

Glossary

absolute zero | the lowest possible temperature; the temperature at which all molecular motion ceases

AC current | current that fluctuates sinusoidally with time.

AC voltage | voltage that fluctuates sinusoidally with time.

acceleration | the rate of change in velocity; the change in velocity over time

acceleration due to gravity | acceleration an object undergoes while in free-fall

activity | the rate of decay for radioactive nuclides

adiabatic process | a process in which no heat transfer takes place

air resistance | a frictional force that slows the motion of objects as they travel through the air; when solving basic physics problems, air resistance is assumed to be zero

alpha decay | type of radioactive decay in which an atomic nucleus emits an alpha particle

alpha ray | a component of nuclear radioactivity; consists of two protons and two neutrons

alternating current | (AC) the flow of electric charge that periodically reverses direction

ampere | (amp) the SI unit for current; $1 \text{ A} = 1 \text{ C/s}$

Ampere's law | the physical law that states that the magnetic field around an electric current is proportional to the current; each segment of current produces a magnetic field like that of a long straight wire, and the total field of any shape current is the vector sum of the fields due to each segment

amplitude | the maximum displacement from the equilibrium position of an object oscillating around the equilibrium position

amplitude | the height, or magnitude, of an electromagnetic wave

amplitude modulation (AM) | a method for placing information on electromagnetic waves by modulating the amplitude of a carrier wave with an audio signal, resulting in a wave with constant frequency but varying amplitude

Anger camera | a common medical imaging device that uses a scintillator connected to a series of photomultipliers

angular acceleration | the rate of change of angular velocity with time

angular momentum | the product of moment of inertia and angular velocity

angular velocity | the rate of change of angular position with time

antielelectron | decay series

antimatter | composed of antiparticles

antinode | the location of maximum amplitude in standing waves

apparent weight | sensation of weight due to contact forces; usually the same as normal force

Archimedes' principle | the buoyant force on an object equals the weight of the fluid it displaces

atomic mass | the total mass of the protons, neutrons, and electrons in a single atom

atomic number | number of protons in a nucleus

audible range | frequencies between 20 Hz and 20,000 Hz

average acceleration | the change in velocity divided by the time over which it changes

average speed | distance traveled divided by time during which motion occurs

average velocity | displacement divided by time over which displacement occurs

axis of a polarizing filter | the direction along which the filter passes the electric field of an EM wave

B-field | another term for magnetic field

banked curve | the curve in a road that is sloping in a manner that helps a vehicle negotiate the curve

baryon number | a conserved physical quantity that is zero for mesons and leptons and ± 1 for baryons and antibaryons, respectively

baryons | hadrons that always decay to another baryon

beat frequency | the frequency of the amplitude fluctuations of a wave

becquerel | half-life

Bernoulli's equation | the equation resulting from applying conservation of energy to an incompressible frictionless fluid: $P + 1/2\rho v^2 + \rho gh = \text{constant}$, through the fluid

Bernoulli's principle | Bernoulli's equation applied at constant depth: $P_1 + 1/2\rho v_1^2 = P_2 + 1/2\rho v_2^2$

beta decay | type of radioactive decay in which an atomic nucleus emits a beta particle

beta ray | a component of nuclear radioactivity; consists of an electron

Biot-Savart law | a physical law that describes the magnetic field generated by an electric current in terms of a specific equation

birefringent | crystals that split an unpolarized beam of light into two beams

blackbody | an ideal radiator, which emits thermal radiation ideally and absorbs all radiation incident on it at all wavelengths

blackbody radiation | a thermal radiation, usually modeled for a blackbody

Bohr radius | the mean radius of the orbit of an electron around the nucleus of a hydrogen atom in its ground state

Boltzmann constant | k , a physical constant that relates energy to temperature; $k = 1.38 \times 10^{-23} \text{ J/K}$

boson | particle with zero or an integer value of intrinsic spin

bow wake | V-shaped disturbance created when the wave source moves faster than the wave propagation speed

break-even | when fusion power produced equals the heating power input

breeder reactors | reactors that are designed specifically to make plutonium

breeding | reaction process that produces ^{239}Pu

buoyant force | the net upward force on any object in any fluid

capacitor | an arrangement of conductors designed to store charge using voltage difference

carbon-14 dating | a radioactive dating technique based on the radioactivity of carbon-14

Carnot cycle | a cyclical process that uses only reversible processes, the adiabatic and isothermal processes

