figure with the control point at the center of symmetry are called paneling.

target column #A post to which targets are attached when leveling by a river-crossing method.#

targeting #The process of marking or otherwise distinguishing ground control points so that they are identifiable on aerial photographs.#

target rod See *leveling rod.*

taut-wire apparatus #A stranded, 100-m sounding wire, graduated at 25-m intervals, used to measure the distances between offshore control buoys during a hydrographic survey.#

tectonics #The Earth science dealing with large-scale changes, such as folding and faulting, in the structure of the Earth.#

tectonics, plate See *plate tectonics.*

teledetection #The detection of objects or events at great distances.#

Detection is usually followed by measurement. Teledetection differs from telemetry in that in the latter, the instrument that does the detecting and measuring is placed close to the object or event involved, and the data are transmitted over great distances to the observer. In teledetection, the instrument is far from the object or event and obtains information by collecting acoustical or electromagnetic radiation from the object.

The term is is roughly equivalent to remote sensing.

telemeter (1) #(verb) To measure at one place and send the data to another place some distance away.#

The measuring device is usually unattended.

(2) #(noun) Any instrument that makes measurements at one place and sends the data to another place some distance away.#

The data are usually transmitted by wire or radio. However, some telemeters transmit the data pneumatically or hydraulically through tubes.

(3) #An instrument for determining the distance from one point to another.# The term is used sometimes for a *tachymeter*.

telemetry #The transmission of information by means of a *telemeter*.#

telescope #An instrument that collects electromagnetic radiation from a distant object to create an image of that object.#

A telescope may be designated according to the frequency of the radiation it collects (e.g., radio telescope, infrared telescope, or optical telescope), according to the means by which the radiation is collected (reflecting telescope or refracting telescope), or according to the type of mounting involved (equatorial telescope or meridian telescope). Unless specifically stated otherwise, the word telescope is usually assumed to mean an optical telescope.

Optical telescopes may be constructed with lenses, mirrors, or a combination of both. Most telescopes used in theodolites and leveling instruments contain only lenses (refracting telescopes). They consist essentially of two lens systems: an objective (object glass, in older terminology) which brings rays of light from a distant object to a focus within the telescope tube; and an eyepiece (ocular) that magnifies the image formed by the objective. A reticle placed at the principal focus of the objective establishes a definite line of sight, thus making the telescope into a precise instrument for surveying or for astronomical observation.

telescope, achromatic #A telescope with an achromatic lens system as its objective.#

See *lens, achromatic*.

telescope, anallatic #A telescope in which a point in object space is imaged on the axis about which the telescope rotates.#

The image point is called the anallatic center. The instrument is also called an anallactic telescope.

telescope, astrographic #A telescope used primarily for photographing fields of stars to determine their relative positions.#

Also called an astrograph.

telescope, Cassegrainian #A *reflecting telescope* in which radiation from the parabolic primary mirror is redirected by a small, hyperbolic secondary mirror through a hole in the primary mirror, back to the observer.#

Cassegrainian telescopes have been made for observing radiation from many parts of the spectrum, from radio waves through ultraviolet. The combination of parabolic and hyperbolic mirrors makes it possible to make the telescope shorter than one in which a flat secondary had been used.

telescope, catadioptric See *optical system, catadioptric*.

telescope, catoptric See *optical system, catoptric*.

telescope, equatorial #A telescope that can be moved about two independent perpendicular axes of rotation: a polar axis, parallel to the Earth's axis of rotation, and a declination axis, parallel to the line in which the meridian plane and the equatorial plane intersect.#

telescope, erecting #A telescope that presents an upright image to an observer.#

The eyepiece in an erecting telescope usually has four lenses. The usual telescope, with a simple, two-element eyepiece (sometimes called an inverting telescope), presents an inverted image to the observer.

telescope, finder #A small, low power telescope with a wide angular field of view attached to a larger telescope of very restricted field of view; used for finding the object at which the larger telescope is to be pointed.#

telescope, inverting See *telescope, erecting*.

telescope, meridian (1) #A portable telescope designed for use either as an *astronomical transit* or as a *zenith telescope*.#

The meridian telescope is also known as the Davidson meridian instrument (after George Davidson of the U.S. Coast Survey, who designed it in 1858).

(2) #A fixed telescope mounted on a horizontal, transverse axis of rotation; the bearings of the transverse axis are permanently fixed so the telescope line of sight lies permanently in the local meridian.#

telescope, Newtonian #A *reflecting telescope* in which radiation reflected from the parabolic primary mirror is redirected, by a small, planar mirror, off at right angles to the axis of the primary and to the observer.#

The Newtonian telescope is one of the simplest to construct. However, to keep the secondary mirror small, it must be located within a short distance of the primary mirror's focus. The telescope must therefore be long if the focal length is long, and the observer's location is therefore often inconvenient.

telescope, photographic zenith #A telescope constructed for photographing stars in the immediate vicinity of the zenith.#

Also called a photographic zenith tube.

Portable versions are used primarily for determining latitude and longitude; fixed versions are used for determining time and variations in latitude. The optical axis of the portable telescope is pointed vertically by leveling against very sensitive levels; photographs are taken with the negative in one position only. In the fixed versions, the photographic plate is commonly rotated through 180° after each exposure. Detailed descriptions are given in Ross (1915) and Markowitz (1960).

telescope, radio #A radio used for receiving and recording radio waves from natural sources of such radiation.#
It consists of an antenna in which voltages and currents are set up by incoming waves, an amplifier for amplifying these waves, and a recording subsystem for modifying and recording the output of the amplifier. Because the waves to be detected are extremely weak, the antennas are usually very large to collect as much energy as possible. This may be done either by multiplying the number of antennas—usually dipoles or long wires—or by building large reflectors around the antennas to focus a considerable amount of power on the antennas. The *radio interferometer* is a radio telescope that consists either of two widely spaced antennas connected to a common mixer and amplifier, or of two independent radio telescopes that record the signals independently and correlate them later.

telescope, reflecting #A telescope that uses a large mirror for collecting light and one or more smaller mirrors for directing the light to the observer.# Also called a catoptric or reflector telescope.

telescope, refracting #A telescope that uses a large lens or lens system for collecting the light and one or more smaller lens systems or mirrors for directing the light to the observer.#
Also called a dioptric or refractor telescope.

telescope, Ritchey-Chretien #A *reflecting telescope* whose two mirrors are positioned to give an image free from *spherical abberation* and *coma* at the Cassegrainian focus.#

telescope, Schmidt #A *reflecting telescope* with a primary mirror with spherical curvature and a plate across the aperture to correct for *coma.* #
The Schmidt camera has a large field of view for its focal length; typically, 50° for a focal length of 0.6 m. The focal surface is curved, so the film must be cut to fit.

telescope, zenith #In general, any telescope designed for making stellar observations near the zenith.#
In particular, a portable telescope adapted for the measurement of small differences of zenith distance, and used in the determination of astronomic latitude. This instrument consists of a telescope equipped with an ocular micrometer and a spirit level, and so mounted on a vertical axis that it may be placed in the plane of the meridian for observation on a star culminating north (or south) of the zenith, and then rotated 180° in azimuth and a second star observed as it culminates south (or north) of the zenith. The difference of the zenith distances of the two stars is measured with the micrometer; the spirit level is used to determine any change that may occur in the direction of the axis of rotation of the telescope between the two observations. See *latitude determination, zenith-telescope method of.*

telluroid #The locus of points whose distances (if positive, i.e., measured upwards) from the *normal ellipsoid* are equal to the *normal heights* of the corresponding points on the surface.#
See *height, normal*. The telluroid is not an equipotential surface but approximates one fairly closely. Its distance from the Earth's surface is given by the *height anomaly.*

temperature #On a submicroscopic scale, a measure of the average speed of the randomly moving elementary particles composing a body; on a macroscopic scale, a measure of the rate of transfer of heat (thermal energy) from one body to another.#
In general, the degree of hotness or coldness as measured on a *temperature scale* by a thermometer. Temperature is *not* a measure of the amount of heat in a body. A body to which heat will flow from any other body is said to be at *absolute zero*.

temperature, absolute scale of #A general name for temperature scales related to *absolute zero.*#
The Kelvin temperature scale is an example.

temperature, ambient #The temperature of the medium immediately around an instrument.#
Unless specifically stated otherwise, the average temperature of the medium is meant. If the instrument is large and very sensitive to differences in temperature at various places on the instrument, an average value will not be adequate.

temperature, noise #The temperature that would cause a black body to radiate the same amount of power that is present as noise in a particular electrical circuit.#
Noise temperature is a convenient way of expressing the amount of unwanted power (called *noise*) present in the circuit, particularly in an antenna.

temperature correction See *leveling correction, temperature* or *tape length, temperature correction to.*

temperature scale #A numerical representation of the range of molecular activity of a substance under various conditions of heat energy.#
Usually, a temperature scale has "anchor points" at *absolute zero*, and at the freezing and boiling points of water at standard conditions of elevation and atmospheric pressure. The sizes of the intervals that are used as divisions between the anchor points can be arbitrary (Fahrenheit scale) or thermodynamic (kelvin, absolute, and Celsius scales). See *temperature scale, thermodynamic.*

temperature scale, absolute #A *temperature scale* that assigns the value zero to the temperature at *absolute zero.* #
Units in the absolute scale are identical in dimension to those in the Celsius and Kelvin scales.

temperature scale, Celsius (1) #A *temperature scale* on which 0 °C denotes the triple point (essentially the freezing point) of water and 100 °C denotes the boiling point of water at standard atmospheric pressure.#
Until recently, known as the centigrade temperature scale. *Absolute zero* in this scale is approximately −273.16 °C.
The scale originally proposed by Celsius inverted the values of the triple point and boiling point of water shown above.

temperature scale, centigrade #The former name for the scale now known as the *Celsius temperature scale.* #

temperature scale, Fahrenheit #A *temperature scale* on which 32 °F marks the freezing point and 212 °F the boiling point of water at 760 mm barometric pressure.#

The inventor of this scale used the freezing point of a saturated solution of salt in water as the 0 °F point of the scale.

temperature scale, International #A *temperature scale*, introduced in 1927 and revised in 1948 and 1968, based on six defined points:

	1948	*1968*
boiling point of oxygen:	−182.970 °C	−182.962 °C
melting point of ice:	0 °C	—
triple point of water:	—	0.01 °C
boiling point of water:	+100 °C	+100 °C
freezing point of zinc:	—	419.58 °C
boiling point of sulfur:	+444.600 °C	—
freezing point of silver:	+960.8 °C	961.93 °C
freezing point of gold:	+1063.0 °C	1064.43 °C#

In 1960, this scale was revised by incorporating a new definition of the kelvin unit (that resulting from defining the thermodynamic temperature of the triple-point of water as exactly 273.16 K). The temperature scale as defined in 1948 was called the "International Practical Temperature Scale" (IPTS-48). The IPTS of 1948 was superseded by the IPTS-68 (adopted 1967), which added 5 fixed points at the lower end of the IPTS-48, down to -259.34 °C.

temperature scale, kelvin #A *temperature scale* with the kelvin (K) as its thermodynamic unit and the triple point of water, at 273.16 K, as fixed point.#

Until 1954, the standard thermodynamic unit was the centigrade (Celsius) degree, which was defined as the 1/100 of the interval between the freezing point of water and the boiling point of water under standard pressure (760 mm). In 1954 the standard unit was redefined by the General Conference on Weights and Measures as 1/273.16 of the thermodynamic temperature of the triple point of water. The absolute zero point is then at 273.16 kelvins below the triple-point. The kelvin unit is the SI temperature unit.

temperature scale, Rankine #A *temperature scale* in which the size of the unit is the same as that of the Fahrenheit temperature scale, the ice point is 491.69 °Rankine, and the boiling point of water, under standard conditions, is 671.69 °Rankine.#

temperature scale, Reaumur #A *temperature scale* in which 0 °R marks the freezing point and 80 °R the boiling point of water at 760 mm barometric pressure.#

In some of the earliest geodetic work, the Reaumur scale was used in stating the temperature of base line measuring apparatus (base apparatus).

temperature scale, thermodynamic #A *temperature scale* in which the temperature is taken to be proportional to the energy contained in a given volume of a perfect gas.#

The thermodynamic temperature scale in which the unit is equivalent to the degree Celsius (centigrade) is the kelvin temperature scale.

template (also templet) (1) #A gauge or pattern to guide certain work that is to be done.#

A template is often a thin sheet of transparent material upon which guidelines are drawn. Examples are the ordinary protractor or, in photographic mapping, a transparent plastic overlay for a photograph.

(2) #A device used to record the directions from the radial center of a photograph to objects imaged on the photograph or on neighboring photographs.#

It is usually a sheet of transparent plastic, a plate, rod, or other object which can be assembled with similar objects to represent the connections between points on an assemblage of aerial photographs.

The transparent sheet shows the center and all radial lines from the center through images of control and other important points, as well as lines connecting the main center to images of the centers of other photographs in the assemblage.

Plates are generally slotted; the slots radiate from a round hole representing the principal point, the nadir point, or another significant point of the photograph, and go in the directions of pass points, intersection points, etc. Individual plates are assembled by studs passing through the slots. These plates, generally made of paperboard or plastic, are slotted differently for each photograph. The time and cost of slotting plates is eliminated by using spider templets (see *templet, spider).*

template, Hayford #A template used in calculating geoidal heights, deflections of the vertical, etc., devised by J.F. Hayford for use in studies of the figure of the Earth and isostasy.#

Calculation by these devices has been largely replaced by use of computers.

templet, calibration #A template of glass, plastic, or metal that, by use of the data provided by calibration, shows the relationship of the *principal point* of a camera to the fiducial marks.#

It is used to accurately and quickly mark principal points on a series of photographs.

templet, hand #A template made by tracing the *radials* from a photograph onto a transparent sheet.#

Hand templets are manually laid out and adjusted to form the radial triangulation.

templet, slotted See *template* (2).

templet, spider #A template formed by attaching slotted steel arms representing radials to a central stud.#

The spider templet can be disassembled and the parts used again.

Also called a mechanical-arm templet.

ten-mile rule #The rule which limits inland waters at coastal indentations to a distance of 10 miles between headlands. For indentations 10 miles or less at the entrance, a headland-to-headland line would mark the limits; for indentations wider than 10 miles, the limit would be a line drawn across the bay in the part nearest the entrance at the first point where the width does not exceed 10 miles.#

tension, normal (1) #The tension that must be applied to a surveyor's tape to compensate for the shortening effect of sag and to bring the tape to standard length.#

(2) #The pull at which the correction for tension and correction for sag exactly balance.#

tension correction See *tape length, tension correction to.*

tensor, Marussi #The tensor whose elements are the second derivatives, with respect to rectangular Cartesian coordinates rotating with the Earth, of the gravitational potential of the Earth.#

term, periodic #A term in a function that represents repetition.#

Common examples are the circular functions: the sine, cosine, etc.

term, secular #A term in a function that indicates steady increase or decrease.#

The presence of secular terms in a series of terms does not mean that there is necessarily a secular change in the function, since the sum of all the secular terms may be periodic or zero.

termini at headlands #The points on shore (the low-water mark, in the international law of the sea) between which the closing line at indentations is drawn to mark the seaward limits of inland waters.#

See *ten-mile rule.*

terrace, continental #A zone, around the continents, extending from the low-water line to the base of the *continental slope.* #

terrain correction See *gravity correction, topographic.*

terrain model See *map, relief.*

Terrain Profile Recorder See *Airborne Profile Recorder.*

terroid See *telluroid.*

tesla #The name in SI units for *magnetic flux density (weber per square meter).* #

tesseral harmonic See *harmonic, spherical.*

test mass #A body of accurately known mass.#

Used particularly in referring to such a body in an accelerometer.

thalweg (1) #The line following the lowest part of a valley, whether or not it is under water.#

The intricacy of detail in ordinary relief often makes it difficult in practice to locate a thalweg; in surveying a political boundary line, this difficulty may be considerable.

(2) #The line down the center of the main channel of a stream.#

thalweg, rule of #The rule that, where a navigable river separates two nations, the middle of the main channel, rather than the geographical middle of the river, is the boundary between them.#

The rule of thalweg has also been applied to other boundaries where the boundary is described as being "the middle (or center) of the main channel" of a navigable river.

theodolite #A precise surveying instrument consisting of an *alidade* with a *telescope* mounted so it can be rotated about a vertical axis; the amount of rotation is measured on an accurately graduated, stationary horizontal circle. The alidade sometimes carries a graduated vertical circle against which rotation of the telescope in a vertical plane can be measured.#

There are two major categories of theodolites: *direction theodolites*, often referred to as direction instruments, and *repeating theodolites*. See *cine-theodolite, gyrotheodolite, phototheodolite*, and *transit.*

theodolite, astronomical See *altazimuth instrument.*

theodolite, cine See *cine-theodolite.*

theodolite, direction #A theodolite on which the graduated horizontal circle remains in a fixed position during a set of observations, while the telescope is pointed on a number of targets in succession and the direction of each is read on the circle.#

For greater accuracy (and to detect blunders), several sets of observations are taken; the circle is rotated systematically between sets, so that each direction is measured on a number of different parts of the circle.

