

# Glossary

**ABSOLUTE MAXIMUM** A value  $f(c)$  is an absolute maximum value of  $f$  if  $f(c) \geq f(x)$  for all  $x$  in the domain of  $f$ , p. 96.

**ABSOLUTE MINIMUM** A value  $f(c)$  is an absolute minimum value of  $f$  if  $f(c) \leq f(x)$  for all  $x$  in the domain of  $f$ , p. 96.

**ABSOLUTE VALUE OF A COMPLEX NUMBER** The absolute value of the complex number  $z = a + bi$  is given by  $\sqrt{a^2 + b^2}$ ; also, the length of the segment from the origin to  $z$  in the complex plane, p. 551.

**ABSOLUTE VALUE OF A REAL NUMBER** Denoted by  $|a|$ , represents the number  $a$  or the positive number  $-a$  if  $a < 0$ , p. 14.

**ABSOLUTE VALUE OF A VECTOR** See *Magnitude of a vector*.

**ACUTE ANGLE** An angle whose measure is between  $0^\circ$  and  $90^\circ$ , p. 360.

**ACUTE TRIANGLE** A triangle in which all angles measure less than  $90^\circ$ , p. 478.

**ADDITION PROPERTY OF EQUALITY** If  $u = v$  and  $w = z$ , then  $u + w = v + z$ , p. 24.

**ADDITION PROPERTY OF INEQUALITY** If  $u < v$ , then  $u + w < v + w$ , p. 27.

**ADDITIVE IDENTITY FOR THE COMPLEX NUMBERS**  $0 + 0i$  is the complex number zero, p. 54.

**ADDITIVE INVERSE OF A REAL NUMBER** The opposite of  $b$ , or  $-b$ , p. 6.

**ADDITIVE INVERSE OF A COMPLEX NUMBER** The opposite of  $a + bi$ , or  $-a - bi$ , p. 54.

**ALGEBRAIC EXPRESSION** A combination of variables and constants involving addition, subtraction, multiplication, division, powers, and roots, p. 6.

**ALGEBRAIC MODEL** An equation which relates variable quantities associated with a phenomena being studied, p. 71.

**AMBIGUOUS CASE** A triangle in which two sides and a nonincluded angle are known, p. 479.

**AMPLITUDE** See *Sinusoid*.

**ANCHOR** See *Mathematical induction*.

**ANGLE** Union of two rays with a common endpoint (the vertex). The beginning ray (the initial side) can be rotated about its endpoint to obtain the final position (the terminal side), p. 370.

**ANGLE BETWEEN VECTORS** The angle formed by two non-zero vectors in standard position, sharing a common initial point, p. 515.

**ANGLE OF DEPRESSION** The acute angle formed by the line of sight (downward) and the horizontal, p. 425.

**ANGLE OF ELEVATION** The acute angle formed by the line of sight (upward) and the horizontal, p. 425.

**ANGULAR SPEED** Speed of rotation, typically measured in radians or revolutions per unit time, p. 354.

**ANNUAL PERCENTAGE RATE (APR)** The annual interest rate, p. 340.

**ANNUAL PERCENTAGE YIELD (APY)** The rate that would give the same return if interest were computed just once a year, p. 337.

**ANNUITY** A sequence of equal periodic payments, p. 338.

**APHELION** The farthest point from the Sun in a planet's orbit, p. 649.

**ARC LENGTH FORMULA** The length of an arc in a circle of radius  $r$  intercepted by a central angle of  $\theta$  is  $s = r\theta$ , p. 353.

**ARCCOSECANT FUNCTION** See *Inverse cosecant function*.

**ARCCOSINE FUNCTION** See *Inverse cosine function*.

**ARCCOTANGENT FUNCTION** See *Inverse cotangent function*.

**ARCSECANT FUNCTION** See *Inverse secant function*.

**ARCSINE FUNCTION** See *Inverse sine function*.

**ARCTANGENT FUNCTION** See *Inverse tangent function*.

**ARGUMENT OF A COMPLEX NUMBER** The argument of  $a + bi$  is the direction angle of the vector  $\langle a, b \rangle$ , p. 551.

**ARITHMETIC SEQUENCE** A sequence  $\{a_n\}$  in which  $a_n = a_{n-1} + d$  for every integer  $n \geq 2$ . The number  $d$  is the common difference, p. 734.

**ARROW** The notation  $\overrightarrow{PQ}$  denoting the directed line segment with initial point  $P$  and terminal point  $Q$ .

**ASSOCIATIVE PROPERTIES**  $a + (b + c) = (a + b) + c$ ,  $a(bc) = (ab)c$ , p. 7.

**AUGMENTED MATRIX** A matrix that represents a system of equations, p. 596.

**AVERAGE RATE OF CHANGE OF  $f$  OVER  $[a, b]$**  The number  $\frac{f(b) - f(a)}{b - a}$ , provided  $a \neq b$ , p. 172.

**AVERAGE VELOCITY** The change in position divided by the change in time, p. 795.

**AXIS OF SYMMETRY** See *Line of symmetry*.

**BACK-TO-BACK STEM PLOT** A stemplot with leaves on either side used to compare two distributions, p. 763.

**BAR CHART** A rectangular graphical display of categorical data, p. 760.

**BASE** See *Logarithmic function, nth power of a*.

**BASIC LOGISTIC FUNCTION** The function  $f(x) = \frac{1}{1 + e^{-x}}$ , p. 283.

**BEARING** Measure of the clockwise angle that the line of travel makes with due north, p. 351.

**BINOMIAL** A polynomial with exactly two terms, p. 711.

**BINOMIAL COEFFICIENTS** The numbers in Pascal's triangle:

$${}_nC_r = \binom{n}{r} = \frac{n!}{r!(n-r)!}, \text{ p. 712.}$$

**BINOMIAL PROBABILITY** In an experiment with two possible outcomes, the probability of one outcome occurring  $k$  times in  $n$  independent trials is  $P(E) = \frac{n!}{k!(n-k)!} p^k(1-p)^{n-k}$ , where  $p$  is the probability of the outcome occurring once, p. 727.

**BINOMIAL THEOREM** A theorem that gives an expansion formula for  $(a + b)^n$ , p. 711.

**BOUNDARY** The set of points on the "edge" of a region, p. 618.

**BOUNDED** A function  $f$  is bounded if there are numbers  $b$  and  $B$  such that  $b \leq f(x) \leq B$  for all  $x$  in the domain of  $f$ , p. 95.

**BOUNDED ABOVE** A function  $f$  is bounded above if there is a number  $B$  such that  $f(x) \leq B$  for all  $x$  in the domain of  $f$ , p. 95.

**BOUNDED BELOW** A function  $f$  is bounded below if there is a number  $b$  such that  $b \leq f(x)$  for all  $x$  in the domain of  $f$ , p. 95.

**BOUNDED INTERVAL** An interval that has finite length (does not extend to  $\infty$  or  $-\infty$ ), p. 5.

**BOXPLOT (OR BOX-AND-WHISKER PLOT)** A graph that displays a five-number summary, p. 777.

**BRANCHES** The two separate curves that make up a hyperbola, p. 656.

**CARDIOID** A limaçon whose polar equation is  $r = a \pm a \sin \theta$ , or  $r = a \pm a \cos \theta$ , where  $a > 0$ , p. 545.

**CARTESIAN COORDINATE SYSTEM** An association between the points in a plane and ordered pairs of real numbers; or an association between the points in three-dimensional space and ordered triples of real numbers, p. 14.

**CATEGORICAL VARIABLE** A variable (in statistics) that identifies each individual as belonging to a distinct class, p. 759.

**CENTER** The central point in a circle, ellipse, hyperbola, or sphere, pp. 18, 647.

**CENTRAL ANGLE** An angle whose vertex is the center of a circle, p. 350.

**CHARACTERISTIC POLYNOMIAL OF A SQUARE MATRIX A**  $\det(xI_n - A)$ , where  $A$  is an  $n \times n$  matrix, p. 593.

**CHORD OF A CONIC** A line segment with endpoints on the conic, p. 635.

**CIRCLE** A set of points in a plane equally distant from a fixed point called the center, p. 18.

**CIRCLE GRAPH** A circular graphical display of categorical data, p. 760.

**CIRCULAR FUNCTIONS** Trigonometric functions when applied to real numbers are circular functions, p. 378.

**CLOSED INTERVAL** An interval that includes its endpoints, p. 5.

**COEFFICIENT** The real number multiplied by the variable(s) in a term, p. 200.

**COEFFICIENT OF DETERMINATION** The number  $r^2$  or  $R^2$  that measures how well a regression curve fits the data, p. 158.

**COEFFICIENT MATRIX** A matrix whose elements are the coefficients in a system of linear equations, p. 597.

**COFUNCTION IDENTITY** An identity that relates the sine, secant, or tangent to the cosine, cosecant, or cotangent, respectively, p. 446.

**COMBINATION** An arrangement of elements of a set, in which order is not important, p. 704.

**COMBINATIONS OF  $n$  OBJECTS TAKEN  $r$  AT A TIME**

$${}_nC_r = \frac{n!}{r!(n-r)!}, \text{ p. 704.}$$

**COMBINATORICS** A branch of mathematics related to determining the number of elements of a set or the number of ways objects can be arranged or combined, p. 700.

**COMMON DIFFERENCE** See *Arithmetic sequence*.

**COMMON LOGARITHM** A logarithm with base 10, p. 302.

**COMMON RATIO** See *Geometric sequence*.

**COMMUTATIVE PROPERTIES**  $a + b = b + a$ ,  $ab = ba$ , p. 7.

**COMPLEMENTS OR COMPLEMENTARY ANGLES** Two angles of positive measure whose sum is  $90^\circ$ , p. 446.

**COMPLETELY FACTORED POLYNOMIAL** A polynomial written in factored form with all prime factors, p. 232.

**COMPLETING THE SQUARE** A method of adding a constant to an expression in order to form a perfect square, p. 45.

**COMPLEX CONJUGATES** Complex numbers  $a + bi$  and  $a - bi$ , p. 55.

**COMPLEX FRACTION** See *Compound fraction*.

**COMPLEX NUMBER** An expression  $a + bi$ , where  $a$  (the real part) and  $b$  (the imaginary part) are real numbers, p. 53.

**COMPLEX PLANE** A coordinate plane used to represent the complex numbers. The  $x$ -axis of the complex plane is called the real axis and the  $y$ -axis is the imaginary axis, p. 550.

**COMPONENT FORM OF A VECTOR** If a vector's representative in standard position has a terminal point  $(a, b)$  (or  $(a, b, c)$ ), then  $\langle a, b \rangle$  (or  $\langle a, b, c \rangle$ ) is the component form of the vector, and  $a$  and  $b$  are the horizontal and vertical components of the vector (or  $a, b$ , and  $c$  are the  $x$ -,  $y$ -, and  $z$ -components of the vector, respectively), p. 503.

