

Glossary

A

aberration (ab-er-RAY-shun) Distortion in an image produced by a lens. (30.8)

absolute zero The temperature at which a substance has no kinetic energy per particle (thermal) to give up. This temperature corresponds to 0 K, or to -273°C . (21.1, 24.1)

acceleration (ak-sel'-er-RAY-shun) The rate at which velocity is changing. The change may be in magnitude, direction, or both. (4.4)

action force One of the pair of forces described in Newton's third law. (7.2)

additive primary colors Red, blue, and green light. These colors when added together produce white light. (28.5)

adiabatic (ay-dee-ah-BAT-ik) Term applied to expansion or compression of a gas occurring without gain or loss of heat. (24.3)

air resistance Friction, or drag, that acts on something moving through air. (6.4)

alternating current (AC) Electric current that repeatedly reverses direction, twice each cycle. Usually at 60 cycles per second, or hertz (Hz), in North America, or 50 hertz elsewhere. (34.7)

ampere (AM-peer) SI unit of electric current. A flow of one coulomb of charge per second is one ampere (symbol A). (34.2)

amplitude (AMP-lih-tewd) The distance from the midpoint to the maximum (crest) of a wave or, equivalently, from the midpoint to the minimum (trough). (25.2)

aneroid barometer (AN-er-oyd buh-ROM-uh-ter) An instrument used to measure atmospheric pressure; based on the movement of the lid of a metal box. (20.4)

angle of incidence (IN-sih-dens) Angle between an incident ray and the normal to a surface (see Figure 29.3). (29.2)

angle of reflection Angle between a reflected ray and the normal to a surface (see Figure 29.3). (29.2)

angular momentum (mo-MEN-tum) Product of rotational inertia and rotational velocity. (12.4)

antinodes The positions on a standing wave where the largest amplitudes occur. (25.8)

apogee (AP-uh-jee) The point in a satellite's elliptical orbit farthest from the center of Earth. (14.4)

Archimedes' principle (ark-uh-MEE-deez) The relationship between buoyancy and displaced fluid: An immersed object is buoyed up by a force equal to the weight of the fluid it displaces. (19.3)

astigmatism (uh-STIG-muh-tizm) A defect of the eye caused when the cornea is curved more in one direction than in another. (30.7)

atom The smallest particle of an element that can be identified with that element. Consists of protons and neutrons in a nucleus surrounded by electrons. (17.1)

atomic mass number Total number of nucleons (neutrons and protons) in the nucleus of an atom. (39.4)

atomic number Number of protons in the nucleus of an atom. (17.7, 39.4)

average speed Path distance divided by time interval. (4.2)

axis (AK-sis) (a) The straight line around which an object may rotate or revolve. (10.1) (b) A horizontal or vertical reference line in a graph. (Appendix C)

B

barometer An instrument used to measure the pressure of the atmosphere. (20.3)

beats A periodic variation in the loudness of sound caused by interference when two tones of slightly different frequencies are sounded together. (26.10)

Bernoulli's principle (ber-NOO-leez) The statement that the pressure in a fluid decreases as the speed of the fluid increases. (20.7)

bimetallic strip (bi'-meh-TAL'-ik) Two strips of different metals, such as one of brass and one of iron, welded or riveted together into one strip. Because the two substances expand at different rates, when heated or cooled the strip bends. Used in thermostats. (21.8)

black hole A mass that has collapsed to so great a density that its enormous local gravitational field prevents light from escaping. (13.10)

blue shift An increase in the measured frequency of light from an approaching source; called the blue shift because the apparent increase is toward the high-frequency, or blue, end of the color spectrum. Also occurs when an observer approaches a source. (25.9)

boiling The change of phase from liquid to gas that occurs beneath the surface in the liquid. The gas forms bubbles that rise to the surface and escape. (23.4)

bow wave The V-shaped wave produced by an object moving on a liquid surface faster than the wave speed. (25.10)

Boyle's law For a constant number of molecules of gas at constant temperature, the product of pressure and volume is constant. (20.5)

breeder reactor A nuclear fission reactor that not only produces power but produces more nuclear fuel than it consumes by converting a nonfissionable uranium isotope into a fissionable plutonium isotope. (40.5)

Brownian motion The perpetual random movement of microscopic particles suspended in a fluid medium. (17.4)

buoyancy (BOY-un-see) The apparent loss of weight of an object immersed or submerged in a fluid. (19.2)

buoyant force (BOY-unt) The net upward force exerted by a fluid on a submerged or immersed object. (19.2)

C

calorie (KAL-er-ee) A unit of heat. One calorie (symbol cal) is the heat required to raise the temperature of one gram of water one Celsius degree. One Calorie (with a capital C) is equal to one thousand calories and is the unit used in describing the energy available from food. (1 cal = 4.186 J, or 1 J = 0.24 cal) (21.5)

capacitor (kuh-PAS-ih-ter) A device used to store charge in a circuit. (33.6)

Carnot efficiency (KAR-no) The ideal maximum percentage of input energy that can be converted to work in a heat engine. (24.5)