Also called a direction instrument.

theodolite, engineer's transit See *transit, engineer's.*

theodolite, Parkhurst #A *direction theodolite* designed by and named for D.L. Parkhurst, and formerly used on first- and second-order control surveys in the United States of America.#

theodolite, reiteration See *theodolite, repeating.*

theodolite, repeating #A theodolite designed so the sum of successive measures of an angle may be read directly on the graduated horizontal circle.#

The value of the angle is obtained by dividing the total arc passed through (the final reading on the circle, plus the appropriate multiple of 360°) in making the series of observations by the number of times the angle has been observed. The repeating theodolite is also called a repeating instrument. Theoretically, it is an instrument of great precision, but in its mechanical operation it does not give results as satisfactory as those obtained with a direction instrument.

The repeating theodolite differs basically from a direction theodolite in that the vertical axis of rotation is represented physically by two concentric spindles. One of these lets the alidade be rotated independently of the horizontal circle and the other, by a clamping device, permits simultaneous rotation of the alidade and the horizontal circle.

theodolite, transit #A theodolite with a telescope that can be rotated about a horizontal axis through 180°, from horizon to horizon.#

theodolite, universal (1) #A theodolite which can be used for determining both first-order astronomic positions and first-order geodetic positions.#

It is commonly equipped with a *transit micrometer* and *Horrebow-Talcott level* or the equivalent.

(2) #A theodolite constructed so it can be used both for engineering and for geodetic surveying.#

thermistor #A resistor, fabricated of semiconducting metallic oxides, that exhibits very large changes of resistance with small increases or decreases of temperature.#

It is widely used for the measurement of temperature changes.

thermometer #An instrument used for measuring temperature.#

The most common types are the liquid-in-glass thermometers, that depend on the expansion and consequent rise of a liquid in a narrow tube, and metallic thermometers, that depend on the expansion of a metal or combination of metals. The liquid-in-glass type is capable of measuring temperature with extremely great accuracy (0.001° or better); the metallic types are usually not so accurate. Thermistors, thermocouples, etc., which cause changes in current or voltage proportional to the temperature being measured, are widely used for measuring temperature far from the observer or recorder, particularly when the temperatures are to be recorded automatically. Thermometers for measuring extremely high temperatures generally measure radiation flux as a means for calculating the temperature of the radiation source. Such instruments are called pyrometers, bolometers, heliometers, etc. Surveyors generally use mercurial thermometers; however, thermistors are replacing these for many applications.

thermometer, bimetallic #A thermometer utilizing the difference of the coefficients of thermal expansion of two metals to determine the temperature of the surrounding fluid.#

See *Borda scale.*

thermometer, Borda scale See *Borda scale.*

thermometer, liquid-in-glass #A thermometer consisting of a graduated glass tube containing a liquid, such as mercury or alcohol and closed at both ends.#

The liquid and glass change volume at different rates as temperature changes. Since the coefficient of expansion of a liquid is usually much larger than that of glass, a large reservoir of liquid is contained in a bulb at one end of the narrow bore of the tube. The liquid, whether mercury or alcohol, rises and falls almost linearly with temperature against the scale on the glass.

thermometer, reversing #A thermometer, of the mercury-in-glass type, that records the temperature when it is inverted and retains the recorded temperature until it is turned upward to its normal position.#

Reversing thermometers are generally used in oceanography. They usually are sent down in pairs fastened to a special mounting attached to a cable. One of the thermometers is left exposed to the full pressure of the surrounding water; the other is protected by a shield from the pressure. When the thermometers are at depths where temperature readings are required, a weight is released from the ship end of the cable. When the weight reaches the thermometers, it sets off a mechanism that inverts them. The protected thermometer indicates only the water temperature; the number indicated by the unprotected thermometer results from a combination of effects of temperature and pressure. The water pressure can be calculated from a comparison of the readings of the two thermometers.

thermosteric anomaly #The *steric anomaly* that sea water at any point would attain if it were brought isothermally to a standard pressure of one atmosphere; i.e., it is the steric anomaly (specific volume anomaly) for a standard pressure.#

thread of the river, middle #The line equidistant between low water lines on the two sides of a river, extending from headland to headland without considering arms, inlets, creeks, and affluents as parts of the river.#

thread of the stream #The center of the main channel of a stream.#

If there are two prominent channels, the thread of the stream is the center of the channel used for navigation. See *thalweg* (2).

three-body problem #The problem of determining the orbits of three mutually attracting (or repelling) bodies, given the laws of attraction or repulsion and the locations and velocities of the three bodies at some specified instant.#

Unlike the *two-body problem*, the three-body problem has no closed solution except in a few simple cases. Most solutions are obtained by numerical integration. The problem occurs in geodesy principally in determining the orbit of an artificial satellite about the Earth with the Moon as the disturbing body.

three-point problem #The problem of determining the horizontal location of a point from observations, at the point, of two horizontal angles between three points of known location.#

Also called Potenot's problem or the Potenot-Snellius problem. See *resection.*

three-wire method See *leveling, three-wire.*

tidal constant #Any characteristic of the tide that remains practically constant for a particular locality.#

Tidal constants are classified as harmonic or nonharmonic. The harmonic constants are the amplitudes and epochs of the tidal constituents. The nonharmonic constants include the ranges and intervals derived directly from observations of high water and low water.

tidal constituent See *constituent.*

tidal datum plane #A reference plane for elevations, determined from tidal measurements.# (Marmer 1951).

tidal plane See *plane, tidal.*

tidal plane, Indian #A plane of reference used for a number of ports in India; also used for a time for Puget Sound, Washington, and for all Alaskan waters except at the mouth of the Yukon River.#

It corresponded closely to a plane 2 feet below *mean lower low water*.

Also called harmonic tide plane.

tidal wave (1) #A wave, in the oceans and seas, produced by tides and tidal currents.#

The term is used by some to denote only the tidal wave in shallow waters.

(2) In popular language and in some of the older scientific literature, "tidal wave" is a synonym for any unusually high wave, and also (mistakenly) for what is now known as a *tsunami* or earthquake wave.

tide (1) #Periodic changes in the shape of the Earth, other planets, or their moons that relate to the positions of the Sun, Moon and other members of the solar system.#

In particular, (2) #those changes in the size and shape of a body that are caused by movement through the gravitational field of another body.#

The word is most frequently used to refer to changes in size and shape of the Earth in response to the gravitational attractions of the other members of the Solar System, in particular, the Moon and Sun. In such cases, three different tides are usually distinguished: the atmospheric tide, acting on the gaseous envelope of the Earth; the earth tide, which acts on the solid Earth; and the oceanic tide (usually simply called "the tide"), which acts on the hydrosphere.

Also called the astronomic or astronomical tide.

(3) #An extension of the above definition to include similar changes caused by the influence of other bodies in general.#

For example, thermal tides are changes caused by the heating and cooling of a body, such as the Earth's atmosphere, by solar radiation. For historical reasons and for reasons connected with the method of measurement, oceanographers restrict the use of the word *tide* to vertical movements of the water; horizontal movements are called tidal currents.

tide, age of the See *inequality, age of phase.*

tide, apogean #A tide that occurs when the Moon is farthest from the Earth during a lunar month.#

See *tide, perigean.*

tide, astronomic (astronomical) (1) #The periodic change in magnitude and direction of gravity as caused by attraction of the Sun, Moon, and other members of the Solar system.#

(2) #The level of the tide at a given place, as predicted from astronomical considerations only.# See *tide* (2).

(3) See *tide, equilibrium.*

tide, diurnal constituent of #Any *constituent* of the tide whose period approximates that of a *lunar day* (24.8 solar hours).#

tide, double #(1) A *high water* consisting of two maxima, of nearly the same height, separated by a relatively small depression.#

(2) #A *low water* consisting of two minima of nearly the same depth, separated by a relatively small elevation.#

The double tide phenomenon is sometimes called an agger.

tide, Earth See *Earth tide.*

tide, ebb #The portion of the tidal cycle between *high water* and the following *low water*.#

Also called a falling tide.

tide, equilibrium (1) #The hypothetical tide that would occur if the oceans covered the Earth completely and uniformly, and responded instantaneously to the gravitational attraction of the Sun and Moon as the longitudes, latitudes, and distances of these bodies changed with respect to the Earth.#

(2) #The hypothetical tide that would occur if the oceans covered the Earth completely and uniformly, and the Sun and Moon were at fixed geographical longitudes and latitudes and distances with respect to the Earth.#

The two definitions are almost equivalent, except that definition (1) implies a different configuration of the equilibrium tide for each configuration of Earth, Sun, and Moon, while definition (2) deals with a fixed configuration. However, definition (1) requires a theory able to deal with a liquid that has mass but not inertia (note the "instantaneous response" requirement).

Also called the gravitational, the astronomic, or the astronomical tide.

tide, falling See *tide, ebb.*

tide, flood #The portion of the tidal cycle between *low water* and the following *high water*.#

Also called a rising tide.

tide, gravitational (1) #Periodic motion of an equipotential surface (e.g., the geoid) in response to the gravitational attraction of the Sun, the Moon, and other members of the Solar System.#

This is not the same as the Earth or oceanic tide, a movement of the material surface. Spirit leveling gives the elevation of the Earth's surface, as affected by the Earth tide; the position of the equipotential surface (the geoid, with respect to which elevations are calculated) is itself affected by the gravitational tide.

(2) See *tide, equilibrium* and *tide, astronomic.*

tide, great diurnal range of #The difference in tidal elevation between *mean higher high water* and *mean lower low water*.#

Also called diurnal range.

tide, great tropic range of #The difference in tidal elevation between tropic higher high water and tropic lower low water. See *tide, tropic.* #

tide, harmonic analysis of #A representation (or the process of finding such a representation, such as a Fourier series), of the variation in height of the tide at a particular place.#

The usual representation, in oceanography, takes the form of a multiple Fourier series. See *Doodson number*. Detailed expositions of tidal constituents can be found in Schureman (1958) which does not employ the Doodson numbers representation, and in Neumann and Pierson (1966) which does.

tide, internal #A *tidal wave* moving along a sharp density discontinuity in the water, such as at a thermocline, or in a region of gradual vertical change in density.#

tide, lithospheric #A tide in the solid Earth.#

See *Earth tide.*

tide, lowest astronomical #The lowest tidal elevation that can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions.#

tide, lunar #The portion of the tide that can be attributed directly to attraction by the Moon.#

tide, mean rise of #The tidal elevation of *mean high water* above the reference level of *chart datum*.#

tide, meteorological constituent of #A tidal *constituent* having its origin in the daily or seasonal variations in weather conditions.#

These conditions may occur with some degree of periodicity. The principal meteorological constituents recognized in the tides are *Sa*, *Ssa*, and S_l (terms due to the Sun with annual, semiannual, and daily frequencies).

tide, neap #A tide of decreased range that occurs semimonthly as the result of the Moon being in *quadrature*.#

The *neap range* of the tide is the average, semidiurnal range occurring at the time of neap tides. It is smaller than the mean range where the type of tide is either semidiurnal or mixed, and is of no practical significance where the type of tide is diurnal. The average height of the high waters of the neap tides is called neap high water or high water neaps; the average tidal height of the corresponding low waters is called neap low water or low water neaps.

tide, nodal line of #In a tidal region, the line about which oscillations of the tide are at a minimum.#

tide, over See *overtide.*

tide, perigean #The tide that occurs when the Moon is closest to the Earth during a lunar month.#

See *tide, apogean.*

tide, perigean spring #The tide that occurs when the Sun and Moon line up with the Earth (have the same right ascension) and the Moon is in perigee (closest to the Earth).#

Tides are extremely high at such times.

tide, periodicity of the #A classification of tides as semidiurnal, mixed or diurnal, when the ratio $(K_1 + O_1)/(M_2 + S_2)$ is less than 0.25, between 0.25 and 1.5, or greater than 1.5 respectively. K_1 and O_1 are the magnitudes of the two largest diurnal tides, and M_2 and S_2 are the two largest semidiurnal tides.#

tide, pole #A tide, caused by the *Chandlerian motion* of the Earth, with a period of between 433 and 437 days and an amplitude of no more than a few millimeters.#

tide, radiational #Periodic variations in water level related primarily to meteorological changes such as the semidiurnal cycle in barometric pressure, daily land and sea breezes, and seasonal changes in temperature.#

tide, range of #The difference in elevation between consecutive high and low waters.#

tide, semidiurnal #A tide having a period of approximately one-half of a *tidal day*.#

The predominating type of tide throughout the world is semidiurnal; the two high waters and two low waters of each tidal day are approximately equal in height.

tide, small diurnal range of the #The difference in elevation between mean *lower high water* and mean *higher low water*.#

See *tide, great diurnal range of.*

tide, small tropic range of the #The difference in elevation between tropic lower high water and tropic higher low water. See *tide, tropic*.#

tide, spring #A tide of increased range that occurs semimonthly, when the Moon, the Earth, and the Sun are aligned in right ascension.#

tide, stand of #A time during the occurrence of high or low water when there is no sensible change in the height of the tide.#

tide, thermal #A change in the size and shape of the Earth that occurs as a result of the heating of the Earth by the Sun and the re-radiating of this heat into space.#

At the present rate of rotation of the Earth, the solid Earth and hydrosphere are not affected more than a few tens of meters below the surface and so do not show appreciable thermal tides. The atmosphere, however, reacts more strongly to solar heating and nighttime cooling and so displays marked diurnal thermal tides.

tide, tropic #A tide occurring semimonthly when the effect of the Moon's maximum declination is greatest.#

At these times, there is a tendency for the diurnal range to increase. The tidal datums pertaining to the tropic tides are designated as tropic higher high water, tropic lower high water, tropic higher low water, and tropic lower low water.

tide, type of #A classification of the tides based on the characteristic forms of a graph of tidal height against time (tide curve). The three types are semidiurnal, diurnal, and mixed tide.# See *tide, harmonic analysis of; tide, periodicity of*; and *constituent* (tides).

tide, vanishing #A semidiurnal tide whose presence is hidden by the diurnal tide.#

In a mixed tide with very large diurnal inequality, the *lower high water* (or *higher low water*) frequently becomes indistinct (or vanishes) at time of extreme lunar declination. During these periods the diurnal tide has such an overriding dominance that the semidiurnal tide, although still present, cannot readily be seen on the tide curve.

tide gauge #A device for measuring the rise and fall, and the current height of the tide.#

The simplest form is a simple, graduated staff placed vertically in the water; the height of the water is read visually from markings on the staff. A more common version has a float with pointer attached to the staff; the float is free to move up and down the staff with the tide. Readings may be made visually or may be recorded on paper. Still another variety determines the height of the tide by relating it to the pressure needed to force a constant stream of bubbles out of an open duct near the bottom of the well. See *tide staff, tide station, stilling well*, and *float well.*

tide gauge zero #A horizontal plane established at a tide gauge by reference to the *contact mark* and used as a practical definition of *tide gauge datum.* #

From this plane, tidal heights at a particular station are measured in the day-to-day operation of the tide gauge. Adjustments may be required in the relationship between tide gauge zero and the contact mark as a result of periodic levelings to the tide gauge bench mark.

tideland #Any coastal region between mean low tide and mean high tide, i.e., regions that are ordinarily covered and uncovered by the ebb and flow of the ordinary, daily tides.#

tide level #The height of the tide above a specified level.#

See *height* (3).

tide level, mean (1) #The tide level half way between mean high tide and mean low tide.#

Also called ordinary tide level.

(2) #The reference surface halfway between surfaces of *mean high water* and *mean low water*.#

tides, sequence of #The order in which the four tides of a day (two high, two low) occur, with special reference as to whether the *higher high water* immediately precedes or follows the *lower low water*.#

tide staff #A graduated staff (of sufficient length when held vertically to extend above the highest tide) upon which the height of the water is measured.#

A tide staff may be either fixed, and not readily removable, or portable. A portable tide staff, although fastened securely while in use, can be easily removed for installation elsewhere.

tide station (1) #The geographic location at which tidal observations are made.#

(2) #The equipment used to make tidal observations and its housing.#

Equipment and housing may include a shelter, a tide gauge, a tide staff, and tidal bench marks. According to the importance of the observations and the period over which they have been made continuously, a tide station is classified as a primary control, subordinate, secondary control, or tertiary tide station. At a primary-control tide station, observations have been made over at least 19 years; at a secondary-control tide station, observations have been made for more than 1 year but less than 19 years; and at a tertiary tide station, observations have been made for at least 30 days but for less than 1 year.