**COMPONENTS OF A VECTOR** See *Component form of a vector*.

**COMPOSITION OF FUNCTIONS**  $(f \circ g)(x) = f(g(x))$ , p. 118.

**COMPOUND FRACTION** A fractional expression in which the numerator or denominator may contain fractions, p. 854.

**COMPOUND INTEREST** Interest that becomes part of the investment, p. 334.

**COMPOUNDED ANNUALLY** See *Compounded  $k$  times per year*.

**COMPOUNDED CONTINUOUSLY** Interest compounded using the formula  $A = Pe^{rt}$ , p. 337.

**COMPOUNDED  $k$  TIMES PER YEAR** Interest compounded using the formula  $A = P\left(1 + \frac{r}{k}\right)^{kt}$ , where  $k = 1$  is compounded annually,  $k = 4$  is compounded quarterly,  $k = 12$  is compounded monthly, etc., p. 335.

**COMPOUNDED MONTHLY** See *Compounded  $k$  times per year*.

**CONDITIONAL PROBABILITY** The probability of an event  $A$  given that an event  $B$  has already occurred ( $P(A|B)$ ), p. 724.

**CONE** See *right circular cone*.

**CONIC SECTION (OR CONIC)** A curve obtained by intersecting a double-napped right circular cone with a plane, p. 632.

**CONJUGATE AXIS OF A HYPERBOLA** The line segment of length  $2b$  that is perpendicular to the focal axis and has the center of the hyperbola as its midpoint, p. 657.

**CONSTANT** A letter or symbol that stands for a specific number, p. 6.

**CONSTANT FUNCTION (ON AN INTERVAL)**  $f(x_1) = f(x_2)$  for any  $x_1$  and  $x_2$  (in the interval), p. 93.

**CONSTANT TERM** See *Polynomial function*.

**CONSTANT OF VARIATION** See *Power function*.

**CONSTRAINTS** See *Linear programming problem*.

**CONTINUOUS FUNCTION** A function that is continuous on its entire domain, p. 109.

**CONTINUOUS AT  $x = a$**   $\lim_{x \rightarrow a} f(x) = f(a)$ , p. 91.

**CONVERGENCE OF A SEQUENCE** A sequence  $\{a_n\}$  converges to  $a$  if  $\lim_{n \rightarrow \infty} a_n = a$ .

**CONVERGENCE OF A SERIES** A series  $\sum_{k=1}^{\infty} a_k$  converges to a sum  $S$  if  $\lim_{n \rightarrow \infty} \sum_{k=1}^n a_k = S$ .

**CONVERSION FACTOR** A ratio equal to 1, p. 155.

**COORDINATE(S) OF A POINT** The number associated with a point on a number line, or the ordered pair associated with a point in the Cartesian coordinate plane, or the ordered triple associated with a point in the Cartesian three-dimensional space, pp. 3, 14, 685.

**COORDINATE PLANE** See *Cartesian coordinate system*.

**CORRELATION COEFFICIENT** A measure of the strength of the linear relationship between two variables, p. 158.

**COSECANT** The function  $y = \csc x$ , p. 399.

**COSINE** The function  $y = \cos x$ , p. 386.

**COTANGENT** The function  $y = \cot x$ , p. 397.

**COTERMINAL ANGLES** Two angles having the same initial side and the same terminal side, p. 370.

**COURSE** See *Bearing*.

**CUBE ROOT**  $n$ th root, where  $n = 3$  (see *Principal  $n$ th root*), p. 557.

**CUBIC** A degree 3 polynomial function, p. 200.

**CYCLOID** The graph of the parametric equations  $x = t - \sin t$ ,  $y = 1 - \cos t$ , p. 532.

**DAMPING FACTOR** The factor  $Ae^{-at}$  in an equation such as  $y = Ae^{-at} \cos bt$ , p. 410.

**DATA** Facts collected for statistical purposes (singular form is *datum*), p. 759.

**DE MOIVRE'S THEOREM**  $(r(\cos \theta + i \sin \theta))^n = r^n(\cos n\theta + i \sin n\theta)$ , p. 554.

**DECREASING ON AN INTERVAL** A function  $f$  is decreasing on an interval  $I$  if, for any two points in  $I$ , a positive change in  $x$  results in a negative change in  $f(x)$ , p. 93.

**DEDUCTIVE REASONING** The process of utilizing general information to prove a specific hypothesis, p. 80.

**DEFINITE INTEGRAL** The definite integral of the function  $f$  over  $[a, b]$  is  $\int_a^b f(x) dx = \lim_{n \rightarrow \infty} \sum_{i=1}^n f(x_i) \Delta x$  provided the limit of the Riemann sums exists, p. 808.

**DEGREE** Unit of measurement (represented by the symbol  $^\circ$ ) for angles or arcs, equal to  $1/360$  of a complete revolution, p. 351.

**DEGREE OF A POLYNOMIAL (FUNCTION)** The largest exponent on the variable in any of the terms of the polynomial (function), p. 170.

**DEMAND CURVE**  $p = g(x)$ , where  $x$  represents demand and  $p$  represents price, p. 574.

**DEPENDENT EVENT** An event whose probability depends on another event already occurring, p. 725.

**DEPENDENT VARIABLE** Variable representing the range value of a function (usually  $y$ ), p. 86.

**DERIVATIVE OF  $f$**  The function  $f'$  defined by

$$f'(x) = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \text{ for all of } x \text{ where the limit exists, p. 797.}$$

**DERIVATIVE OF  $f$  AT  $x = a$**   $f'(a) = \lim_{x \rightarrow a} \frac{f(x) - f(a)}{x - a}$  provided the limit exists, p. 797.

**DESCRIPTIVE STATISTICS** The gathering and processing of numerical information, p. 771.

**DETERMINANT** A number that is associated with a square matrix, p. 585.

**DIFFERENCE IDENTITY** An identity involving a trigonometric function of  $u - v$ , pp. 464-465.

**DIFFERENCE OF COMPLEX NUMBERS**  
 $(a + bi) - (c + di) = (a - c) + (b - d)i$ , p. 53

**DIFFERENCE OF FUNCTIONS**  $(f - g)(x) = f(x) - g(x)$ , p. 117.

**DIFFERENCE OF TWO VECTORS**  $\langle u_1, u_2 \rangle - \langle v_1, v_2 \rangle$   
 $= \langle u_1 - v_1, u_2 - v_2 \rangle$  or  $\langle u_1, u_2, u_3 \rangle - \langle v_1, v_2, v_3 \rangle$   
 $= \langle u_1 - v_1, u_2 - v_2, u_3 - v_3 \rangle$ , p. 690.

**DIFFERENTIABLE AT  $x = a$**   $f'(a)$  exists, p. 797.

**DIHEDRAL ANGLE** The angle formed along the common edge of two intersecting planes, p. 491.

**DIRECTED ANGLE** See *Polar coordinates*.

**DIRECTED DISTANCE** See *Polar coordinates*.

**DIRECTED LINE SEGMENT** See *Arrow*.

**DIRECTION ANGLE OF A VECTOR** The angle that the vector makes with the positive  $x$ -axis, p. 507.

**DIRECTION VECTOR FOR A LINE** A vector in the direction of a line in three-dimensional space, p. 692.

**DIRECTION OF AN ARROW** The angle the arrow makes with the positive  $x$ -axis, p. 503.

**DIRECTRIX OF A PARABOLA, ELLIPSE, OR HYPERBOLA** A line used to determine the conic, pp. 634, 675.

**DISCRIMINANT** For the equation  $ax^2 + bx + c$ , the expression  $b^2 - 4ac$ ; for the equation  $Ax^2 + Bxy + Cy^2 + Dx + Ey + F = 0$ , the expression  $B^2 - 4AC$ , pp. 56, 671.

**DISTANCE (IN A COORDINATE PLANE)**

The distance  $d(P, Q)$  between  $P(x, y)$  and  $Q(x, y)$ ,

$$d(P, Q) = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}, \text{ p. 16.}$$

**DISTANCE (ON A NUMBER LINE)** The distance between real numbers  $a$  and  $b$ , or  $|a - b|$ , p. 15.

**DISTANCE (IN CARTESIAN SPACE)** The distance  $d(P, Q)$  between  $P(x, y, z)$  and  $Q(x, y, z)$ , or

$$d(P, Q) = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}, \text{ p. 686.}$$

**DISTRIBUTIVE PROPERTY**  $a(b + c) = ab + ac$  and related properties, p. 7.

**DIVERGENCE** A sequence or series diverges if it does not converge, p. 773.

**DIVISION**  $\frac{a}{b} = a\left(\frac{1}{b}\right)$ ,  $b \neq 0$ , p. 6.

**DIVISION ALGORITHM FOR POLYNOMIALS** Given  $f(x)$ ,  $d(x) \neq 0$  there are unique polynomials  $q(x)$  (quotient) and  $r(x)$  (remainder) with  $f(x) = d(x)q(x) + r(x)$  with either  $r(x) = 0$  or degree of  $r(x) <$  degree of  $d(x)$ , p. 214.

**DIVISOR OF A POLYNOMIAL** See *Division algorithm for polynomials*.

**DMS MEASURE** The measure of an angle in degrees, minutes, and seconds, p. 351.

**DOMAIN OF A FUNCTION** The set of all input values for a function, p. 86.

**DOT PRODUCT** The number found when the corresponding components of two vectors are multiplied and then summed, p. 514.

**DOUBLE-ANGLE IDENTITY** An identity involving a trigonometric function of  $2u$ , p. 471.

**DOUBLE INEQUALITY** A statement that describes a bounded interval, such as  $3 \leq x < 5$ , p. 28.

**ECCENTRICITY** A nonnegative number that specifies the shape of a conic, pp. 650, 660, 675.

**ELEMENTARY ROW OPERATIONS** The following three row operations: Multiply all elements of a row by a nonzero constant; interchange two rows; and add a multiple of one row to another row, p. 598.

**ELEMENTS OF A MATRIX** See *Matrix element*.

**ELIMINATION METHOD** A method of solving a system of linear equations, p. 571.

**ELLIPSE** The set of all points in the plane such that the sum of the distances from a pair of fixed points (the foci) is a constant, p. 644.

**ELLIPSOID OF REVOLUTION** A surface generated by rotating an ellipse about its major axis, p. 651.

**EMPTY SET** A set with no elements, p. 720.

**END BEHAVIOR** The behavior of a graph of a function as  $|x| \rightarrow \infty$ , p. 203.

**END BEHAVIOR ASYMPTOTE OF A RATIONAL FUNCTION** A polynomial that the function approaches as  $|x| \rightarrow \infty$ , p. 240.

**ENDPOINT OF AN INTERVAL** A real number that represents one “end” of an interval, p. 5.

**EQUAL COMPLEX NUMBERS** Complex numbers whose real parts are equal and whose imaginary parts are equal, p. 53.

**EQUAL MATRICES** Matrices that have the same order and equal corresponding elements, p. 579.

**EQUALLY LIKELY OUTCOMES** Outcomes of an experiment that have the same probability of occurring, p. 718.

**EQUATION** A statement of equality between two expressions, p. 24.

**EQUILIBRIUM POINT** A point where the supply curve and demand curve intersect. The corresponding price is the equilibrium price, p. 574.

**EQUILIBRIUM PRICE** See *Equilibrium point*.

**EQUIVALENT ARROWS** Arrows that have the same magnitude and direction, p. 503.

**EQUIVALENT EQUATIONS (INEQUALITIES)** Equations (inequalities) that have the same solutions, pp. 25, 27.

**EQUIVALENT SYSTEMS OF EQUATIONS** Systems of equations that have the same solution, p. 594.

**EQUIVALENT VECTORS** Vectors with the same magnitude and direction, p. 503.

**EVEN FUNCTION** A function whose graph is symmetric about the y-axis ( $f(-x) = f(x)$  for all  $x$  in the domain of  $f$ ), p. 97.

