I N D E X

A page number followed by f indicates a figure; a number followed by t indicates a table; a number followed by n indicates a footnote.

absolute value function, 115-117, 132 abstract variables, relationship between, 16-18 Acadia National Park, Maine, night temperatures at, 93 acceleration average, 566, 567f, 567t, 576 defined, 566 of falling body, 559, 566-567 and force relationship, 410, 411 gravity as cause of, 566, 567, 569, 575t and mass relationship, 410, 411 and time relationship, 411 and velocity relationship, 411 acidic or alkaline classification, 246-247 acidic solution (defined), 255, 357 acidity, measuring, 357-359 acid rain. 246, 358 acre (defined), 233, 257 adding functions, 521-522, 548 addition of ordinates, 529 additive versus log scales. See linear versus log scales aerobic exercise heart rate, target, achieving through, 207 level, recommended, 200-201 pulse rate, minimum and maximum during, 191 aerospace industry, net loss and profit of, 70 Africa, elephant population in, 70 age height as function of, 102 human versus dog, 206 pulse rate, minimum and maximum based on, 191 age distribution calculating, 8t for Ghana, 12f for Tanzania, 5, 5f, 6 age for U.S. population distribution of, 4, 4f, 5f, 6, 11, 12f median age, 13-14, 13f, 68 ages of presidents, 11 aggravated assault, juvenile arrests for, 74t AIDS cases in U.S., 19f, 86f airborne toxins, simulated, release of, 532 airplane collisions, preventing, 181–182 air temperature-water temperature relationship, 81 air traffic computers and controllers, 181-182 alcohol consumption versus education level, 81falkaline solution (defined), 357 allometry, 434-437 Alpha Centauri (star), 232 American Lung Association, 125 ammonia, hydrogen ion concentration of, 358 ammonia, pH of, 358t ampicillin dosage, 29

AM radio waves, 247 Andromeda galaxy, 215, 255 angstrom (defined), 217, 232, 234 annual percentage rate (APR), 341, 379 annual percentage yield (APY), 341, 342, 379 anthrax spores, 232, 246 antifreeze for car radiators, 107 ant, length of, 246 apartments in Manhattan, purchase price of, 7 Apple Computer, 134 area, maximizing, 459 arguments, selecting, 14 Armenia, earthquakes in, 245 aspirin levels in bloodstream, 377f asteroids, 229-30 astronomical unit (defined), 262 asymptotes, 423, 526. See also horizontal asymptotes; vertical asymptotes AT&T's One Rate plan, 101 atmospheric pressure at sea level, 340, 419 atomic weapons, 302, 303 atoms first, age of, 261t radius of, 246, 261t size of, 213t, 215–216, 316 Australia rabbit population, increase in, 368 automobile insurance, average cost of, 69 average (word origin), 6n average acceleration, 566, 567f, 567t, 576 average loan rates, 45f average rate of change calculating and interpreting, 65, 67-69, 76-79.131 change in, 71-73, 72f, 72t limitations of, 68-69 for linear and exponential functions, 273 for quadratic functions, 493-495, 496, 547 as slope, 76-79 in time-distance relationship, 561-562, 562t, 572 of velocity (see acceleration) average velocity, 562-563, 562f, 565, 566 Avogadro's number, 217, 229 axes, labeled, 4 axis of symmetry, 454, 457, 458, 547 "baby boom echo," 73 baby names, 54f bacteria, 225, 266. See also under specific type of bacteria, e.g.: E. coli bacteria Baja California, population growth of, 296 ballast water, bacteria contained in, 225 ball thrown upward, height of, 549, 570f, 576 ball traveling distance down inclined plane, 396 Bank of America, 379 bar charts, 2-3, 2f, 5, 8f. See also histograms barometric pressure, calculating, 367

base defined, 218, 219, 255 effect of. 284-285 equalizing, 336 natural base e, 340-341, 342-344, 346, 363-366 baseball players, major league, average salaries for. 135f basic solution (defined), 255, 357 bathtub, capacity of, 445 bathtub, water level in, 61f battleship gun range, quadratic model for, 481 Bayer aspirin bottle, contents of, 445 bee hives, average price for, 553t beer, pH of, 379 Bejan, Adrian, Constructal Theory of, 447 Bell, Alexander Graham, 359 best-fit distance versus time function, 563, 563f best-fit exponential function, 268, 269f, 298, 304f best-fit line. See also regression line for children's heights, 123 on log-log plot, 432, 435-436 overview of, 123, 132 on semi-log plot, 371 smokers, percentage of, 125, 126f best-fit linear function, 565f Betelgeuse (star), 233 bicycle use statistics, 51f Big Bang, 216-217 binary numbers, polynomial expressions for, 509 biological half-life, 325 bird and egg masses, 440t birth rate data, 20f. 73 population size, impact on, 182 per second, 258 for unmarried mothers, 270 bismuth-214, decay of, 340 blood alcohol concentration (BAC) average values for, 107t calculating, 102-103, 103t, 108, 297 legal limits for, 191 blood, hydrogen ion concentration of, 359 blood lead levels, children's, reducing, 377f blood, pH of, 247, 359 blood type, U.S. population by, 53f body mass oxygen consumption versus, 441f population density versus, 441f surface area versus, 434-436, 435f body mass index (BMI), 203, 203f, 234 body temperature, surface area to volume ratio impact on, 387 boiling temperature of water, 163t, 246 bone marrow transplant, white blood cell count growth following, 303-304

books shipped by publishers, number of, 120f Boston Marathon, women's winning times for, 162fBoston radio stations, transmitting frequency of. 247 boundary lines, 183, 187 Bourton-on-the-Water, England, scale models of. 325 bowling ball floating in water, 396 Boyle's Law for Gases, 410-411, 412-413, 418-419, 420 Braille code, 108 brakes, reaction time before hitting, 521 braking distance, 521-522 Brazil, inflation rate in, 306 breakeven point, 187-189, 188f breast cancer risk of, 19-20, 19f, 130f survival rates for, 546 tumor growth, modeling, 540-542, 546 brick, mass and volume of, 258 British pounds versus euros, 107 British thermal unit (BTU) (defined), 257 BSA (body surface area) as drug dosage determining factor, 259 Bush, George W., body mass index (BMI) of, 234 caffeine levels, measuring, 280-281, 291-292 calculators log function of, 249, 250 scientific notation display by, 216 speed of. 214n2 square root function of, 236 California, tomato production in, 551 calories burned from exercising, 55t, 162t, 206t Canadian-U.S. exchange rate, 135, 544 cancer trends, projecting, 22 candy corn production, 229 carbon-12, 312 carbon-14, decay of, 312 carbon dioxide, percent of greenhouse gas emissions, 138 carrying capacity (defined), 268 car sales, domestic, new versus Japanese, 70 Carthage, new, perimeter of, 479 cart, motion of, 478f car, trade-in value of, decrease in, 297 categorial (qualitative) data, 2 causation versus correlation, 145, 153-154 CD (compact disk), storage capacity of, 214, 222 ceiling function, 137 cell, living, radius of, 243 cell phones, U.S. households with, 130f cell phones, U.S. subscriptions to, 135 cells living, components of, manipulating, 246 marking, 349 size of, 213t chain letters, 315-316 chemotherapy, white blood cell count growth following, 270 child-bearing versus childless women, breast cancer risk of. 130f childhood obesity, 20, 20f children out of school, global breakdown of, 56f