Celsius scale (SEL-see-us) A temperature scale with 0 as the melt-freeze temperature for water and 100 as the boil-condense temperature of water at standard pressure (one atmosphere at sea level). (21.1)

center of gravity The point at the center of an object's weight distribution, where the force of gravity can be considered to act. Abbreviated CG. (11.4)

center of mass The point at the center of an object's mass distribution, where all its mass can be considered to be concentrated. For everyday conditions, it is the same as the center of gravity. (13.3)

centrifugal force (sen-TRIH-fuh-gul) An apparent outward force on a rotating or revolving body. It is fictitious in the sense that it is not part of an interaction but is due to the tendency of a moving body to move in a straight-line path. (10.4)

centripetal force (sen-TRIH-peh-tul) A center-directed force that causes an object to move in a curved (sometimes circular) path. (10.3)

chain reaction A self-sustaining reaction in which one reaction event stimulates one or more additional reaction events to keep the process going. (40.1)

charge The fundamental electrical property to which the mutual attractions or repulsions between electrons or protons is attributed. (32.1)

chemical formula A description that uses numbers and symbols of elements to describe the proportions of elements in a compound or reaction. (17.6)

circuit (SER-kit) Any complete path along which charge can flow. (35.1)

coherent (ko-HEER-ent) As applied to light waves, having identical frequency and identical phase, and traveling in the same direction. Lasers produce coherent light. (31.6)

complementary colors (kom'-pluh-MENT'-uh-ree) Two colors of light beams that when added together appear white. (28.6)

component (kom-PO-nent) One of the vectors, often mutually perpendicular, whose sum is a resultant vector. Any resultant vector may be regarded as the combination of two or more components. (See resultant.) (5.3)

compound A chemical substance made of atoms of two or more different elements combined in a fixed proportion. (17.6)

compression (kom-PRE-shun) (a) In mechanics, the act of squeezing material and reducing its volume. (18.4) (b) In sound, a pulse of compressed air (or other matter); opposite of rarefaction. (26.2)

concave lens A lens that is thinnest in the middle and that causes parallel rays of light to diverge. Also known as a *diverging lens*. (30.1)

condensation (kon'-den-SAY'-shun) The change of phase of a gas into a liquid; the opposite of evaporation. (23.2)

conduction (a) In heat, energy transfer from particle to particle within certain materials, or from one material to another when the two are in direct contact. (22.1) (b) In electricity, the flow of charge through a conductor. (32.4)

conductor (a) Material through which heat can be transferred. (22.1) (b) Material, usually a metal, through which electric charge can flow. Good conductors of heat are generally good charge conductors. (32.4)

conservation of charge The principle that net electric charge is neither created nor destroyed but is transferable from one material to another. (32.2)

conserved Term applied to a physical quantity, such as momentum, energy, or electric charge, that remains unchanged during interactions. (8.4)

constructive interference Addition of two or more waves when wave crests overlap to produce a resulting wave of increased amplitude. (25.7)

convection A means of heat transfer by movement of the heated substance itself, such as by currents in a fluid. (22.2)

converging lens A lens that is thickest in the middle, causing parallel rays of light to converge to a focus. Also known as a *convex lens*. (30.1)

convex lens A lens that is thickest in the middle, causing parallel rays of light to converge or focus. Also known as a *converging lens*. (30.1)

cornea (KOR-nee-uh) The transparent covering over the eyeball. (30.6)

correspondence principle If a new theory is valid, it must account for the verified results of the old theory in the region where both theories apply. (16.3)

coulomb (KOO-lom) SI unit of charge. One coulomb (symbol C) is equal to the total charge of 6.24×10^{18} electrons. (32.3)

Coulomb's law The relationship among electrical force, charges, and distance: The electrical force between two charges varies directly as the product of the charges and inversely as the square of the distance between them. (32.3)

crest One of the places in a wave where the wave is highest or the disturbance is greatest. (25.2)

critical angle The minimum angle of incidence for which a light ray is totally reflected within a medium. (29.12)

critical mass The minimum mass of fissionable material in a nuclear reactor or nuclear bomb that will sustain a chain reaction. (40.1)

crystal (KRIS-tul) A regular geometric shape found in a solid in which the component particles are arranged in an orderly, three-dimensional, repeating pattern. (18.1)

current See *electric current*.

D

density (DEN-sih-tee) A property of a substance, equal to its mass per volume. (18.2)

destructive interference Combination of waves where crests of one wave overlap troughs of another, resulting in a wave of decreased amplitude. (25.7)

diode (DY-ohd) An electronic device that restricts current to flow in a single direction in an electric circuit. (34.8)

diffraction (dih-FRAK-shun) The bending of a wave around a barrier, such as an obstacle or the edges of an opening. (31.2)

diffraction grating A series of closely spaced parallel slits or grooves that are used to separate colors of light by interference. (31.4)

diffuse reflection (dih-FYOOS) The reflection of waves in many directions from a rough surface (see Figure 29.7). (29.4)

direct current (DC) Electric current whose flow of charge is always in one direction. (34.7)

dispersion (dih-SPER-zhun) The separation of light into colors arranged according to their frequency, by interaction with a prism or diffraction grating, for example. (29.10)

diverging lens A lens that is thinnest in the middle and that causes parallel rays of light to diverge. Also known as a *concave lens*. (30.1)

Doppler effect (DOP-ler) The apparent change in frequency of a wave due to the motion of the source or of the receiver. (25.9)

E

eddy Changing, curling paths in turbulent flow of a fluid. (20.7)

efficiency In a machine, the ratio of useful energy output to total energy input, or the percentage of the work input that is converted to work output. (9.9)

elapsed time The time that has passed since the beginning of an event. (4.5)

elastic Term applied to a material that returns to its original shape after it has been stretched or compressed. (18.3)

elastic collision Collision in which colliding objects rebound without lasting deformation or heat generation. (8.5)

elastic limit The distance of stretching or compressing beyond which an elastic material will not return to its original shape. (18.3)

elasticity (ih-las-TIH-sih-tee) The property of a solid wherein a change in shape is experienced when a deforming force acts on it, with a return to its original shape when the deforming force is removed. (18.3)

electric charge See *charge*.