**EVENT** A subset of a sample space, p. 718.

**EXPANDED FORM** The right side of  $u(v + w) = uv + uw$ , p. 7.

**EXPANDED FORM OF A SERIES** A series written explicitly as a sum of terms (not in summation notation), p. 747.

**EXPERIMENT** A procedure that has one or more possible outcomes, p. 718.

**EXPLICITLY DEFINED SEQUENCE** A sequence in which the  $k$ th term is given as a function of  $k$ , p. 732

**EXPONENT** See *nth power of a*, p. 8.

**EXPONENTIAL DECAY FUNCTION** Decay modeled by  $f(x) = a \cdot b^x$ ,  $a > 0$  with  $0 < b < 1$ , p. 279.

**EXPONENTIAL FORM** An equation written with exponents instead of logarithms, pp. 276, 300.

**EXPONENTIAL FUNCTION** A function of the form  $f(x) = a \cdot b^x$ , where  $a \neq 0$ ,  $b > 0$ ,  $b \neq 1$ , p. 276.

**EXPONENTIAL GROWTH FUNCTION** Growth modeled by  $f(x) = a \cdot b^x$ ,  $a > 0$ ,  $b > 1$ , p. 279.

**EXPONENTIAL REGRESSION** A procedure for fitting an exponential function to a set of data, p. 157.

**EXTRACTING SQUARE ROOTS** A method for solving equations in the form  $x^2 = k$ , p. 45.

**EXTRANEOUS SOLUTION** Any solution of the resulting equation that is not a solution of the original equation, p. 248.

**FACTOR THEOREM**  $x - c$  is a factor of a polynomial if and only if  $c$  is a zero of the polynomial, p. 216.

**FACTORED FORM** The left side of  $u(v + w) = uv + uw$ , p. 7.

**FACTORIZING (A POLYNOMIAL)** Writing a polynomial as a product of two or more polynomial factors, p. 47.

**FEASIBLE POINTS** Points which satisfy the constraints in a linear programming problem, p. 620.

**FIBONACCI NUMBERS** The terms of the Fibonacci sequence, p. 738.

**FIBONACCI SEQUENCE** The sequence 1, 1, 2, 3, 5, 8, 13, ..., p. 738.

**FINITE SEQUENCE** A function whose domain is the first  $n$  positive integers for some fixed integer  $n$ , p. 732.

**FINITE SERIES** Sum of a finite number of terms, p. 743.

**FIRST-DEGREE EQUATION IN  $x$ ,  $y$ , AND  $z$**  An equation that can be written in the form  $Ax + By + Cz + D = 0$ , p. 689.

**FIRST OCTANT** The points  $(x, y, z)$  in space with  $x \geq 0$ ,  $y \geq 0$ , and  $z \geq 0$ , p. 685.

**FIRST QUARTILE** See *Quartile*.



## 882 GLOSSARY

**FITTING A LINE OR CURVE TO DATA** Finding a line or curve that comes close to passing through all the points in a scatter plot, p. 155.

**FIVE-NUMBER SUMMARY** The minimum, first quartile, median, third quartile, and maximum of a data set, p. 775.

**FOCAL AXIS** The line through the focus and perpendicular to the directrix of a conic, p. 644.

**FOCAL CHORD OF A PARABOLA** A chord of a parabola that passes through the focus, p. 635.

**FOCAL LENGTH OF A PARABOLA** The *directed distance* from the vertex to the focus, p. 635.

**FOCAL WIDTH OF A PARABOLA** The length of the chord through the focus and perpendicular to the axis, p. 635.

**FOCUS, FOCI** See *Ellipse, Hyperbola, Parabola*.

**FREQUENCY** Reciprocal of the period, p. 388.

**FREQUENCY (IN STATISTICS)** The number of individuals or observations with a certain characteristic, p. 764.

**FREQUENCY DISTRIBUTION** See *Frequency table*.

**FREQUENCY TABLE (IN STATISTICS)** A table showing frequencies, p. 764.

**FUNCTION** A relation that associates each value in the domain with exactly one value in the range, pp. 86, 690.

**FUNDAMENTAL THEOREM OF ALGEBRA** A polynomial function of degree  $n > 0$  has  $n$  complex zeros (counting multiplicity), p. 228.

**FUTURE VALUE OF AN ANNUITY** The net amount of money returned from an annuity, p. 339.

**GAUSSIAN CURVE** See *Normal curve*.

**GAUSSIAN ELIMINATION** A method of solving a system of  $n$  linear equations in  $n$  unknowns, p. 594.

**GENERAL FORM (OF A LINE)**  $Ax + By + C = 0$ , where  $A$  and  $B$  are not both zero, p. 33.

**GEOMETRIC SEQUENCE** A sequence  $\{a_n\}$  in which  $a_n = a_{n-1} \cdot r$  for every positive integer  $n \geq 2$ . The nonzero number  $r$  is called the common ratio, p. 735.

**GEOMETRIC SERIES** A series whose terms form a geometric sequence, p. 748.

**GRAPH OF A FUNCTION  $f$**  The set of all points in the coordinate plane corresponding to the pairs  $(x, f(x))$  for  $x$  in the domain of  $f$ , p. 76.

**GRAPH OF A POLAR EQUATION** The set of all points in the polar coordinate system corresponding to the ordered pairs  $(r, \theta)$  that are solutions of the polar equation, p. 541.

**GRAPH OF A RELATION** The set of all points in the coordinate plane corresponding to the ordered pairs of the relation, p. 123.

**GRAPH OF AN EQUATION IN  $x$  AND  $y$**  The set of all points in the coordinate plane corresponding to the pairs  $(x, y)$  that are solutions of the equation, p. 34.

**GRAPH OF AN INEQUALITY IN  $x$  AND  $y$**  The set of all points in the coordinate plane corresponding to the solutions  $(x, y)$  of the inequality, p. 617.

**GRAPH OF PARAMETRIC EQUATIONS** The set of all points in the coordinate plane corresponding to the ordered pairs determined by the parametric equations, p. 522.

**GRAPHER OR GRAPHING UTILITY** Graphing calculator or a computer with graphing software, p. 35.

**GRAPHICAL MODEL** A visible representation of a numerical or algebraic model, p. 72.

**HALF-ANGLE IDENTITY** Identity involving a trigonometric function of  $u/2$ , p. 473.

**HALF-LIFE** The amount of time required for half of a radioactive substance to decay, p. 291.

**HALF-PLANE** The graph of the linear inequality  $y \geq ax + b$ ,  $y > ax + b$ ,  $y \leq ax + b$ , or  $y < ax + b$ , p. 618.

**HERON'S FORMULA** The area of  $\triangle ABC$  with semiperimeter  $s$  is given by  $\sqrt{s(s-a)(s-b)(s-c)}$ , p. 490.

**HIGHER-DEGREE POLYNOMIAL FUNCTION** A polynomial function whose degree is  $\geq 3$ , p. 200.

**HISTOGRAM** A graph that visually represents the information in a frequency table using rectangular areas proportional to the frequencies, p. 764.

**HORIZONTAL ASYMPTOTE** The line  $y = b$  is a horizontal asymptote of the graph of a function  $f$  if  $\lim_{x \rightarrow -\infty} f(x) = b$  or  $\lim_{x \rightarrow \infty} f(x) = b$ , p. 100.

**HORIZONTAL COMPONENT** See *Component form of a vector*.

**HORIZONTAL LINE**  $y = b$ , p. 34.

**HORIZONTAL LINE TEST** A test for determining whether the inverse of a relation is a function, p. 130.

**HORIZONTAL SHRINK OR STRETCH** See *Shrink, stretch*.

**HORIZONTAL TRANSLATION** A shift of a graph to the left or right, p. 138.

**HYPERBOLA** A set of points in a plane, the absolute value of the difference of whose distances from two fixed points (the foci) is a constant, p. 656

**HYPOTENUSE** Side opposite the right angle in a right triangle, p. 360.

**IDENTITY** An equation that is always true throughout its domain, p. 444.

**IDENTITY FUNCTION** The function  $f(x) = x$ , p. 106.

**IDENTITY MATRIX** A square matrix with 1's in the main diagonal and 0's elsewhere, p. 584.

**IDENTITY PROPERTIES**  $a + 0 = a$ ,  $a \cdot 1 = a$ , p. 7.

**IMAGINARY AXIS** See *Complex plane*.

**IMAGINARY PART OF A COMPLEX NUMBER** See *Complex number*.

**IMAGINARY UNIT** The complex number  $i = \sqrt{-1}$ , p. 53.

**IMPLIED DOMAIN** The domain of a function's algebraic expression, p. 88.

**INCREASING ON AN INTERVAL** A function  $f$  is increasing on an interval  $I$  if, for any two points in  $I$ , a positive change in  $x$  results in a positive change in  $f(x)$ , p. 93.

**INDEPENDENT EVENTS** Events  $A$  and  $B$  such that  $P(A \text{ and } B) = P(A)P(B)$ , p. 722.

**INDEPENDENT VARIABLE** Variable representing the domain value of a function (usually  $x$ ), p. 86.

**INDEX** See *Radical*.

**INDEX OF SUMMATION** See *Summation notation*.

**INDUCTIVE STEP** See *Mathematical induction*.

**INEQUALITY** A statement that compares two quantities using an inequality symbol, p. 4.

**INEQUALITY SYMBOL**  $<$ ,  $>$ ,  $\leq$ , or  $\geq$ , p. 4.

**INFERENCE STATISTICS** Using the science of statistics to make inferences about the parameters in a population from a sample, p. 771.

**INFINITE DISCONTINUITY AT  $x = a$**   $\lim_{x \rightarrow a^+} f(x) = \pm\infty$  or  $\lim_{x \rightarrow a^-} f(x) = \pm\infty$ , p. 91.

**INFINITE LIMIT** A special case of a limit that does not exist, p. 819.

**INFINITE SEQUENCE** A function whose domain is the set of all natural numbers, p. 732.

**INITIAL POINT** See *Arrow*.

**INITIAL SIDE OF AN ANGLE** See *Angle*.

**INITIAL VALUE OF A FUNCTION**  $f(0)$ , p. 173.

**INSTANTANEOUS RATE OF CHANGE** See *Derivative at  $x = a$* .

**INSTANTANEOUS VELOCITY** The instantaneous rate of change of a position function with respect to time, p. 793.

**INTEGERS** The numbers  $\dots, -3, -2, -1, 0, 1, 2, \dots$ , p. 2.

**INTEGRABLE OVER  $[a, b]$**   $\int_a^b f(x) dx$  exists, p. 808.

**INTERCEPT** Point where a curve crosses the  $x$ -,  $y$ -, or  $z$ -axis in a graph, pp. 33, 76, 689.

**INTERCEPTED ARC** Arc of a circle between the initial side and terminal side of a central angle, p. 351.

**INTERMEDIATE VALUE THEOREM** If  $f$  is a polynomial function and  $a < b$ , then  $f$  assumes every value between  $f(a)$  and  $f(b)$ , p. 206.