children's blood lead levels, reducing, 377f China area in square miles, 225, 378 oil production and consumption in, 205f population, 22f, 225, 312 U.S. trade with, 376f, 376t chip computing power, increase in, 368, 368t chlorine level in swimming pools, 296 cholesterol, measuring, 191 cigarettes, U.S. consumption and exports of, 71t circles area of, 390, 454 circumference of, 390 circumference to area ratio for, 387 radius of, 390, 532, 554 civil disturbances in U.S., 78-79, 79f, 79t closed interval (defined), 34 clothing sizes, international differences in, 134 Coca-Cola beverage consumption, 225, 233 Classic, 232 hydrogen ion concentration of, 358 pH of, 358t cocaine-related emergency room episodes, number of, 128t coefficient. See also correlation coefficient of friction, 396 in power functions, 400-402, 401f, 423, 424, 426-429, 442-444, 451-452 in scientific notation, 215, 216, 255 in time-distance relationship, 564, 566, 569 coffee cooling, 42, 42f, 517 hydrogen ion concentration of, 358 pH of, 358t, 363 college graduates, U.S., number of, 127f colleges, mean cost of 4-year, public versus private, 161f collinear points, 80 collision of objects and force exerted on, 513 Colorado River, length of, 257 common factors, 482 common logarithms calculating, 211, 248-249, 249t defined, 248, 256, 374 exponential functions as inverse of, 355 overview of 349 representing, 352, 353f, 353t rules for, 329, 331-335, 350, 355, 374 comparisons of numbers, 211, 217, 220-221 completing the square (strategy), 473 complex number (defined), 487, 547 complex number expressions, multiplying, 492 complex zeros, 488 compound calculations, 305-306 compound inequality, 183-184, 187, 201 compound interest calculations based on, 343 overview of, 341-342, 374-375 rates, 304-306, 315 compression, function transformation through, 453, 468, 548 compression, vertical of graph, 400-401, 402, 442, 464, 465, 510 computer expenditures for universities, 528 computers in schools, statistics on, 70 computer storage, measurement units for, 217, 234

computer worms, 325 concave down (defined), 40, 50f concave up (defined), 40, 50f concert numbers versus attendance, 160f cone, volume of, 546 constant of proportionality, 108, 390, 410, 412, 417, 431, 442, 443 of vertical and horizontal intercepts, 111 constant dollars, 306, 326 constant functions, 498t constant percent change, 290-294 constant percent growth rates, 301-302 constant rate of change, 65, 87-89, 109 Constructal Theory, 447 continuous compounding, 329, 341-344, 343t, 366.375 continuous growth or decay rate, 344, 345-346, 364, 365, 366, 375 continuous role in deflection, 397 contracting expression, 334, 350-351 conversion factors, 230, 231 cooking devices, designing, 455-456 corpse, temperature of, 520 correlation coefficient, 151-152, 153, 156, 160 correlation versus causation, 145, 153-154 cosmic chronology, 247 cost comparisons of heating systems, 167-168, 167f cost versus revenue, 188-189 cotton and wool fabrics, shrinking of, 192 counterarguments, examining, 14 countries, square areas of, 257t credit card debt, increase in, 298-299 crimes in U.S., 19t, 79f crude oil prices, 207f Cruithne (asteroid), 230 cryptology, 545 cube duplication of, 449 scaling up, 384-386, 388 surface area of, 384-385, 389, 454 volume of, 385-386, 389 cubic functions, 498, 498t, 501f Current Population Survey (CPS), 146, 147t, 157 cylinder plastic in aspirin bottle, 445 surface area of, 388 volume of, 388, 397, 413-414 dark energy, 214n3 dark matter, 214n3 data defined, 2 dictionary, 146, 147t presentation and interpretation, biases in, 82-84 table, exponential equation solving with, 330t daylight, hours of, seasonal, 520f death, causes of, international breakdown of, death rate. See also under cause of death, e.g.: large intestine cancer, U.S. death rate from population size, impact on, 182 per second, 258 from smoking, 319, 319f

decay factor annual, 301 daily, 500f defined, 279, 280, 284, 364 determining, 281, 282, 300, 364, 499 hourly, 281 representing, 292, 321 decay phenomena, modeling, 265, 280 decay rate, 292, 293, 300, 302-333, 321, 364, 499 decay rate, determining through, 293 decay, time required for, 337 decibel scale, 359-361, 360t, 381 decimal form, decay rate in, 292 decimal form, growth rate in, 291, 292, 299 deep space, 212-213 deep time, 216-217 deflection, 394, 396-397 Δ notation, 76 demand curve, 176, 176f, 177 Deneb (star), 220, 232, 233 density, formula for determining, 258 dependent variables, 24, 29, 30, 31, 35, 50 depreciation, rate of, calculating, 89, 89f, 89t Dido, queen of Carthage, 479 digital information, generation of, 258 direct proportionality of cube surface area to square of edge length, 385 for linear functions, 108-109, 120, 132, 390 with more than one variable, 393-394, 397 overview of, 383 for power functions, 390-394, 396, 410, 442 properties of, 390-393 and weight-length relationship, 390 disco dancing, calories burned from, 55t discriminant, 484, 485, 486, 490, 547 distance-gravity relationship, 411 distance-time relationship average rate of change in, 561-562, 562t, 572 for falling bodies, 559, 561, 561f, 561t, 563-564, 565-566, 569, 573 for vehicles, 577 distributive law, 488, 525 dividing functions, 521, 548 division property in logarithms, 335 DNA double helix, 213 DNA molecule, 213 DNA strand, unwound, length of, 243 dog versus human life years, 206 dollar, value of, inflation impact on, 305-306 domain, 33-37, 50, 124, 538 "dotcom bubble," 42 doubling time calculating, 301-302 defined, 299, 321 for E. coli bacteria, 329 for investment, 336 for lung cancer, 325 and Moore's law, 368 for vibration frequency, 307 Dow Jones Industrial Average, 19f, 371-372, 371f Dragons of Eden, The (Sagan), 247 drug dosages, BSA (body surface area) as determining factor, 259

drug elimination from body, 312 duckling species, weights of, 271 duplicate lines, linear equation system represented by, 171f, 174, 175-176, 176f e (natural base). See natural base e as constant percent, 290-291 plotting, 268, 269f predicting, 266-267, 266f, 266t, 267t, 339 semi-log plot of, 316-17, 316f time calculations for, 329, 330, 336 Earth age of, 216t, 218f, 252, 252f, 253f, 256f, 261t circumference of, 229, 449, 538 companion asteroids of, 230 core of, 392 land, square miles on, 223 mass of, 258 moon distance from, 217 orbit, radius of, 233 organisms, living, first, 261t radius of, 212t, 221, 236, 246, 258, 261t, 388. 392. 538 stars' distances from, 233 sun distance from, 232, 233, 268 surface area of, 236 volume of, 221, 392 earthquakes, energy magnitude of, 379 earthquakes, magnitude of, 243-244, 243t, 245, 359.379 E. coli bacteria, growth of economics, linear systems in, 176-177 education as variable, 2-3, 2f education-health relationship, 81f education level college, 127f and earnings, relationship between, 145-154, 148f, 150f, 156, 157, 159f high school, 70, 70t, 73t effective interest rate, 341, 342, 344, 350, 375, 379 egg masses, 440t electrical resistance as wire length function, 120, 419 electrical resistance relationship to voltage and wattage, 446 electromagnetic radiation, 234, 247 electron, mass of, 218 electron, weight of, 246 elephant population, 69, 70 elephant seals, 257 elimination method of solving system of linear equations, 172, 173-174 ellipse, 17f, 18 embryo, average growth of, 480t energy calculating formula for, 397 comparisons, 259t consumption, projections for, 324 units of, 258 English versus metric unit conversion, 211, 212t, 218, 231 Environmental Protection Agency, 138 equations describing change with, 16-18 in function form, 31-33, 172-173, 175 function representation through, 23 in two variables, 50