Carnot efficiency | the maximum theoretical efficiency for a heat engine

Carnot engine | a heat engine that uses a Carnot cycle

carrier wave | an electromagnetic wave that carries a signal by modulation of its amplitude or frequency

cathode-ray tube | a vacuum tube containing a source of electrons and a screen to view images

Celsius scale | temperature scale in which the freezing point of water is 0°C and the boiling point of water is 100°C

center of mass | the point where the entire mass of an object can be thought to be concentrated

centripetal acceleration | the acceleration of an object moving in a circle, directed toward the center

centripetal force | any net force causing uniform circular motion

change in angular velocity | the difference between final and initial values of angular velocity

change in entropy | the ratio of heat transfer to temperature Q/T

change in momentum | the difference between the final and initial momentum; the mass times the change in velocity

chart of the nuclides | a table comprising stable and unstable nuclei

chemical energy | the energy in a substance stored in the bonds between atoms and molecules that can be released in a chemical reaction

classical physics | physics that was developed from the Renaissance to the end of the 19th century

classical velocity addition | the method of adding velocities when $v \ll c$; velocities add like regular numbers in one-dimensional motion: $u = v + u'$, where v

is the velocity between two observers, u is the velocity of an object relative to one observer, and u' is the velocity relative to the other observer

coefficient of performance | for a heat pump, it is the ratio of heat transfer at the output (the hot reservoir) to the work supplied; for a refrigerator or air conditioner, it is the ratio of heat transfer from the cold reservoir to the work supplied

conduction | heat transfer through stationary matter by physical contact

conductor | an object with properties that allow charges to move about freely within it

conservation of mechanical energy | the rule that the sum of the kinetic energies and potential energies remains constant if only conservative forces act on and within a system

conservation of momentum principle | when the net external force is zero, the total momentum of the system is conserved or constant

conservation of total baryon number | a general rule based on the observation that the total number of nucleons was always conserved in nuclear reactions and decays

conservation of total muon family number | a general rule stating that the total muon family number stays the same through an interaction

conservative force | a force that is a function of position alone, with the result that the work done by the force depends only on the starting and ending points of a motion and not on the particular path taken

constructive interference | when two waves arrive at the same point exactly in phase; that is, the crests of the two waves are precisely aligned, as are the troughs

convection | heat transfer by the macroscopic movement of fluid

converging lens | a convex lens in which light rays that enter it parallel to its axis converge at a single point on the opposite side

converging mirror | a concave mirror in which light rays that strike it parallel to its axis converge at one or more points along the axis

conversion factor |

a ratio expressing how many of one unit are equal to another unit

correspondence principle | in the classical limit (large, slow-moving objects), quantum mechanics becomes the same as classical physics

Coulomb force | another term for the electrostatic force

Coulomb's law | the mathematical equation calculating the electrostatic force vector between two charged particles

critical mass | minimum amount necessary for self-sustained fission of a given nuclide

criticality | condition in which a chain reaction easily becomes self-sustaining

curie | the activity of 1g of ^{226}Ra , equal to $3.70 \times 10^{10}\text{Bq}$

Curie temperature | the temperature above which a ferromagnetic material cannot be magnetized

current | the flow of charge through an electric circuit past a given point of measurement

cyclical process | a process in which the path returns to its original state at the end of every cycle

damping force | a frictional force which converts the mechanical energy of the oscillatory motion into thermal energy

daughter | the nucleus obtained when parent nucleus decays and produces another nucleus following the rules and the conservation laws

de Broglie wavelength | the wavelength possessed by a particle of matter, calculated by $\lambda = h/p$

decay | the process by which an atomic nucleus of an unstable atom loses mass and energy by emitting ionizing particles

decay constant | quantity that is inversely proportional to the half-life and that is used in equation for number of nuclei as a function of time

decay equation | the equation to find out how much of a radioactive material is left after a given period of time

decay series | process whereby subsequent nuclides decay until a stable nuclide is produced

deformation | displacement from equilibrium

deformation | displacement from equilibrium

degree Celsius | unit on the Celsius temperature scale

degree Fahrenheit | unit on the Fahrenheit temperature scale

density | the mass per unit volume of a substance or object

derived units | units that can be calculated using algebraic combinations of the fundamental units

destructive interference | when two identical waves arrive at the same point exactly out of phase; that is, precisely aligned crest to trough

direct current | (DC) the flow of electric charge in only one direction

direction of magnetic field lines | the direction that the north end of a compass needle points

direction of polarization | the direction parallel to the electric field for EM waves

dispersion | spreading of white light into its full spectrum of wavelengths

displacement | the change in position of an object

distance | the magnitude of displacement between two positions

distance traveled | the total length of the path traveled between two positions

diverging lens | a concave lens in which light rays that enter it parallel to its axis bend away (diverge) from its axis