**INTERQUARTILE RANGE** The difference between the third quartile and the first quartile, p. 775.

**INTERVAL** Connected subset of the real number line with at least two points, p. 5.

**INTERVAL NOTATION** Notation used to specify intervals, p. 5.

**INVERSE COSECANT FUNCTION** The function  $y = \csc^{-1} x$ .

**INVERSE COSINE FUNCTION** The function  $y = \cos^{-1} x$ .

**INVERSE COTANGENT FUNCTION** The function  $y = \cot^{-1} x$ .

**INVERSE FUNCTION** The inverse relation of a one-to-one function, p. 131.

**INVERSE OF A MATRIX** The inverse of a square matrix  $A$ , if it exists, is a matrix  $B$ , such that  $AB = BA = I$ , where  $I$  is an identity matrix, p. 584.

**INVERSE PROPERTIES**  $a + (-a) = 0$ ,  $a \cdot \frac{1}{a} = 1$  ( $a \neq 0$ ), p. 7.

**INVERSE RELATION (OF THE RELATION  $R$ )** A relation that consists of all ordered pairs  $(b, a)$  for which  $(a, b)$  belongs to  $R$ , p. 130.

**INVERSE RULE OF LOGARITHMS**  $b^{\log_b x} = x$  and  $\log_b b^y = y$ , p. 301.

**INVERSE SECANT FUNCTION** The function  $y = \sec^{-1} x$ .

**INVERSE SINE FUNCTION** The function  $y = \sin^{-1} x$ , p. 414.

**INVERSE TANGENT FUNCTION** The function  $y = \tan^{-1} x$ , p. 417.

**INVERTIBLE LINEAR SYSTEM** A system of  $n$  linear equations in  $n$  variables whose coefficient matrix has a nonzero determinant, p. 601.

**IRRATIONAL NUMBERS** Real numbers that are not rational, p. 2.

**IRRATIONAL ZEROS** Zeros of a function that are irrational numbers, p. 218.

**IRREDUCIBLE QUADRATIC OVER THE REALS** A quadratic polynomial with real coefficients that cannot be factored using real coefficients, p. 232.

**JUMP DISCONTINUITY AT  $x = a$**   $\lim_{x \rightarrow a^-} f(x)$  and  $\lim_{x \rightarrow a^+} f(x)$  exist but are not equal, p. 91.

**$k$ TH TERM OF A SEQUENCE** The  $k$ th expression in the sequence, p. 732.

**LAW OF COSINES**  $a^2 = b^2 + c^2 - 2bc \cos A$ ,  
 $b^2 = a^2 + c^2 - 2ac \cos B$ ,  $c^2 = a^2 + b^2 - 2ab \cos C$ , p. 487.

**LAW OF SINES**  $\frac{\sin A}{a}$ ,  $\frac{\sin B}{b}$ ,  $\frac{\sin C}{c}$ , p. 478.

**LEADING COEFFICIENT** See *Polynomial function in  $x$* .

**LEADING TERM** See *Polynomial function in  $x$* .

**LEAF** The final digit of a number in a stemplot, p. 760.

**LEAST-SQUARES LINE** See *Linear regression line*.

**LEIBNIZ NOTATION** The notation  $dy/dx$  for the derivative of  $f$ , p. 798.

**LEFT-HAND LIMIT OF  $f$  AT  $x = a$**  The limit of  $f$  as  $x$  approaches  $a$  from the left, p. 817.

**LEMNISCATE** A graph of a polar equation of the form  $r^2 = a^2 \sin 2\theta$  or  $r^2 = a^2 \cos 2\theta$ , p. 547.

**LENGTH OF AN ARROW** See *Magnitude of an arrow*.

**LENGTH OF A VECTOR** See *Magnitude of a vector*.

**LIMAÇON** A graph of a polar equation  $r = a \pm b \sin \theta$  or  $r = a \pm b \cos \theta$  with  $a > 0$ ,  $b > 0$ , p. 545.

**LIMIT**  $\lim_{x \rightarrow a} f(x) = L$  means that  $f(x)$  gets arbitrarily close to  $L$  as  $x$  gets arbitrarily close (but not equal) to  $a$ , p. 813.

**LIMIT TO GROWTH** See *Logistic growth function*.

**LIMIT AT INFINITY**  $\lim_{x \rightarrow \infty} f(x) = L$  means that  $f(x)$  gets arbitrarily close to  $L$  as  $x$  gets arbitrarily large;  $\lim_{x \rightarrow -\infty} f(x)$  means that  $f(x)$  gets arbitrarily close to  $L$  as  $-x$  gets arbitrarily large, pp. 805, 819.

**LINE GRAPH** A graph of data in which consecutive data points are connected by line segments, p. 765.

**LINE OF SYMMETRY** A line over which a graph is the mirror image of itself, p. 177.

**LINE OF TRAVEL** The path along which an object travels, p. 351.

**LINEAR COMBINATION OF VECTORS  $\mathbf{u}$  AND  $\mathbf{v}$**  An expression  $a\mathbf{u} + b\mathbf{v}$ , where  $a$  and  $b$  are real numbers, p. 507.

**LINEAR CORRELATION** A scatter plot with points clustered along a line. Correlation is positive if the slope is positive and negative if the slope is negative, p. 174.

**LINEAR EQUATION IN  $x$**  An equation that can be written in the form  $ax + b = 0$ , where  $a$  and  $b$  are real numbers and  $a \neq 0$ , p. 24.

**LINEAR FACTORIZATION THEOREM** A polynomial  $f(x)$  of degree  $n > 0$  has the factorization  $f(x) = a(x - z_1)(x - z_2) \cdots (x - z_n)$  where the  $z_i$  are the zeros of  $f$ , p. 228.

**LINEAR FUNCTION** A function that can be written in the form  $f(x) = mx + b$ , where  $m \neq 0$  and  $b$  are real numbers, p. 171.

**LINEAR INEQUALITY IN TWO VARIABLES  $x$  AND  $y$**  An inequality that can be written in one of the following forms:  $y < mx + b$ ,  $y \leq mx + b$ ,  $y > mx + b$ , or  $y \geq mx + b$  with  $m \neq 0$ , p. 617.

**LINEAR INEQUALITY IN  $x$**  An inequality that can be written in the form  $ax + b < 0$ ,  $ax + b \leq 0$ ,  $ax + b > 0$ , or  $ax + b \geq 0$ , where  $a$  and  $b$  are real numbers and  $a \neq 0$ , p. 26.

**LINEAR PROGRAMMING PROBLEM** A method of solving certain problems involving maximizing or minimizing a function of two variables (called an objective function) subject to restrictions (called constraints), p. 620.

**LINEAR REGRESSION** A procedure for finding the straight line that is the best fit for the data, p. 157.

**LINEAR REGRESSION EQUATION** Equation of a linear regression line, p. 157.

**LINEAR REGRESSION LINE** The line for which the sum of the squares of the residuals is the smallest possible, p. 157.

**LINEAR SYSTEM** A system of linear equations, p. 568.

**LOCAL EXTREMUM** A local maximum or a local minimum, p. 96.

**LOCAL MAXIMUM** A value  $f(c)$  is a local maximum of  $f$  if there is an open interval  $I$  containing  $c$  such that  $f(x) \leq f(c)$  for all values of  $x$  in  $I$ , p. 96.

**LOCAL MINIMUM** A value  $f(c)$  is a local minimum of  $f$  if there is an open interval  $I$  containing  $c$  such that  $f(x) \geq f(c)$  for all values of  $x$  in  $I$ , p. 96.

**LOGARITHM** An expression of the form  $\log_b x$  (see *Logarithmic function*), p. 300.

**LOGARITHMIC FORM** An equation written with logarithms instead of exponents, p. 300.

**LOGARITHMIC FUNCTION WITH BASE  $b$**  The inverse of the exponential function  $y = b^x$ , denoted by  $y = \log_b x$ , p. 300.



**LOGARITHMIC RE-EXPRESSION OF DATA** Transformation of a data set involving the natural logarithm: exponential regression, natural logarithmic regression, power regression, p. 328.

**LOGARITHMIC REGRESSION** See *Natural logarithmic regression*.

**LOGISTIC CURVE** The graph of the logistic growth function, p. 283.

**LOGISTIC GROWTH FUNCTION** A model of population growth:

$$f(x) = \frac{c}{1 + a \cdot b^x} \text{ or } f(x) = \frac{c}{1 + ae^{-kx}}, \text{ or, where } a, b, c, \text{ and } k$$

are positive with  $b < 1$ .  $c$  is the limit to growth, p. 283.

**LOGISTIC REGRESSION** A procedure for fitting a logistic curve to a set of data, p. 157.

**LOWER BOUND OF  $f$**  Any number  $b$  for which  $b \leq f(x)$  for all  $x$  in the domain of  $f$ , p. 95.

**LOWER BOUND FOR REAL ZEROS** A number  $c$  is a lower bound for the set of real zeros of  $f$  if  $f(x) \neq 0$  whenever  $x < c$ , p. 220.

**LOWER BOUND TEST FOR REAL ZEROS** A test for finding a lower bound for the real zeros of a polynomial, p. 220.

**LRAM** A Riemann sum approximation of the area under a curve  $f(x)$  from  $x = a$  to  $x = b$  using  $x_i$  as the left-hand endpoint of each subinterval, p. 810.

**MAGNITUDE OF AN ARROW** The magnitude of  $\overline{PQ}$  is the distance between  $P$  and  $Q$ .

**MAGNITUDE OF A REAL NUMBER** See *Absolute value of a real number*.

**MAGNITUDE OF A VECTOR** The magnitude of  $\langle a, b \rangle$  is  $\sqrt{a^2 + b^2}$ . The magnitude of  $\langle a, b, c \rangle$  is  $\sqrt{a^2 + b^2 + c^2}$ .

**MAIN DIAGONAL** The diagonal from the top left to the bottom right of a square matrix, p. 584.

**MAJOR AXIS** The line segment through the foci of an ellipse with endpoints on the ellipse, p. 645.

**MAPPING** A function viewed as a mapping of the elements of the domain onto the elements of the range, p. 86.

**MATHEMATICAL MODEL** A mathematical structure that approximates phenomena for the purpose of studying or predicting their behavior, p. 70.

**MATHEMATICAL INDUCTION** A process for proving that a statement is true for all natural numbers  $n$  by showing that it is true for  $n = 1$  (the anchor) and that, if it is true for  $n = k$ , then it must be true for  $n = k + 1$  (the inductive step), p. 752.

**MATRIX,  $m \times n$**  A rectangular array of  $m$  rows and  $n$  columns of real numbers, p. 579.

**MATRIX ELEMENT** Any of the real numbers in a matrix, p. 579.

**MAXIMUM  $r$ -VALUE** The value of  $|r|$  at the point on the graph of a polar equation that has the maximum distance from the pole, p. 542.

**MEAN (OF A SET OF DATA)** The sum of all the data divided by the total number of items, p. 772.

**MEASURE OF AN ANGLE** The number of degrees or radians in an angle, p. 351.

**MEASURE OF CENTER** A measure of the typical, middle, or average value for a data set, p. 772.

**MEASURE OF SPREAD** A measure that tells how widely distributed data are, p. 775.

**MEDIAN (OF A DATA SET)** The middle number (or the mean of the two middle numbers) if the data are listed in order, p. 772.