A subordinate tide station is either (a) one at which a relatively short series of observations has been made and reduced by comparing them with records from a nearby tide station with a long series of observations, or it is (b) one listed in the *National Ocean Service Tide Tables* for which predictions are to be obtained by means of differences and ratios applied to the full predictions for a nearby tide station.

tie #A survey made to determine, from a point of known location, the location of another point.#

The location of a supplementary point may be needed for mapping or as a referent, or to close a survey on a previously determined point. To "tie in" is to make such a survey. The point to which the survey is made is called a tie point.

tie point (1) See *tie*.

(2) #Image points identified on photographs in the overlap between two or more adjacent strips of photographs.#

Tie points serve to connect the individual sets of photographs into a single unit and to connect photographs from adjacent flights into a common network.

tier #Any series of contiguous townships situated east and west of each other; also, *sections* similarly situated within a township.#

tie strip #An overlay showing all planimetric and topographic features in the area along the edge of a map or chart.#

It is used to ensure the matching of these features on adjoining sheets. Also called a match strip.

(2) See *photography, strip*.

tilt (1) #The dihedral angle between the plane of a photograph and a horizontal plane.#

The line of intersection of the two planes is called the axis of tilt. The angle is commonly resolved into two components: *x-tilt* and *y-tilt*.

(2) #In photogrammetry using a *multiplex* plotter, the term means x-tilt. #

(3) #The failure of the optical axis of a lens to be parallel to the optical axis of a preceding or following lens in a lens system.#

The term is applied particularly to the objective of a camera.

tilt, cross #An error introduced into stereotriangulation because it is not possible to determine the exact camera stations for successive pairs of photographs.#

This error is generally caused by variations in equipment, materials, or imperfect relative orientation.

tilt, relative #The dihedral angle between the plane of a photograph and some other plane (not necessarily horizontal) such as that of the adjacent photograph in a strip.#

tilt, x- See *x-tilt* and *tilt*.

tilt, y- See *y-tilt* and *tilt*.

tilt circle #In a tilted aerial photograph, a circle passing through the *isocenter* with a diameter lying along the *principal line*.#

When this diameter is drawn to a convenient linear scale, then any chord through the isocenter gives the component of tilt for that particular direction.

tilt determination, Church method of #A rigorous, mathematical method of determining the tilt of an aerial photograph by solving first for the coordinate of the perspective center, given the coordinates of at least three ground points, and then solving for tilt, swing, and azimuth.#

tilt determination, displacement method of #A method of determining the amount of tilt in an aerial photograph by comparing the displacements of image points for which the vertical and horizontal coordinates of the corresponding ground points are known.#

tilt determination, Morse method of #A method of determining the tilt of an aerial photograph by using three or more ground points whose horizontal and vertical coordinates are known and another point whose horizontal coordinates are known and whose image is near the center of the photograph.#

tilt determination, scale-point method of #A method of determining the amount of tilt in an aerial photograph by using the scale at three points (scale points) in the photograph for which the elevations of the corresponding ground points are known.#

tilt displacement See *displacement, tilt.*

tiltmeter #An instrument for measuring changes in difference of elevation between points on or in the Earth.#

time See specific entries below.

time, apparent See *time, apparent solar.*

time, apparent solar #Time measured by the observable (apparent) diurnal motion of the Sun.#

Also called true solar time or apparent time.

At any given instant at a point on the Earth, the apparent solar time is the *hour angle* of the Sun. In civil usage, apparent solar time is counted from the two branches of the meridian through civil noon. The hours from (east of) the upper branch (the half of the celestial meridian that includes the zenith) are marked "p.m." (post meridian); those from (west of) the lower branch are marked "a.m." (ante meridian). In astronomical work before 1925, apparent solar time was counted from the upper branch of the meridian through 24 hours (see *time, astronomical*); since 1925 the count has been from the lower branch, and the *civil day* has taken the place of the the *astronomical day*. Naming the meridian used as reference is essential to the complete identification of the time; e.g., 75th-meridian apparent solar time; Greenwich apparent solar time; local apparent solar time (at the meridian of the observer). Because of variations in the apparent motion of the Sun, a clock cannot be adjusted to show apparent solar time. Apparent solar time is determined by observations on the Sun; i.e., it is equivalent to the time shown by a sundial. See *time, equation of.*

time, astronomic #Time measured by the motion of celestial bodies.#

Also called astronomical time.

time, astronomical #The part of a solar day beginning at noon (0^h) and continuing for 24 hours, ending at noon of the next day.#

By convention, the second noon belongs to the next day. Astronomical time may be either *apparent solar time* or *mean solar time*, depending on whether the apparent Sun or the *mean Sun* is used. Before 1925, tabulations in the national ephemerides and almanacs were in terms of astronomical time; since then tabulations have been in terms of universal time, which is the same as Greenwich Mean Time.

time, atomic #In general, time determined from a specified epoch in terms of the *atomic second.*#

Many nations such as the United States determine atomic times using their own atomic clocks. These times are, however, subordinate to International Atomic Time which, according to a definition approved by the 14th Federal Conference on Weights and Measures in 1971, is the atomic time determined by the Bureau International de l'Heure.

time, civil #Solar time in a day (civil day) that begins at midnight.#

Civil time may be either *apparent* or *mean solar time*; it may be counted in two series of 12 hours each; one beginning at midnight and marked "a.m." (ante meridian), the other at noon and marked "p.m." (post meridian), or in a single series of 24 hours beginning at midnight.

time, clock #Time determined by reference to the indications of a clock.#

It is conventional to differentiate between atomic time, which is that indicated by clocks using the frequency of radiation from particular kinds of atoms or molecules, and those indicated by clocks that use the frequency of mechanical vibrations such as the swinging of a pendulum, the vibration of a quartz crystal, or the oscillations of a balance wheel. See *clock, Shortt; clock, crystal*; and *chronometer.*

time, coordinated universal (UTC) (1) #The time kept by a clock whose rate is controlled by atomic clocks so as to be as uniform as possible for 1 year, but with the rate chosen by the Bureau International de l'Heure and subject to change at the beginning of a calendar year.#

This time was used for many broadcast signals from 1960 through 1971.

(2) #The time kept by a clock controlled by atomic clocks and running at the correct rate (zero offset in frequency) but changed by the infrequent addition or deletion of 1 second to keep the time within $0.^s7$ of *universal time* 1 (UT1).#

Definition (2) was adopted by the International Radio Consultive Committee in Geneva in February 1971 and became effective January 1, 1972.

time, daylight saving #A clock time advanced by 1 hour from *standard time*.#

In the United States of America, daylight saving time is required by Federal law from the first Sunday in April (effective 1987) to the last Sunday in October to make greater use of daylight hours. However, individual States may exempt themselves from the use of daylight saving time. During World War II, double daylight saving time (a 2-hour time advance) was put into effect nationwide and was called war time.

time, dynamical See *time, ephemeris.*

time, ephemeris (1) #The time determined by the equations of motion of the planets and moons of the Solar System and by observations of the coordinates of these bodies.#

(2) #Those values which, when substituted for the independent variable *t* in the equations of motion of members

of the Solar System, cause the predicted coordinates to best agree with the observed ones.#

Sometimes called dynamical time. The term "ephemeris time" has replaced "universal time" in most ephemerides. Ephemeris time is calculated from the instant near the beginning of A.D. 1900 when the geometric mean longitude of the Sun was 279° 41′ 48.″04. At that instant, ephemeris time was January 1900 0^d 12^h E.T. precisely.

time, equation of #The difference in *hour angle* between *apparent solar time* and *mean solar time*.#

The real Sun reaches the local meridian sometimes before and sometimes after the *mean Sun* by an amount that ranges from 0 to about 16 minutes of time. Because the equation of time may be expressed as a correction either to apparent solar time or to mean solar time, care must be taken to use its sign in the proper (+ or −) sense.

Time, Greenwich Civil #*Mean solar time* for the Greenwich Meridian, counted from midnight.#

Also called *universal time*. Greenwich Civil Time was used in the *American Ephemeris and Nautical Almanac* for 1925 and thereafter. Universal time is no longer used as a synonym for Greenwich Civil Time in ephemerides; *ephemeris time* is used instead.

Time, Greenwich Lunar #The arc of the celestial Equator between the lower branch of the Greenwich celestial meridian and the hour circle of the Moon, measured westward from the lower branch of the Greenwich celestial meridian through 24 hours.#

It is equivalent to *local lunar time* at the Greenwich meridian and to the Greenwich hour angle of the Moon, expressed in time units, plus 12 hours.

Time, Greenwich Mean See *time, universal.*

Time, Greenwich Sidereal #The arc of the celestial Equator, or the angle at the celestial pole, between the upper branch of the Greenwich celestial meridian and the hour circle of the vernal equinox, measured westward from the upper branch of the Greenwich celestial meridian through 24 hours.#

It is equivalent to local sidereal time at the Greenwich meridian, and to the Greenwich hour angle of the vernal equinox, expressed in time units.

Time, International Atomic #Time established by the Bureau International de l'Heure in accordance with the definition of the second in SI.# This definition is that arrived by the General Congress on Weights and Measures, 1971.

time, local apparent #The *apparent solar time* for the meridian of the observer.#

time, local lunar #The arc of the celestial Equator, or the angle at the celestial pole, between the lower branch of the local celestial meridian and the hour circle of the Moon, measured westward from the lower branch of the local celestial meridian through 24 hours.#

It is equivalent to the local hour angle of the Moon, expressed in time units, plus 12 hours.# See *Time, Greenwich Lunar.*

time, local mean #The *mean solar time* at the meridian of the observer.#

time, local sidereal #The *sidereal time* at the meridian of the observer.#

time, lunar (1) #Time based upon the rotation of the Earth relative to the Moon.#

(2) #Time on the Moon.#

time, mean solar #*Time* measured by the diurnal motion of a fictitious body, the mean Sun, which is supposed to move at a constant angular speed along the celestial Equator, completing the circuit in one *tropical year*.# Often called mean time.

The mean Sun may be considered as moving along the celestial Equator and having a right ascension equal to the average celestial longitude of the true Sun. Naming the meridian of reference is essential to completely identify the time (for example, Greenwich mean solar time). By using the same meridian as reference over a belt or zone of the Earth, clocks are adjusted to show the same mean solar time throughout the region. The Greenwich Meridian is the reference for the worldwide standard of mean solar time, which is called *universal time*. Because the mean Sun is a fictitious body, mean solar time cannot be determined directly by observation. See *time, equation of*; *time, standard*; and *time, apparent solar.*

time, origin of #The *epoch* from which a date, or instant of time, is determined.#

The origin usually used by astronomers is the one for which the Julian date is 0. That used by geologists is the present time; time before the present is called time B.P. The origin commonly used for civilian purposes and many scientific purposes assigns the date October 15 A.D. 1582 to the day on which the Gregorian calendar replaced the Julian calendar then in use. This day has the date October 5 A.D. 1582 in the Julian calendar. There is no year "zero in civil practice. The year immediately preceding the origin is the year 1 B.C., that following the origin is the year 1 A.D. In astronomical practice, the year immediately preceding the origin is designated year 0 (zero); the other years B.C. are designated by negative numbers. The position of the origin within a day depends on how the day is defined. The civil date has usually begun at midnight. Before 1925, astronomers reckoned mean solar time from noon, the mean solar day beginning at noon 12 hours after the midnight at the beginning of the same civil date. In 1925, the national ephemerides began reckoning the day from midnight also, so that December 31.5, 1924 was designated January 1.0, 1925 in the new ephemerides.

time, real (1) #*Time* considered as a real quantity rather than as an imaginary quantity.#

This is usually the case in relativistic mechanics. The spatial coordinates of a point are then imaginary quantities.

(2) #A time very close to the instant of observation or other activity.#

time, sidereal #The *local hour angle* of the vernal equinox.#

If the true (apparent) vernal equinox is used, we have apparent sidereal time; if the mean equinox is used, we have mean sidereal time. If the hour angle is referred to the average meridian of Greenwich, rather than to the local meridian, we have Greenwich mean sidereal time.

time, solar #Time determined by reference to the position of the Sun.# See *time, apparent solar* and *time, mean solar.*

time, standard #*Mean solar time* for a particular meridian adopted for use throughout a zone (time belt).#

In the continental United States, the meridians used as reference for standard time are at multiples of 15° of longitude (1-hour increments) from the initial Greenwich Meridian. The standard time for each zone is identified by the number of its meridian, and by a name of geographic significance, such as Eastern Standard Time.

Standard time was established in 1883 to correlate schedules of trains of various railroads in the same regions. The zones of standard time were planned to be roughly symmetrical with respect to the meridians of reference, and to extend 7.5° to either side thereof. Practical considerations, such as the need to correlate time in cities outside the original boundaries of a zone with time in cities within the zone, have caused a gradual shifting of those boundaries until some now exhibit large irregularities. See *time, daylight saving.*

time, stepped atomic #The time kept by an atomic clock whose rate is correct (zero offset) but reset periodically to maintain the time within $0.^{s}1$ of *universal time* 2 (UT2).#

time, true solar See *time, apparent solar.*

time, universal (UT) #Twelve hours plus the *Greenwich hour angle* of a point on the Equator whose *right ascension,* measured from the *mean equinox* of date, is:

$$18^{h}38^{m}45.^{s}836 + 8640184.^{s}542\ T + 0.^{s}0929\ T^{2}$$

where T is the number of Julian centuries (consisting of 36,525 *mean solar days*) elapsed since the epoch of Greenwich mean noon (12^{h} UT) on 1900 Jan 0 (Nautical Almanac Office, 1961, p. 73).#

Universal time corresponds to *Greenwich Civil Time,* and is the same as Greenwich Mean Time except that January 1, 1925 divides the old reckoning (noon to noon) of Greenwich Mean Time from the new reckoning (midnight to midnight) of universal time. The astronomical day of December 31, 1924 was only 12 hours long, so December 31.5, 1924 is January 1.0, 1925.

Universal time is actually only one of three different kinds of time. (a) The first, referred to as "UT0", is the kind defined above. It is obtained directly from observations and is not corrected for motion of the pole or for seasonal variations in rate of rotation.

(b) The second, referred to as "UT1" is obtained from UT0 by correcting for the difference between the instantaneous and the average longitude at the observer. This is derived from measurement of polar motion. Because UT1 is related directly to the instantaneous rotation of the Earth, which is not strictly uniform, UT1 does not progress uniformly as compared with time measured by an atomic clock.

(c) The third kind, referred to as "UT2", is derived from UT1 by correcting it for seasonal, periodic variations in the rate of rotation of the Earth. It is the average angular motion of the Earth and is free of predictable periodic variations but is still affected by irregular and secular variations.

time determination, Bessel's formula for See *Bessel's formula.*

time determination, Dellen's method of See *Doellen's method.*

time determination, Mayer's formula for See *longitude determination, Mayer's formula for.*

time determination, Tsinger method of See *longitude determination, Tsinger method of.*

time dial (attachment to globe) #A disk, graduated in time units (0 hours to 24 hours), attached to a globe with its center coincident with a pole of the globe, and adjustable to show the relation between local time and the time at any other meridian.#

time interval #The elapsed time between two specified instants of time.#

time scale #The system of units into which the time axis of a coordinate system is divided.#

The location of the origin is irrelevant. Time scales are usually classified according to the method used for measuring time such as *astronomic time*, in which scale is determined by the quasiperiodic rotation or revolution of celestial bodies (Earth, Moon, Sun, etc.); *clock time*, which is determined by the more or less periodic movements of a mechanism; and *atomic time*, in which the scale is set by the (approximately) constant frequency of molecular or atomic phenomena (and displayed by an atomic clock).

There are three different kinds of astronomic time scales in general use. These are the time intervals taken for (a) one rotation of the Earth about its axis with respect to a celestial body, (b) one revolution of the Moon about the Earth, and (c) one revolution of the Earth about the Sun. They are called, respectively, the *day*, the *month,* and the *year*. Month, in the present sense, is always identified by an adjective (e.g., synodical or draconic month) to distinguish it from the civil month, which consists of a variable number of integral days.