diverging mirror | a convex mirror in which light rays that strike it parallel to its axis bend away (diverge) from its axis

domains | regions within a material that behave like small bar magnets

Doppler shift | the change in wave frequency due to relative motion of source and observer

double-slit interference | an experiment in which waves or particles from a single source impinge upon two slits so that the resulting interference pattern may be observed

dynamics | the study of how forces affect the motion of objects and systems

elapsed time | the difference between the ending time and beginning time

elastic collision | a collision that also conserves total kinetic energy, in addition to the total momentum

elastic potential energy | potential energy stored as a result of deformation of an elastic object, such as the stretching of a spring

electric charge | a physical property of an object that causes it to be attracted toward or repelled from another charged object; each charged object generates and is influenced by a force called an electromagnetic force

electric current | the rate at which charge flows, $I = \Delta Q / \Delta t$

electric field | a three-dimensional map of the electric force extended out into space from a point charge

electric field | a vector quantity (E); the lines of electric force per unit charge, moving radially outward from a positive charge and in toward a negative charge

electric field lines | a series of lines drawn from a point charge representing the magnitude and direction of force exerted by that charge

electric field lines | a pattern of imaginary lines that extend between an electric source and charged objects in the surrounding area, with arrows pointed away from positively charged objects and toward negatively charged objects. The more lines in the pattern, the stronger the electric field in that region

electric field strength | the magnitude of the electric field, denoted E -field

electric potential | potential energy per unit charge

electric power | the rate at which electrical energy is supplied by a source or dissipated by a device; it is the product of current times voltage

electrical energy | the energy carried by a flow of charge

electromagnet | an object that is temporarily magnetic when an electrical current is passed through it

electromagnetic force | one of the four fundamental forces of nature; the electromagnetic force consists of static electricity, moving electricity and magnetism

electromagnetic induction | the process of inducing a voltage with a change in magnetic flux

electromagnetic spectrum | the full range of wavelengths or frequencies of electromagnetic radiation

electromagnetic waves | radiation in the form of waves of electric and magnetic energy

electromagnetism | the use of electrical currents to induce magnetism

electron | a particle orbiting the nucleus of an atom and carrying the smallest unit of negative charge

electron capture | the process in which a proton-rich nuclide absorbs an inner atomic electron and simultaneously emits a neutrino

electron capture equation | equation representing the electron capture

electron family number | the number ± 1 that is assigned to all members of the electron family, or the number 0 that is assigned to all particles not in the electron family

electron volt | the energy given to a fundamental charge accelerated through a potential difference of one volt

electron's antineutrino | antiparticle of electron's neutrino

electron's neutrino | a subatomic elementary particle which has no net electric charge

electrostatic equilibrium | an electrostatically balanced state in which all free electrical charges have stopped moving about

electrostatic force | the amount and direction of attraction or repulsion between two charged bodies

electrostatic precipitators | filters that apply charges to particles in the air, then attract those charges to a filter, removing them from the airstream

electrostatics | the study of electricity in electrostatic equilibrium

electroweak theory | theory showing connections between EM and weak forces

energies of hydrogen-like atoms | Bohr formula for energies of electron states in hydrogen-like

$$\text{atoms: } E_n = -\frac{Z^2}{n^2} E_0 (n = 1, 2, 3, \dots)$$

energy | the ability to do work

energy-level diagram | a diagram used to analyze the energy level of electrons in the orbits of an atom

English units | system of measurement used in the United States; includes units of measurement such as feet, gallons, and pounds

entropy | a measurement of a system's disorder and its inability to do work in a system

external force | a force acting on an object or system that originates outside of the object or system

extremely low frequency (ELF) | electromagnetic radiation with wavelengths usually in the range of 0 to 300 Hz, but also about 1kHz

Fahrenheit scale | temperature scale in which the freezing point of water is 32°F and the boiling point of water is 212°F

Faraday cage | a metal shield which prevents electric charge from penetrating its surface

Faraday's law of induction | the means of calculating the voltage in a coil due to changing magnetic flux, given by $V = -N \frac{\Delta\Phi}{\Delta t}$

fermion | particle with a half-integer value of intrinsic spin

ferromagnetic | materials, such as iron, cobalt, nickel, and gadolinium, that exhibit strong magnetic effects