equilibrium number (defined), 182 equilibrium point, 176, 176f, 177, 182 equivalent equations, 171f, 175–176 Eratosthenes, 449 Eros (asteroid), 230 estimates of solutions to problems, 17-18, 168-69, 223, 242, 330-331, 459-460 ethnicity, classifying, 2 eukarvotes, first, age and size of, 261t euros versus British pounds, 107 euros versus U.S. dollars, 107, 110, 545 evidence, selecting, 14 exchange rates, 107, 110, 135, 544, 545 excretion, drug elimination through, 312 exercise, pulse rate, minimum and maximum during, 191 expanding expression, 334, 350 experimentation, 560 exponential decay constant percent decrease, 291-293 graph of, 285, 287, 320, 320f versus growth, 280, 364, 375 overview of, 279-82 exponential decay function, 279-281, 285, 287, 292, 300, 320, 345 exponential equations estimating solutions for, 330-331 interpreting, 268 versus linear equations, 272 solving with logarithms, 329, 330, 331-335, 336-337, 374 exponential functions average rate of change for, 273 base e transformation of, 344-347, 363-366 compound interest rates, 304-306 constant percent change, 290-294 constructing, 268, 299, 300, 371-372 defined, 317 equations for, 329, 405t height-weight relationships expressed as, 434 identifying, 275-276 input, finding for, 329 inverses of, 540 logarithmic functions, relationship to, 329, 354-356 overview of 43, 265 versus power functions, 390, 405-407 properties of, 321 representing, 265, 284, 292, 320, 321 selecting for set of data, 383 semi-log plots of, 265, 316-317, 316f, 321, 369-372.375 shift of, 515-516, 517 visualizing, 284-287, 317, 405-407, 429, 430 exponential growth base effect on, 284-285, 287 by constant percent increase, 290-291 versus decay, 280, 364, 375 E. coli bacteria example, 266-268, 269f function, 267-268, 271-276, 272f, 272t, 279, 293–294, 300, 320 versus linear growth (see linear growth versus exponential growth) versus logarithmic growth, 354 variables affecting, 320 visualizing, 320f

Index 693

exponential models for continuous compounding, 329 exponential models of data, 274-275, 369-372 exponents base 10, 212, 213 defined, 255 errors involving, 221-222 fractional, 235-238, 239-240 logarithm relationship to, 248, 249 log scale labeling with, 253 negative, 213, 240 negative integer, 219, 226-228 positive integer (non-base 10), 218-222 as rational numbers, 219 rules for, 211, 219-221, 223, 226-228, 235, 238, 255, 332, 333 expressions, simplification of using exponents, 211 extrapolation, 126, 127f factoring for polynomials, 505 factoring for quadratics, 480, 481, 482-483 Factor Theorem, 488, 505, 547 falling object distance-time relationship for, 559, 561, 561f, 561t, 563-564, 565-566, 573 distance traveled by, 397, 551, 555-556 experimentation on, 560-562, 568f, 568t, 570-573 height, equation for, 568-569 family tree as fractal tree, 310 FAM1000 Census Graphs, 146, 149, 159 farmable land, people per square mile of, 223 farmable land, portion being farmed, 224 farm output, gross, 128f father functions, 531 federal debt, 47, 47f, 220-221, 315t federal debt per person, 523-524 federal funds rate, 44, 45f, 119 Federal Reserve, 44, 119 federal surplus or deficit, 14-15, 14f, 22, 47 female clothing sizes, international differences in. 134 Fidelity Fund investment, growth of, 319-320, 320f film exposure relationship to luminance, 323 first-class stamp prices, U.S., 122t fish and shellfish production, U.S., 340f fish caught, metric tons of, 53t flat versus graduated income tax, 193-198, 195f, 197t, 198f, 209 floor function, 137 flying bodies, cruising speed of, 447 FM radio waves, 247 focal length (defined), 458, 463 focal point of parabola, 454, 455, 456, 458, 547 FOIL technique, 456n, 488, 492 Food and Drug Administration, 191 food commodities, per capita consumption of, 283tfood production increase, predicting, 308-309, -308f foods, pH of, 357, 358t, 363 football field, dimensions of, 233, 257 football players, salaries of, 257 force-acceleration relationship, 410, 411 force as function of time, 513

force-distance relationship, 410, 411 fractal tree, 309-310, 309 fractional exponents, 219, 235-238, 239-240, 255 free fall experiment, 560-562, 568f, 568t, 570-573 freezing point as function of salinity, 107t frequency count. 2. 3 distribution tables, 8 radio (defined), 247 frictional force between rope and pole, 242 "Friends and Family" long-distance service program, 315 functions algebra of, 521, 548 combining, 453, 521-527 composing, 531-533, 548 defined, 1, 22-23, 50 equations for. 538 families of, 43 finding from graph, 469 identifying, 26-27, 26f, 33, 35 increasing or decreasing, 40, 50f language of, 29-32, 33-37, 50 models, selecting, 383, 429-442 overview of, 22-26 product of, 531 properties of, 1 quotient of, 523-524 representing, 1, 23-24 requirements of, 536-537, 539 transforming, 453, 510-517, 513f, 533, 548 (see also quadratic functions: transforming) undefined, 35, 36, 37 visualizing, 39-43, 50f, 61 galaxies, recession rate from one another, 226 Galileo, 559, 563, 564, 565, 573, 660 gamma rays, wavelengths of, 234 gas consumption rate, speed impact on, 479 Gas Guzzler Tax, 131t gas prices international, 205t in Maine, 56t U.S. averages, 135t genealogy functions, 531, 536, 537 girls' weight, median, constant rate of change for, 87-89, 88f, 88t global warming, 326, 553 gold price increases, 84f government trust fund, growth of, 314 graduated versus flat income tax, 193-198, 195f, 197t, 198f, 209 grain production and consumption, worldwide, 204f graphing calculators, 158 graphs of absolute value function, 115-116, 116f, average rates of change represented through, 76-79 of cube surface areas, 385f of cube surface area/volume ratios, 386f of cube volumes, 385f data interpretation, role in, 83-84