The *second*, a unit of time in physics, is a fundamental unit only in atomic time. In astronomic time, the second is defined as a specified fraction of the year.

time zone #A geographic region in which the time used in civil affairs is everywhere the same.#

Time zones are prescribed by law, and differ by an integral number of hours from Greenwich Mean Time. See *time, standard.*

tint, gradient See *tint, hypsometric.*

tint, hyposometric #One of a succession of shades or graduated colors used to depict ranges of elevation.#

Also called gradient tint or elevation limits.

toise #A French unit of length based on a French legal standard of length of the same name and equal to about 6.4 English feet.#

The actual length varied according to the standard used in the definition. It was used in early geodetic surveys and was the basis, in many countries, for the standard of length. Excluding the Rhineland Rod used by Snell, the toise was the first geodetic unit of length. See *Toise of Peru*.

Toise of Peru #The length of an iron bar used as standard in measuring the base lines that controlled lengths in the Peruvian Arc (of triangulation) surveyed in 1736-1743, to determine the figure and size of the Earth.#

The Toise of Peru became the legal standard of length in France in 1776. From it the *French legal meter* was derived as follows. The toise was divided into 6 pieds (feet); each pied was divided into 12 pouces (inches); each pouce was divided into 12 lignes (lines); and one French legal meter was defined as equal to exactly 443.296 lignes at a temperature of 13° Reaumur. (The Peruvian Arc does not lie in modern Peru, but in Ecuador, which was part of the old Spanish presidency of Peru).

In the first decades of the 1800's, direct copies of the Toise of Peru were made and used by various states as *base line apparatus* for their triangulation. Carelessness in handling the original bar representing the Toise of Peru resulted in its loss. The primary and secondary copies of the bar were then used as reference for the true length of the Toise.

tolerance #The permissible deviation from a specified value.#

In surveying, a permissible probable error or standard deviation may be regarded as an expression of tolerance, though the term tolerance is seldom used. Its use may well be confined to stating the permissible deviation from exactness in the fitting together of component parts of instruments, for example, the pivot inequality of an astronomical transit.

topangulator #An instrument for measuring vertical angles in the principal plane of an oblique photograph.#

topocentric (adjective) #Referred to a point on the surface.# Contrasted to *geocentric*.

topographic correction See *gravity correction, topographic*.

topographic deflection See *deflection of the vertical, topographic*.

topographic feature #A prominent or conspicuous *topographic form* or a salient part thereof.#

topographic form #A *landform* considered only with regard to its form, but not with regard to its origin, cause, or history.#

topography #The form of the features of the actual surface of the Earth in a particular region considered collectively.# Also called relief.

A single feature, such as a mountain or valley, is called a *topographic feature*.

topography, dynamic See *dynamic topography*.

topography, geopotential See *dynamic topography*.

toponymy #The branch of cartography dealing with the names of places.#

torr #A unit of pressure exactly equal to 1/760th of an atmosphere.#

One torr is equal to 133.322 pascals.

Torrens Registration System #A method of recording the ownership of land, in which the title to the land is registered instead of, as in other systems, registration of the evidence of such title. The State then insures the owner against loss in case the title is defective.#

Upon the land owner's application, the court may, after appropriate proceedings, direct the issuance of a certificate of title. With some exceptions, this certificate is conclusive as to applicant's estate in land. After registration, all deeds and documents affecting the property are duly registered. See *abstract of title*.

Torrens title system See *Torrens Registration System*.

torsion balance #A device for measuring very small differences of attraction caused by gravitational or magnetic fields, etc., and consisting basically of a bar suspended horizontally by an elastic fiber. One end of the bar is subjected, because of the variation of the attraction from place to place in the field, to a greater force of attraction than the other end, and the bar therefore rotates until the difference in force is balanced by the torque of the fiber. The attracting force is measured by the amount of rotation of the bar.# In geophysics, a form of torsion balance is used to determine the gradient of gravity (the rate of change of gravity with distance from a point).

In geophysical prospecting over a large region, a large mass of abnormal density may be detected by use of the torsion balance. See *gravity gradiometer*.

total station (1) #A *tachymeter.*#

(2) #A tachymeter which senses angles and distances electronically.#

This designation originated around 1980, and is now (1986) very common in the United States of America.

tower (surveying) #A structure used to elevate the line of sight above intervening obstacles.#

tower, Bilby #A tower used in triangulation and consisting of two tripods, one within the other. The Bilby tower is constructed (according to the design of J. S. Bilby of the U.S. Coast and Geodetic Survey) so that an observer on a platform at the top of the outer tripod can move about without disturbing an instrument mounted on the top of the inner tripod.#

The Bilby tower was put into use in 1927 and was used in triangulation by the National Geodetic Survey up to 1984. The tower can readily be put up, taken down, and moved to new locations.

tower, Lambert "twin" #A tower used primarily in surveying for horizontal control, consisting of a 9-inch diameter vertical pipe supporting the instrument and a vertical, triangular prism, 12 inches on a side, that surrounds the pipe and supports an observing platform at the top.#

The pipe is kept vertical by cables connected internally to the prism. The prism is kept vertical by guying cables connecting it to anchors in the ground. If the tower is more than 15 feet high, its rigidity is increased by external bracing wires. Both pipe and prism are made in 15-foot long modules, permitting the erection of towers as high as 60 feet.

tower, triangulation #A tower used in triangulation that consists of two independent, separate structures. One is an inner structure that supports the theoodolite and, sometimes, the target or signal lamps; the other is an outer structure that supports the observer and assistants and, sometimes, the target or signal lamps.#

Before 1927, towers constructed of wood were used; the inner structure was a tripod and the outer structure a four-legged scaffold. In 1927, the Bilby steel tower was put into use. Triangulation towers more than 100 feet high were frequently used.

township #The unit of land into which the public lands of the United States of America were officially divided by surveys; normally it is a quadrangle approximately 6 miles on a side with boundaries conforming to meridians and parallels, and located with respect to the initial point of a principal meridian and base line.# Townships are numbered consecutively north and south from a *base line*; thus "township 14 north" indicates a township in the 14th tier north of a base line. The word "range" is used together with the appropriate number and direction to indicate the coordinates of a particular township with respect to the initial point; thus "township 14 north, range 3 east" indicates the 3rd township east of the *principal meridian* in the 14th tier north of the base line controlling the surveys in that area. The plural form, "townships" or "tps.," is used whenever more than one unit is to be indicated; thus, "townships 14 north, ranges 3, 4, and 5 east" and "townships 14 and 15 north, range 3 east."

township, fractional #A township containing appreciably less than 36 *sections* of normal size, usually because the township was invaded by a segregated body of water, or by other land that could not properly be surveyed as part of that township.#

Townships may be made fractional by closing the public land surveys on State boundaries or other limiting lines.

township line #An external boundary of a township extending in an east-west direction.#

trace, horizon See *horizon trace*.

tract (1) #Generally, a *metes and bounds* survey of a region within a township (U.S.A.).#

(2) #A parcel of land that lies in more than one *section*. #

(3) #A parcel of land that cannot be identified completely as a part of a particular section.#

trajectory #The points in space-time occupied by a body starting from a specified point and moving to, and ending at, another specific point.#

The body may be acted upon by forces generated within itself, as well as by external forces. An *orbit* differs from a *trajectory* in that end points are not specified and no forces other than those naturally present in the environment act on the body.

Tranet #The worldwide tracking network which provides the *precise ephemerides* for the *Navy Navigational Satellite System*. #

transducer (1) #Any device that converts one kind of physical phenomenon (energy, power, force, motion, etc.) into another—as, for example, heat into motion or pressure into displacement.#

Almost any measuring instrument is a transducer. In electronic engineering, the output of a "transducer" is assumed to be voltage or current.

(2) #A device that accepts power from one source and transfers it to another.#

transfer function #The ratio between the Laplace or Fourier transform of the output function of a system and the Laplace or Fourier transform of the input function, subject to the specified boundary conditions.#

It is the analog, in the frequency domain, of the quantity "output per unit input". Transfer functions are used because an input function can usually be expressed as a Fourier series, so that the system's performance can be specified as a sum of independent, periodic terms.

transfer function, modulation See *transfer function, optical*.

transfer function, optical #The complex ratio of the Fourier transform of the light distribution over an image to the Fourier transform of the light distribution over the corresponding regions of the object.#

This is the same as the (complex) Fourier transform of the *line-spread function*. The absolute value of the optical transfer function (OTF) is called the modulation transfer function (MTF); the phase is called the phase transfer function (PTF).

transfer function, phase (PTF) See *transfer function, optical*.

transfer instrument #An instrument used to transfer detail from a photograph or photographs to a manuscript.#

There are two principal types: the single-point transfer instrument used to transfer planimetric detail from a single photograph to the manuscript; and the stereoscopic transfer instrument used to transfer detail from a stereoscopic pair of photographs to the manuscript. The specification of detail distinguishes transfer instruments from *plotting instruments*.

transfer instrument, single-point See *transfer instrument*.

transfer instrument, stereoscopic See *transfer instrument*.

transfer of water level See *water-level transfer*.

transform #An integral

$$F(\vec{k}) = \int G(\vec{x}, \vec{k}) f(\vec{x}) d\vec{x}$$

where $\overrightarrow{x}$ and $\overrightarrow{k}$ are vectors.# F is the transform of f, and G is called the kernel.

transformation, affine #In geodetic application, a set of linear equations of the form

$$y_j = \sum_i a_{ij} k_i + b_j$$

in which a_{ij} and b_j are constants, and $j \leq i$.#

Affine transformations used in geodesy are generally two- or three-dimensional. The transformation may be only locally affine, as in the situation represented by

$$dy_j = \sum_i (\partial y_j / \partial x_i) dx_i .$$

transformation, projective #A set of equations of the form

$$y_j = \left(\sum_i a_{ij} x_i\right) \Big/ \left(\sum_i b_{ij} x_i\right)$$

in which a_{ij} and b_{ij} are constants, and $j \leq i$.#

transformer #A photogrammetric *rectifier* in which the angle or angles of tilt are fixed, as for the rectification of the eight oblique photographs into the plane of the central photograph, taken with a nine-lens camera.#

transit (1) #The apparent passage of a star or other celestial body across a specified line or through a specified plane.#

The line may be on the celestial sphere as a meridian, prime vertical, or almucantar, or it may be in the reticle of a telescope, or some marked line of sight, or it may mark the limb or disk of a larger celestial body.

When no line is specified, a transit across the meridian is usually meant. The transit of a star across the meridian occurs at the moment of its culmination; the two terms are sometimes used with identical meanings although such usage is not correct, even when the instrument is in perfect adjustment. The reason for this is that, while a star may have no culmination at the poles, it will transit the meridians. Examples of the transit of a small celestial body across a larger one are the transit of the planet Mercury across the disk of the Sun, and the transit of a satellite of Jupiter across the disk of that planet.

(2) #An astronomical or surveying instrument consisting primarily of a telescope that can be rotated about a horizontal axis to describe an arc of about 180° from horizon to horizon.#

(a) An astronomical transit is usually designed with the horizontal axis fixed (except for small adjustments) and perpendicular to the plane of the local meridian. Portable or quasi-portable astronomical transits, such as the Bamberg transit, may be rotatable about a vertical axis also, but this capability is for establishing the direction of the horizontal axis and is not for measuring horizontal angles.

A transit used in astronomical work is usually called either an astronomical transit or a transit instrument.

(b) A surveyor's or engineer's transit permits both vertical and horizontal rotation and contains a graduated horizontal circle for measuring horizontal angles.

The term transit is sometimes used as a synonym for theodolite or is intended to mean a surveying instrument similar to a theodolite but of insufficient accuracy to permit it to be used to establish geodetic control.

Transit See *Navy Navigation Satellite System.*

transit, astronomical See *transit* (2).

transit, Bamberg See *transit, broken-telescope.*

transit, broken-telescope #An astronomical transit with its telescope shaped so that a ray of light entering the objective is reflected at right angles by a prism placed within the telescope and then passes to the eyepiece which is in the horizontal axis of the telescope but outside the supports of the axis.#

One make of broken-telescope transit, called the Bamberg broken-telescope transit, or the Bamberg instrument, is described in F. Morse and O. B. French (1916); and in G. D. Cowie and E. A. Eckhardt (1924). This instrument has also been called a bent transit. The design permits use of the instrument to determine latitude by the zenith telescope method. The instrument is heavy but without undesirable flexure. This feature and the unusually long distance between the supporting wyes make for stability. The striding level used with straight-telescope instruments is replaced by a hanging level. The position of the eyepiece is independent of the altitude of the object observed and so makes observing easier. This instrument has been used for first-order accuracy determinations of astronomic longitudes, latitudes, and azimuths at stations in high altitudes. See *azimuth determination by the micrometer method.*

transit, engineer's #An angle-measuring instrument consisting principally of a telescope mounted so that it can be rotated through 360° in a horizontal plane and through 180° in a vertical plane, and capable of measuring the amount of rotation in these planes. A long level-vial is fastened longitudinally to the telescope.#

Also called an engineer's transit theodolite. An instrument similar to this engineer's transit but without a long level-vial and not usable for measuring vertical angles is called a plain transit. See *theodolite, repeating.* #

(2) #A transit or theodolite usable for measuring both horizontal and vertical angles with an accuracy acceptable for civil or construction engineering but not for establishing geodetic control.#

transit, jig #A precise transit without horizontal or vertical circles or compass, but with an optical micrometer on the telescope.#

It usually contains a lamp to provide a collimated beam of light. Also called a jig collimator.

transit, mining #An *engineer's transit* designed particularly for surveying in mines.#

It is usually provided with an auxiliary telescope or other means of taking very sharply or even vertically inclined sights.

transit, optical #A theodolite with graduated horizontal and vertical circles of glass that are read through a microscope connected optically to the circles by prisms and mirrors.#

transit, plain #An *engineer's transit* without a vertical circle or a level on the telescope.#

transit, solar #A *transit theodolite* designed for use in place of a *solar compass*.#

transit, solar attachment for See *solar attachment.*

transit, vernier #A transit having graduated, metallic horizontal and vertical circles with verniers.#

transit instrument See *transit* (2).

transit level #An instrument combining the major features of a *transit* and a *leveling instrument*.#

Such instruments are usually not as precise or accurate as either a theodolite or a leveling instrument but are more convenient for some kinds of surveying.

transit line #Any line of a traverse which is projected, either with or without measurement, by the use of a transit or other device.#

Also called traverse line.

transit micrometer See *micrometer.*

transit rule See *traverse adjustment, transit rule for.*

transit time (1) #The time needed for a signal to pass through an instrument or a component thereof.#

Transit time within a *transponder* must be added to the time of travel from transmitter to transponder and from transponder to receiver.

(2) #The time between the transit of the leading edge (limb) of a celestial object and its trailing edge.#

transmittance #The ratio of the intensity of light transmitted through a unit area of a translucent medium to the intensity of the light incident on that area.#

Also called "transmission".