electric current The flow of electric charge; measured in amperes (C/s). (34.2)

electric field A force field that fills the space around every electric charge or group of charges. Measured by force per charge (N/C). (33.1)

electric potential Electrical potential energy per coulomb (J/C) at a location in an electric field; measured in volts and often called voltage. (33.5)

electric power The rate at which electrical energy is converted into another form, such as light, heat, or mechanical energy (or converted from another form into electrical energy). (34.11)

electric resistance The resistance of a material to the flow of electric current through it; measured in ohms (symbol Ω). (34.4)

electrical force A force that one charge exerts on another. When the charges are the same sign, they repel; when the charges are opposite, they attract. (32.1)

electrical potential energy Energy a charge has due to its location in an electric field. (33.4)

electrically polarized Term applied to an atom or molecule in which the charges are aligned so that one side is slightly more positive or negative than the opposite side. (32.7)

electromagnet (ih-lek'-tro-MAG'-net) Magnet with a field produced by electric current; usually in the form of a wire coiled around a piece of iron. (36.5)

electromagnetic induction (ih-lek'-tro-mag-NET'-shun) The phenomenon of inducing a voltage in a conductor by changing the magnetic field near the conductor. (37.1)

electromagnetic spectrum The range of electromagnetic waves extending from radio waves to gamma rays. (27.3)

electromagnetic wave A wave that is partly electric and partly magnetic and carries energy. Emitted by vibrating electric charges. (27.3)

electrostatics (ih-lek'-tro-STAT'-iks) The study of electric charges at rest. (32.0)

element A substance made of only one kind of atom. Examples of elements are carbon, hydrogen, oxygen, and nitrogen. (17.1)

ellipse (ih-LIPS) An oval-shaped curve that is the path of a point that moves such that the sum of its distances from two fixed points (foci) is constant (see Figure 14.8). (14.3)

energy The property of an object or a system that enables it to do work; measured in joules. (9.3)

entropy A measure of the amount of disorder in a system. (24.7)

equilibrium (ee-kwih-LIH-bree-um) See *mechanical equilibrium* or *equilibrium rule*.

equilibrium rule An object is in mechanical equilibrium whenever the net force on the object is zero. (2.2).

escape speed The minimum speed necessary for an object to escape permanently from a gravitational field that holds it. (14.5)

evaporation (ih-vap'-or-AY'-shun) The change of phase from liquid to gas that takes place at the surface of a liquid. (23.1)

excited state A state with greater energy than an atom's lowest state. (28.11)

eyepiece Lens of a telescope closest to the eye; enlarges the real image formed by the first lens. (30.5)

F

fact A close agreement by competent observers of a series of observations of the same phenomena. (1.4)

Fahrenheit scale (FA-ren-hit) The temperature scale in common use in the United States. The number 32 is assigned to the freezing point of water and the number 212 to the boiling point of water (at standard atmospheric pressure). (21.1)

Faraday's law (FA-ruh-dayz) Induced voltage in a coil is proportional to the product of the number of loops and the rate at which the magnetic field changes within those loops. (37.2) In general, an electric field is induced in any region of space in which a magnetic field is changing with time. The magnitude of the induced electric field is proportional to the rate at which the magnetic field changes. (37.7)

farsighted Term applied to a person who has trouble focusing on nearby objects because the eyeball is so short that images form behind the retina. (30.7)

field See *force field*.

first law of thermodynamics Heat added to a system is transformed to an equal amount of some other form of energy; a version of the law of conservation of energy. (24.2)

first postulate of special relativity All the laws of nature are the same in all uniformly moving reference frames. (15.2)

fission See *nuclear fission*.

fluid Anything that flows; in particular, any liquid or gas. (6.4, 19.6)

focal length The distance between the center of a lens and either focal point. (30.1)

focal plane A plane passing through either focal point of a lens that is perpendicular to the principal axis. For a converging lens, any incident parallel beam of light converges to a point somewhere on a focal plane. For a diverging lens, such a beam appears to come from a point on a focal plane. (30.1)

focal point For a converging lens, the point at which a beam of light parallel to the principal axis converges. For a diverging lens, the point from which such a beam appears to come. (30.1)

focus (FO-kus); pl. **foci** (FO-si) (a) For an ellipse, one of the two points for which the sum of the distances to any point on the ellipse is a constant. A satellite orbiting Earth moves in an ellipse that has Earth at one focus. (14.3) (b) For optics, the point where parallel light rays converge. (30.1)

force Any influence that tends to accelerate an object; a push or pull; measured in newtons. A vector quantity. (2.1)

forced vibration The vibration of an object that is made to vibrate by another vibrating object that is nearby. The sounding board in a musical instrument amplifies the sound through forced vibration. (26.7)

force field That which exists in the space surrounding a mass, electric charge, or magnet, so that another mass, electric charge, or magnet introduced to this region will experience a force. Examples of force fields are gravitational fields, electric fields, and magnetic fields. (13.1)

free-body diagram A diagram showing all the forces acting on an object. (6.4)

free fall Motion under the influence of the gravitational force only. (4.5)

freezing Change in phase from liquid to solid. (23.5)

frequency (FREE-kwen-see) The number of events (cycles, vibrations, oscillations, or any repeated event) per time; measured in hertz (or events per time). Inverse of period. (25.2)

friction The force that acts to resist the relative motion (or attempted motion) of objects or materials that are in contact. (3.3)

fuel cell A device in which hydrogen and oxygen are compressed at electrodes to produce water and electric current. (9.10)

fulcrum (FOOL-krum) The pivot point of a lever. (9.8)

fusion See *nuclear fusion*.