Feynman diagram | a graph of time versus position that describes the exchange of virtual particles between subatomic particles

field | a map of the amount and direction of a force acting on other objects, extending out into space

first law of thermodynamics | states that the change in internal energy of a system equals the net heat transfer *into* the system minus the net work done *by* the system

first postulate of special relativity | the idea that the laws of physics are the same and can be stated in their simplest form in all inertial frames of reference

fission fragments | a daughter nuclei

flow rate | abbreviated Q, it is the volume V that flows past a particular point during a time t, or $Q = V/t$

fluids | liquids and gases; a fluid is a state of matter that yields to shearing forces

focal length | distance from the center of a lens or curved mirror to its focal point

focal point | for a converging lens or mirror, the point at which converging light rays cross; for a diverging lens or mirror, the point from which diverging light rays appear to originate

force | a push or pull on an object with a specific magnitude and direction; can be represented by vectors; can be expressed as a multiple of a standard force

free charge | an electrical charge (either positive or negative) which can move about separately from its base molecule

free-body diagram | a sketch showing all of the external forces acting on an object or system; the system is represented by a dot, and the forces are represented by vectors extending outward from the dot

free-fall | the state of movement that results from gravitational force only

free-fall | a situation in which the only force acting on an object is the force due to gravity

frequency | number of events per unit of time

frequency | the number of complete wave cycles (up-down-up) passing a given point within one second (cycles/second)

frequency modulation (FM) | a method of placing information on electromagnetic waves by modulating the frequency of a carrier wave with an audio signal, producing a wave of constant amplitude but varying frequency

friction | a force that opposes relative motion or attempts at motion between systems in contact

fundamental frequency | the lowest frequency of a periodic waveform

fundamental units | units that can only be expressed relative to the procedure used to measure them

gamma camera | another name for an Anger camera

gamma decay | type of radioactive decay in which an atomic nucleus emits a gamma particle

gamma ray | (γ ray); extremely high frequency electromagnetic radiation emitted by the nucleus of an atom, either from natural nuclear decay or induced nuclear processes in nuclear reactors and weapons. The lower end of the γ -ray frequency range overlaps the upper end of the X-ray range, but γ rays can have the highest frequency of any electromagnetic radiation

gamma ray radioactivity | a component of nuclear radioactivity; consists of a high-energy photon

gauge boson | particle that carries one of the four forces

gauss | G, the unit of the magnetic field strength; $1G = 10^{-4}T$

Geiger tube | a very common radiation detector that usually gives an audio output

gluons | exchange particles, analogous to the exchange of photons that gives rise to the electromagnetic force between two charged particles

gluons | eight proposed particles which carry the strong force

grand unified theory | theory that shows unification of the strong and electroweak forces

gravitational constant | a proportionality factor used in the equation for Newton's universal law of gravitation; it is a universal constant—that is, it is thought to be the same everywhere in the universe

gravitational potential energy | energy associated with height of objects on the Earth

gray (Gy) | the SI unit for radiation dose which is defined to be $1Gy = 1J/kg = 100rad$

grounded | connected to the ground with a conductor, so that charge flows freely to and from the Earth to the grounded object

hadrons | particles that feel the strong nuclear force

half-life | the time in which there is a 50% chance that a nucleus will decay

hearing | the perception of sound

heat | the spontaneous transfer of energy due to a temperature difference

heat engine | a machine that uses heat transfer to do work

heat of sublimation | the energy required to change a substance from the solid phase to the vapor phase

heat pump | a machine that generates heat transfer from cold to hot

Heisenberg's uncertainty principle | a fundamental limit to the precision with which pairs of quantities (momentum and position, and energy and time) can be measured

hertz | an SI unit denoting the frequency of an electromagnetic wave, in cycles per second

Higgs boson | a massive particle that, if observed, would give validity to the theory that carrier particles are identical under certain circumstances

high dose | a dose greater than 1 Sv (100 rem)

horizontally polarized | the oscillations are in a horizontal plane

hormesis | a term used to describe generally favorable biological responses to low exposures of toxins or radiation

horsepower | an older non-SI unit of power, with $1hp = 746W$

human metabolism | conversion of food into heat transfer, work, and stored fat

hydrogen spectrum wavelengths | the wavelengths of visible light from hydrogen; can be

$$\text{calculated by } \frac{1}{\lambda} = R \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

hydrogen-like atom | any atom with only a single electron

ideal banking | the sloping of a curve in a road, where the angle of the slope allows the vehicle to negotiate the curve at a certain speed without the aid of friction between the tires and the road; the net external force on the vehicle equals the horizontal centripetal force in the absence of friction

ideal gas law | the physical law that relates the pressure and volume of a gas to the number of gas molecules or number of moles of gas and the temperature of the gas