The angle of incidence should be specified when it is not zero.

transponder #A device which, upon receiving a signal, transmits a second signal.#

This second signal may be merely an amplified version of the first, in which case the transponder is a relay, or may be different in frequency or in content or both. Its principal geodetic application is in the measurement of distances to satellites. The transponder on the satellite acts as a relay for signals transmitted from the ground.

traverse #A route and a sequence of points on it at which observations are made; or the route, the points, and the observations at those points; or the process by which the route and sequence are established.#

In particular, a *survey traverse.*

Unless specifically stated otherwise, a traverse is horizontal, i.e., a procedure for determining only the horizontal coordinates of the points in the traverse. See *traverse, survey.*

traverse, astronomical #A *survey traverse* in which the geographic coordinates of the stations are obtained by astronomic observation, and lengths and azimuths of lines are obtained by computation.#

traverse, classification of #A *survey traverse* is commonly classified on the basis of the accuracy of the control established by it; in the United States it is the same as the classification of that control.#

See *control, classification of.*

Horizontal control networks in the United States contain some traverses that established control with much higher accuracy than that required for first-order control; such traverses are called high-precision traverses by the National Geodetic Survey.

traverse, closed #A *survey traverse* that starts and ends upon the same station, or upon stations whose relative locations have been determined by other surveys.#

traverse, control #A survey traverse made to establish control.#

traverse, first-order #A *survey traverse* which by itself forms a *closed traverse,* or which extends between adjusted locations of first-order control, and the points of which are first-order control.#

The standards for first-order control are given in Federal Geodetic Control Committee (1984). See *control, classification of.*

The standards and criteria supersede those recommended earlier by the U.S. Bureau of the Budget in 1958. This earlier category for first-order traverse was roughly equivalent to the second-order class II category of 1974 and to the "first-order traverse" category of the 1925 classification. Before 1925, the 1925 first-order category was known as "precise traverse".

traverse, fourth-order #A survey traverse establishing control less accurate than that of *third-order traverse*.#

In a fourth-order traverse, angles are observed with a transit or sextant, or are determined graphically, and distances are measured with tape, stadia, or wheel.

traverse, framed #A traverse with complete location and bearing control.#

traverse, geodetic #A *survey traverse* for the establishment of geodetic control.#

traverse, geographical-exploration #A route along which approximate locations are determined by surveying or by navigational methods.#

traverse, open #A *survey traverse* that starts from a station of known or adopted position, but that does not end upon such a station.#

traverse, plane-table #A traverse done using a *plane table* to obtain directions or angles.#

A surveyor's tape is usually used for distances in such a traverse, but a stadia rod may be used with the proper kind of alidade.

traverse, precise See *traverse, first-order.*

traverse, random #A *survey traverse* run from one station toward another survey station which is out of sight of the first station, in order to determine their relative locations.# See *line, random.*

traverse, second-order #A *survey traverse* which by itself forms a closed traverse or extends between control points of the same or higher category, and which consists of second-order control.# See *control, classification of.*

The U.S. Federal Board of Surveys and Maps established the second-order traverse category in May 1925. Because the bases for classification were different from those used for the 1974 classification, the second-order traverse category of 1925 cannot be equated to one of the categories of the 1974 scheme of classification. It probably fits somewhere between third-order class I and second-order class II of the 1974 scheme.

traverse, specifications for #Specifications of certain procedures and criteria that are considered essential for obtaining horizontal control of a desired category in a survey traverse.#

See *control, classification of.*

traverse, survey #A route and a sequence of points between which distances and directions have been obtained by or from field measurements and have been used in determining locations of the points.#

It is usually referred to simply as a *traverse*, when no confusion is likely. A survey traverse may determine the relative locations of the points which it connects in sequence. If the locations are determined with the use of coordinates of control stations on an adopted datum, the locations may be referred to that datum. Survey traverses are classified and identified in a variety of ways such as: according to methods used, e.g., an astronomical traverse; quality of results, e.g., a first-order traverse; purpose served, e.g., a geographical-exploration traverse; or according to form, e.g., a closed traverse.

traverse, three-dimensional #A *survey traverse* in which all three coordinates of each point in the traverse are determined.#

traverse, third-order #A *survey traverse* which by itself forms a closed loop or which extends between control points of the same or higher category, and which consists of control of third-order or higher category.#

See *control, classification of.*

The earlier, "third-order traverse" category of the U.S. Federal Board of Surveys and Maps recommended in May 1925 was roughly equivalent to the same category in the 1974 classification. However, the bases for classification in the two schemes are so different that exact equivalence cannot be determined.

traverse, transit #A *survey traverse* in which the angles are measured with an engineer's transit or theodolite and the lengths are measured with a surveyor's tape.#

A transit traverse is the usual mode for control of local surveys and is of second- or third-order quality.

traverse adjustment #Determining the coordinates of a set of points in a traverse, or the distances and directions (or angles) of the lines in the traverse, in such a manner that the resulting coordinates, distances, directions, or angles are the best obtainable under the given conditions from the observations used.#

A traverse usually is a loop beginning and ending at a known point, or a line beginning and ending at known points. The misclosure is then the only datum with which corrections to the several courses of the traverse can be computed. There are always fewer misclosures than there are corrections to be made. Therefore assumptions must be made about the way the errors behave from course to course in the traverse. The rules or methods for adjusting traverses therefore differ according to the kind of assumptions made.

Also called balancing a survey.

traverse adjustment, angle method of #A method of adjusting a traverse, in which angles between successive courses are used as the observed quantities.#

traverse adjustment, Bowditch's method for (1) #Calculation of corrections to measured distances and directions in a traverse, using the assumption (the Bowditch hypothesis) that the end of a line in the traverse is likely to be located with equal precision in the direction along the line as in the direction at right angles to it.#

(2) See *traverse adjustment, compass rule for.*

traverse adjustment, compass rule for #The rule that the correction to be applied to the departure (latitude) of any course in a traverse has the same ratio to the total misclosure in departure, with sign changed, as the length of the course has to the total length of the traverse.#

The compass rule is used when it is assumed that the misclosure results as much from errors in angles as from errors in measured distances.

Also called Bowditch's rule.

traverse adjustment, Crandall's rule for #The corrections to the components of a traverse course as given by Crandall (1901).#

Crandall's rule distributes the misclosure into the lengths of the courses only and does not change the angles.

traverse adjustment, direction method of #A method of traverse adjustment in which the directions (azimuths) of courses are used as the observed quantities.#

traverse adjustment, Jolly method of #A method of traverse adjustment, using least squares, with the following modifications from standard least squares: (a) the angular misclosure is distributed equally among the angles, with the adjusted angles used to obtain the bearings of the courses, (b) the coordinates are referred to the *barycenter* of the traverse, and (c) the linear weights and the angular weights are constant throughout the traverse.#

traverse adjustment, transit rule for #The correction to be applied to the departure (latitude) of any course has the same ratio to the total misclosure (with sign changed) in departure as the departure of the course has to the arithmetical sum of all the departures in the traverse.#

The transit rule is used when it is believed that the misclosure is caused less by errors in the measured angles than by errors in the measured distances. It meets the assumptions on which it is based only when the courses are parallel to those of the coordinate system used.

traverse network #A geodetic network in which the stations are traverse stations and the lines represent adjusted distances and directions between stations.#

traverse station #A survey station which has had its horizontal coordinates determined by traverse, i.e., by measurement of distance and direction from either a station of previously known coordinates or from a station which is itself a traverse station.#

traverse tables #Mathematical tables listing the lengths of the sides opposite the oblique angles for each of a series of right triangles, as functions of the length and azimuth (or bearing) of the hypotenuse.#

Traverse tables have been used in computing latitudes (departures) in surveying and in computing courses in navigation.

triangle #A geometric figure consisting of three non-collinear points and the three line segments joining them.#

There are five kinds of triangles of geodetic interest: (a) a set of three points in a plane and the straight lines joining them, (b) a set of three points on a sphere and the great circle arcs joining them, (c) a set of three points on a sphere and a set of great circle or small circle arcs joining them, (d) a set of three points on an ellipsoid and the geodesics joining them, (e) a set of three points on an ellipsoid and the normal section arcs joining them.

Small circle arcs and normal section arcs on the ellipsoid are not uniquely defined by two points, so an additional specification is needed.

triangle, astronomical #The triangle on the celestial sphere formed by arcs of great circles connecting the celestial pole, the zenith, and a celestial body.#

The angles of an astronomical triangle are: at the pole, the *hour angle*; at the celestial body, the *parallactic angle;* at the zenith, the *azimuth angle*. The sides (arcs) are: from pole to zenith, the *colatitude*; from zenith to celestial body, the *zenith distance*; and from celestial body to pole, the *polar distance*. The astronomical triangle includes the celestial form of the navigational triangle.

triangle, celestial #A spherical triangle on the celestial sphere.#

In particular, see *triangle, navigational.*

triangle, excess of a See *excess, triangular.*

triangle, geodetic #A triangle whose sides are geodesics.#

triangle, navigational #The spherical triangle used in computing angular elevation and azimuth or in solving great circle problems in sailing.#

It occurs in two forms: celestial and terrestrial. The celestial triangle is formed on the celestial sphere by the great circles connecting the elevated pole, the zenith of the assumed location of the observer, and a celestial body. The terrestrial triangle is formed on a spherical Earth by the great circles connecting the pole and two places on Earth, either the assumed location of the observer and geographic location of the nadir point of the body used for celestial observations, or the points of departure and destination for great circle sailing problems.

The term "navigational triangle" applies to either the celestial or the terrestrial form.

triangle, spherical #The triangular figure formed by three points on a sphere and the three arcs of great circles joining them.#

To each set of three points correspond eight different spherical triangles.

triangle, spherical excess of See *excess, spherical.*

triangle, spheroidal #A set of three points on a spheroid and the geodesics joining them.#

triangle, spheroidal excess of See *excess, spheroidal.*

triangle, terrestrial See *triangle, navigational.*

triangle of doubt #In a simple *two-point problem*, the triangle resulting when a third line drawn as a check fails to pass through the point of intersection of the other two intersecting lines.#

triangle of error #The triangle formed when three plotted lines fail to intersect perfectly.#

The center of the triangle may be considered to be the adjusted position. See *resection.*

triangulation (1) #A method of surveying in which the points whose locations are to be determined, together with a suitable number (at least two) of points of known location, are connected in such a way as to form the vertices of a network of triangles. The angles in the network are measured and the lengths of the sides are either measured or calculated from known points and lengths.#

Sides with measured lengths are called base lines. Classically, only a very few, short base lines are in the network; these are connected to the sides of triangles of normal size by a sequence of triangles of increasing size.

Triangulation permits selection of sites for stations and base lines that are favorable both from topographic and geometric considerations (see *strength of figure*). Triangulation is well adapted to the use of precise instruments and methods in all its operations, and can yield results of great accuracy and precision. It is generally used where the region to be surveyed is large. The term triangulation may be considered as including not only the actual operations of observing angles and measuring base lines, and the reduction of the data, but also the reconnaissance and any astronomic observations that precede those operations.

(2) #The *survey network* resulting from triangulation in sense (1) above.#

triangulation, aerial See *aerotriangulation.*

triangulation, arc #Triangulation designed to progress in a single, general direction and to produce a network of limited width but considerable length.#

Arc triangulation is done to connect independent and widely separated survey networks, to coordinate and correlate local networks along the arc, to furnish data for the determination of a geodetic datum, to provide a network of control points for a countrywide survey, and the like. See *triangulation, area* and *triangulation, arc of.*

triangulation, arc of (1) #A *triangulation network* forming a band or belt on the surface of the Earth or on the reference ellipsoid.#

The axis (a line running down the center of the band and giving its general directions) of an arc of triangulation may approximate, in position, an arc on the ellipsoid following a meridian of longitude, a parallel of latitude, or an oblique arc. It may follow a natural feature, such as a river, or may follow an artificial feature such as a civil boundary. It is usually given a name identifying its general or particular location, such as the Mississippi River Arc, the Ninety-eighth Meridian Arc, and the Arc of the 30th (meridian).

triangulation, area #A triangulation designed to progress in every direction.#

Area triangulation provides geodetic control over a region, such as a city or county, or fills in the regions between arcs of triangulation that extend over a large region such as a county or State. See *triangulation, arc.*

triangulation, base-extension See *triangulation network, base-extension.*

triangulation, classification of #The category of a triangulation project or network is the same as the category of the control established by that project or contained in that network.# See *control, classification of.*

In the schemes of classification used by the U.S. Government, the practice has been to name categories in order of increasing size of relative error involved. Before 1921, the categories were primary, secondary, and tertiary triangulation. From 1921 to 1924, they were precise, primary, secondary, and tertiary triangulation. From 1925 to 1957 they were first-order, second-order, third-order, and fourth-order triangulation. In 1957, they were changed to first-order, second-order, third-order triangulation, and each of these categories was subdivided into classes: first-order triangulation was classified as special, class I, and class II; second-order triangulation was classified as class I and class II. In 1974, a different subdivision was adopted. First-order triangulation is not subdivided into classes, while second-order and third-order triangulation each contain two classes—class I and class II.

triangulation, first-order #A triangulation network which consists of first-order control (see *control, classification of*), or a triangulation that leads to such a network.#

The category first-order of the February 1974 classification does not correspond exactly to any category of earlier classifications. The closest is the first-order, class I of the March 1957 scheme. First-order of the preceding scheme of 1925 is roughly equivalent to second-order class I of the 1974 scheme.

triangulation, flare #A method of triangulation in which observations of a flare at very high altitude are made simultaneously from a number of stations.#

The flare is usually carried aloft by a rocket or airplane and ejected, to float downward under a parachute, or to be towed by an airplane. This method is used for extending triangulation over lines so long that the ends are not intervisible.

triangulation, photo See *phototriangulation.*

triangulation, precise #A term used to denote triangulation corresponding to the category of precise control in the U.S. Government's classification scheme of 1921.#

The term was dropped in 1925 and was replaced by "first-order."

triangulation, primary #Before 1921, the category containing triangulation with the highest accuracy. From 1921 to 1925, it was the category for triangulation next in accuracy after precise triangulation.#

The term was dropped after 1925, when the terms "first-order," "second-order," "third-order," and "fourth-order" triangulation were introduced.

triangulation, radial See *aerotriangulation, radial.*

triangulation, satellite #Any method of determining the coordinates of points on the Earth by measuring directions from these points to one or more artificial satellites.#

One method has been to photograph the satellite against a stellar background, so the stars can be used to obtain directions. Although it is theoretically possible to do without stars by measuring the vertical and horizontal angles to the satellite from each point, the directions thus determined are less accurate than those determined using stars. Usually, the term is assumed to imply that observations are made simultaneously, or nearly so, from two or more points on the ground.

triangulation, secondary #Before 1921, the second category of triangulation, in order of decreasing accuracy of the control involved. Between 1921 and 1925, it was the third category, following precise and primary triangulation.#

See *control, classification of.*

triangulation, second-order #A triangulation (network or survey) which includes second-order and sometimes first-order control.#

In the U.S. Government's classification of 1974, there are two sets of standards for second-order control, leading to the categories of second-order class I and second-order class II triangulation.

See *control, classification of.*

The category "second-order triangulation" in the 1974 scheme of classification does not correspond exactly to a particular category in any earlier scheme. First-order class II of the 1957 scheme and second-order class I of the 1974 scheme are roughly equivalent, while first-order class II and second-order class I of the 1957 scheme are approximately equivalent to second-order class II of the 1974 scheme. The second-order triangulation of the 1925 scheme was roughly equivalent to third-order triangulation of the 1974 scheme.

triangulation, second-order class I See *control, classification of.*

triangulation, second-order class II See *control, classification of.*

triangulation, ship-shore #A method for extending triangulation along a coast by making simultaneous observations from three or more stations on shore to a target mounted on an anchored ship.#

This method is used only when it is impractical to establish a chain of triangles or quadrilaterals entirely on land.

triangulation, special first-order #The category of most accurate triangulation in the 1957 scheme of classification.#

triangulation, specifications for #Specifications of certain procedures and criteria that are considered essential for obtaining, by triangulation, horizontal control of designated order and class.#

The procedures and criteria considered essential by the National Geodetic Survey (U.S.A.) are given in Federal Geodetic Control Committee (1980, 1984).

triangulation, stellar #A method of determining directions between points on the Earth's surface by simultaneously photographing, from three or more of the points, a beacon or lighted object against a background of stars.#

Photographing the light in at least two different parts of the sky, as seen from each pair of points on the ground, establishes a direction between the pair. If three or more points are involved simultaneously, a network of directions is established that determines, except for scale, the relative locations of the points. Rocket-borne flares were used in a stellar triangulation connecting Bermuda to the United States. Light-carrying or Sun-illuminated artificial satellites have been used to establish vertical and horizontal control across continents or between continents (see *triangulation, satellite*). The term probably covers all varieties of stellar triangulation except that in which the Moon is photographed against a stellar background.

triangulation, stereo See *stereotriangulation.*

triangulation, tertiary #Before 1921, a category of triangulation third in order of decreasing accuracy of the control contained in it. Between 1921 and 1925, it was fourth in order, following precise, primary, and secondary triangulation. After 1925, it was no longer used.#

triangulation, third-order #Triangulation (network or project) which includes third-order, and sometimes higher order control.#

See *control, classification of.*

The term "third-order" was also used for certain categories of control in the classification schemes of 1925 and 1957. These categories are not equivalent to the category third-order of the 1974 scheme, although there is rough equivalence between the 1957 and 1974 categories.

triangulation, third-order class I See *control, classification of.*

triangulation, third-order class II See *control, classification of.*

triangulation adjustment #Determining, from a set of measured distances and angles, another set of distances and angles between points of a triangulation network, or the coordinates of the points of the network, in such a way that (a) the network is fully determined by the set of values thus determined, (b) all geometric conditions are exactly satisfied, and (c) values calculated for the derived set for the measured distances and angles agree with those values in some specified, "best" manner.#

The "best" agreement is usually taken to be that which minimizes the sum of the squares of the differences between the original set of values and the set of values calculated from the derived set. Therefore, the method of least squares is used for most adjustments. It is customary to distinguish between the method of least squares used for deriving distances and angles and the method of least squares used for deriving coordinates. The first variant is called adjustment by conditions or adjustment of observations; the second is called adjustment by observation equations or adjustment of coordinates. Both variants are mathematically identical and differ only in details of the process of calculation.

triangulation adjustment, angle method of #A method of triangulation adjustment, by observations, which determines corrections to observed angles.#

The angle method should be used where a chain of single triangles is to be adjusted. For an extensive triangulation with overlapping triangles, the direction method of adjustment is preferred.

triangulation adjustment, arc method of #Determination of corrections to coordinates of control points in a triangulation network by separating the network into sets of connecting arcs, determining the corrections in each arc separately, and then modifying the results so there is no disagreement between coordinates at the intersections of the arcs.#

The *Bowie method of triangulation adjustment* is an arc method.

triangulation adjustment, Bowie method of #A method devised in the U.S. Coast and Geodetic Survey, under the direction of William Bowie, for the adjustment of large triangulation networks. At every junction between chains, the length and azimuth of one side are assumed correct and carried into a suitable figure at the junction. Directions or angles in chains between these junction figures are then computed, the individual chains computed, and the misclosures passed into the longitudes and latitudes of the initially fixed sides in the junctions by a least squares adjustment over the entire network.#

A description of the method is given in Adams (1930).

triangulation adjustment, direction method of #A method of triangulation adjustment, by observations, which determines corrections to observed directions. Each angle is considered as the difference between two directions, for each of which a separate correction is determined.#

The direction method is used in the adjustment of triangulation which is composed of overlapping triangles, but for some work, where the triangulation consists of a chain of single triangles, the angle method of triangulation adjustment may be preferred.

triangulation adjustment, local #The satisfying of conditions existing among angles measured at a survey station without regard to other conditions.#

In a local triangulation adjustment, two kinds of discrepancy may have to be removed: the sum of a set of measured angles closing the horizon may not equal exactly 360°, or the sum of several contiguous angles comprising a larger angle and measured separately may not equal the larger angle measured directly. (The term "observed angles" is also applied to the measured angles after they have been corrected by local triangulation adjustment.)