G

- geodesics** Lines of shortest distance between two points in curved space. (16.5)
- general theory of relativity** Einstein's generalization of special relativity, where gravity causes space to become curved and time to slow down. (16.3)
- generator** A machine that produces electric current by rotating a coil within a stationary magnetic field. (37.3)
- global warming** See *greenhouse effect*.
- gravitational field** (grav'-ih-TAY'-shun-ul) A force field that exists in the space around every mass or group of masses. (13.1)
- gravitational shift** A slight decrease in the frequency of light due to the effect of strong gravitational fields, such as those of stars. (16.6)
- gravitational waves** Ripples that travel outward from gravitational sources at the speed of light. (16.5)
- greenhouse effect** The warming effect whose cause is that short-wavelength radiant energy from the sun can enter the atmosphere and be absorbed by Earth more easily than long-wavelength energy from Earth can leave. (22.7)
- grounding** Allowing charges to move freely along a connection between a conductor and the ground. (32.6)
- group** Elements in the same column of the periodic table. (17.8)

H

- half-life** The time required for half the atoms of a radioactive isotope of an element to decay. Also used for decay processes in general. (39.5)
- heat** Energy transfer from one object to another because of a temperature difference. (21.2)
- heat engine** A device that changes internal energy to mechanical work. (24.5)
- heat pump** A device that moves heat. (23.8)
- hertz (HERTZ)** The SI unit of frequency. One hertz (Hz) is one cycle per second. (25.2)
- hologram (HOL-uh-gram)** A three-dimensional version of a photograph produced by interference patterns of laser beams. (31.7)

Hooke's law The distance of stretch or squeeze (extension or compression) of an elastic material is directly proportional to the applied force. (18.3)

Huygens' principle (HI-gunz) Every point on any wave front can be regarded as a new point source of secondary waves. (31.1)

hypothesis (hi-POTH-uh-sis) An educated guess; a reasonable explanation of an observation or experimental result that is not fully accepted as factual until tested over and over again by experiment. (1.4)

impulse (IM-puls) Product of force and time interval during which the force acts. Impulse equals momentum change. (8.2)

incoherent (in'-ko-HEER'-ent) As applied to light waves, having a jumbled mixture of frequency, phase, and possibly direction. (31.6)

induced (in-DEWSD) (a) Term applied to electric charge that has been redistributed on an object because of the presence of a charged object nearby. (32.6) (b) Term applied to a voltage, electric field, or magnetic field that is created due to a change in or motion through a magnetic field or electric field. (37.1, 37.7)

induction (in-DUK-shun) The charging of an object without direct contact. (32.6) See also *electromagnetic induction*.

inelastic Term applied to a material that does not return to its original shape after it has been stretched or compressed. (Also called plastic.) (18.3)

inelastic collision A collision in which the colliding objects become tangled or coupled together, distorted and/or generate heat during the collision. (8.5)

inertia (ih-NER-shuh) The property of any body to resist changes in its state of motion. Mass is the measure of inertia. (3.3)

infrared Electromagnetic waves of frequencies lower than the red of visible light. (27.3)

infrasonic (in'-fruh-SON'-ik) Term applied to sound pitch too low to be heard by the human ear, that is, below 20 hertz. (26.1)

in parallel Term applied to portions of an electric circuit that are connected at two points and provide alternative paths for the current between those two points. (35.2)

in phase (FAYZ) Term applied to two or more waves whose crests (and troughs) arrive at a place at the same time, so that their effects reinforce each other. (25.7)

in series Term applied to portions of an electric circuit that are connected in a row so that the current that goes through one must go through all of them. (35.2)

instantaneous speed (in-stan-TAY-nee-us) Speed at any instant of time. (4.2)

insulator (IN-suh-lay-ter) (a) A material that is a poor conductor of heat and that delays the transfer of heat. (22.1) (b) A material that is a poor conductor of electricity. (32.4)

interaction A mutual action between objects where each object exerts an equal and opposite force on the other. (7.1)

interference pattern (in'-ter-FEER'-ens) A pattern formed by the overlapping of two or more waves that arrive in a region at the same time. (25.7)

internal energy The total energy stored in the atoms and molecules within a substance. (21.4)

inverse-square law A physical quantity varies inversely as another quantity squared. Example: Illumination varies inversely as the square of the distance from the source. (3.5)

inversely When two values change in opposite directions, so that if one increases the other decreases. (6.2)

ion (I-un) An atom (or group of atoms bound together) with a net electric charge, which is due to the loss or gain of electrons. (17.8)

iridescence (ih-rih-DES-ens) The phenomenon whereby interference of light waves of mixed frequencies reflected from the top and bottom of thin films produces a spectrum of colors. (31.5)

iris (I-ris) The colored part of the eye that surrounds the black opening through which light passes. The iris regulates the amount of light entering the eye. (30.6)

isotope (I-suh-top) A form of an element having a particular number of neutrons in the nuclei of its atoms. Different isotopes of a particular element have the same atomic number but different atomic mass numbers. (17.7, 39.4)

J

joule (JOOl) The SI unit of work and of all other forms of energy. One joule (symbol J) of work is done when a force of one newton is exerted on an object moved one meter in the direction of the force. (9.1)

K

kelvin (KEL-vin) The SI unit of temperature. A temperature measured in kelvins (symbol K) indicates the number of units above absolute zero. Since the divisions on the Kelvin scale and Celsius scale are the same size, a change in temperature of one kelvin equals a change in temperature of one Celsius degree. (21.1)