**MIDPOINT (IN A COORDINATE PLANE)** For the line segment with endpoints  $(a, b)$  and  $(c, d)$ ,  $\left(\frac{a+c}{2}, \frac{b+d}{2}\right)$ , p. 17.

**MIDPOINT (ON A NUMBER LINE)** For the line segment with endpoints  $a$  and  $b$ ,  $\frac{a+b}{2}$ , p. 17.

**MIDPOINT (IN CARTESIAN SPACE)** For the line segment with endpoints  $(x_1, y_1, z_1)$  and  $(x_2, y_2, z_2)$ ,  $\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}, \frac{z_1+z_2}{2}\right)$ , p. 687.

**MINOR AXIS** The perpendicular bisector of the major axis of an ellipse with endpoints on the ellipse, p. 645.

**MINUTE** Angle measure equal to  $1/60$  of a degree, p. 351.

**MODE OF A DATA SET** The category or number that occurs most frequently in the set, p. 773.

**MODIFIED BOXPLOT** A boxplot with the outliers removed, p. 778.

**MODULUS** See *Absolute value of a complex number*.

**MONOMIAL FUNCTION** A polynomial with exactly one term, p. 190.

**MULTIPLICATION PRINCIPLE OF COUNTING** A principle used to find the number of ways an event can occur, p. 701.

**MULTIPLICATION PROPERTY OF EQUALITY** If  $u = v$  and  $w = z$ , then  $uw = vz$ , p. 24.

**MULTIPLICATION PROPERTY OF INEQUALITY** If  $u < v$  and  $c > 0$ , then  $uc < vc$ . If  $u < v$  and  $c < 0$ , then  $uc > vc$ , p. 27.

**MULTIPLICATIVE IDENTITY FOR MATRICES** See *Identity matrix*.

**MULTIPLICATIVE INVERSE OF A COMPLEX NUMBER**

The reciprocal of  $a + bi$ , or  $\frac{1}{a + bi} = \frac{a}{a^2 + b^2} - \frac{b}{a^2 + b^2}i$ , p. 55.

**MULTIPLICATIVE INVERSE OF A MATRIX** See *Inverse of a matrix*.

**MULTIPLICATIVE INVERSE OF A REAL NUMBER** The reciprocal of  $b$ , or  $1/b$ ,  $b \neq 0$ , p. 6.

**MULTIPLICITY** The multiplicity of a zero  $c$  of a polynomial  $f(x)$  of degree  $n > 0$  is the number of times the factor  $(x - c)$  occurs in the linear factorization  $f(x) = a(x - z_1)(x - z_2)\cdots(x - z_n)$ , p. 205.

**NATURAL EXPONENTIAL FUNCTION** The function  $f(x) = e^x$ , p. 281.

**NATURAL LOGARITHM** A logarithm with base  $e$ , p. 303.

**NATURAL LOGARITHMIC FUNCTION** The inverse of the exponential function  $y = e^x$ , denoted by  $y = \ln x$ , p. 305.

**NATURAL LOGARITHMIC REGRESSION** A procedure for fitting a curve to a set of data, p. 157.

**NATURAL NUMBERS** The numbers 1, 2, 3, ..., p. 2.

**NAUTICAL MILE** Length of 1 minute of arc along the Earth's equator, p. 354.

**NDER  $f(a)$**  See *Numerical derivative of  $f$  at  $x = a$* , p. 826.

**NEGATIVE ANGLE** Angle generated by clockwise rotation, p. 370.

**NEGATIVE LINEAR CORRELATION** See *Linear correlation*.

**NEGATIVE NUMBERS** Real numbers shown to the left of the origin on a number line, p. 3.

**NEWTON'S LAW OF COOLING**  $T(t) = T_m + (T_0 - T_m)e^{-kt}$ , p. 326.

**$n$  FACTORIAL** For any positive integer  $n$ ,  $n$  factorial is  $n! = n \cdot (n - 1) \cdot (n - 2) \cdot \cdots \cdot 3 \cdot 2 \cdot 1$ ; zero factorial is  $0! = 1$ , p. 702.

**NINT( $f(x)$ ,  $x$ ,  $a$ ,  $b$ )** A calculator approximation to  $\int_a^b f(x) dx$ , p. 827.

**NONSINGULAR MATRIX** A square matrix with nonzero determinant, p. 584.

**NORMAL CURVE** The graph of  $f(x) = e^{-x^2/2}$ , p. 780.

**NORMAL DISTRIBUTION** A distribution of data shaped like the *normal curve*, p. 780.

**$n$ -SET** A set of  $n$  objects, p. 702.

**$n$ TH POWER OF  $a$**  The number  $a^n = a \cdot a \cdot \cdots \cdot a$  (with  $n$  factors of  $a$ ), where  $n$  is the exponent and  $a$  is the base, p. 8.

**$n$ TH ROOT** See *Principal  $n$ th root*.

**$n$ TH ROOT OF A COMPLEX NUMBER  $z$**  A complex number  $v$  such that  $v^n = z$ , p. 555.

**$n$ TH ROOT OF UNITY** A complex number  $v$  such that  $v^n = 1$ , p. 555.

**NUMBER LINE GRAPH OF A LINEAR INEQUALITY** The graph of the solutions of a linear inequality (in  $x$ ) on a number line, p. 28.

**NUMERICAL DERIVATIVE OF  $f$  AT  $a$** 

NDER  $f(a) = \frac{f(a + 0.001) - f(a - 0.001)}{0.002}$ , p. 826.

**NUMERICAL MODEL** A model determined by analyzing numbers or data in order to gain insight into a phenomenon, p. 70.

**OBJECTIVE FUNCTION** See *Linear programming problem*.

**OBTUSE TRIANGLE** A triangle in which one angle is greater than  $90^\circ$ , p. 478.

**OCTANTS** The eight regions of space determined by the coordinate planes, p. 685.

**ODD-EVEN IDENTITY** An identity involving a trigonometric function of  $-x$ , p. 447.

**ODD FUNCTION** A function whose graph is symmetric about the origin ( $f(-x) = -f(x)$  for all  $x$  in the domain of  $f$ ), p. 98.

**ONE-TO-ONE FUNCTION** A function in which each element of the range corresponds to exactly one element in the domain, p. 132.

**ONE-TO-ONE RULE OF EXPONENTS**  $x = y$  if and only if  $b^x = b^y$ , p. 320.

**ONE-TO-ONE RULE OF LOGARITHMS**  $x = y$  if and only if  $\log_b x = \log_b y$ , p. 320.

**OPEN INTERVAL** An interval that does not include its endpoints, p. 5.

**OPENS UPWARD OR DOWNWARD** A parabola  $y = ax^2 + bx + c$  opens upward if  $a > 0$  and opens downward if  $a < 0$ , p. 636.

**OPPOSITE** See *Additive inverse of a real number and Additive inverse of a complex number*.

**ORDER OF MAGNITUDE (OF  $n$ )**  $\log n$ , p. 323.

**ORDER OF AN  $m \times n$  MATRIX** The order of an  $m \times n$  matrix is  $m \times n$ , p. 579.

**ORDERED PAIR** A pair of real numbers  $(x, y)$ , p. 14.

**ORDERED SET** A set is ordered if it is possible to compare any two elements and say that one element is “less than” or “greater than” the other, p. 3.

**ORDINARY ANNUITY** An annuity in which deposits are made at the same time interest is posted, p. 338.

**ORIGIN** The number zero on a number line, or the point where the  $x$ - and  $y$ -axes cross in the Cartesian coordinate system, or the point where the  $x$ -,  $y$ -, and  $z$ -axes cross in Cartesian three-dimensional space, p. 3.

**ORTHOGONAL VECTORS** Two vectors  $\mathbf{u}$  and  $\mathbf{v}$  with  $\mathbf{u} \cdot \mathbf{v} = 0$ , p. 516.

**OUTCOMES** The various possible results of an experiment, p. 718.

**OUTLIERS** Data items more than 1.5 times the IQR below the first quartile or above the third quartile, p. 777.

**PARABOLA** The graph of a quadratic function, or the set of points in a plane that are equidistant from a fixed point (the focus) and a fixed line (the directrix), p. 634.

**PARABOLOID OF REVOLUTION** A surface generated by rotating a parabola about its line of symmetry, p. 639.

**PARALLEL LINES** Two lines that are both vertical or have equal slopes, p. 35.

**PARALLELOGRAM REPRESENTATION OF VECTOR ADDITION** Geometric representation of vector addition using the parallelogram determined by the position vectors.

**PARAMETER** See *Parametric equations*.

**PARAMETER INTERVAL** See *Parametric equations*.

**PARAMETRIC CURVE** The graph of parametric equations, p. 522.

**PARAMETRIC EQUATIONS** Equations of the form  $x = f(t)$  and  $y = g(t)$  for all  $t$  in an interval  $I$ . The variable  $t$  is the parameter and  $I$  is the parameter interval, pp. 127, 522.

**PARAMETRIC EQUATIONS FOR A LINE IN SPACE** The line through  $P_0(x_0, y_0, z_0)$  in the direction of the nonzero vector  $\mathbf{v} = \langle a, b, c \rangle$  has parametric equations  $x = x_0 + at$ ,  $y = y_0 + bt$ ,  $z = z_0 + ct$ , p. 692.

**PARAMETRIZATION** A set of parametric equations for a curve, p. 522.

**PARTIAL FRACTION DECOMPOSITION** See *Partial fractions*.

**PARTIAL FRACTIONS** The process of expanding a fraction into a sum of fractions. The sum is called the partial fraction decomposition of the original fraction, p. 608.

**PARTIAL SUMS** See *Sequence of partial sums*.

**PASCAL'S TRIANGLE** A number pattern in which row  $n$  (beginning with  $n = 0$ ) consists of the coefficients of the expanded form of  $(a + b)^n$ , p. 712.

**PERIHELION** The closest point to the Sun in a planet's orbit, p. 649.

**PERIOD** See *Periodic function*.

**PERIODIC FUNCTION** A function  $f$  for which there is a positive number  $c$  such that  $f(t + c) = f(t)$  for every value  $t$  in the domain of  $f$ . The smallest such number  $c$  is the period of the function, p. 379.

**PERMUTATION** An arrangement of elements of a set, in which order is important, p. 702.

**PERMUTATIONS OF  $n$  OBJECTS TAKEN  $r$  AT A TIME**

$${}^n P_r = \frac{n!}{(n-r)!}, \text{ p. 703.}$$

**PERPENDICULAR LINES** Two lines that are at right angles to each other, p. 35.

**PH** The measure of acidity, p. 325.

**PHASE SHIFT** See *Sinusoid*.

**PIECEWISE-DEFINED FUNCTION** A function whose domain is divided into several parts and a different function rule is applied to each part, p. 111.

**PIE CHART** See *Circle graph*.

**PLANE IN CARTESIAN SPACE** The graph of  $Ax + By + Cz + D = 0$ , where  $A$ ,  $B$ , and  $C$  are not all zero, p. 689.

**POINT-SLOPE FORM (OF A LINE)**  $y - y_1 = m(x - x_1)$ , p. 32.

**POLAR AXIS** See *Polar coordinate system*.

**POLAR COORDINATE SYSTEM** A coordinate system whose ordered pair is based on the directed distance from a central point (the pole) and the angle measured from a ray from the pole (the polar axis), p. 534.