describing and creating, 1 direct proportionality represented by, 108, 108f, 109f domain and range, finding from, 34-36 elements of, 4 of equations, 16-18, 32, 50 exponential equation solving with, 330t of exponential functions, 265, 285f, 286f, 287, 317, 320, 345f, 406, 406f, 407f, 443 of functions, 23, 26, 26f, 31f, 35, 36f, 37, 39f, 40, 529 of inequalities, 184f, 185f of inverse functions, 355-356, 375 of linear equation systems, 167, 167f, 171, 171fof linear functions, 90, 94, 97, 99-100, 100f, 101, 101f, 131-132, 406, 406f, 443 of logarithmic functions, 353-354, 514, 515f of piecewise linear functions, 114f, 115f, 193f, 195-196, 195f, 202f of polynomial functions, 453, 500-506, 501f, 507, 515, 547-548 of power functions, 383, 397-405, 406, 407f, 410f, 420-429, 431, 442, 443, 511, 512 of projectile's paths, 460f of quadratic functions, 453, 454, 457, 458, 468, 469, 547 of rational functions, 527, 527f of revenue versus cost, 188f of step functions, 118f time as variable in, 13-14, 13f transforming, 469 zooming in on, 504-505 gravitational constant, 564 gravity acceleration due to, 566, 567, 569, 575t force between objects, 411, 415 impact on falling objects, 555-556 greatest integer function, 122, 137 greenhouse gas emissions, carbon dioxide, percent in, 138 gross domestic product (GDP), health care costs, U.S. as percentage of, 130t growth factor for bacteria, 268, 290-291 for cancerous tumors, 540, 541 defined, 267, 284, 364 determining, 282, 299, 371 growth rate used in determining, 291 for populations, 274 representing, 292, 293, 321 for white blood cells, 304 growth patterns, 41-42 growth phenomena, modeling, 265 growth rate, converting to growth factor, 291, 321 growth rate, determining, 293, 299, 304, 364, 371 hair conditioners, acidic, 357n Haldane, J. B. S., 387 HALE (health-adjusted life expectancy) versus health spending per person, 441f half-life biological, 325 of bismuth-214, 340 defined, 299

of drugs, 312 exponential applications, 321 of radioactive substances, 300-301, 302-303, 311, 313, 348 half-open intervals, 34 Harvard Bridge, length of, 232 HDL (good cholesterol), 191 health care costs, U.S., 130t, 374t health care expenditures, increase in, 270, 324 health care expenditures, projected, 324 health-education relationship, 81f health spending per person, HALE (healthadjusted life expectancy) versus, 441f health spending per person, international breakdown of, 52f hearing, threshold of, 359, 360t, 363 heart attack, survival chances after, 297 heart rate of small versus large animals, 383, 384, 438f heart rate, target, aerobic exercise aimed at, 207 heart, restarting, timing impact on survival chances, 297 heating systems, solar versus conventional, 165, 166-169, 167f heat wave (defined), 552 hectare (defined), 233 hectometer, square (defined), 233 height age, function of, 102, 200t children's mean, 123-125, 123f, 123t children's versus weight, 431-434, 431f, 431t fathers' versus sons', 160 of first Homo sapiens, 261t in metric units, 213, 213t, 220, 246 paper thicknesses versus human, 268 hertz (defined), 247 hidden variable, 154, 157 high school completion, 70, 70t, 73t Hispanics, 2, 8f, 10f histograms, 4-5 Holdeen, Jonathan, 314 holding breath, avoidance of, 383, 412-413 home owners, U.S. percentage of, 70 home prices, increase in Medford, 278 home, single-family, median price for, 134 Homo sapiens, first, age of, 261t horizontal asymptotes, 287, 320, 420, 420f, 422, 424, 442, 526, 527 horizontal intercept of parabola, 457, 458, 459-460, 480-483, 484-490 of polynomial, 500, 502, 503-505, 503f, 506, 507, 525, 526, 547 of quadratic function, 490, 547 of rational function, 525, 548 of vertical line, 111 horizontal lines, 110, 111, 132 horizontal line test, 539-540, 548 hot water heater, diameter and volume of, 397 household income, median black versus white, 86f increase in. 324f inflation-adjusted, 44f, 306 household net worth, 15, 15f Hubble constant, 226 Hubble, Edwin, 216 Hubble's Law, 226

human life, origin of, 216t, 217 humidity impact on perceived temperature, 552 hydrogen atom, radius of, 215-216, 232, 243 hydrogen bomb, 312 hydrogen ion concentration, 246, 254, 357, 357f, 358, 359 icing temperature, salt impact on, 544 ideal body weight (IBW), formulas for, 546 imaginary numbers (defined), 487 immigration rate per second, 258 immigration rate, rise in, 73 income age impact on, 155 disposable, growth projection for, 291 and education level, relationship between, 159f gender impact on, 155-156, 160 household median, 44f, 86f, 306, 324f U.S. inequality of, 514, 514f incomes in United Kingdom (UK), 53 independent variable defined, 24, 29, 30, 50 graphical representation of, 31 reinitializing, 125-126 time as, 35 India area in square miles, 378 population, 378 wireless data market, growth of, 293 individual cell phone number mapping, 536t inequalities, manipulating, 184-189 infant mortality rates, U.S., decline in, 297, 4391 infant mortality rates, U.S., male-female breakdown of, 129f infant mortality rates versus literacy rates, 129f inflation impact on money worth, 305-306 influenza-related deaths, 20-21, 21f information, relevant, collecting, 14 infrared light as electromagnetic radiation, 247 initial value, 267, 285-286 input in data tables, 31t doubling, 412 as independent variable, 24, 29, 30, 31, 50 insanity versus radio ownership, 154 instantaneous growth or decay rate, 344, 345-346, 364, 365, 366, 375 integer exponents, 218-222, 226-228, 238, 239 intercepts. See also horizontal intercept; vertical intercept characteristics of, 458 determining, 453, 457 estimating, 459-460 interest rate, 44, 119 Internet access, percent of U.S. adults with, 127f backbone bandwidth, 326f teenager use of, 8, 9f Internet users, increase in, 312, 324 Internet users, projections for, 324 interpolation, 126, 127f

human body temperature, normal, 122

human height. See height

intersection points in linear equation system, 171, 171*f*, 172, 174–176, 182, 195–196 interval notation, 34, 36 inverse functions, 355-356, 375, 453, 534-540, 546.548 inverse proportionality (for power functions), 383, 411-422, 442 inverse square laws, 415-417, 446 investments comparing, 305, 305t doubling, 302, 336 growth of, 319-320, 320f, 515-516, 539f growth, targeted, interest required for, 504-505 mixed portfolio of, 553 iodine-131, decay of, 279, 280, 325 iPod sales, 134 Iraq war, U.S. opinion on, 54f Japan area in square miles, 225 Japan population, 57f, 225, 378 jet airplanes, noise level of, 361 job type and income, 156 jointly proportional variable (defined), 396 Jordan, Hamilton, 22 joule (defined), 258 joule measurement, applications of, 379 jump, height and velocity of, 576 Jupiter falling object, distance traveled on, 551 radius of, 224 sun distance from, 232 juvenile arrests, 56f, 74t Kalama, Egypt study on children's heights, 123 - 125Kenya, elephant population in, 69 Kepler, Johannes, 262 key ideas, identifying, 14 kilograms versus pounds, 128t kilometers to miles conversion, 231 King, Martin Luther, assassination of, 79 Kleiber's Law, 436-437 K-12 education, federal spending on, 85f labor force, participation by gender, 170f land, measuring, 233 land on Earth, square miles of, 223 large intestine cancer, U.S. death rate from, 439f Las Vegas, NV population trends, 170f LDL (bad cholesterol), 191 lead-206, 311 lead-210, 311, 368 lemon juice, pH of, 246 Libby, Willard, 312 life expectancy increase in, 326f U.S. by race and sex, 71t U.S. increase in, 137f world versus Botswana, 55f light Andromeda galaxy, time to travel to, 255 intensity of, 415, 418 speed of, 230, 231, 233, 234, 554 visible, wavelengths of, 234 lightning and thunder, delay between, 554 light year, 220, 225, 232