Kelvin scale A temperature scale whose zero (called absolute zero) is assigned to the lowest temperature possible. $0\text{ K} = -273^\circ\text{C}$. There are no negative temperatures on the Kelvin scale. (21.1)

kilocalorie (KIL-o-kal-er-ee) A unit of heat. One kilocalorie equals 1000 calories, or the amount of heat required to raise the temperature of one kilogram of water by 1°C . (21.5)

kilogram (KIL-o-gram) The fundamental SI unit of mass. One kilogram (symbol kg) is the amount of mass in one liter of water at 4°C . See *Appendix A*. (3.5)

kinetic energy (kih-NET-ik) Energy of motion, equal to half the mass multiplied by the speed squared. (9.5)

L

laser (LAY-zer) An optical instrument that produces a beam of coherent light—that is, having the waves all the same frequency, phase, and direction. (31.6)

law A general hypothesis or statement about the relationship of natural quantities that has been tested over and over again and has not been contradicted. Also known as a principle. (1.4)

law of conservation of angular momentum An object or system of objects will maintain a constant angular momentum unless acted upon by an unbalanced external torque. (12.5)

law of conservation of energy Energy cannot be created or destroyed. It may be transformed from one form into another, but the total amount of energy never changes. (9.6)

law of conservation of momentum In the absence of a net external force, the momentum of an object or system of objects is unchanged. (8.4)

law of inertia Every body continues in its state of rest, or of motion in a straight line at constant speed, unless acted upon by a nonzero force. Also known as *Newton's first law*. (3.4)

law of reflection The angle of incidence for a wave that strikes a surface is equal to the angle of reflection. This is true for both partially and totally reflected waves. (29.2)

law of universal gravitation For any pair of objects, each object attracts the other object with a force that is directly proportional to the product of the masses of the objects, and inversely proportional to the square of the distance between their centers of mass. (3.4)

length contraction The observable shortening of objects moving at speeds approaching the speed of light. (15.6)

lens (LENZ) A piece of glass (or other transparent material) that can bend parallel rays of light so that they cross, or appear to cross, at a single point. (30.1)

lever (LEH-ver, LEE-ver) A simple machine, made of a bar that turns about a fixed point. (9.8)

lever arm The perpendicular distance between an axis and the line of action of a force that tends to produce rotation about that axis. (11.1)

lift In application of Bernoulli's principle, the net upward force produced by the difference between upward and downward pressures. When lift equals weight, horizontal flight is possible. (20.8)

light-year The distance light travels through a vacuum during one year. (27.2)

line spectrum A pattern of distinct lines of color, corresponding to particular wavelengths, that are seen in a spectroscope when a hot gas is viewed. (28.11)

linear momentum Product of the mass and the velocity of an object. Also called momentum. (This definition applies at speeds much less than the speed of light.) (12.4)

linear speed The path distance moved per unit of time. Also called simply speed. (10.2)

longitudinal wave (lon-jih-TEWD-ih-nul) A wave in which the vibration is in the same direction as that in which the wave is traveling, rather than at right angles to it. (25.6)

M

machine A device for increasing (or decreasing) a force or simply changing the direction of a force. (9.8)

magnetic domain A microscopic cluster of atoms with their magnetic fields aligned. (36.4)

magnetic field A force field that fills the space around every magnet or current-carrying wire. (36.2)

magnetic pole One of the regions on a magnet that produces magnetic forces. (36.1)

mass A measure of an object's inertia; also a measure of the amount of matter in an object. Depends only on the amount of and kind of particles that compose an object—not on its location (as weight does). (3.5)

mechanical advantage The ratio of output force to input force for a machine. (9.8)

mechanical energy The energy due to the position or the movement of something; potential or kinetic energy (or a combination of both). (9.3)

mechanical equilibrium A state wherein no physical change occurs. (2.2)

mirage (mih-RAHZH) A floating image that appears in the distance and is due to the refraction of light in Earth's atmosphere. (29.9)

molecule (MOL-uh-kyool) The smallest particle of substance consisting of two or more atoms of the same or different elements bonded together. (17.5)

momentum The product of the mass and the velocity of an object (provided the speed is much less than the speed of light). Has magnitude and direction (a vector quantity). Also called linear momentum. (8.1)

monochromatic (mon'-o-kro-MAT'-ik) Having a single color or frequency. (31.4)

N

natural frequency A frequency at which an elastic object, once energized, will vibrate. Minimum energy is required to continue vibration at that frequency. Also called resonant frequency. (26.6)

neap tide A tide that occurs when the moon is halfway between a new moon and a full moon, in either direction. The tides due to the sun and the moon partly cancel, so that the high tides are lower than average and the low tides are not as low as average. (13.9)

nearsighted Term applied to a person who can clearly see nearby objects but not clearly see distant objects. The eyeball is elongated so that images focus in front of rather than on the retina. (30.7)

net force The combination of all the forces that act on an object. (2.1)

neutral equilibrium The state of an object balanced so that any small movement neither raises nor lowers its center of gravity. (11.7)

neutron An electrically neutral particle that is one of the two kinds of particles that compose an atomic nucleus. (17.7)

newton SI unit of force. One newton (N) is the force applied to a one-kilogram mass that will produce an acceleration of one meter per second per second. (3.5)

Newton's first law See *law of inertia*.