**POLAR COORDINATES** The numbers  $(r, \theta)$  that determine a point's location in a polar coordinate system. The number  $r$  is the directed distance and  $\theta$  is the directed angle, p. 534.

**POLAR DISTANCE FORMULA** The distance between the points with polar coordinates  $(r_1, \theta_1)$  and  $(r_2, \theta_2)$

$$= \sqrt{r_1^2 + r_2^2 - 2r_1 r_2 \cos(\theta_2 - \theta_1)}, \text{ p. 540.}$$

**POLAR EQUATION** An equation in  $r$  and  $\theta$ , p. 537.

**POLAR FORM OF A COMPLEX NUMBER** See *Trigonometric form of a complex number*.

**POLE** See *Polar coordinate system*.

**POLYNOMIAL FUNCTION** A function in which  $f(x)$  is a polynomial in  $x$ , p. 170.

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**POLYNOMIAL IN  $x$**  An expression that can be written in the form  $a_n x^n + a_{n-1} x^{n-1} + \cdots + a_1 x + a_0$ , where  $n$  is a nonnegative integer, the coefficients are real numbers, and  $a_n \neq 0$ . The degree of the polynomial is  $n$ , the leading coefficient is  $a_n$ , the leading term is  $a_n x^n$ , and the constant term is  $a_0$ . (The number 0 is the zero polynomial), p. 170.

**POLYNOMIAL INTERPOLATION** The process of fitting a polynomial of degree  $n$  to  $(n + 1)$  points, p. 208.

**POSITION VECTOR OF THE POINT  $(a, b)$**  The vector  $\langle a, b \rangle$ , p. 502.

**POSITIVE ANGLE** Angle generated by a counterclockwise rotation, p. 370.

**POSITIVE LINEAR CORRELATION** See *Linear correlation*.

**POSITIVE NUMBERS** Real numbers shown to the right of the origin on a number line, p. 3.

**POWER FUNCTION** A function of the form  $f(x) = k \cdot x^a$ , where  $k$  and  $a$  are nonzero constants.  $k$  is the constant of variation and  $a$  is the power, p. 188.

**POWER-REDUCING IDENTITY** An identity involving the square of a trigonometric function, p. 472.

**POWER REGRESSION** A procedure for fitting a curve  $y = a \cdot x^b$  to a set of data, p. 157.

**POWER RULE OF LOGARITHMS**  $\log_b R^c = c \log_b R$ ,  $R > 0$ , p. 310.

**PRESENT VALUE OF AN ANNUITY** The net amount of your money put into an annuity, p. 339.

**PRINCIPAL  $n$ TH ROOT** If  $b^n = a$ , then  $b$  is an  $n$ th root of  $a$ . If  $b^n = a$  and  $a$  and  $b$  have the same sign,  $b$  is the principal  $n$ th root of  $a$  (see *Radical*), p. 555.

**PRINCIPLE OF MATHEMATICAL INDUCTION** A principle related to mathematical induction, p. 753.

**PROBABILITY DISTRIBUTION** The collection of probabilities of outcomes in a sample space assigned by a probability function, p. 719.

**PROBABILITY OF AN EVENT IN A FINITE SAMPLE SPACE** The number of outcomes in the event divided by the number of outcomes in the sample space, p. 720.

**PROBABILITY FUNCTION** A function  $P$  that assigns a real number to each outcome  $O$  in a sample space satisfying:  $0 \leq P(O) \leq 1$ ,  $P(\emptyset) = 0$ , and the sum of the probabilities of all outcomes is 1, p. 720.

**PRODUCT OF COMPLEX NUMBERS**  $(a + bi)(c + di) = (ac - bd) + (ad + bc)i$ , pp. 54, 552.

**PRODUCT OF A SCALAR AND A VECTOR** The product of scalar  $k$  and vector  $\mathbf{u} = \langle u_1, u_2 \rangle$  (or  $\mathbf{u} = \langle u_1, u_2, u_3 \rangle$ ) is  $k \cdot \mathbf{u} = \langle ku_1, ku_2 \rangle$  (or  $k \cdot \mathbf{u} = \langle ku_1, ku_2, ku_3 \rangle$ ), pp. 505, 690.

**PRODUCT OF FUNCTIONS**  $(fg)(x) = f(x)g(x)$ , p. 117.

**PRODUCT OF MATRICES  $A$  AND  $B$**  The matrix in which each entry is obtained by multiplying the entries of a row of  $A$  by the corresponding entries of a column of  $B$  and then adding, p. 581.

**PRODUCT RULE OF LOGARITHMS**  $\log_b (RS) = \log_b R + \log_b S$ ,  $R > 0$ ,  $S > 0$ , p. 310.

**PROJECTILE MOTION** The movement of an object that is subject only to the force of gravity, p. 63.

**PROJECTION OF  $\mathbf{u}$  ONTO  $\mathbf{v}$**  The vector  $\text{proj}_{\mathbf{v}} \mathbf{u} = \left( \frac{\mathbf{u} \cdot \mathbf{v}}{|\mathbf{v}|} \right) \mathbf{v}$ , p. 517.

**PYTHAGOREAN IDENTITIES**  $\sin^2 \theta + \cos^2 \theta = 1$ ,  $1 + \tan^2 \theta = \sec^2 \theta$ , and  $1 + \cot^2 \theta = \csc^2 \theta$ , p. 446.

**PYTHAGOREAN THEOREM** In a right triangle with sides  $a$  and  $b$  and hypotenuse  $c$ ,  $c^2 = a^2 + b^2$ , p. 16.

**QUADRANT** Any one of the four parts into which a plane is divided by the perpendicular coordinate axes, p. 14.

**QUADRANTAL ANGLE** An angle in standard position whose terminal side lies on an axis, p. 375.

**QUADRATIC EQUATION IN  $x$**  An equation that can be written in the form  $ax^2 + bx + c = 0$  ( $a \neq 0$ ), p. 45.

**QUADRATIC FORMULA** The formula  $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$  used to solve  $ax^2 + bx + c = 0$ , p. 46.

**QUADRATIC FUNCTION** A function that can be written in the form  $f(x) = ax^2 + bx + c$ , where  $a$ ,  $b$ , and  $c$  are real numbers, and  $a \neq 0$ , p. 176.

**QUADRATIC REGRESSION** A procedure for fitting a quadratic function to a set of data, p. 157.

**QUADRIC SURFACE** The graph in three dimensions of a second-degree equation in three variables, p. 690.

**QUANTITATIVE VARIABLE** A variable (in statistics) that takes on numerical values for a characteristic being measured, p. 759.

**QUARTIC FUNCTION** A degree 4 polynomial function, p. 200.

**QUARTIC REGRESSION** A procedure for fitting a quartic function to a set of data, p. 157.

**QUARTILE** The first quartile is the median of the lower half of a set of data, the second quartile is the median, and the third quartile is the median of the upper half of the data, p. 775.

**QUOTIENT IDENTITIES**  $\tan \theta = \frac{\sin \theta}{\cos \theta}$  and  $\cot \theta = \frac{\cos \theta}{\sin \theta}$ , p. 445.

**QUOTIENT OF COMPLEX NUMBERS**  
 $\frac{a + bi}{c + di} = \frac{ac + bd}{c^2 + d^2} + \frac{bc - ad}{c^2 + d^2}i$ , pp. 56, 552.

**QUOTIENT OF FUNCTIONS**  $\left(\frac{f}{g}\right)(x) = \frac{f(x)}{g(x)}$ ,  $g(x) \neq 0$ , p. 117.

**QUOTIENT RULE OF LOGARITHMS**  $\log_b\left(\frac{R}{S}\right) = \log_b R - \log_b S$ ,  $R > 0$ ,  $S > 0$ , p. 310.

**QUOTIENT POLYNOMIAL** See *Division algorithm for polynomials*.

**RADIAN** The measure of a central angle whose intercepted arc has a length equal to the circle's radius, p. 351.

**RADIAN MEASURE** The measure of an angle in radians, or, for a central angle, the ratio of the length of the intercepted arc to the radius of the circle, p. 352.

**RADICAND** See *Radical*.

**RADIUS** The distance from a point on a circle (or a sphere) to the center of the circle (or the sphere), pp. 18, 687.

**RANGE OF A FUNCTION** The set of all output values corresponding to elements in the domain, p. 86.

**RANGE (IN STATISTICS)** The difference between the greatest and least values in a data set, p. 775.

**RANGE SCREEN** See *Viewing window*.

**RATIONAL EXPRESSION** An expression that can be written as a ratio of two polynomials, p. 852.

**RATIONAL FUNCTION** Function of the form  $\frac{f(x)}{g(x)}$ , where  $f(x)$

and  $g(x)$  are polynomials and  $g(x)$  is not the zero polynomial, p. 237.

**RATIONAL NUMBERS** Numbers that can be written as  $a/b$ , where  $a$  and  $b$  are integers, and  $b \neq 0$ , p. 2.

**RATIONAL ZEROS** Zeros of a function that are rational numbers, p. 218.

**RATIONAL ZEROS THEOREM** A procedure for finding the possible rational zeros of a polynomial, p. 218.

**REAL AXIS** See *Complex plane*.

**REAL NUMBER** Any number that can be written as a decimal, p. 2.

**REAL NUMBER LINE** A horizontal line that represents the set of real numbers, p. 3.

**REAL PART OF A COMPLEX NUMBER** See *Complex number*.

**REAL ZEROS** Zeros of a function that are real numbers, p. 205.

**RECIPROCAL FUNCTION** The function  $f(x) = \frac{1}{x}$ , p. 107.

**RECIPROCAL IDENTITY** An identity that equates a trigonometric function with the reciprocal of another trigonometric function, p. 445.

**RECIPROCAL OF A REAL NUMBER** See *Multiplicative inverse of a real number*.

**RECTANGULAR COORDINATE SYSTEM** See *Cartesian coordinate system*.

**RECURSIVELY DEFINED SEQUENCE** A sequence defined by giving the first term (or the first few terms) along with a procedure for finding the subsequent terms, p. 732.

**REDUCED ROW ECHELON FORM** A matrix in row echelon form with every column that has a leading 1 having 0's in all other positions, p. 599.

**RE-EXPRESSION OF DATA** A transformation of a data set, p. 314.

**REFERENCE ANGLE** See *Reference triangle*.

**REFERENCE TRIANGLE** For an angle  $\theta$  in standard position, the reference triangle is the triangle formed by the terminal side of angle  $\theta$ , the  $x$ -axis, and a perpendicular dropped from a point on the terminal side to the  $x$ -axis. The angle in the reference triangle at the origin is the reference angle, p. 373.

**REFLECTION** Two points that are symmetric with respect to a line or a point, p. 132.

**REFLECTION ACROSS THE  $x$ -AXIS**  $(x, y)$  and  $(x, -y)$  are reflections of each other across the  $x$ -axis, p. 141.

**REFLECTION ACROSS THE  $y$ -AXIS**  $(x, y)$  and  $(-x, y)$  are reflections of each other across the  $y$ -axis, p. 141.