Index 695

linear correlation, 153 linear equations applications of, 122-123, 132 constructing, 65, 90, 100-103, 124 duplicate lines represented by, 171f, 174, 175-176, 176f versus exponential equations, 272 systems of, 165, 166-169, 171-173, 201 linear factors, 482 linear functions average rates of change for, 273, 493-495, 496 constructing, 371 data approximation through, 149 direct proportionality for, 108-109, 120, 132, 390 equations for, 90–91, 131, 405t identifying, 275-276, 369-370 inverses of, 540 overview of, 43, 87-91, 265 piecewise, 114-118, 132, 165, 193-198, 202 polynomials, other, compared to, 498t, 499 selecting for set of data, 383 visualizing, 94-97, 131-132, 405-406, 429 linear growth versus exponential growth functions, 271-276, 272f, 272t, 293-294 overview of, 265, 320, 320f population growth versus food production, 308-309, 308f linear inequalities, 165, 183-189, 201 linear models of data, 65, 122-127, 150, 156, 274-275, 429 linear regression (defined), 160 linear relationship, 65, 109, 122-123, 150 linear versus log scales, 244, 244f, 245, 245f, 252, 316 literacy rates, 129f Little Rock, Arkansas, earthquakes in, 245 Litvinenko, Alexander, 378 logarithmic functions and exponential functions, relationship between, 329, 354-356 inverses of, 540 power functions translated into, 430 visualized, 515f logarithmic growth, 354 logarithms applications of, 357-361 base *e* (see natural logarithms) base 10 (see common logarithms) calculating, 250-251 contracting expressions with, 334, 350-351 defined, 248, 374 errors, common in using, 335 expanding expressions with, 334, 350 exponential equation solving with, 329, 330, 331-335, 336-337, 374 functions of, 43, 329, 352-361, 375 inverse functions and, 538, 546 numbers, calculating based on, 251 properties of, 353, 514 rules for, 331-335, 337, 374 simplifying expressions with, 334 solving equations containing, 335 log-linear plots. See semi-log plots log-log plots of height versus weight data, 432, 432f

power functions on, 431, 432-433 of surface area versus body mass, 435-436, 435fvisualizing, 429, 429f, 430, 443 log scales. See also semi-log plots advantages of, 369 equivalent variations of, 370, 370f as function model selection aid, 383 noise, measuring with, 359 overview of, 244-245 plotting numbers on, 251-253, 252f, 253f, 256 sample, 247f long-distance phone calls, cost of, 101 Los Angeles, earthquakes in, 245 luminance, film exposure relationship to, 323 lung cancer, doubling times for, 325 lung cancer risk, smoking-related, 323, 369, 369f lung tumor, growth of, 314 lye, pH of, 379 magnitude of slope, 95-97, 96f major league baseball players, average salaries for. 135f Malthusian dilemma, 308-309 manufacturing employment, growth projection for. 291 margarine, consumption of, decrease in, 70 marital status of U.S. population, 71t Mars, falling object, distance traveled on, 551 mass-acceleration relationship, 410, 411 Massachusetts flat versus graduated income tax debate, 196-198, 197t, 198f Massachusetts Registry of Motor Vehicles, 359 mass-gravity relationship, 411 mathematical model (defined), 16 Matterhorn, height of, 268 maximum value, 39, 50f MCI "Friends and Family" program, 315 mean calculating, 7-8, 7n defined, 6 limitations of, 68 overview of, 6-7 regression lines, 152 meat, pH of, 358t median, 6, 7, 7n median age, 13-14, 13f, 22, 68 median regression lines, 152 medical degrees awarded to women, 129f Medicare, 298, 366 medicine dosage, calculating, 29 men's mile, world records for, 162f metabolic mass, body surface area as indicator of, 259 metabolic rate of small versus large animals, 383, 384, 436f metabolic rate versus body mass, 436-437 metabolism, drug elimination through, 312 methane gas, increase in, 326f metric system, 212, 214, 230-231 metric to English unit conversion, 211, 212t, 567 Mexico City, population decline of, 296 Mexico population, growth rate of, 302 microorganisms, global distribution of, ballast as factor in, 225

microwaves as electromagnetic radiation, 247 military reserve enlisted personnel, 48, 48f milk pH of, 363 supply and demand curves, 177 whole, per capita consumption of, 339 Milky Way age of, 261t limits of, 268 radius of, 212t, 232, 246, 261t minimum value, 39, 50f minimum wage, 117–118, 118f minimum wage workers, salaries of, 257 Mirex pesticide, decay of, 324 mirror images, graphs as, 355-356, 356f, 375, 401, 424, 442 mirror images of parabolas, 458 Missouri state tax, 200t mole (defined), 217 Monaco area in square miles, 225, 257t Monaco population, 225 money, spending breakdown/distribution of, 9f, 10# money, worth of, inflation impact on, 305-306 moon Earth distance from, 217 radius of, 246 sun distance from, 232 Moore's law, 317, 368 mortality rate for children, male and female in Sweden, 137f, 138 mortgage interest rates, 30-year, 85f mother functions, 531, 536, 537 motion bodies in, 559 describing, 453 equation of, 564, 573 experiments on, 660 upward versus downward, 569 motor vehicle accidents, deaths in, 69t motor vehicle registrations, number of, 74t, 164fmultilevel marketing, 316 multiplicative scales. See log scales multiplying functions, 521, 531, 548 multivariable analysis, 155 murder, juvenile arrests for, 56f musical pitch, 307 mute swans, population growth of, 278 myelodysplastic syndrome, 303 nails, size and weight of, 240 nanometer (defined), 234 nanosecond (defined), 233 "nanotweezers," 246 National Assessment of Educational Progress (NAEP) reading scores, 85f National Association of Realtors, 134 natural base e base conversion to, 346, 365-366 continuous compounding using, 341, 342-344 defined, 340-341 exponential functions, transforming to, 344-347.363-366 overview of, 340-341 natural disasters, 54f, 377f natural gas production, 40, 40f

Index 697

natural logarithms defined, 349, 374 inverse of, 355 overview of, 349-351 representing, 352, 353f, 353t rules for, 329, 350, 355, 374 NEAR (robot spacecraft), 229-230 NEC company, 214 negative integer exponents, 219, 226-228 negative integer powers, 398, 409-429, 442 negative logarithms, 249 neutral solution (defined), 255, 357 neutrons, number in nuclear reactor, 368 neutrons, radius of, 246 news communication in U.S., methods of, 76 Newton's Law of Cooling, 369, 520 Newton's Law of Universal Gravitation, 411 New York City taxi fares, 205 1918 flu epidemic, population figure impact of, 73 nitric oxide, concentration of, 397 Nobel prizes in science, 86f noise exposure, maximum safe limits for, 314t level, legal limits of, 359 measuring, 359-361 nominal interest rate, 341, 342t, 344, 350, 374-375.379 nonagriculture employment, growth projection for. 291 noninvertible functions, 536, 537 Norman window, shape of, 479 notation. See also scientific notation Δ, 76 of functions, 29-33, 50 $\Sigma, 11$ nth roots, 237-238 nuclear energy generation in U.S. versus United Kingdom, 225 nuclear reactor, neutrons, number in, 368 number in poverty, 42f, 43 object sizes comparing with ratios, 220-221 on linear scale, 244f on order-of-magnitude (logarithmic) scale, 244fobjects thrown upward, height of, 478, 549, 569-570, 570f, 576 observation, use of, 560 ocean wave velocity, calculating, 419 octaves, function of, vibration frequency as, 307 odd versus even powers inverse functions and, 540 for polynomial functions, 502 for power functions, 399-400, 399f, 400f, 422-423, 422f, 442, 512 oil, barrel of, U.S. versus British, 233 Old Faithful geyser, 576 Olympic shot put, 24–26, 25t, 129f one-child-per-family policy, 378 one-to-one functions, 537, 538, 539-540, 545, 548 open interval (defined), 34 orange juice, hydrogen ion concentration of, 255 orbital period, 262, 262t, 263t