Newton's law of cooling The rate of cooling of an object—whether by conduction, convection, or radiation—is approximately proportional to the temperature difference between the object and its surroundings. (22.6)

Newton's second law The acceleration produced by a net force on a body is directly proportional to the magnitude of the net force, is in the same direction as the net force, and is inversely proportional to the mass of the body. (6.3)

Newton's third law Whenever one body exerts a force on a second body, the second body exerts an equal and opposite force on the first. (7.2)

node Any part of a standing wave that remains stationary. (25.8)

normal A line perpendicular to a surface. (29.2)

normal force For an object resting on a horizontal surface, the upward force that balances the weight of the object; also called the support force. (2.3)

nuclear fission (FIH-shun) The splitting of an atomic nucleus, particularly that of a heavy element such as uranium-235, into two main parts accompanied by the release of much energy. (40.1)

nuclear fusion (FEW-zhun) The combining of nuclei of light atoms, such as hydrogen, into heavier nuclei accompanied by the release of much energy. (40.7)

nucleon (NEW-klee-on) The principal building block of the nucleus; a neutron or a proton. (17.7, 39.1)

nucleus The positively charged center of an atom, which contains protons and neutrons and has almost all the mass of the entire atom but only a tiny fraction of the volume. (17.7)

neutron An electrically neutral particle that is one of the two kinds of particles found in the nucleus of an atom. (17.7)



objective lens In an optical device using compound lenses, the lens closest to the object observed. (30.5)

ohm (OM) The SI unit of electric resistance. One ohm (symbol Ω) is the resistance of a device that draws a current of one ampere when a voltage of one volt is impressed across it. (34.4)

Ohm's law The statement that the current in a circuit is directly proportional to the voltage impressed across the circuit, and is inversely proportional to the resistance of the circuit. (34.5)

opaque Term applied to materials that absorb light without reemission, and consequently do not allow light through them. (27.5)

optical fiber A transparent fiber, usually of glass or plastic, that can transmit light down its length by means of total internal reflection. (29.12)

out of phase Term applied to two waves for which the crest of one wave arrives at a point at the same time that a trough of the second wave arrives. Their effects cancel each other. (25.7)




parallel circuit An electric circuit in which devices are connected to the same two points of the circuit, so that any single device completes the circuit independently of the others. (35.4)

pascal (pas-KAL) The SI unit of pressure. One pascal (symbol Pa) of pressure exerts a normal force of one newton per square meter. (6.5)

Pascal's principle Changes in pressure at any point in an enclosed fluid at rest are transmitted undiminished to all points in the fluid and act in all directions. (19.6)

penumbra A partial shadow that appears where light from part of the source is blocked and light from another part of the source is not blocked. (27.6)

perigee (PEH-rih-jee) The point in a satellite's elliptical orbit where it is nearest the center of Earth. (14.4)

- period** (a) The time required for a complete orbit. (14.2) (b) The time required for a pendulum to make one to-and-fro swing. In general, the time required to complete a single cycle. (25.1)
- periodic table** A chart that lists elements by atomic number and by electron arrangements, so that elements with similar chemical properties are in the same column (Figure 17.12). (17.8)
- perturbation** The deviation of an orbiting object from its path around a center of force caused by the action of an additional center of force. (13.11)
- phase** One of the four possible forms of matter: solid, liquid, gas, and plasma. Often called state. (23.0)
- photoelectric effect** The ejection of electrons from certain metals when exposed to certain frequencies of light. (38.3)
- photon** (FO-ton) In the particle model of electromagnetic radiation, a particle that travels only at the speed of light and whose energy is related to the frequency of the radiation in the wave model. (27.1, 38.2)
- pigment** A material that selectively absorbs colored light. (28.3)
- pitch** Term that refers to how high or low sound frequencies appear to be. (26.1)
- Planck's constant** A fundamental constant of quantum theory that determines the scale of the small-scale world. Planck's constant (symbol h) multiplied by the frequency of radiation gives the energy of a photon of that radiation. (38.2)
- plasma** (PLAZ-muh) A fourth phase of matter, in addition to solid, liquid, and gas. In the plasma phase, which exists mainly at high temperature, matter consists of positively charged ions and free electrons. (17.9)
- polarization** (po-ler-ih-ZAY'-shun) The aligning of vibrations in a transverse wave, usually by filtering out waves of other directions. (27.7)
- postulate** (POS-tyoo-lit) A fundamental assumption. (15.1)
- potential** See *electric potential*.
- potential difference** The difference in electric potential (voltage) between two points. Free charge flows when there is a difference and will continue until both points reach a common potential. (34.1)
- potential energy** Energy of position, usually related to the relative position of two things, such as a stone and Earth, or an electron and a nucleus. (9.4)
- power** Rate at which work is done or energy is transformed, equal to the work done or energy transformed divided by time; measured in watts. (8.2)
- pressure** Force per unit of surface area where the force is perpendicular to the surface; measured in pascals. (6.5)
- principal axis** The line joining the centers of curvature of the surfaces of a lens. (30.1)
- principle** A general hypothesis or statement about the relationship of natural quantities that has been tested over and over again and has not been contradicted; also known as a law. (1.4)
- principle of equivalence** Local observations made in an accelerated frame of reference cannot be distinguished from observations made in a Newtonian gravitational field. (16.4)
- projectile** Any object that moves through the air or through space, acted on only by gravity (and air resistance, if any). (5.4)
- proton** A positively charged particle that is one of the two kinds of particles found in the nucleus of an atom. (17.7)
- pulley** A type of lever that is a wheel with a groove in its rim, which is used to change the direction of a force exerted by a rope or cable. A pulley or system of pulleys can also multiply forces. (9.8)
- pupil** The opening in the eyeball through which light passes. (30.6)
-  **quantum** (pl. quanta) (KWONT-um) The fundamental "size" unit; the smallest amount of anything. One quantum of light energy is called a photon. (38.2)
- quantum mechanics** The branch of physics that is the study of the motion of particles in the microworld of atoms and nuclei. (38.8)
- quantum physics** The branch of physics that is the general study of the microworld of photons, atoms, and nuclei. (38.8)