ignition | when a fusion reaction produces enough energy to be self-sustaining after external energy input is cut off

impulse | the average net external force times the time it acts; equal to the change in momentum

index of refraction | for a material, the ratio of the speed of light in vacuum to that in the material

induced current | the current created by a changing magnetic field through voltage induced over a conducting path

inelastic collision | a collision in which total kinetic energy is not conserved

inertia | the tendency of an object to remain at rest or remain in motion

inertial confinement | a technique that aims multiple lasers at tiny fuel pellets evaporating and crushing them to high density

infrared radiation (IR) | a region of the electromagnetic spectrum with a frequency range that extends from just below the red region of the visible light spectrum up to the microwave region, or from $0.74 \mu m$ to $300 \mu m$

infrasound | sound waves below audible frequencies (less than 20 Hz)

ink-jet printer | small ink droplets sprayed with an electric charge are controlled by electrostatic plates to create images on paper

instantaneous acceleration | acceleration at a specific point in time

instantaneous speed | magnitude of the instantaneous velocity

instantaneous velocity | velocity at a specific instant, or the average velocity over an infinitesimal time interval

internal energy | the sum of the kinetic and potential energies of a system's atoms and molecules

ionizing radiation | a radiation that produces ionization; examples include alpha rays, beta rays, gamma rays, and X-rays

irreversible process | a process which occurs in only one direction in nature; a process that cannot be exactly reversed

isobaric process | constant-pressure process in which a gas does work

isochoric process | a constant-volume process

isothermal process | a constant-temperature process

isotopes | nuclei having the same Z and different N s

joule | SI unit of work and energy, equal to one newton-meter

Joule's law | the relationship between potential electrical power, voltage, and resistance in an electrical circuit, given by: $P_e = IV$

Kelvin scale | temperature scale in which 0 K is the lowest possible temperature, representing absolute zero

kilocalorie | 1kilocalorie = 1000calories

kilogram | the SI unit for mass, abbreviated (kg)

kilowatt-hour | (kW · h)unit used primarily for electrical energy provided by electric utility companies

kinematics | the study of motion without considering its causes

kinetic energy | the energy an object has by reason of its motion, equal to $\frac{1}{2}mv^2$ for the translational (i.e., non-rotational) motion of an object of mass m moving at speed v

kinetic friction | a force that opposes the motion of two systems that are in contact and moving relative to one another

laser printer | uses a laser to create a photoconductive image on a drum, which attracts dry ink particles that are then rolled onto a sheet of paper to print a high-quality copy of the image

latent heat coefficient | a physical constant equal to the amount of heat transferred for every 1 kg of a substance during the change in phase of the substance

law | a description, using concise language or a mathematical formula, a generalized pattern in nature that is supported by scientific evidence and repeated experiments

law of conservation of angular momentum | angular momentum is conserved, i.e., the initial angular momentum is equal to the final angular momentum when no external torque is applied to the system

law of conservation of charge | states that whenever a charge is created, an equal amount of charge with the opposite sign is created simultaneously

law of conservation of energy | the general law that total energy is constant in any process; energy may change in form or be transferred from one system to another, but the total remains the same

law of inertia | see Newton's first law of motion

law of reflection | angle of reflection equals the angle of incidence

law of reflection | angle of reflection equals the angle of incidence

length contractionrelativistic Doppler effects | L , the shortening of the measured length of an object moving relative to the observer's frame:

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}} = \frac{L_0}{\gamma}$$

Lenz's law | the minus sign in Faraday's law, signifying that the voltage induced in a coil opposes the change in magnetic flux

leptons | particles that do not feel the strong nuclear force

lever arm | the perpendicular distance between the center of rotation and the point at which force is being applied

linear hypothesis | assumption that risk is directly proportional to risk from high doses

linear momentum | the product of mass and velocity

liquid drop model | a model of nucleus (only to understand some of its features) in which nucleons in a nucleus act like atoms in a drop

liter | a unit of volume, equal to 10^{-3} m^3

longitudinal wave | a wave in which the disturbance is parallel to the direction of propagation

low dose | a dose less than 100 mSv (10 rem)

macrostate | an overall property of a system

magic numbers | a number that indicates a shell structure for the nucleus in which closed shells are more stable

magnetic confinement | a technique in which charged particles are trapped in a small region because of difficulty in crossing magnetic field lines

magnetic field | the representation of magnetic forces

magnetic field | a vector quantity (B); can be used to determine the magnetic force on a moving charged particle