**REFLECTION THROUGH THE ORIGIN**  $(x, y)$  and  $(-x, -y)$  are reflections of each other through the origin.

**REFLEXIVE PROPERTY OF EQUALITY**  $a = a$ , p. 24.

**REGRESSION MODEL** An equation found by regression and which can be used to predict unknown values, p. 155.

**RELATION** A set of ordered pairs of real numbers, p. 122.

**RELEVANT DOMAIN** The portion of the domain applicable to the situation being modeled, p. 88.

**REMAINDER POLYNOMIAL** See *Division algorithm for polynomials*.

**REMAINDER THEOREM** If a polynomial  $f(x)$  is divided by  $x - c$ , the remainder is  $f(c)$ , p. 215.

**REMOVABLE DISCONTINUITY AT  $x = a$**   $\lim_{x \rightarrow a^-} f(x) = \lim_{x \rightarrow a^+} f(x)$  but either the common limit is not equal to  $f(a)$  or  $f(a)$  is not defined, p. 91.



## 890 GLOSSARY

**REPEATED ZEROS** Zeros of multiplicity  $\geq 2$  (see *Multiplicity*), p. 205.

**RESIDUAL** The difference  $y_1 - (ax_1 + b)$ , where  $(x_1, y_1)$  is a point in a scatter plot and  $y = ax + b$  is a line that fits the set of data, p. 187.

**RESISTANT MEASURE** A statistical measure that does not change much in response to outliers, p. 772.

**RESOLVING A VECTOR** Finding the horizontal and vertical components of a vector, p. 507.

**RICHTER SCALE** A logarithmic scale used in measuring the intensity of an earthquake, pp. 318, 324.

**RIEMANN SUM** A sum  $\sum_{i=1}^n f(x_i) \Delta x$  where the interval  $[a, b]$  is divided into  $n$  subintervals of equal length  $\Delta x$  and  $x_i$  is in the  $i$ th subinterval, p. 808.

**RIGHT ANGLE** A  $90^\circ$  angle, p. 360.

**RIGHT-HAND LIMIT OF  $f$  AT  $x = a$**  The limit of  $f$  as  $x$  approaches  $a$  from the right, p. 817.

**RIGHT TRIANGLE** A triangle with a  $90^\circ$  angle, p. 16.

**RIGID TRANSFORMATION** A transformation that leaves the basic shape of a graph unchanged, p. 138.

**ROOT OF A NUMBER** See *Principal  $n$ th root*.

**ROOT OF AN EQUATION** A solution, p. 76.

**ROSE CURVE** A graph of a polar equation  $r = a \cos n\theta$  or  $r = a \sin n\theta$ , p. 544.

**ROW ECHELON FORM** A matrix in which rows consisting of all 0's occur only at the bottom of the matrix, the first nonzero entry in any row with nonzero entries is 1, and the leading 1's move to the right as we move down the rows, p. 597.

**ROW OPERATIONS** See *Elementary row operations*.

**RRAM** A Riemann sum approximation of the area under a curve  $f(x)$  from  $x = a$  to  $x = b$  using  $x_i$  as the right-hand endpoint of each subinterval, p. 810.

**SAMPLE SPACE** Set of all possible outcomes of an experiment, p. 718.

**SAMPLE STANDARD DEVIATION** The *standard deviation* computed using only a sample of the entire population, p. 778.

**SCALAR** A real number, p. 504.

**SCATTER PLOT** A plot of all the ordered pairs of a two-variable data set on a coordinate plane, p. 15.

**SCIENTIFIC NOTATION** A positive number written as  $c \times 10^m$ , where  $1 \leq c < 10$  and  $m$  is an integer, p. 9.

**SECANT** The function  $y = \sec x$ , p. 398.

**SECANT LINE OF  $f$**  A line joining two points of the graph of  $f$ , p. 796.

**SECOND** Angle measure equal to  $1/60$  of a minute, p. 351.

**SECOND QUARTILE** See *Quartile*.

**SECOND-DEGREE EQUATION IN TWO VARIABLES**  $Ax^2 + Bxy + Cy^2 + Dx + Ey + F = 0$ , where  $A$ ,  $B$ , and  $C$  are not all zero, p. 633.

**SEMIMAJOR AXIS** Line segment with endpoints at the center of and on an ellipse, containing one of the foci, p. 645.

**SEMIMINOR AXIS** Line segment with endpoints at the center of and on an ellipse, and perpendicular to the major axis, p. 645.

**SEMIPERIMETER OF A TRIANGLE** One-half of the sum of the lengths of the sides of a triangle, p. 490.

**SEQUENCE** See *Finite sequence*, *Infinite sequence*.

**SEQUENCE OF PARTIAL SUMS** The sequence  $\{S_n\}$ , where  $S_n$  is the  $n$ th partial sum of the series, that is, the sum of the first  $n$  terms of the series, p. 747.

**SERIES** A finite or infinite sum of terms, p. 742.

**SHRINK OF FACTOR  $c$**  A transformation of a graph obtained by multiplying all the  $x$ -coordinates (horizontal shrink) by the constant  $1/c$  or all of the  $y$ -coordinates (vertical shrink) by the constant  $c$ ,  $0 < c < 1$ , p. 145.

**SIMPLE HARMONIC MOTION** Motion described by  $d = a \sin \omega t$  or  $d = a \cos \omega t$ , p. 428.

**SINE** The function  $y = \sin x$ , p. 386.

**SINGULAR MATRIX** A square matrix with zero determinant, p. 584.

**SINUSOID** A function that can be written in the form  $f(x) = a \sin(b(x - h)) + k$  or  $f(x) = a \cos(b(x - h)) + k$ . The number  $a$  is the amplitude, and the number  $h$  is the phase shift, p. 386.

**SINUSOIDAL REGRESSION** A procedure for fitting a curve  $y = a \sin(bx + c) + d$  to a set of data, p. 157.

**SLANT ASYMPTOTE** An end behavior asymptote that is a line and is not horizontal or vertical, p. 241.

**SLOPE** Ratio  $\frac{\text{change in } y}{\text{change in } x}$ , p. 31.

**SLOPE-INTERCEPT FORM (OF A LINE)**  $y = mx + b$ , p. 33.

**SOLUTION SET OF AN INEQUALITY** The set of all solutions of an inequality, p. 26.

**SOLUTION OF A SYSTEM IN TWO VARIABLES** An ordered pair of real numbers that satisfies all of the equations or inequalities in the system, p. 568.

**SOLUTION OF AN EQUATION OR INEQUALITY** A value of the variable (or values of the variables) for which the equation or inequality is true, p. 24.

**SOLVE AN EQUATION OR INEQUALITY** To find all solutions of the equation or inequality, p. 24.

**SOLVE A TRIANGLE** To find one or more unknown sides or angles of a triangle, p. 364.

**SOLVE A SYSTEM** To find all solutions of a system, p. 568.

**SOLVE BY ELIMINATION OR SUBSTITUTION** Methods for solving systems of linear equations, p. 571.

**SOLVE BY SUBSTITUTION** Method for solving systems of linear equations, p. 568.

**SPEED** The magnitude of the velocity vector, given by distance/time, p. 508.

**SPHERE** A set of points in Cartesian space equally distant from a fixed point called the center, p. 687.

**SPIRAL OF ARCHIMEDES** The graph of the polar curve  $r = \theta$ , p. 546.

**SQUARE MATRIX** A matrix whose number of rows equals the number of columns, p. 579.

**STANDARD DEVIATION** A measure of how a data set is spread, p. 778.

**STANDARD FORM:**

**EQUATION OF A CIRCLE**  $(x - h)^2 + (y - k)^2 = r^2$ , p. 18.

**EQUATION OF AN ELLIPSE**  $\frac{(x - h)^2}{a^2} + \frac{(y - k)^2}{b^2} = 1$  or  $\frac{(y - k)^2}{a^2} + \frac{(x - h)^2}{b^2} = 1$ , p. 647.

**EQUATION OF A HYPERBOLA**  $\frac{(x - h)^2}{a^2} - \frac{(y - k)^2}{b^2} = 1$  or  $\frac{(y - k)^2}{a^2} - \frac{(x - h)^2}{b^2} = 1$ , p. 659.

**EQUATION OF A PARABOLA**  $(x - h)^2 = 4p(y - k)$  or  $(y - k)^2 = 4p(x - h)$ , p. 637.

**EQUATION OF A POLYNOMIAL**  
 $a_n x^n + a_{n-1} x^{n-1} + \dots + a_1 x + a_0$ , pp. 200.

**EQUATION OF A QUADRATIC FUNCTION**  
 $f(x) = ax^2 + bx + c$  ( $a \neq 0$ ), p. 177.

**STANDARD FORM OF A COMPLEX NUMBER**  $a + bi$ , where  $a$  and  $b$  are real numbers, p. 53.

**STANDARD FORM POLAR EQUATION OF A CONIC**  
 $r = \frac{ke}{1 \pm e \cos \theta}$  or  $r = \frac{ke}{1 \pm e \sin \theta}$ , p. 677.

**STANDARD POSITION (ANGLE)** An angle positioned on a rectangular coordinate system with its vertex at the origin and its initial side on the positive  $x$ -axis, pp. 360, 370.

**STANDARD REPRESENTATION OF A VECTOR** A representative arrow with its initial point at the origin, p. 503.

**STANDARD UNIT VECTORS** In the plane  $\mathbf{i} = \langle 1, 0 \rangle$  and  $\mathbf{j} = \langle 0, 1 \rangle$ ; in space  $\mathbf{i} = \langle 1, 0, 0 \rangle$ ,  $\mathbf{j} = \langle 0, 1, 0 \rangle$ , and  $\mathbf{k} = \langle 0, 0, 1 \rangle$ , p. 507.

**STATISTIC** A number that measures a quantitative variable for a sample from a population, p. 771.

**STATUTE MILE** 5280 feet, p. 355.

**STEM** The initial digit or digits of a number in a stemplot, p. 760.

**STEMPLOT (OR STEM-AND-LEAF PLOT)** An arrangement of a numerical data set into a specific tabular format, p. 760.

**STRETCH OF FACTOR  $c$**  A transformation of a graph obtained by multiplying all the  $x$ -coordinates (horizontal stretch) by the constant  $1/c$ , or all of the  $y$ -coordinates (vertical stretch) of the points by a constant  $c$ ,  $c > 1$ , p. 144.

**SUBTRACTION**  $a - b = a + (-b)$ , p. 6.

**SUM IDENTITY** An identity involving a trigonometric function of  $u + v$ , p. 463.

**SUM OF A FINITE ARITHMETIC SERIES**

$$S_n = n \left( \frac{a_1 + a_n}{2} \right) = \frac{n}{2} [2a_1 + (n - 1)d], \text{ p. 743.}$$

**SUM OF A FINITE GEOMETRIC SERIES**  $S_n = \frac{a_1(1 - r^n)}{1 - r}$ , p. 745.

**SUM OF AN INFINITE GEOMETRIC SERIES**  $S_n = \frac{a}{1 - r}$ ,  $|r| < 1$ , p. 748.

**SUM OF AN INFINITE SERIES** See *Convergence of a series*.

**SUM OF COMPLEX NUMBERS**  $(a + bi) + (c + di) = (a + c) + (b + d)i$ , p. 53.

**SUM OF FUNCTIONS**  $(f + g)(x) = f(x) + g(x)$  p. 117.

**SUM OF TWO VECTORS**  $\langle u_1, u_2 \rangle + \langle v_1, v_2 \rangle = \langle u_1 + v_1, u_2 + v_2 \rangle$  or  $\langle u_1, u_2, u_3 \rangle + \langle v_1, v_2, v_3 \rangle = \langle u_1 + v_1, u_2 + v_2, u_3 + v_3 \rangle$ , p. 505.