R

radiant energy Any energy, including heat, light, and X-rays, that is transmitted by radiation. It occurs in the form of electromagnetic waves. (22.3)

radiation (a) Energy transmitted by electromagnetic waves. (22.3) (b) The charged particles and energy given off by radioactive atoms such as uranium. (39.2)

radioactive Term applied to an atom with a nucleus that is unstable and that can spontaneously emit a particle and become the nucleus of another element. (39.2)

rarefaction (rayr-uh-FAK-shun) A disturbance in air (or matter) in which the pressure is lowered. Opposite of compression. (26.2)

ray A thin beam of light. (27.6)

ray diagram A diagram showing rays that can be drawn to determine the size and location of an image formed by a mirror or lens. (30.3)

reaction force The force that is equal in strength and opposite in direction to the action force, which acts simultaneously on whatever is exerting the action force. (7.2)

real image An image that is formed by converging light rays and that can be displayed on a screen. (30.2)

red shift A decrease in the measured frequency of light (or other radiation) from a receding source; called the red shift because the decrease is toward the low-frequency, or red, end of the color spectrum. (25.9)

reflection The bouncing back of a particle or wave that strikes the boundary between two media. (29.1)

refraction The change in direction of a wave as it crosses the boundary between two media in which the wave travels at different speeds. (29.6)

regelation The phenomenon of ice melting under pressure and freezing again when the pressure is reduced. (23.7)

relative Regarded in relation to something else. Depends on point of view, or frame of reference. Sometimes referred to as "with respect to." (4.1)

relative humidity A ratio between how much water vapor is in the air and the maximum amount of water vapor that could be in the air at the same temperature. (23.2)

relativistic momentum Momentum at very high speeds approaching the speed of light. (16.1)

resolution (rez-uh-LOO-shun) (a) The process of resolving a vector into components. (5.3) (b) In optics, a measure of how well closely adjacent optical images are distinguished.

resonance (REZ-uh-nuns) A phenomenon that occurs when the frequency of forced vibrations on an object matches the object's natural frequency, and a dramatic increase in amplitude results. (26.8)

rest energy The "energy of being," given the equation $E = mc^2$. (16.2)

rest mass The intrinsic mass of an object, a fixed property independent of speed or energy. (16.1)

resultant (rih-ZUL-tunt) The vector sum of two or more component vectors. (2.5)

retina (RET-ih-nuh) The layer of light-sensitive tissue at the back of the eye. (30.6)

reverberation (rih-verb-er-AY-shun) Persistence of a sound, as in an echo, due to multiple reflections. (29.5)

revolution Motion of an object turning around an axis outside the object. (10.1)

rotation The spinning motion that takes place when an object rotates about an axis located within the object (usually an axis through its center of mass). (10.1)

rotational inertia The resistance of an object to changes in its state of rotation, determined by the distribution of the mass of the object and the location of the axis of rotation or revolution. (12.1)

rotational speed The number of rotations or revolutions per unit of time; often measured in rotations or revolutions per second or per minute (RPM). (10.2)

rotational velocity Rotational speed together with a direction for the axis of rotation or revolution. (12.4)

S

satellite An object that falls around Earth or some other body rather than falling into it. (14.1)

saturated Term applied to a substance, such as air, that contains the maximum amount of another substance, such as water vapor, at a given temperature and pressure. (23.2)

- scalar quantity** A quantity in physics, such as mass, volume, and time, that can be completely specified by its magnitude, and has no direction. (2.1)
- scaling** The study of how size affects the relationship among weight, strength, and surface area. (18.5)
- scattering** A process in which sound or light is absorbed and reemitted in all directions. (28.8)
- schematic diagram** A diagram that describes an electric circuit, using special symbols to represent different devices in the circuit. (35.5)
- scientific method** An orderly method for gaining, organizing, and applying new knowledge. (1.3)
- second law of thermodynamics** Heat will never of itself flow from one object to another of higher temperature. (24.4)
- second postulate of special relativity** The speed of light in empty space always has the same value regardless of the motion of the source or the motion of the observer. (15.3)
- semiconductor** Material that can be made to behave as either a conductor or an insulator of electricity. (32.4)
- series circuit** An electric circuit in which devices are arranged so that charge flows through each in turn. If one part of the circuit should stop the current, it will stop throughout the circuit. (35.3)
- shadow** A shaded region that results when light falls on an object and thus cannot reach into the region on the far side of the object. (27.6)
- shell model of the atom** A model in which the electrons of an atom are pictured as grouped in concentric shells around the nucleus. (17.8)
- shock wave** A cone-shaped wave produced by an object moving at supersonic speed through a fluid. (25.11)
- simple harmonic motion** The back-and-forth vibratory motion of a swinging pendulum. (25.2)
- sine curve** A curve whose shape represents the crests and troughs of a wave, as traced out by a swinging pendulum that drops a trail of sand over a moving conveyor belt. (25.2)
- sonic boom** The sharp crack heard when the shock wave that sweeps behind a supersonic aircraft reaches the listener. (25.11)
- space-time** A combination of space and time, which are viewed in special relativity as two parts of one whole. (15.1)
- special theory of relativity** The theory, introduced in 1905 by Albert Einstein, that describes how time is affected by motion in space at a constant velocity, and how mass and energy are related. (15.1)
- specific gravity** The ratio of the mass (or weight) of a substance to the mass (or weight) of an equal volume of water. (18.2)
- specific heat capacity** The quantity of heat required to raise the temperature of a unit mass of a substance by one degree Celsius. Often simply called "specific heat" or "heat capacity." (21.6)
- spectroscope** An instrument used to separate the light from a hot gas or other light source into its constituent frequencies. (28.11)
- spectrum** For sunlight and other white light, the spread of colors seen when the light is passed through a prism or diffraction grating. In general, the spread of radiation by frequency, so that each frequency appears at a different position. (28.1)
- speed** How fast something is moving; the path distance moved per time. The magnitude of the velocity vector. (4.2)
- spring tide** A high or low tide that occurs when the sun, Earth, and the moon are all lined up so that the tides due to the sun and moon coincide, making the high tides higher than average and the low tides lower than average. (13.9)
- stable equilibrium** The state of an object balanced so that any small displacement or rotation raises its center of gravity. (11.7)
- standing wave** Wave in which parts of the wave remain stationary and the wave appears not to be traveling. The result of interference between an incident (original) wave and a reflected wave. (25.8)
- stellar radiation** The radiant energy emitted by the stars. (22.4)
- streamline** The smooth path of a small region of fluid in steady flow. (20.7)
- strong force** The force that attracts nucleons to one another within the nucleus; a force that is very strong at close distances but decreases rapidly as the distance increases. (39.1)