magnetic field lines | the pictorial representation of the strength and the direction of a magnetic field

magnetic field lines | a pattern of continuous, imaginary lines that emerge from and enter into opposite magnetic poles. The density of the lines indicates the magnitude of the magnetic field

magnetic field strength | the magnitude of the magnetic field, denoted B -field

magnetic field strength (magnitude) produced by a long straight current-carrying wire | defined as $B = \frac{\mu_0 I}{2\pi r}$, where I is the current, r is the shortest distance to the wire, and μ_0 is the permeability of free space

magnetic field strength at the center of a circular loop | defined as $B = \frac{\mu_0 I}{2R}$ where R is the radius of the loop

magnetic field strength inside a solenoid | defined as $B = \mu_0 nI$ where n is the number of loops per unit length of the solenoid ($n = N/l$, with N being the number of loops and l the length)

magnetic flux | the amount of magnetic field going through a particular area, calculated with $\Phi = B_{\perp} A$, where B_{\perp} is the magnetic field strength perpendicular to the area A

magnetic force | the force on a charge produced by its motion through a magnetic field

magnetic monopoles | an isolated magnetic pole; a south pole without a north pole, or vice versa (no magnetic monopole has ever been observed)

magnetized | to be turned into a magnet; to be induced to be magnetic

magnification | ratio of image height to object height

magnitude of kinetic friction | $f_k = \mu_k N$, where μ_k is the coefficient of kinetic friction

magnitude of static friction | $f_s \leq \mu_s N$, where μ_s is the coefficient of static friction and N is the magnitude of the normal force

mass | the quantity of matter in a substance; measured in kilograms

mass number | number of nucleons in a nucleus

Maxwell's equations | a set of four equations that describe electromagnetic phenomena

Maxwell's equations | a set of four equations that comprise a complete, overarching theory of electromagnetism

mechanical energy | the sum of kinetic energy and potential energy

mechanical energy | sum of the kinetic energy and potential energy of a system; this sum is a constant

mechanical equivalent of heat | the work needed to produce the same effects as heat transfer

meson | hadrons that can decay to leptons and leave no hadrons

meter | the SI unit for length, abbreviated (m)

meter | common application of magnetic force on a current-carrying loop that is very similar in construction to a motor; by design, the force is proportional to I and not θ , so the needle deflection is proportional to the current

metric system | a system in which values can be calculated in factors of 10

Michelson-Morley experiment | an investigation performed in 1887 that proved that the speed of light in a vacuum is the same in all frames of reference from which it is viewed

Michelson-Morley experimentinertial frame of reference | a reference frame in which a body at rest remains at rest and a body in motion moves at a constant speed in a straight line unless acted on by an outside force

microgravity | an environment in which the acceleration of a body due to non-gravitational forces is small compared with that produced by Earth on its surface

microshock sensitive | a condition in which a person's skin resistance is bypassed, possibly by a medical procedure, rendering the person vulnerable to electrical shock at currents about 1/1000 the normally required level

microstate | each sequence within a larger macrostate

microwaves | electromagnetic waves with wavelengths in the range from 1 mm to 1 m; they can be produced by currents in macroscopic circuits and devices

mirror | smooth surface that reflects light at specific angles, forming an image of the person or object in front of it

model | representation of something that is often too difficult (or impossible) to display directly

model | simplified description that contains only those elements necessary to describe the physics of a physical situation

moderate dose | a dose from 0.1 Sv to 1 Sv (10 to 100 rem)

modern physics | the study of relativity, quantum mechanics, or both

motion | displacement of an object as a function of time

motor | loop of wire in a magnetic field; when current is passed through the loops, the magnetic field exerts force on the loops, which rotates a shaft; electrical energy is converted to mechanical work in the process

muon family number | the number ± 1 that is assigned to all members of the muon family, or the number 0 that is assigned to all particles not in the muon family

natural frequency | the frequency at which a simple harmonic oscillator oscillates if it is set in motion without a driving force

net external force | the vector sum of all external forces acting on an object or system; causes a mass to accelerate

net work | work done by the net force, or vector sum of all the forces, acting on an object

neutrino | an electrically neutral, weakly interacting elementary subatomic particle

neutron | a neutral particle that is found in a nucleus

neutron-induced fission | fission that is initiated after the absorption of neutron

Newton's first law of motion | a body at rest remains at rest, or, if in motion, remains in motion at a constant velocity unless acted on by a net external force; also known as the law of inertia

Newton's second law of motion | The acceleration of a system is directly proportional to and in the same direction as the net external force acting on the system, and inversely proportional to its mass.