Also called station adjustment.

triangulation adjustment, station See *triangulation adjustment, local.*

triangulation arc See *triangulation, arc of.*

triangulation network #A *survey network* in which the survey stations are triangulation stations and the lines represent adjusted distances or directions.#

The lines are called arcs of triangulation or triangulation arcs.

triangulation network, base-extension #The part of a triangulation network that consists of a measured base line and the sequence of triangles by which the measured length is transformed into the length of the side of one of the triangles of average size in the network.#

Also called base net, base network, and base-line-extension network.

triangulation signal See *signal.*

triangulation station See *station.*

triangulation tower See *tower, triangulation.*

tribrach #The three-armed base of a surveying instrument which carries the foot screws used in leveling the instrument.#

Some surveying instruments have a four-armed base, or *quadribrach*, for the foot screws. Tribrachs are used for control surveys rather than quadribrachs because they do not introduce strains into the base of the instrument. Such strains tend to change the instrument's orientation in azimuth during observations.

trier, level See *level trier.*

trig list #A publication containing all available data on locations of control points in a particular region, with the descriptions of horizontal or vertical control, and usually organized according to the location of the control points within the limits of large-scale maps of the region.#

trilateration (1) #The method of extending horizontal control by measuring the sides rather than the angles of triangles.# Some angles may also be measured. See *triangulation.*

(2) #The network resulting by measuring the sides of triangles formed by lines connecting points.#

This usage is rare; the term trilateration network is generally used instead.

(3) #Any method of surveying in which the location of one point with respect to two others is determined by measuring the distances between all three points.#

trilateration, classification of #The categories (order and class) of trilateration and of trilateration networks are the same as the categories of the horizontal control established by or contained in the trilateration or trilateration network.#

Specifications for trilateration were published first in 1974. See *control, classification of.*

trilateration, first-order #A trilateration network that produces first-order control.#

trilateration, second-order #A trilateration network that produces (or consists of) second-order control.#

trilateration, specifications for #Specifications of certain procedures and criteria that are considered essential for obtaining geodetic control of a certain order and class by trilateration.#

The essential procedures and criteria are given in Federal Geodetic Control Committee (1984).

trilateration, third-order #A trilateration network that produces (or consists of) third-order control.#

trilateration network #A *survey network* in which the survey stations have been located by trilateration.#

The lines connecting survey stations represent adjusted distances. The term applies strictly only to networks consisting solely of survey stations located by trilateration. A network constructed partly by trilateration and partly by triangulation is usually referred to as a *triangulation network*. However, *control network* or *survey network* would be preferable.

trilateration network, classification of See *trilateration, classification of, and control, classification of.*

triple point See *water, triple-point of.*

tripod (1) #Any three-legged structure used to hold or support a platform, a signal, or an instrument.#

(2) #In surveying, a three-legged structure used for supporting an instrument or survey signal.#

Tripods designed for supporting instruments generally consist of a "head" (a disk-like platform) on which the instrument is placed, three "legs" (usually of wood) fastened by hinges at one end to the head, and one "shoe" at the unhinged end of each leg. The shoe is a metallic cone that may be driven into the ground by applying pressure to the leg. The shoe often has a projecting spur (cleat or foot pad) so the surveyor can drive the shoe into the ground with his foot. The spur also helps keep the shoe from sinking into the ground while observations are being made.

trivet #A device used instead of a tripod for mounting a theodolite or leveling instrument; it consists essentially of a head with three very short legs cast as a single piece of metal.#

It is used for placing a theodolite or leveling instrument either in a position where a regular tripod could not be conveniently used, or where greater stability is desired. When used for a theodolite, a trivet may include the foot-plate with V-shaped grooves cut into it to receive the feet of the leveling screws.

Tropic of Cancer (1) #The *parallel of declination* passing through the (Northern Hemisphere) *summer solstice*.#

(2) #The *geographic parallel* whose latitude corresponds to the declination of the (Northern Hemisphere) *summer solstice.* #

Although the obliquity of the ecliptic is steadily changing so that the summer solstice is not a point of fixed declination, the Tropic of Cancer is shown on terrestrial maps as a line of fixed latitude at 23°27′ N.

Tropic of Capricorn (1) #The *parallel of declination* passing through the (Northern Hemisphere) *winter solstice.* #

(2) #The *geographic parallel* whose latitude corresponds to the declination of the *winter solstice.* #

Although the obliquity of the ecliptic is steadily changing, so that the winter solstice is not a point of fixed declination, the Tropic of Capricorn is shown on terrestrial maps as a line of fixed latitude at 23°27′ S.

tropopause #The boundary layer separating the *stratosphere* from the *troposphere*.#

The tropopause normally occurs at an altitude of about 8 to 14 km in polar and temperate zones, and at 17 km in the tropics.

troposphere #The lowest layer of the atmosphere, extending from the Earth's surface to the *tropopause*.#

In the troposphere, temperature decreases with height at a mean rate of 0.6 °C/100 m. It contains about three-fourths of the entire mass of the atmosphere. Almost all clouds, precipitation, and storms occur in this layer.

true (adjective). (1) #Actual, existing, or observed, as contrasted to ideal or theoretical.#

(2) #Corresponding to what would be predicted by a theory accounting for all systematic effects.#

(3) #*Average* for all possible cases.#

(4) #A term applied to distinguish among similar concepts, such as *true anomaly* from *mean anomaly* and *eccentric anomaly.* #

In surveying and navigation, true is used to distinguish astronomical quantities from corresponding magnetic ones. The terms "true bearing", "true meridian", "true north", etc. occur frequently in reports of land surveys, distinguishing them from magnetic quantities. In descriptions of boundaries, the use of *true* has legal significance and, except in rare instances, refers to values based directly on astronomical observations.

For terms containing *true* as a modifier, see under word modified, such as *Equator, true; equinox, true; anomaly, true; value, true*; and *place, true.*

Tsinger method See *longitude determination, Tsinger method of.*

tsunami #The wave or set of waves caused in bodies of water by an earthquake or volcanic explosion.#

In the open oceans, tsunamis have heights of the order of a meter and lengths of 100 to 200 km, with speeds of up to 200 ms^{-1} and periods of 20 to 60 minutes or more. On nearing coastlines, a tsunami shortens in wavelength and its height correspondingly increases, with waves reaching heights of from 30 m to more than 50 m. Landslides, particularly submarine landslides, also cause tsunamis. In the older literature, tsunamis are called "tidal waves". Since tsunamis have no relation to tides, they should not be referred to as tidal.

tube, photographic zenith See *telescope, zenith* and *telescope, photographic zenith.*

turtle #A *foot plate.* #

two-body problem #The problem, in mechanics, of determining the coordinates of two bodies as a function of time, given the law of attraction or repulsion between the bodies and the initial locations and velocities of the bodies.#

The usual procedure for solving the problem is to integrate the equations of motion of the two bodies and to determine, from the initial conditions, the constants of integration. In geodesy, the problem appears principally to be that of determining the orbit of a body of negligible mass (an artificial satellite) moving in the gravitational field of the Earth.

two-peg test See *C-test.*

two-point problem #The problem of determining the location of a point occupied by an observer when the locations of two other inaccessible, but observable, points are known.#

The method also involves observing from a fourth point close to the occupied point and is quite time-consuming.

Also called Hansen's problem.

U

ultraviolet radiation #The portion of the electromagnetic spectrum containing radiation at wavelengths between about 400 nanometers (nm) to 5 nm.#

uncertainty (1) #A numerical representation of the inaccuracy of a value.#

(2) #The *standard deviation* or *probable error* of a value.#

Also sometimes used to denote the complement of the probability of an event (i.e., 1 minus the probability), or the complement of the probability associated with one standard deviation. The meaning of the term is usually inferred from context.

undulation (1) #A rise and fall with time, such as the undulation of the ocean's surface.#

(2) #A rise and fall with distance, e.g., the undulating hills of Oklahoma.#

(3) #*Height*.# E.g., "geoidal height" and "geoidal undulation" are sometimes used synonymously.

undulation, geoidal See *undulation of the geoid.*

undulation of the geoid (1) #The rise and fall of the geoid with distance, i.e., the "waviness of the geoid".# Also called geoidal undulation.

(2) See *height, geoidal.*

unit, astronomical See *astronomical unit.*

unit, base #One of the units of length, mass, time, thermodynamic temperature, electric current, amount of substance, or luminous intensity; these are the base units of the SI system.#

See *Système International d'Unités, le.*

unit, derived #A unit which can be expressed as a combination of product and quotient of *base units.* #

unit, fundamental See *unit, base.*

unit, supplementary #A unit which is the ratio of two dimensionally equal quantities and can thus be considered dimensionless.#

In the SI system, the *radian* and *steradian* are supplementary units.

universal instrument See *altazimuth instrument.*

Universal Water Chart #A series of featureless charts at 1:1,000,000 scale, published for each 4° band of latitude.#

These charts are used for aerial navigation over water or for plotting positions, distances, and courses in travel over unmapped lands, such as in Antarctica.

upland (1) #Land situated above *mean high water.* #

(2) #Land situated at a higher elevation than *riparian* land or land adjacent to riparian areas but remote from the body of water and having no *riparian rights.* #

U.S. Public Land System #The set of rules by which boundaries of public lands have been established in the United States of America, in particular, the rules according to which subdivisions of the public lands were classified by size and location.#

The U.S. Public Land System is frequently used for designating the location of a parcel of land. See *description.*

V

valley crossing #The procedure used to determine differences of elevation between points on opposite sides of a valley into which leveling cannot be carried.#

The method also is used for *water crossing*. For details see *NOAA Manual NOS NGS* 3, Geodetic leveling, by Schomaker and Berry (1982).

valley-crossing attachment #A wedge-shaped prism attached to the telescope of a leveling instrument; it is rotatable about an axis parallel to the optical axis of the telescope and deflects the line of sight.#

It is used in *valley crossing* and *water crossing*.

value, adjusted #A value derived from observed data by some orderly process that optimizes, in some specified sense, the relationship between the observations and a theoretical model.#

The process, called an *adjustment*, may be made by graphical (mechanical) or analytical (arithmetical) methods.

value, most probable #The value which has the greatest mathematical probability of resulting from a given set of observed values containing random errors.#

An adjusted value determined by the method of least squares is a most probable value if the observed quantity has a Gaussian distribution.

value, observed #A value obtained by measurement.#

Also called a true value or an apparent value. The term observed value is often applied to the value derived from a measurement after systematic errors have been removed by applying corrections, but before random errors have been removed by adjustment. An angle obtained with a repeating theodolite, after correction for closure of horizon has been applied, is considered an observed angle.

value, standard #A number accepted as the value for a particular constant.# Also called normal value.

value, true (1) #The value of a quantity which is completely free from errors of all kinds.#

Since the errors to which physical measurements are subject cannot be known exactly, it follows that the true value of a quantity can never be known exactly. In surveying, the most probable value is taken as being the value most representative of the true value of the quantity.

(2) *#Observed value.#*

(3) #The average value, i.e., the value derived from measurements taken over all possible cases or instances.#

vara #An obsolete Spanish unit of length with values, relative to metric or English units of length, that vary with locality and time of use.#

In 1919, the legislature of Texas enacted a law that defines the vara to be exactly 33 1/3 inches; however, the law does not affect vara measurements (cited in conveyances, etc.) made before that date.

variable, random (1) #Any quantity for which the sequence of assigned values is such that the value at any point in the sequence is not predictable from a knowledge of the values elsewhere in the sequence.#

(2) #Any quantity to each of whose values is assigned a number, from 0 to +1, called the probability of the value.#

variance #The square of the *standard deviation.*#

variation (lunar) #An *inequality* in the Moon's longitude with a period of one-half of a *synodical month*, or about 14-3/4 days, and an amplitude of 39′ 29.″9.#

variation, magnetic See *magnetic variation.*

variation of latitude See *latitude, variation of.*

variation of the pole See *polar motion.*

velocity #The rate of change of location with time.#

Velocity specifies both the direction and the speed of the motion, and is thus a vector. *Speed,* defined as the absolute value of velocity, is not a vector.

The velocity of a point moving along a planar curve is often resolved into two components: e.g., *radial velocity* and *transverse velocity*. If the point is moving along a nonplanar curve, a third component, such as that along the binormal to the curve, must be specified also.

velocity, angular #The rate of change of angle with respect to time.#

velocity, areal #The area of a bounded surface generated by a moving segment of a straight line, divided by the time needed to generate the surface, or the limit of the above ratio as the interval of time approaches zero.#

In astronomy, the segment is fixed at one end and rotates about an axis through that end. Areal velocity is a vector and has the same direction as, but a different magnitude than, the vector of angular velocity.

velocity, escape #The minimal velocity that a body in the gravitational field of another body must attain to ensure that it neither falls back onto the other body nor goes into orbit about it.#

Escape velocity from the Earth's surface is about 11.2 km/s; from the Moon's surface, about 2.4 km/s; and from the Sun's photosphere, about 617.2 km/s.

velocity, normal #The component of the velocity of a moving point which is in the direction of the *normal* to the path.#

Its paired (planar) component is *tangential velocity*.

velocity, orbital (1) #The velocity of an orbiting body at any point along its orbital path.#

In general, the orbital velocity varies along the path.

(2) #The minimal velocity that a body in the gravitational field of another body must be given in order to maintain it in a particular orbit.#

velocity, radial #The component of the velocity of a moving point which lies on the line joining the moving point to a reference point. The component is usually taken to be positive in the direction away from the reference point.#

Its paired (planar) component is *transverse velocity.*

Also called range rate when determined by radar.

velocity, tangential #The component of velocity of a moving point that lies on the tangent to the path followed by the moving point. It is usually taken as positive in the direction of motion.#

Its paired (planar) component is *normal velocity.*

velocity, transverse #The component of the velocity of a moving point which is perpendicular to, and is in the same plane as, the *radial velocity* and the tangent to the path at the point.#

Vening Meinesz' formula #The formula for the *gravimetric deflections of the vertical* as derived by F. Vening Meinesz from *Stokes' formula*. The formula is:

$$\left.\begin{matrix}\xi\\ \eta\end{matrix}\right\} = \frac{1}{4\pi\bar{g}} \int_S F \begin{Bmatrix}\cos A\\ \sin A\end{Bmatrix} \Delta g dS$$

where ξ and η are the components of the deflection in the meridian and prime vertical planes of a point P; $\bar{g}$ is the average value of gravity over S, the surface of the Earth considered as a sphere; Δg is the *gravity anomaly* on an element dS of the surface; A is the azimuth, on the surface, of dS from P; F is given by

$$F = -\frac{\cos\theta}{2\sin^2\theta} + 8\sin 2\theta - 6\cos\theta - \frac{3(1-\sin\theta)}{\sin^2\theta}$$
$$+3\sin 2\theta\ \ell n(\sin\theta + \sin^2\theta)$$

and θ is one-half the angular distance on the surface between dS and P.#

F is called Vening Meinesz' function.