subtractive primary colors The colors of magenta, yellow, and cyan. These are the three colors most useful in color mixing by subtraction. (28.7)

superconductivity A property of a material that has infinite conductivity at very low temperatures, so that charge flows through it without resistance. (34.4)

support force The upward force that balances the weight of an object on a surface; also called normal force. (2.3)

T

tangential speed The speed of an object moving along a circular path. (10.2)

temperature The property of a material that tells how warm or cold it is relative to some standard. In an ideal gas, the molecular kinetic energy per molecule. (21.1)

terminal speed The speed at which the acceleration of a falling object is zero because friction balances the weight. (6.7)

terminal velocity Terminal speed together with the direction of motion (down for falling objects). (6.7)

terrestrial radiation Radiant energy emitted from Earth. (22.7)

theory A synthesis of a large body of information that encompasses well-tested and verified hypotheses about aspects of the natural world. (1.4)

thermal contact The state of two or more objects or substances in contact such that it is possible for heat to flow from one object or substance to another. (21.2)

thermal equilibrium The state of two or more objects or substances in thermal contact when they have reached the same temperature. (21.3)

thermodynamics The study of heat and its transformation to mechanical energy. (24.0)

thermonuclear fusion Nuclear fusion brought about by extremely high temperatures. (40.7)

thermostat A type of valve or switch that responds to changes in temperature and that is used to control the temperature of something. (21.8)

third law of thermodynamics No system can reach absolute zero. (24.4)

time dilation An observable stretching, or slowing, of time in a frame of reference moving past the observer at a speed approaching the speed of light. (15.4)

torque (TORK) The rotational analog of force; the product of force and the lever arm (measured in newton-meters). Torque tends to produce rotational acceleration. (11.1)

total internal reflection The 100% reflection (with no transmission) of light that strikes the boundary between two media at an angle greater than the critical angle. (29.12)

transformer A device for increasing or decreasing voltage through electromagnetic induction. (37.5)

transmutation The changing of one element into another element through a loss or gain in the number of protons. (39.6)

transparent Term applied to materials that allow light to pass through them in straight lines. (27.4)

transverse wave A wave with vibration at right angles to the direction the wave is traveling. (25.5)

trough (TRAWF) One of the places in a wave where the wave is lowest, or the disturbance is greatest, in the opposite direction from a crest. (25.2)

U

ultrasonic Term applied to sound frequencies above 20,000 hertz, the normal upper limit of human hearing. (26.1)

ultraviolet Electromagnetic waves of frequencies higher than those of violet light. (27.3)

umbra The darker part of a shadow where all the light is blocked. (27.6)

unstable equilibrium The state of an object balanced so that any small displacement or rotation lowers its center of gravity. (11.7)

universal gravitational constant The constant G in the equation for Newton's law of universal gravitation; measures the strength of gravity. (3.4)

V

vector An arrow whose length represents the magnitude of a quantity and whose direction represents the direction of the quantity. (2.1)

vector quantity A quantity in physics, such as force, that has both magnitude and direction. (2.1)

velocity Speed together with the direction of motion. (4.3)

vibration An oscillation, or repeating back-and-forth motion, about an equilibrium position. (25.0)

virtual image An image formed through reflection or refraction that can be seen by an observer but cannot be projected on a screen because light from the object does not actually come to a focus. (29.3, 30.2)

volt The SI unit of electric potential. One volt (symbol V) is the electrical potential difference across which one coulomb of charge gains or loses one joule of energy. (33.5)

voltage (VOL-tij) (a) Electric potential; measured in volts. (33.5) (b) Potential difference; measured in volts. (34.1)

voltage source A device, such as a battery or generator, that provides a potential difference. (34.3)

W

watt (WAT) The SI unit of power. One watt is expended when one joule of work is done in one second. (9.2)

wave A disturbance that repeats regularly in space and time and that is transmitted progressively from one place to the next with no actual transport of matter. (25.0)

wave front The crest, trough, or any continuous portion of a two-dimensional or three-dimensional wave in which the vibrations are all the same way at the same time (see Figure 29.14). (29.6)

wavelength The distance from the top of the crest of a wave to the top of the following crest, or equivalently, the distance between successive identical parts of the wave. (25.2)

weight The force on a body due to the gravitational attraction of another body (commonly Earth). (3.5)

weightlessness The condition of free fall toward or around Earth, in which an object experiences no support force (and exerts no force on a scale). (13.5)

weight density The weight of a substance divided by its volume. (18.2)

white light Light, such as sunlight, that is a combination of all the colors. Under white light, white objects appear white and colored objects appear in their individual colors. (28.1)

work The product of the force on an object and the distance through which the object is moved (when force is constant and motion is in a straight line in the direction of the force); measured in joules. (9.1)

work-energy theorem The theorem that states that whenever work is done, energy changes. (9.5)