Newton's third law of motion | Whenever one body exerts a force on a second body, the first body experiences a force by the second body that is equal in magnitude and opposite in direction to the force that it itself exerts.

Newton's universal law of gravitation | every particle in the universe attracts every other particle with a force along a line joining them; the force is directly proportional to the product of their masses and inversely proportional to the square of the distance between them

nodes | the points where the string does not move; more generally, nodes are where the wave disturbance is zero in a standing wave

normal force | the force that a surface applies to an object to support the weight of the object; acts perpendicular to the surface on which the object rests

north magnetic pole | the end or the side of a magnet that is attracted toward Earth's geographic north pole

nuclear energy | energy released by changes within atomic nuclei, such as the fusion of two light nuclei or the fission of a heavy nucleus

nuclear fission | reaction in which a nucleus splits

nuclear fusion | a reaction in which two nuclei are combined, or fused, to form a larger nucleus

nuclear radiation | radiation that originate in the nuclei of atoms; alpha, beta, and gamma rays are among most common forms; also see "radioactivity"

nuclear reaction energy | the energy created in a nuclear reaction

nucleons | the particles found inside nuclei

nucleus | a region consisting of protons and neutrons at the center of an atom

nuclide | a type of atom whose nucleus has specific numbers of protons and neutrons

ohm | the unit of resistance, given by $1\Omega = 1V/A$

ohmic | a type of a material for which Ohm's law is valid

Ohm's law | an empirical relation stating that the current I is proportional to the potential difference V . It is often written as $I = V/R$, where R is the resistance

Ohm's law | the relationship between current, voltage, and resistance within an electrical circuit: $V = IR$

optically active | substances that rotate the plane of polarization of light passing through them

order of magnitude | refers to the size of a quantity as it relates to a power of 10

oscillate | moving back and forth regularly between two points

oscillate | to fluctuate back and forth in a steady beat

Otto cycle | a thermodynamic cycle, consisting of a pair of adiabatic processes and a pair of isochoric processes, that converts heat into work, e.g., the four-stroke engine cycle of intake, compression, ignition, and exhaust

overtones | multiples of the fundamental frequency of a sound

parallel | the wiring of resistors or other components in an electrical circuit such that each component receives an equal voltage from the power source; often pictured in a ladder-shaped diagram, with each component on a rung of the ladder

parallel-plate capacitor | an example of capacitor using arrangement of two parallel conducting plates placed near each other

parent | the original state of nucleus before decay

perfectly inelastic collision | a collision in which the colliding objects stick together

period | time it takes to complete one oscillation

periodic motion | motion that repeats itself at regular time intervals

permeability of free space | the measure of the ability of a material, in this case free space, to support a magnetic field; the constant $\mu_0 = 4\pi \times 10^{-7} T \cdot m/A$

photoconductor | a substance that is an insulator until it is exposed to light, when it becomes a conductor

photoelectric effect | the phenomenon whereby some materials eject electrons when light is shined on them

photomultiplier | a device that converts light into electrical signals

photon | a quantum, or particle, of electromagnetic radiation

photon energy | the amount of energy a photon has; $E = hf$

physical quantity | a characteristic or property of an object that can be measured or calculated from other measurements

physics | the science concerned with describing the interactions of energy, matter, space, and time; it is especially interested in what fundamental mechanisms underlie every phenomenon

pitch | the perception of the frequency of a sound

Planck law | first successful theoretical description of thermal radiation which used quantization of energy hypothesis

Planck's constant | $h = 6.626 \times 10^{-34} J \cdot s$

planetary model of the atom | the most familiar model or illustration of the structure of the atom

point charge | A charged particle, designated Q , generating an electric field

polarization | the attribute that wave oscillations have a definite direction relative to the direction of propagation of the wave

polarized | a state in which the positive and negative charges within an object have collected in separate locations

polarized | waves having the electric and magnetic field oscillations in a definite direction

position | the location of an object at a particular time

positron | the particle that results from positive beta decay; also known as an antielectron

positron decay | type of beta decay in which a proton is converted to a neutron, releasing a positron and a neutrino

positron emission tomography (PET) | tomography technique that uses β^+ emitters and detects the two annihilation γ rays, aiding in source localization

potential difference (or voltage) | change in potential energy of a charge moved from one point to another, divided by the charge; units of potential difference are joules per coulomb, known as volt

potential energy | energy due to position, shape, or configuration

power | the rate at which work is done

power | inverse of focal length

precession | a type of motion that an object possessing angular momentum undergoes, as a torque perpendicular to the direction of angular momentum is applied, causing the direction of angular momentum to change; the circular wobbling motion traced by a slightly tilted circular top is an example