Although S is supposed to comprise the entire surface of the Earth, in practice ξ and η can be obtained approximately by restricting S to a suitable portion of the surface surrounding P.

Vening Meinesz' formula can be generalized to compute the *external deflection of the vertical* and to the case where P is on the actual surface of the Earth, and where the reference surface S is ellipsoidal. See Heiskanen and Moritz (1967: pp. 233-236, 312-320).

vernier #An auxiliary sliding scale graduated so that the total length of a certain number of divisions on the slide is equal to the total length of one or one fewer of the same number of divisions on the primary scale.#

The vernier is a device for precise interpolation between divisions of the primary scale.

vernier, contact #A *vernier* lying in direct, or nearly direct, contact with the primary scale.#

This is the usual type of vernier.

vernier, optical #A microscope for viewing a graduated line. The viewer has a *vernier* ruled on a glass slide located in the focal plane of the objective and the eyepiece for comparison with the image of the graduated line.#

vertex of curve See *curve, point of intersection of a.*

vertical (1) #The direction in which the force of gravity acts.#

It is the direction indicated by a *plumb line* of infinitesimal length.

(2) #A line along which the downward-pointing tangent has the direction of gravity at the point of tangency.#

Note: a *normal* is the perpendicular to a given spheroid; the *vertical* is the perpendicular to an equipotential surface of gravity.

Compare *plumb line* for the distinction between (1) and (2) above.

vertical, deflection anomaly of the See *deflection anomaly.*

vertical, deflection of the See *deflection of the vertical* and *deflection anomaly.*

vertical, prime (1) #A *vertical circle* perpendicular to the plane of the celestial meridian.# The plane of the prime vertical cuts the horizon in the east and west points.

(2) #At a given point on an ellipsoid, the geodesic perpendicular to the meridian through that point.#

vertical circle See *circle, vertical.*

vertical-circle left #The position of the theodolite, relative to an observer, in which the vertical circle is to the observer's left when looking through the telescope.#

Also called "circle left" and "direct".

vertical-circle right #The position of a theodolite, relative to an observer, in which the vertical circle is to the observer's right when looking through the telescope.#

Also called "circle right" and "reverse".

vibration (pendulum) #A single movement of a pendulum in either direction, to or fro.# See *oscillation.*

vignetting (1) (optical system) #The diminution in brightness at the edges of an image caused by obstructions in the optical system that cut off light rays near the edges of the field of view.#

(2) (photography) #A gradual reduction in exposure of parts of a photograph because some of the rays arriving at the camera are prevented from reaching the film.#

The mounting of a lens may interfere with extremely oblique rays. An antivignetting filter gradually decreases in density from its center toward its edges; it is used with many wide-angle lenses to produce a photograph of uniform density by reducing the exposure at the center of the photograph.

(3) (lithography) #A photographic process which portrays a solid color as shading off gradually into the unprinted paper.#

Open water is often shown by this method.

vinculum (surveying) #A short, horizontal bar placed over the seconds value of a numerically expressed angle or direction to indicate that the seconds value is used with a minutes value 1 less than is recorded.#

A double vinculum indicates association with a minutes value 2 less than is recorded.

vision, binocular #The form of vision which depends on the reception by the brain of signals from two eyes rather than one.#

It should not be confused with *stereoscopic vision*, a particular kind of binocular vision.

vision, stereoscopic #The particular use of *binocular vision* that enables an observer to form an impression of depth by observing an object from two different perspectives.#

For example, this can be done by viewing simultaneously two photographs of an object taken from different camera stations.

VLBI #Standard abbreviation for *very-long-baseline-interferometry.* #

volume, specific (1) #The reciprocal of *specific gravity.* #

(2) #The reciprocal of density.#

Also called standard volume.

vulgar establishment See *establishment of the port.*

W

wading rod #A rod, graduated in feet and tenths of feet or in centimeters, used for gauging depths in shallow water, particularly streams.#

walk, random See *random walk.*

wander, polar (1) See *Chandlerian motion.*

(2) #*Polar motion* other than Chandlerian.#

(3) #*Polar motion* as a whole.#

(4) #A secular or long-period component of *polar motion*.#

Sometimes referred to simply as wander.

water (1) #A synonym for *tide*, in the sense of the elevation of the surface of the hydrosphere at a particular longitude and latitude.#

The National Ocean Service uses "water" as the preferred term.

(2) When combined with the appropriate adjective, the term denotes #state of horizontal motion of the water or some quality having to do with motion, e.g., *slack water.*#

(3) #The surface of the water in the vicinity of a tide gauge or a mathematical surface approximating the position of the water.#

water, extreme high #The greatest elevation reached by the sea during a given period as recorded by a tide gauge.#

water, extreme low #The lowest elevation reached by the sea during a given period, as recorded by a tide gauge.#

water, high (1) #The greatest elevation reached by a rising tide.#

(2) #The surface of the water at the instant when the elevation reached by a rising tide is greatest.#

water, higher high #The higher of the two high waters occurring on a particular tidal day.#

water, higher low #The higher of the two low waters occurring on a particular tidal day.#

water, Indian spring low #A *tidal datum* depressed below mean sea level by an amount equal to the sum of the amplitudes of the constituents M_2, S_2, K_1 and O_1.# See *tide, harmonic analysis of* and *Doodson number.*

The datum, invented by George H. Darwin when he was investigating the tides of India, is approximately the water determined from all *lower low waters* at spring tides.

water, inland #A body of water, both tidal and nontidal, that lies landward of the low water mark or of the seaward limits of ports, harbors, bays, and rivers.#

Also called national water, interior water, or internal water.

water, international low #A plane so low that the tide will seldom fall below it.#

This definition was originally suggested at the International Hydrographic Conference in London in 1919, was discussed further at the Monaco Conference in 1926, but was never generally adopted.

water, low (1) #The least elevation reached by a falling tide.#

(2) #The position of the water's surface at the time when the least elevation is reached by the falling tide.#

water, lower low #The lower of two low waters of any tidal day.#

water, lower high #The lower of two high waters of any tidal day.#

water, mean high (MHW) (1) #The average elevation of all high waters recorded at a particular point or station over a considerable period of time, usually 19 years.#

For tidal waters, the cycle of change covers a period of about 18.6 years, and mean high water is the average of all high waters for that period. For any body of water, it is the average of all high waters over a period of time sufficiently long that increasing its length does not appreciably change the average.

(2) #The average of the high-water elevations observed over the *National Tidal Datum Epoch.*#

water, mean higher high (MHHW) (1) #The arithmetic average of the elevations of the higher high waters of a mixed tide over a specific 19-year period.#

Only the higher high water of each pair of high waters of a tidal day is included in the average.

(2) #The average of the higher high water elevations of each tidal day that were observed over the *National Tidal Datum Epoch.*#

water, mean low (MLW) (1) #The average elevation of all low waters at a particular point or station over a considerable period of time.#

For tidal waters, the cycle of change covers the same period that is used for computing *water, mean high* and *water, mean higher high*.

For a semidiurnal or mixed tide, the two low waters of each tidal day are included in the average. For a diurnal tide, the one low water of each tidal day is used. If a second low water occurs, only the diurnal low water is included.

(2) #The average of the low water elevations observed over the *National Tidal Datum Epoch.*#

water, mean lower low (MLLW) (1) #The average elevation of all the lower low waters recorded over a 19-year period.# It is usually associated with a tide exhibiting mixed characteristics. Only the lower low water of each pair of low waters of a tidal day is included in the average.

(2) #The average of the lowest low water elevations of each tidal day observed over the *National Tidal Datum Epoch*.#

water, navigable #The waters which are or can be used as water highways for commerce.#

water, neap high See *tide, neap.*

water, neap low See *tide, neap.*

water, spring high See *water springs, mean high.*

water, spring low See *water springs, mean low.*

water, slack (1) #The state of a tidal current when its speed is near zero.#

(2) #The moment when a reversing tidal current changes direction.#

The term is also applied to the entire period of low speed near the time of turning of the current when it is too weak to be of any practical importance in navigation.

water, triple-point of #The temperature at which, or the state in which, ice, water, and water vapor are in equilibrium under a pressure of 101,325.0 pascals (1 standard atmosphere).#

Also called the ice point. The water should have the isotopic composition of oceanic water. The temperature of the triple point is 273.16 K or 0.0100 °C.

water crossing #A special set of observations taken when extending a level line across a stream or other body of water, when no suitable bridge is available and the width of the body of water is greater than the greatest length of sight allowable for the leveling.#

Also called "river crossing" in the older literature. See *valley crossing*.

water datum See *datum*.

water equinoctial springs, low #*Low water spring* s near the times of the equinoxes.#

See *water springs, mean low*.

water full and change, high #The average time interval between the transit (upper or lower) of the full or new moon and the next high water.#

See *establishment of the port*.

water full and change, low #The average time interval between the transit (upper or lower) of the full or new Moon and the next low water.#

See *establishment of the port*.

water inequality, low See *inequality, diurnal*.

water inequality, mean diurnal high #Half the average difference between the elevations of the two *high waters* of each tidal day over a 19-year period; obtained by subtracting the average of all high waters from the average of all *higher high waters*.#

water inequality, mean diurnal low #Half the average difference between the elevations of the two *low waters* of each tidal day over a 19-year period; obtained by subtracting the average of the *lower low waters* from the average of all low waters.#

water interval, high See *interval, lunitidal*.

water interval, higher high #The time interval between the transit (upper or lower) of the Moon over the local or Greenwich meridian and the next *higher high water*.#

This expression is used when there is considerable diurnal inequality. See *water full and change, high*.

water interval, higher low #The time interval between the transit (upper or lower) of the Moon over the local or Greenwich meridian and the next *higher low water*.#

This expression is used when there is considerable diurnal inequality. See *water full and change, low*.

water interval, low See *interval, lunitidal*.

water interval, lower high #The time interval between the transit (upper or lower) of the Moon over the local or Greenwich meridian and the next *lower high water*.#

This expression is used when there is considerable *diurnal inequality*.

water interval, lower low #The time interval between the transit (upper or lower) of the Moon over the local or Greenwich meridian and the next *lower low water*.#

This expression is used when there is considerable *diurnal inequality*.

water level #The elevation of a particular point or small patch on the surface of a body of water above a specific point or surface, averaged over a period of time sufficiently long to remove the effects of short period disturbances.#

This should not be confused with "sea level", the elevation of the general surface of a sea.

water level, half-tide (1) #The ideal surface halfway between *mean high water* and *mean low water*.#

(2) #The average of the elevations of high and low waters.#

Also called mean tide level.

(3) #The plane that lies exactly midway between the points of high water and low water.#

water level, legal #The stage of a body of water where the shore line defines the *riparian* boundaries, such as the normal high water line on a lake.#

water level, mean (1) #The average position of the water's free surface at a particular place.#

(2) #The elevation determined by averaging the elevations of the surface of water at equal intervals of time (usually hourly) over a considerable period of time.#

The second definition is that used by the National Ocean Service.

water level, mean-tide See *water level, half-tide*.

water level, normal #The water level most prevalent in a watercourse, reservoir, lake, or pond; generally indicated by a shoreline of permanent, land-type vegetation.#

Along the shores of large bodies of water, the action of waves may retard the growth of vegetation above normal water level.

water level, still #The elevation or position that the surface of a body of water would assume in the absence of wind-waves.#

This is not the same as the sea's surface in the absence of wind, since swell might still be present, nor is it the same as mean sea level, which is affected by the presence of currents, differences in salinity, and other inhomogeneities.

water-level transfer #The extension of leveling across a lake or between large bodies of water by assuming that the average position of the surface of each body, averaged over a suitable length of time, is a level surface.#

water line #The intersection of the surface of the land with the surface of a body of water.#

water line, low See *low-water line*.

water line, mean high #The intersection of the land with the water surface at the elevation of *mean high water*.#

water lunitidal interval See *interval, lunitidal*.

water mark #A line or mark left on the shores of a body of water by the water as an indication of the water's former elevation.#

Since marks below the usual level of the water tend to be removed by the action of waves, current or tides, water marks usually indicate the highest levels reached by the water.

water mark, high (1) #A line or mark left on tidal flats, beaches, or objects along the shore. Such a mark indicates the elevation reached by high water.#

The mark may be a line of oil or scum on objects, or a more or less continuous deposit of fine shells or debris on the foreshore or berm.

(2) #The line marked on the soil of a shore by the seaward edge of upland vegetation.#

(3) #An established reference mark on a structure or natural object which indicates the greatest observed stage of the tide.#

water mark, low #A physical indication of a former, persistent, low level of water.#

While most low water marks are destroyed by the water's action, some indicators of low water do persist; most are left by animals which live in the intertidal region.

water neaps, mean high (MHWN) #The average elevation of the high waters of *neap tides* (recorded during lunar *quadrature*) over an extended period, usually 19 years or a computed equivalent period.#

Also called neap high water, or high water neaps.

water neaps, mean low (MLWN) #The average elevation of the low waters of *neap tides* (recorded during lunar *quadrature*) over an extended period, such as 19 years or a computed equivalent period.#

Also called neap low water, or low water neaps.

waters #A general term for the *hydrosphere* or some part of it.#

waters, inland #Both the tidal and nontidal waters of a nation that lie landward of the marginal sea (base line), plus the waters, such as lakes and rivers, that lie within its land and over which the nation exercises complete sovereignty.#

water springs #Tides (waters) of increased range occurring semimonthly as the result of the Moon's having approximately the same right ascension (or longitude) as the Sun.#

water springs, lowest low #A surface of reference approximating the mean lowest low water during *syzygy* (spring tides).#

water springs, mean high (MHWS) #The average elevation of all high waters recorded during *syzygy* over a long period, such as 19 years or a computed equivalent period.#

The high water analog of mean low water springs.

water springs, mean higher high (MHHWS) #The average elevation of all higher high waters recorded during *syzygy* over a long period, such as 19 years or a computed equivalent period.#

The National Ocean Service requires averaging over the specific 19-year period designated as the *National Tidal Datum Epoch*.

water springs, mean low (MLWS) #The average of the elevations of low water occurring at the time of the spring tides, observed over an extended period.#

Also called *spring low water*. It is usually derived by taking an elevation depressed below the half-tide level by an amount equal to one-half the spring range of tide, with corrections to reduce the result to an average value. This level is used, to a considerable extent, for hydrographic work outside the United States. It is the level of reference for the Pacific approaches to the Panama Canal. The National Ocean Service specifies that mean low water springs be averaged over the specific 19 year period designated as a *National Tidal Datum Epoch*.

water springs, mean lower low (MLLWS) #The average elevation of all lower low waters recorded during *syzygy* over an extended period, such as 19 years or a computed equivalent period.#

The National Ocean Service specifies a period designated as a *National Tidal Datum Epoch*.

wavelength #The distance between corresponding points on two successive cycles of a periodic wave.#

The wavelength of electromagnetic waves varies from hundreds of kilometers for very low frequency (VLF) radio waves to 10^{-11} of a meter for gamma rays.

wave number #The reciprocal of wavelength.#

wave number, effective #The wave number of monochromatic radiation that would have the same effect as the radiation actually present.#

weber per square meter #The unit of *magnetic flux density* known as the *tesla* in SI.#

The geomagnetic field as measured in teslas varies from about 0.25 (10^{-4}) to 0.7 (10^{-4}) tesla.

wedge, distance See *distance wedge*.

wedge unit #The interval between two graduations on the scale of the rotary wedge attached to an NI 2 leveling instrument for use in river crossings.# See Schomaker and Berry (1982: ch. 4).

Wegener's theory #The theory of continental drift, proposed by Alfred Wegener (1915), according to which the continents were originally part of one, original supercontinent, from which the continents as we know them today split off and drifted to their present positions.#

The split, according to present theory, occurred about 200,000,000 years ago. This theory is the precurser of the present-day theory of plate tectonics.

weight (1) (statistics) #A factor by which a quantity is multiplied to increase or decrease the effect of that quantity on the results of an adjustment.#

Two kinds of weight are in common use: (a) The reciprocal of the variance of a quantity. The method of least squares applied to linear equations is the principal method for weight adjustment in this sense. A generalization of weight is the *weight matrix*, which takes into account the correlation between a number of observed quantities. (b) See *weighting factor*, which was the original meaning. It has been replaced to a large extent in geodesy and other sciences by meaning (a) above.

(2) (physics) #The force equal to the product of the mass of a body and the acceleration of gravity due to an attracting body.#

weighting factor (1) #A number equal to the number of times a particular value occurs among a set of values.#

The larger the weighting factor, the greater its effect on the average and the standard deviation assigned a set of measurements.