orders of magnitude, 242-245, 256, 359 ordinates, addition of, 529 organism length, population density versus, 441forgans, surface areas of, 387 Orion constellation, 233 oscillation frequency, calculating, 418 outliers (defined), 7 output, 24, 29, 30, 31, 31t, 50 oxygen, concentration of, 397 oxygen consumption versus body mass, 441f Pangaea (land mass), 253, 261t paper recycled, 136 paper, thickness of, 268 parabola defined, 454, 547 equation for, 474, 489 intercepts of, 453, 457, 458, 459-460 properties of, 458 parabolic devices, 454-456, 550 parabolic roof, 552 parallel lines, linear equation system represented by, 171f, 174-175, 175f parallel lines, slopes of, 112, 113, 132 parental education, 154 parental socioeconomic status, 154, 157 part-time jobs, 156 patterns, searching for, 14 Pearson, Karl, 160 pedaling into the wind, 391-392 pediatric growth charts, 87, 102 pendulum, period of motion for, 242 Pensacola, Florida tides, 34-35, 35f percentage form, decay rate in, 292 percentage form, growth rate in, 291 perfect square (defined), 235 period of pendulum motion, 242 period of planetary orbit, 262, 262t, 263t perpendicular lines, slopes of, 112-113, 132 perspectives, changing on functions, 534-535 pH function, non-linearity of, 359 pH level, calculating, 358 phone bill, monthly, modeling, 101 phone tree as fractal tree, 310 phosphorus-32, decay of, 349 pH scale, 246-247, 254-255, 357-359, 357f, 357t. 359 piecewise functions (defined), 194-195, 202 piecewise linear functions, 114-118, 132, 165, 193-198, 202 pie charts, 5-6, 8f Pittsburgh, PA population trends, 170f Planck's length, 234 Planck time, 234 planets. See also Earth falling objects on, 551 objects thrown upward on, 478 orbital periods of, 262, 262t, 263t radii of, 224 sun distance from, 232, 233, 262, 262t, 263t plank deflection, calculating, 394, 396-397 Pleiades (galactic cluster), age and size of, 261t plotting numbers on logarithmic scale, 251–253, 252f, 253f, 256 Pluto, height of objects thrown upward on, 478 plutonium, decay of, 302-303

order of magnitude scales. See log scales

plutonium-238, decay of, 284 pneumonia-related deaths, 20-21, 21f point spread in football game (defined), 9 poison ivy, treating, 499 poll results, range in values of, 116 polonium-210, 378 polonium-214, decay of, 311 polynomial functions constructing, 505-507 creating, 453 definition and terminology for, 498-500, 498tin factored form, 505, 507 global characteristics of, 500-502 overview of, 43, 507, 547-548 quotient of, 524-525, 548 ratio of, 453 visualizing, 500-502 polynomials applications of, 498, 499 binary numbers, expressing as, 509 of degree 0, 498t of degree 1 (see linear functions) of degree 2 (see quadratic functions) of degree 3, 498, 498t, 501f of degree 4, 498t, 499, 501f of degree 5, 498t, 499, 501, 501f positive integers, expressing as, 509 polystyrene molecules, components of, manipulating, 246 population density versus body mass, 441f population density versus organism length, 441f population growth predictions, 274-275, 275f, 275t. 308-309. 308f population growth rate, 268 population pyramids, 12, 12f, 57f population size, factors affecting, 182, 268 population statistics, international, 9f positive integer powers, 397-402, 442 positive integers, polynomial expressions for, 509 potassium-40, decay of, 284 pounds versus kilograms, 128t poverty rate, 42f, 43, 82-83, 82f, 82t, 84t power (defined), 219, 255 power functions adding, 453 defined 389 of degree -1, 386 of degree 2, 384 equations for, 389, 405t, 409, 431, 432-433, 443 versus exponential functions, 390, 405-407 height as, 432-433 inverses of, 540 logarithmic functions, translating into, 430-431 with negative powers, 409-417, 442 overview of, 43, 442 with positive powers, 389-394, 397-402, 442 properties of, 383 quadratics as, 464 transformations of, 516 visualizing, 405-406, 420-426, 429, 430 power intensity, calculating, 416, 416f powers of 10, 212-214, 255 predator-prey model, 42, 42f prednisone level, changes in, 499, 500f

Presley, Elvis, impersonators of, 312 prices, increase in, 258t primates, chest circumference and body weight of, 240 principal square root (defined), 235 profit, calculating, 522-523, 523f projectile, trajectory of, 459-460, 480, 481, 481f, 539f projectile, travel distance as function of launch angle, 62 protons, radius of, 246 pulse emission, optical communications laser, speed of, 214 pulse rate, minimum and maximum during aerobic exercise, 191 pyramid growth schemes, 316 pyramids, dimensions of, 449 quadratic formula, 480, 484-487, 490, 492, 547 quadratic functions applications of, 453 average rate of change for, 493-495, 496, 547 equations of, 458 factored form, 488-489, 490, 492, 547 falling object modeling with, 574 forms of, converting, 453, 472-474, 488-489.490 for free fall data, 563 overview of, 454-456, 547 polynomials, other, compared to, 498t, 499, 501f properties of, 457-458 roots or solutions of, 485, 486 standard form, 456, 470-474, 475, 490, 547 terminology for, 456, 498t transforming, 463-466, 467-470, 471-475 vertex and intercepts of (see intercepts; vertex) vertex form, 468-470, 472-474, 475, 547 qualitative (categorial) data, 2 quantitative reports, 14 quantitative variables, 2 quantities as functions of time, 26f quantities, ratios of, 220-221 quartic functions, 498t, 499, 501f Quintana Roo (Mexico), population growth of, 296 quintic functions, 498t, 499, 501, 501f rabbit population, increase in, 368 race, classifying, 2 radiation, electromagnetic. See electromagnetic radiation radiation intensity as wavelength function, 26f radicals, rules for, 238 radioactive decay, 300-301, 311 radioactive substances, storage for, 313, 349 radio ownership versus insanity, 154 radio stations, transmitting frequency of, 247 radio waves, 247 rain, acid, 246, 358 raindrop, weight of, 246 rain, pH of, 246, 361 range, 33-37, 50, 122 range of error, 116, 116*f* rate of change. See also average rate of change constant, 65, 87-89, 109 varied by interval, 68-69, 69f, 69t