**SUMMATION NOTATION** The series  $\sum_{k=1}^n a_k$ , where  $n$  is a natural number (or  $\infty$ ) is in summation notation and is read “the sum of  $a_k$  from  $k = 1$  to  $n$  (or infinity).”  $k$  is the index of summation, and  $a_k$  is the  $k$ th term of the series, p. 742.

**SUPPLY CURVE**  $p = f(x)$ , where  $x$  represents production and  $p$  represents price, p. 574.

**SYMMETRIC DIFFERENCE QUOTIENT OF  $f$  AT  $a$** 

$$\frac{f(x+h) - f(x-h)}{2h}, \text{ p. 826.}$$

**SYMMETRIC MATRIX** A matrix  $A = [a_{ij}]$  with the property  $a_{ij} = a_{ji}$  for all  $i$  and  $j$ , p. 591.

**SYMMETRIC ABOUT THE ORIGIN** A graph in which  $(-x, -y)$  is on the graph whenever  $(x, y)$  is; or a graph in which  $(-r, \theta)$  or  $(r, \theta + \pi)$  is on the graph whenever  $(r, \theta)$  is, p. 98.

**SYMMETRIC ABOUT THE  $x$ -AXIS** A graph in which  $(x, -y)$  is on the graph whenever  $(x, y)$  is; or a graph in which  $(r, -\theta)$  or  $(-r, \pi - \theta)$  is on the graph whenever  $(r, \theta)$  is, p. 97.

**SYMMETRIC ABOUT THE  $y$ -AXIS** A graph in which  $(-x, y)$  is on the graph whenever  $(x, y)$  is; or a graph in which  $(-r, -\theta)$  or  $(r, \pi - \theta)$  is on the graph whenever  $(r, \theta)$  is, p. 97.

**SYMMETRIC PROPERTY OF EQUALITY** If  $a = b$ , then  $b = a$ , p. 24.

**SYNTHETIC DIVISION** A procedure used to divide a polynomial by a linear factor,  $x - a$ , p. 217.

**SYSTEM** A set of equations or inequalities, p. 568.

**TANGENT** The function  $y = \tan x$ , p. 396.

**TANGENT LINE OF  $f$  AT  $x = a$**  The line through  $(a, f(a))$  with slope  $f'(a)$  provided  $f'(a)$  exists, p. 797.

**TERMINAL POINT** See *Arrow*.

**TERMINAL SIDE OF AN ANGLE** See *Angle*.

**TERM OF A POLYNOMIAL (FUNCTION)** An expression of the form  $a_n x^n$  in a polynomial (function), p. 200.

**TERMS OF A SEQUENCE** The range elements of a sequence, p. 732.

**THIRD QUARTILE** See *Quartile*.

**TIME PLOT** A line graph in which time is measured on the horizontal axis, p. 765.

**TRANSFORMATION** A function that maps real numbers to real numbers, p. 138.

**TRANSITIVE PROPERTY** If  $a = b$  and  $b = c$ , then  $a = c$ . Similar properties hold for the inequality symbols  $<$ ,  $\leq$ ,  $>$ ,  $\geq$ , pp. 24, 27.

**TRANSLATION** See *Horizontal translation*, *Vertical translation*.

**TRANSPOSE OF A MATRIX** The matrix  $A^T$  obtained by interchanging the rows and columns of  $A$ , p. 583.

**TRANSVERSE AXIS** The line segment whose endpoints are the vertices of a hyperbola, p. 657.

**TREE DIAGRAM** A visualization of the *Multiplication Principle of Probability*, p. 723.

**TRIANGULAR FORM** A special form for a system of linear equations that facilitates finding the solution, p. 594.

**TRIANGULAR NUMBER** A number that is a sum of the arithmetic series  $1 + 2 + 3 + \dots + n$  for some natural number  $n$ , p. 716.

**TRICHOTOMY PROPERTY** For real numbers  $a$  and  $b$ , exactly one of the following is true:  $a < b$ ,  $a = b$ , or  $a > b$ , p. 4.

**TRIGONOMETRIC FORM OF A COMPLEX NUMBER**

$$r(\cos \theta + i \sin \theta), \text{ p. 551.}$$

**UNBOUNDED INTERVAL** An interval that extends to  $-\infty$  or  $\infty$  (or both), p. 5.

**UNION OF TWO SETS  $A$  AND  $B$**  The set of all elements that belong to  $A$  or  $B$  or both, p. 60.

**UNIT CIRCLE** A circle with radius 1 centered at the origin, p. 377.

**UNIT RATIO** See *Conversion factor*.

**UNIT VECTOR** Vector of length 1, pp. 506.

**UNIT VECTOR IN THE DIRECTION OF A VECTOR** A unit vector that has the same direction as the given vector, p. 506.

**UPPER BOUND FOR  $f$**  Any number  $B$  for which  $f(x) \leq B$  for all  $x$  in the domain of  $f$ , p. 95.

**UPPER BOUND FOR REAL ZEROS** A number  $d$  is an upper bound for the set of real zeros of  $f$  if  $f(x) \neq 0$  whenever  $x > d$ , p. 220.

**UPPER BOUND TEST FOR REAL ZEROS** A test for finding an upper bound for the real zeros of a polynomial, p. 220.

**VALUE OF AN ANNUITY**  $FV = \frac{R(1+i)^n - 1}{i}$ , p. 339.

**VALUE OF AN INVESTMENT**  $A = P\left(1 + \frac{r}{k}\right)^{kt}$  or  $A = Pe^{rt}$ , p. 337.

**VARIABLE** A letter that represents an unspecified number, p. 6.

**VARIABLE (IN STATISTICS)** A characteristic of individuals that is being identified or measured, p. 759.

**VARIANCE** The square of the standard deviation, p. 778.

**VECTOR** An ordered pair  $\langle a, b \rangle$  of real numbers in the plane, or an ordered triple  $\langle a, b, c \rangle$  of real numbers in space. A vector has both magnitude and direction, p. 502.

**VECTOR EQUATION FOR A LINE IN SPACE** The line through  $P_0(x_0, y_0, z_0)$  in the direction of the nonzero vector  $\mathbf{v} = \langle a, b, c \rangle$  has vector equation  $\mathbf{r} = \mathbf{r}_0 + t\mathbf{v}$ , where  $\mathbf{r} = \langle x, y, z \rangle$ , p. 692.

**VELOCITY** A vector that specifies the motion of an object in terms of its speed and direction, p. 508.

**VENN DIAGRAM** A visualization of the relationships among events within a sample space, p. 723.

**VERTEX OF A CONE** See *right circular cone*.

**VERTEX OF A PARABOLA** The point of intersection of a parabola and its line of symmetry, pp. 177, 634.

**VERTEX OF AN ANGLE** See *Angle*.

**VERTEX FORM FOR A QUADRATIC FUNCTION**

$f(x) = a(x - h)^2 + k$ , p. 178.

**VERTICAL ASYMPTOTE** The line  $x = a$  is a vertical asymptote of the graph of the function  $f$  if  $\lim_{x \rightarrow a^+} f(x) = \pm\infty$  or  $\lim_{x \rightarrow a^-} f(x) = \pm\infty$ , pp. 100, 240.

**VERTICAL COMPONENT** See *Component form of a vector*.

**VERTICAL LINE**  $x = a$ , p. 34.

**VERTICAL LINE TEST** A test for determining whether a graph is a function, p. 87.

**VERTICAL STRETCH OR SHRINK** See *Stretch, Shrink*.

**VERTICAL TRANSLATION** A shift of a graph up or down, p. 138.

**VERTICES OF AN ELLIPSE** The points where the ellipse intersects its focal axis, p. 644.

**VERTICES OF A HYPERBOLA** The points where a hyperbola intersects the line containing its foci, p. 659.

**VIEWING WINDOW** The rectangular portion of the coordinate plane specified by the dimensions [Xmin, Xmax] by [Ymin, Ymax], p. 34.

**WEIGHTED MEAN** A mean calculated in such a way that some elements of the data set have higher weights (that is, are counted more strongly in determining the mean) than others, p. 774.

**WEIGHTS** See *Weighted mean*.

**WHOLE NUMBERS** The numbers 0, 1, 2, 3, ..., p. 2.

**WINDOW DIMENSIONS** The restrictions on  $x$  and  $y$  that specify a viewing window. See *Viewing window*.

**WORK** The product of a force applied to an object over a given distance  $W = |\mathbf{F}| |\overline{AB}|$ , p. 519.

**WRAPPING FUNCTION** The function which associated points on the unit circle with points on the real number line, p. 377.

**x-AXIS** Usually the horizontal coordinate line in a Cartesian coordinate system with positive direction to the right, p. 14.

**x-COORDINATE** The directed distance from the  $y$ -axis ( $yz$ -plane) to a point in a plane (space), or the first number in an ordered pair (triple), p. 14.

**x-INTERCEPT** A point that lies on both the graph and the  $x$ -axis, p. 34.

**XMAX** The  $x$ -value of the right side of the viewing window, p. 34.

**XMIN** The  $x$ -value of the left side of the viewing window, p. 34.

**XSCL** The scale of the tick marks on the  $x$ -axis in a viewing window, p. 34.

**xy-PLANE** The points  $(x, y, 0)$  in Cartesian space, p. 685.

**xz-PLANE** The points  $(x, 0, z)$  in Cartesian space, p. 685.

**y-AXIS** Usually the vertical coordinate line in a Cartesian coordinate system with positive direction up, p. 14.

**y-COORDINATE** The directed distance from the  $x$ -axis to a point in a plane ( $xz$ -plane), or the second number in an ordered pair (triple), p. 14.

**y-INTERCEPT** A point that lies on both the graph and the  $y$ -axis, p. 33.

**YMAX** The  $y$ -value of the top of the viewing window, p. 34.

**YMIN** The  $y$ -value of the bottom of the viewing window, p. 34.

**YSCL** The scale of the tick marks on the  $y$ -axis in a viewing window, p. 34.

**yz-PLANE** The points  $(0, y, z)$  in Cartesian space, p. 685.

**z-AXIS** Usually the third dimension in Cartesian space, p. 685.

**z-COORDINATE** The directed distance from the  $xy$ -plane to a point in space, or the third number in an ordered triple, p. 685.

**ZERO FACTOR PROPERTY** If  $ab = 0$ , then either  $a = 0$  or  $b = 0$ , pp. 45, 75.

**ZERO FACTORIAL** See  *$n$  factorial*.

**ZERO OF A FUNCTION** A value in the domain that makes the function value zero, p. 217.

**ZERO MATRIX** A matrix consisting entirely of zeros, p. 581.

**ZERO VECTOR** The vector  $\langle 0, 0 \rangle$  or  $\langle 0, 0, 0 \rangle$ , p. 503.

**ZOOM OUT** A procedure of a graphing utility used to view more of the coordinate plane (used, for example, to find the end behavior of a function), p. 203.