(2) #The relative reliability (or worth) of a quantity as compared with other values of the same quantity.#

(3) #A number by which both sides of an observation equation are multiplied to effect a solution that accords with the reliability of the set of observations.#

Usually taken to be the reciprocal of the variances. (See *weight* (1).)

weight matrix #The inverse of the *covariance matrix* associated with a vector of stochastic variables.#

westerly #A *direction* within 22 1/2 degrees of west (270°).#

westing (1) #The distance westward (positive) or eastward (negative) from a meridian of reference.#

A negative, eastward westing is usually given a positive sign and called an *easting*.

(2) #Correspondingly, scaled distances westward or eastward from a central line (central meridian or y-axis) on a gridded map.#

(3) See *departure* (plane surveying).

wiggling in #Setting an instrument on a direct line between two specified points by successively sighting on the two points from the instrument and moving the instrument until the two sightings differ by exactly 180°.#

wind (spirit leveling) See *level, spirit.* Also spelled wynd.

wind, solar See *solar wind.*

wind level #The lack of parallelism between the axis of the vial of a spirit level and the line joining the centers of its supports.#

When wind (pronounced to rhyme with find) is present and the spirit level is rocked on its supports, the bubble will respond with a longitudinal movement. Also spelled wynd.

window (atmospheric) #A region of the spectrum to which the cloudless atmosphere is almost or completely transparent.#

window, entrance (exit) #The image of the field stop formed by all elements of the optical system on the object (image) side of the field stop.#

wind rose (1) #A diagram showing the relative frequency with which winds blow from different directions. It may also show average wind speed, or the frequency with which various wind speeds occur in different directions.#

(2) #A diagram showing the relative frequency of winds from different directions and their relation to other meteorological phenomena.#

wire, Jäderin #An apparatus consisting of separate steel and brass wires extended under constant tension over reference marks on a base line.#

If the coefficients of expansion and the standardized lengths of the wires are known, the temperature and corrected lengths can be found from the difference in measurement of the same distance by the two wires.

wire, surveyor's #A metallic wire, usually of invar or similar alloy, with a graduated scale attached to each end; used for measuring distances.#

A surveyor's wire is less affected by the action of wind than is a surveyor's tape of the kind used in the United States of America and Great Britain. On the other hand, tape is less likely to twist or curl, and is sturdier. Corrections for slope and catenary of distances measured by wire are the same as those of distances measured by tape; temperature, tension, and calibration corrections to wire length differ from the corresponding corrections to tape length only in the values of the constants used. However, wire undergoes significant changes of length after many reelings and unreelings.

witness corner See *corner, witness.*

witness mark #A material mark placed at a known distance and direction from a property corner, an instrument station, or a survey station, as an aid in its recovery and identification.#

In surveying, a witness mark is established as an aid to recovering and identifying the survey station or other point with which it is associated. A mark established with such precision and accuracy that it can be used to restore or take the place of the original station is more properly called a *reference mark* in control surveys and a *witness corner* in land surveys.

witness post See *witness mark.*

wobble (1) See *Chandlerian motion.*

(2) #*Polar motion* other than Chandlerian.#

(3) See *polar motion.*

work (1) (physics) #The product of the force $\vec{F}$ exerted upon a body times the distance s the body moves in the direction of the force, expressed more precisely by the integral

$$\int_P^Q \vec{F} \cdot d\vec{s},$$

the body being moved from point P to point Q.#

(2) (cartography) #The design (map or chart) to be reproduced.#

(3) (geodesy) #The procedures and operations of geodesy.#

See *leveling; traverse; triangulation*; and *trilateration.*

World, International Map of the See *International Map of the World.*

World Aeronautical Chart #One of a standard series of charts, scale 1:1,000,000, designed for aerial navigation.#

For regions outside the United States, these charts have been superseded by the Operational Navigation Charts.

World Geodetic System 1972 #A set of quantities, developed by the U.S. Department of Defense for determining geometric and physical geodetic relationships on a global scale, based on a geocentric origin and a reference ellipsoid with semimajor axis 6,378,135 and flattening 1/298.26.#

The system is commonly known as WGS 72.

World Geodetic System 1984 #A set of quantities, developed by the U.S. Department of Defense to replace *World Geodetic System 1972*, based on a geocentric origin and the *Geodetic Reference System 1980*.#

This system, commonly known as WGS 84, is scheduled for implementation in 1986. It is designed to agree with the *North American Datum of 1983* in the United States.

wye #A Y-shaped fixture for supporting or holding a cylindrical or disklike object.#

A simple or composite lens is commonly supported on a single wye. The telescope in a wye level is supported on a pair of wyes.

wynd See *wind* (spirit leveling) and *wind level*.

X

x-correction #The correction to an *x-direction*. #

x-direction #An observed *direction* in a triangulation figure for which an approximate value is obtained and treated like an observed direction in adjusting the figure.#

Adjustment of a triangulation figure by the method of least squares sometimes requires the use of an x-direction with an approximate value. Such a value can be obtained by computing distance and direction between two given points, by solving the *three-point problem*, or by other means. This x-direction is then used in the adjustment to obtain a correction (*x-correction*) for it, which makes it consistent with the adjusted values of the observed directions.

x-motion (photogrammetry) #The adjustment of a stereoscopic plotter by means of linear motion approximately parallel to a line connecting two projector stations in the plotter. Effectively, the path of this motion corresponds to the flight line between the two relevant exposure stations.#

x-parallax See *parallax, absolute stereoscopic.*

x-tilt (photogrammetry) #The angle between the y-axis and a horizontal plane, or between the y-axis and the horizontal reference plane of a stereoscopic plotter, given a rectangular Cartesian coordinate system in the plane of an aerial photograph with the x-axis aligned approximately in the direction of flight.#

x-tilt is positive if the y-coordinate of the nadir point is positive.

Also called list or roll when related to the orientation of the aircraft from which the photograph was taken. See *y-tilt*.

Y

yard (1) #A unit of length in the English system equal in the United States since 1866 to exactly 3600/3937 of a meter.# Compare with *foot, survey.*

(2) #A unit of length defined to be exactly 0.9144 meter.# Also known as the *international yard.*

The yard has been the basic unit of length in the English system of measure since at least 1742, when a brass bar inscribed with a 3-foot scale was made by the Royal Society. A copy made in 1760 was adopted by act of Parliament, January 1, 1826, as embodying the legal definition of the yard. This copy, called the Imperial Standard Yard and stored in the Houses of Parliament, was destroyed by fire in 1834. The length of a new standard of bronze and gold, constructed by comparing existing copies, was, in 1855, designated legally to be the Imperial Standard Yard. This standard yard is the distance between marks on two golden plugs in the bronze bar (at a temperature of 62° F). As of 1951, this standard is kept at the Board of Trade in London. The Weights and Measures Act of 1872 defines this standard as the British Imperial Yard. A comparison with the International Meter in 1894 gave

$$1 \text{ meter} = (39.370113/36) \text{ yard.}$$

Later measurements in 1927 and 1934, gave 47 and 38, respectively, instead of 13, in the last two places of the numerator; however, the 1894 value remained the legal value until 1963. In 1959 the International Yard (0.9144 m) was adopted in the British Commonwealth and the United States of America for scientific purposes. In 1963 the British yard was redefined officially as exactly 0.9144 m.

Until 1836 there was no standard unit of measure in the United States. In that year, an act of Congress established the yard as a standard, defining it as the distance between the 27th and 63rd inches of the Troughton bar, an 82-inch-long, graduated, brass bar made by Troughton of England and brought to the United States of America by Hassler in 1813. This was supposed to be a copy of the British Imperial Yard (1760). It was replaced in 1856 by two copies of the 1855 British Imperial Yard. On July 28, 1866, Congress passed a law making use of the metric system legal in the United States of America and defining the yard as 3600/3937 of the meter. On April 5, 1893, the Secretary of the Treasury approved an order by the Office of Weights and Measures (the Mendenhall act) officially establishing the definition given in the act of July 28, 1866. This order applied specifically to weights and measures used officially by the U.S. Government and by the separate States. For base line measurements made by the U.S. Coast and Geodetic Survey, the meter had been in use since 1805, when Hassler brought to the United States a copy (in iron) of the French meter of 1799. Note the distinction (2 parts in 1 million) between the official value of 3600/3937 meter and the *international yard* of 0.9144 m. See *foot, survey.*

yard, international #A unit of length equal to 0.9144 m.#

The international yard was adopted in 1959 by the U.S. National Bureau of Standards as a unit of length for scientific purposes.

yaw (1) #The variation, or amount of variation, of the longitudinal axis of a craft from the direction in which the craft is moving; i.e., the difference between the direction in which a craft is pointed and the direction in which it is moving.#

Also called crab.

(2) #The rotation, or amount of rotation, of a camera or photograph about either the photograph's z-axis or the z-axis in object space.#

Also called *angle of yaw*. If there may be ambiguity as to whether the movement or its amount is meant, use "yaw" for the movement and "angle of yaw" for its amount.

yaw, angle of (1) #The angle between the direction of flight of a craft and the longitudinal axis of the craft, or the angle between the projections of these lines onto a horizontal plane.#

The angle is usually small enough that either of the alternatives gives the same angle within the tolerances allowed by the situation.

(2) #The angle through which a coordinate system fixed in a photograph must be rotated about the z-axis in object space to make the x- and y-axes of the photograph parallel to the x- and y-axes in object space.#

Yaw is usually the third rotation to be considered; pitch and roll usually are corrected for first, so that the z-axis of the photograph is presumed to have already been made parallel to the z-axis in object space.

(3) #The angle through which a coordinate system fixed in a photograph is rotated about a specified line (the z-axis) through the origin of the coordinate system and nearly perpendicular to the photograph. The angle is measured between a specified line in a plane perpendicular to the specified axis of rotation and the projection of the x-axis of the coordinate system of the photograph onto that plane.#

In all the above definitions, the yaw (or crab) angle is usually denoted by κ (kappa).

year #The interval of time needed for the Sun to make two successive passages through some designated plane.#

This is equivalent to specifying the year as the interval between two successive passages of the Earth through some designated plane. The direction of the plane is usually fixed with respect to (a) the stars, resulting in the *sidereal year*; (2) the *vernal equinox*, resulting in the *tropical year*; or (3) *perihelion*, resulting in the *anomalistic year*. There is also a *calendar year* (a conventional interval whose value is based on the tropical year).

year, anomalistic #The period of one revolution of the Earth around the Sun, from perihelion to perihelion.#

This was 365 days, 6 hours, 13 minutes, and 53.16 seconds in 1955, and increasing at the rate of 0.002627 second annually.

year, astronomical (1) #The period of time between two successive passages of the Sun through the same right ascension (the *Besselian year*) or longitude (the *tropical year*).#

The length of the day and the length of the astronomical year are not commensurate.

(2) See *year, tropical.*

year, Besselian #A year beginning when the right ascension of the (fictitious) *mean sun*, as affected by aberration and measured from the mean equinox, is $18^h\,40^m$ (280°), and ending when the right ascension of the same sun is again $18^h\,40^m$.#

Also called a fictitious year. The Besselian year is shorter than the tropical year by $0.148 \times T$, where T is the number of *Julian centuries* since 1900 at a given date. The difference is usually ignored.

year, calendar #The interval of time containing roughly 365 days; designated as a year in a particular calendar.#

A calendar year always contains an integral number of days; an astronomical year never does. The number of days in a calendar year therefore is changed from time to time according to some rule set by law, custom, or religion, so that the average length of the calendar year and the astronomical year will remain approximately equal. See *year, tropical.*

year, eclipse #The interval of time between two successive conjunctions of the Sun with the same node of the Moon's orbit (approximately 346.6200 days).#

year, fictitious See *year, Besselian.*

year, great #The interval of time required for one complete cycle of the motion of the equinoxes around the ecliptic. This is about 25,800 years.#

Also called a Platonic year.

year, Julian #One-hundredth of a *Julian century*, i.e., 365.25 days.#

year, Platonic See *year, great.*

year, sidereal #The interval of time in which the *mean Sun* completes one circuit of the ecliptic, from the longitude of a given star back to the same longitude.#

The term is also applied to the average interval of time needed for this circuit. The average sidereal year is equal to 365.25636 *mean solar days*.

year, tropical #The interval of time during which the Sun's mean longitude, referred to the mean equinox of date, increases by 360°.#

This interval is the basis for the conventional calendar year used in chronology and civil reckoning. It is equal to 365.2422 *mean solar days*, and closely approximates the average length of time the Sun requires to pass from vernal equinox to vernal equinox.

Also called an astronomical year.

Y-level See *level, wye.*

y-parallax #The difference between the perpendicular distances of the two images of a point, on a pair of photographs, from the vertical plane containing the *air base*.#

The existence of y-parallax is an indication of tilt in either or both photographs, or of a difference between the scales of the photographs; as such, it interferes with stereoscopic examination of the pair.

Also called vertical parallax or want of correspondence.

y-tilt (aerial photogrammetry) #The angle between the x-axis and a horizontal plane or between the x-axis and the horizontal reference plane of a stereoscopic plotting instrument, given a rectangular Cartesian coordinate system on a photograph, with the x-axis being more nearly in the line of flight than the y-axis.#

Also called *pitch* in relation to the orientation of the aircraft from which the photograph was taken. See *x-tilt.*

Z

zenith #The point at which a line opposite in direction from that of the plumb line at a given point on the Earth's surface, meets the celestial sphere.#

The zenith and *nadir* are poles of the horizon. The terms *geodetic zenith (geodetic nadir)* and *geocentric zenith (geocentric nadir)* are sometimes used with meanings different from that given. (See *nadir.)*

zenith, geocentric #The point where a line from the center of the Earth through a given point on its surface meets the celestial sphere.#

This term is sometimes used in astronomic work, but seldom appears in *geodetic* work; it should be used only in its entirety, because the single word, zenith, is reserved for designating the point determined by the direction of the plumb line.

zenith, geodetic #The point where the normal to the reference ellipsoid, extended upward, meets the celestial sphere.#

This term has some use in geodesy, but should be used only in its entirety, because the single word, zenith, is reserved for designating the point determined by the direction of the plumb line.

zenithal (cartography) #Azimuthal.#

For example, the Lambert zenithal equal-area map projection is the same as the Lambert azimuthal equal-area map projection.

zenith angle See *angle, zenith.*

zenith distance See *angle, zenith.*

zenith telescope See *telescope, zenith.*

zenith telescope method of determining latitude See *latitude determination, Horrebow-Talcott method of.*

zero, absolute (temperature) See *absolute zero.*

zero, tide gauge See *tide gauge zero.*

zero point (geodesy) #A point taken as the origin of coordinates.#

Also called zero or null point.

Zinger method See *longitude determination, Tsinger method of.*

zonal harmonic See *harmonic, spherical.*

zone (1) #The region between any two concentric circles.#

In gravimetric geodesy, the term is applied to regions lying between concentric circles whose diameters are specified by convention. The common center for the circles is at the point where gravity or geodetic height is to be computed. Hayford zones are an outstanding example.

(2) #The region bounded by two circles of latitude.#

For example, zonal harmonics are functions of latitude which go through one complete cycle of values when the latitude varies from one zonal boundary to the other; the longitude has no effect.

The Northern and Southern Temperate Zones on the Earth are climatic zones bounded respectively by the Arctic Circle and the Tropic of Cancer, and by the Antarctic Circle and the Tropic of Capricorn.

(3) #A narrow region between two lines.#

zone, breaker (1) #The region extending from the line of greatest advance of water on shore (except under extreme conditions), to the line marking the outer boundary at which breakers form.#

Also called the surf zone and the littoral zone.

(2) #The region in which breakers form.#

zone, Hayford #A ring-shaped region, about a point on a level ellipsoid, having inner and outer radii specified according to a scheme devised by Hayford for calculating the effects of topographic masses on gravity (see *template, Hayford).* #

zone, intertidal #The region between *mean high water* and *mean low water.*#

Also called the littoral zone, although this term also has other meanings.

zone, littoral (1) See *zone, intertidal.*

(2) See *zone, breaker.*

zone, nearshore #The region extending seaward from the shore to the seaward limits of the *breaker zone.* #

zone, neritic (1) #The region on the ocean floor extending from the line of low tide to a depth of approximately 200 m, i.e., approximately to the edge of the continental shelf.#

(2) #Those parts of the oceans lying at depths less than 200 m.#

zone, surf See *zone, breaker.*

zoom lens See *optical system, zoom.*

z-term See *Kimura term.*

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