rational exponents (defined), 239 rational functions creating, 453, 548 overview of, 524-525 visualizing, 525-527 rational numbers, 219 ratios, estimating, 242 ratios, object sizes, comparing with, 220-221 reading scores, National Assessment of Educational Progress (NAEP), 85f real dollars (defined), 306 real-world situation, equation describing, 16 rebound height (defined), 340 rectangular area, maximizing, 459 recycled paper, 136 reflections function transformation through, 453 across horizontal and vertical axes, 511, 512, 512f, 514 across horizontal axis, 464-465, 511, 512, 548 across vertical axis, 511, 512, 548 region of profit (defined), 189 regions, terminology describing, 183-184, 189 regression analysis, 149 regression line defined, 149, 160 for earnings versus education, 149f, 150f, 156, 159 for fathers' versus sons' heights, 160 interpreting, 145, 153-154 limitations of, 157 mean versus median, 152 reindeer population growth, St. Paul Island, Alaska, 313 relative frequency, 2, 3 representations of data, bias in, 65 restrictions on domains and ranges, 35-37 retirement allowance, annual, determining, 510 revenue (defined), 463 revenue versus costs, 522-523, 523f Richmond, Virginia population growth patterns, 41-42, 41f Richter scale, 243–244, 243t, 245, 359, 379 Rigel (star), 233 rock band, noise level of, 360-361 roller coaster car, speed of, 41 roots as fractional exponents, 219, 235-238, 239-240, 255 roots of quadratic functions, 485, 486 rope and pole, frictional force between, 242 rope, breaking strenth of, 242 rounding off numbers, 223 rubber ducky race, 91 rule of 70, 301–303, 321, 336, 366 running, calories burned from, 206t Ryan, Nolan, 576 Sagan, Carl, 247

sales tax in Canada, 135 function, 534–535, 537 price, calculating based on, 534–535 in U.S., 23, 24, 93 salinity, freezing point as function of, 107*t* salt, icing temperature, impact on, 544 SAT scores, female, 70 scale, effect of, 434–437 scale models, 325 scaling factor, 448, 449 scatter plots analyzing, 148-149, 153f for education versus earnings, 148-149 for infant mortality versus literacy rates, 129f for linear models of data, 123 overview of, 13-14, 13f, 14f scientific method, 559, 660 scientific notation, 211, 212, 214-217, 214n2, 223 252 255 scuba diving, rule of, 383, 412-413 sea depth impact on species density, 368 sea ice, melting rate for, 292 sea level, global warming impact on, 553 sea water, pH of, 358t seismic energy, 379 self-similar growth, 433-434 self-similarity (defined), 325 semi-log plots defined, 316f exponential function equations, finding on, 329, 370 of exponential functions, 265, 316-317, 316f, 321, 369-372, 375 of height versus weight data, 431, 432f, 434 and other plots compared, 429, 429f, 430, 443 shampoo, alkaline nature of, 357n shifting function transformation through, 453, 510, 514 horizontal, 465, 466-468, 515-516, 548 vertical, 465-466, 467, 468, 517, 548 short-term interest rate, 119 shot put, 24-26, 25t, 129f, 480 \sum notation, 11 sigmoid (defined), 268 sigmoid curve, 269f, 271f sign of slope variable, 94-95, 95f, 96f, 97 single-family home, median price for, 134 single-variable data describing, 2-7 patterns in, 1 visualizing, 2-6, 49 singularity, 423, 525, 526 "60-second summary," 1, 14–15, 40 size and shape, relationship between, 383, 386-387 skid distance, 393, 396, 521-522 slope average rate of change as, 561-562, 562f calculating, 76-78, 90, 94-97, 100, 110-113, 123, 131 function of. 132 in semi-log plot, 371, 375 undefined, 111 smallpox deaths in Sweden, 138 smokers, percentage of adult, 125-126, 125f, 126*f*, 127*f*, 161*t* smokers, state breakdown of, 100f smoking deaths due to, 319, 319f versus education level, 81f lung cancer due to, 323 Smoots (unit) (defined), 232 snow, pH of, 361

snowplow speed versus snow depth, 101, 101f snow tree cricket, chirps per minute of, 106 soap, alkaline nature of, 357n soap, pH of, 358t SoBig (computer worm), 325 Social Security number function and inverse, 537f soda can, designing, 413-414 solar cooking devices, designing, 455-456 solar energy units consumed, number of, 128t solar system, age of, 261t solar system, radius of, 212t, 220, 233, 242, 246, 261*t*, 316 solar versus conventional heating systems, 165, 166-169.167f solution to equation, estimating from graph, 17-18, 168-169 solution to equation for abstract variables, 16-18, 50 solution to system of linear equations, 168-169, 171-173, 174-177, 201 sound circle, radius of, 554 intensity of, 359-360, 363 perception of, 359, 360t, 361 reduction through walls, 447t speed of, 258, 554 sources of data in graphs, 4 Soviet Union, collapse of, 378 space and time, measuring, 212-217 species density, sea depth impact on, 368 speed calculation formula, 233 and calories per minute, relationship between, 162t skid proportionality to, 393 speed-engine efficiency relationship, 479 sphere circumference of, 538 radius of, 538 velocity in fluid, 397 volume of, 387, 388 sport utility vehicle (SUV) sales, 130f square roots, 235–236 standard plots, 429, 429f, 431 star magnitude, calculating, 363, 381 statistics, selecting and interpreting, 84 steepness, appearance versus magnitude of slope, 97 step functions, 117-118, 118f, 132 stocks and bonds, investing in, 174 stretching, function transformation through, 453, 468, 514, 548 stretching, vertical of graph, 400, 442, 464, 465.510 stroke, neuron loss, average from, 161f strontium-90, decay of, 300-301, 301f, 301t, 337, 374f substitution method of solving system of linear equations, 172-173 subtracting functions, 521, 522-523, 548 sulfuric acid, pH of, 358 sun age of, 261t core, temperature of, 246 Earth distance from, 232, 233, 268 Jupiter distance from, 232 moon distance from, 232

planet distances from, 262-263, 262t, 263t radius of, 212t, 221, 243, 246, 261t Venus distance from, 233 volume of, 221 sun protection factor (SPF), 191 Super Bowl game (2004), 9 supply and demand, 176-177 supply curve, 176, 176*f*, 177 surface area to volume ratio for cubes, 384t, 386, 387, 389 surface area to volume ratio for threedimensional objects (general), 386-387 surface area versus body mass, 434-436, 435f Surtsey (volcanic island), 253, 261t swans, population growth of, 278 swimming, calories burned from, 206t swimming pool, chlorine level in, 296 swimming pool, parabolic roof of, 552 symmetry axis of, 454, 457, 458, 547 of graphs, 423, 424, 442, 512-513, 512f, 514, 548 of parabolas, 458, 547 tables exponential equation solving with, 330t frequency distribution, 8 function representation through, 23, 24-26, 25*t*, 31 linear relationships represented through, 102 - 103tank emptying time, calculating, 418 tank filling time, calculating, 417 tap water, pH of, 246 taxpayers, mean income of, 43, 43f tax plans, 193-198, 209 tax rate schedule for single persons, 210t tax rebates, 9 TC (total cholesterol)/HDL (good cholesterol) ratio, 191 teenagers, Internet use by, 8, 9f temperature functions of, 26f, 28, 106 of object, ambient temperature impact on, 369.520 perceived, humidity impact on, 552 rate of change in Acadia National Park, Maine, 93 speed of sound, impact on, 258 textbook prices, increase in, 325 thorium-230, decay of, 368 thorium-234, 311 3-D objects, representing, 448 thunder, delay following lightning, 554 tides, sun and moon effect on, 416-417 time and acceleration relationship, 411 functions of, 22, 26f, 66-67, 513, 540, 541, 551 and space, measuring, 212-217 tumor diameter growth over, 542, 542f time-distance relationship. See distance-time relationship time series, 125-126 time series graph, 13-14, 13f, 49, 49f time zones, 28 toilets, gallons per flush used by, 207 tomatoes, water requirements for, 551

tornadoes, U.S. fatalities due to, 79f total cholesterol (TC)/good cholesterol (HDL) ratio, 191 toxic plumes, 532 trade balance (defined), 319 trade deficit (defined), 319 traffic flow, measuring, 471-472, 472f traffic flow models, describing, 453 transistors per integrated circuit, increase projections for, 317 triangle area, calculating, 397 tritium, decay of, 312 trout, water temperature, optimal for, 119 tub, water level in, 61f tuition revenue, quadratic model for, 456 turning points on graph, 500, 502, 547 TV signal, speed of, 228, 229 two-variable data patterns in, 1 visualizing, 13-15, 49 Tyrannosaurus rex, age and size of, 261t ultraviolet light as electromagnetic radiation, 247 ultraviolet light, wavelengths of, 234 Under Armour sports clothing company, profit increase of, 296 unemployment rate, 81f, 156 union membership, U.S., 164t unit conversions in metric system, 230-231 unit conversions, metric to English, 211, 212t, 567 unit costs, 524 United Kingdom, motor vehicles in, 324 United Kingdom population growth projection (1798) for, 308-309 in 2002, 309 in 2006, 225 units of measurement in graphs, 4 universe age of, 216-217, 216t, 261t edge of, 268 object sizes in, 212, 212t, 244f, 261t, 316 radius of, 242, 261t University of Massachusetts parking fee increases, proposed, 278 unmarried mothers, births to. 270 upward velocity, 569-570 uranium-238, decay of, 311, 348 urban population, growth projection for, 291 U.S. area in square miles, 225 U.S. Army sleeping bags, 184-185 U.S. bicycle use, 51f U.S.-Canadian exchange rate, 135, 544 U.S. Census data, 145, 146, 147t, 157 U.S.-Chinese exchange rate, 55t U.S. dollars versus euros, 107, 110, 545 U.S. GDP, increase in, 326f U.S. government debt, 47, 47f, 220-221, 315t, 523-524 U.S. health care costs, 130t, 374t U.S. infant mortality rates, 129f, 297, 439f U.S. international trade, 69t, 319t, 376f, 376t U.S. life expectancy, 71t, 137f U.S. military sales to foreign governments, 47, 47f U.S. natural gas production, 40, 40f

U.S. newspapers, number of, 76

Index 699

U.S. population age of (see age for U.S. population) average rate of change in, 71-73, 72f, 72t, 75t change in, describing, 66-67, 66f-67f, 66t, 68-69, 83-84, 83f, 84f versus China population, 22f coastal inhabitants, percentage in, 136, 138 federal debt per person, 220-221 growth of, 258f, 296, 311f, 311t growth rate, constant, hypothetical, 87, 87f versus Japan population, 225 marital status of, 71t Pittsburgh, PA, and Las Vegas, NV, trends, 170f racial and ethnic composition of, 10f rural to urban shift, 78, 78f versus United Kingdom population, 225 versus world population, 256 U.S. TV stations, commercial, number of, 76 U.S. venture capital, 42, 42f U.S. wireless data service revenues, growth of, 293 variables defined, 2, 50 and functions, 22-23 relationships between, 13-15, 16-18, 24-26, 32-33, 148 velocitv and acceleration relationship, 411 average, 562-563, 562f, 565, 566 of falling body, 559, 562-563, 565-566, 573 Venus, sun distance from, 233 verbal description of linear equation, 101-102 vertex defined, 454, 458, 547 determining, 453, 457, 463-466, 468, 470-472, 475, 489, 547 formula for, 470-472, 474 for parabolic device, 456 vertical asymptotes, 353-354, 420, 423, 442, 516, 525, 526, 548 vertical intercept as constant, 111 defined 90 determining, 101, 124, 126 function of, 94, 97, 131 negative value for, 150 of parabola, 457, 458 of polynomial function, 502, 503f, 507 of regression line, 156 vertical lines, 111, 132 vertical line test, 26, 26f, 33, 35, 50, 149, 539

vibration frequency as function of octaves, vibration frequency as function of string length, 419, 445-446 Vick, Michael, 257 Vietnam, U.S. troop withdrawal from, 79 vinegar, hydrogen ion concentration of, 357 vinegar, pH of, 358t virus, radius of, 218 visible light as electromagnetic radiation, 247 visible-light spectrum, 234 volume, calculating, 387. See also term volume under name of three-dimensional object, e.g.: cube: volume of volume-diameter relationship, 541 volume-pressure relationship, 410-411, 412-413, 413f, 413t, 420t voter turnout data, 137t walking speed and duration, recommended, 200-201 wall insulation cost, calculating, 396 water acidic-alkaline neutrality of, 246 boiling temperature of, 163t, 246 bottled, cost of, 346-347 bottled, per-capita consumption of, 270 density as temperature function, 26f density of, 258 depth-pressure relationship of, 419t hydrogen ion concentration of, 246 (pure), 254 jet of, shooting up, 576 pH of, 357 salinity, freezing point as function of, 107t tap water, pH of, 363 water temperature air temperature relationship to, 81 boiling, altitude relationship to, 163toptimal for trout, 119 wavelength, frequency, relationship to, 247 wavelength, functions of, 26f Weber-Fechner stimulus law, 359n weight, healthy based on height for men, 185-186, 185f, 191 weight, healthy based on height for women, 106.191 weight impact on blood alcohol concentration, 107*t* weight-length relationship, 390 weightlessness in space, 415 weight of children age, function of, 200t versus height, 431-434, 431f, 431t standard growth curve for, 575

weight versus distance from Earth center, 419 wheat, barrel of, 233 wheelchair ramps, slope of, 81 white blood cell count growth, 270, 303-304 Wikipedia, number of articles posted on, 339 wildfire spread, predicting, 453, 544 wind force, 391-392, 392f speed, 447, 532, 544 velocity, 391-392, 392f wind chill effect, 28 wind chill temperature, estimating, 544 wind turbines, power generated by, 445 wine hydrogen ion concentration of, 357 pH of, 247, 358t U.S. consumption of, 128 wolf population, Yellowstone National Park, 50-51, 50f, 52f women long jump world records of, 163f medical degrees awarded to, 129f recommended weight formula for, 106 in U.S. military, 86t wording role in data interpretation, 83-84 work, amount of and income, 156 world energy use, 257 World Health Organization Report 2005, 52 world population average rate of change in, 73f, 73t current, 323 growth, 15, 15f, 313f historical and projected, 48, 48f predicting, 323 in 2004, 256 in 2005, 233, 313f in 2007, 223 World War I, population figure impact of, 73 World War II, water conservation in, 207 xenon gas (Xe-133), 325 X-rays as electromagnetic radiation, 247 X-rays, wavelengths of, 234

Yangtze River (China), length of, 257 Yellowstone National Park wolf population, 50–51, 50*f*, 52*f* Yemen, population of, 57*f* y-intercept. *See* vertical intercept Yugoslavia, inflation rate in, 314

zero as exponent, 226, 240 zero population growth, 268 zero product rule, 481 zeros of function, 485, 503, 507, 547