pressure | the force per unit area perpendicular to the force, over which the force acts

pressure due to the weight of fluid | pressure at a depth below a fluid surface due to its weight; given by $P = \rho gh$

probability distribution | the overall spatial distribution of probabilities to find a particle at a given location

probability wave | the description of wave characteristic of matter, as revealed by probability distribution experimentally

projectile | an object that travels through the air and experiences only acceleration due to gravity

projectile motion | the motion of an object that is subject only to the acceleration of gravity

proper length | L_0 ; the distance between two points measured by an observer who is at rest relative to both of the points; Earth-bound observers measure proper length when measuring the distance between two points that are stationary relative to the Earth

proton | a particle in the nucleus of an atom and carrying a positive charge equal in magnitude and opposite in sign to the amount of negative charge carried by an electron

proton-proton cycle | the combined reactions ${}^1_1\text{H} + {}^1_1\text{H} \rightarrow {}^2_1\text{H} + e^+ + \nu_e$, ${}^1_1\text{H} + {}^2_1\text{H} \rightarrow {}^3_2\text{He} + \gamma$, and ${}^3_2\text{He} + {}^3_2\text{He} \rightarrow 4{}^1_1\text{H} + {}^4_2\text{He}$

protons | the positively charged nucleons found in a nucleus

quality factor | same as relative biological effectiveness

quantized | the fact that certain physical entities exist only with particular discrete values and not every conceivable value

quantum chromodynamics | the governing theory of connecting quantum number color to gluons

quantum electrodynamics | the theory of electromagnetism on the particle scale

quantum mechanics |

the study of objects smaller than can be seen with a microscope

quantum mechanics | the branch of physics that deals with small objects and with the quantization of various entities, especially energy

rad | the ionizing energy deposited per kilogram of tissue

radar | a common application of microwaves. Radar can determine the distance to objects as diverse as clouds and aircraft, as well as determine the speed of a car or the intensity of a rainstorm

radian | a unit of angular measure defined by the arc length covered by the angle divided by the radius of the circle that the arc length is part of; one full circle is 2π radians.

radiant energy | the energy carried by electromagnetic waves

radiation | heat transfer which occurs when microwaves, infrared radiation, visible light, or other electromagnetic radiation is emitted or absorbed

radiation detector | a device that is used to detect and track the radiation from a radioactive reaction

radiation pressure | pressure exerted by an electromagnetic wave on a surface

radio waves | electromagnetic waves with wavelengths in the range from 1 mm to 100 km; they are produced by currents in wires and circuits and by astronomical phenomena

radioactive | a substance or object that emits nuclear radiation

radioactive dating | an application of radioactive decay in which the age of a material is determined by the amount of radioactivity of a particular type that occurs

radioactivity | the emission of rays from the nuclei of atoms

radiopharmaceutical | compound used for medical imaging

radius of a nucleus | the radius of a nucleus is $r = r_0 A^{1/3}$

rainbow | dispersion of sunlight into a continuous distribution of colors according to wavelength, produced by the refraction and reflection of sunlight by water droplets in the sky

range | the maximum horizontal distance that a projectile travels

range of radiation | the distance that the radiation can travel through a material

rate of decay | the number of radioactive events per unit time

real image | image that can be projected

refraction | changing of a light ray's direction when it passes through variations in matter

relative biological effectiveness (RBE) | a number that expresses the relative amount of damage that a fixed amount of ionizing radiation of a given type can inflict on biological tissues

relativistic Doppler effects | a change in wavelength of radiation that is moving relative to the observer; the wavelength of the radiation is longer (called a red shift) than that emitted by the source when the source moves away from the observer and shorter (called a blue shift) when the source moves toward the observer; the shifted wavelength is described by the equation

$$\lambda_{\text{obs}} = \lambda_s \sqrt{\frac{1 + \frac{u}{c}}{1 - \frac{u}{c}}}$$

where λ_{obs} is the observed wavelength, λ_s is the source wavelength, and u is the velocity of the source to the observer

relativistic kinetic energy | the kinetic energy of an object moving at relativistic speeds:

$$KE_{\text{rel}} = (\gamma - 1)mc^2, \text{ where } \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

relativistic momentum | p , the momentum of an object moving at relativistic velocity; $p = \gamma mu$, where m is the rest mass of the object, u is its velocity relative to an observer, and the relativistic factor $\gamma = \frac{1}{\sqrt{1 - \frac{u^2}{c^2}}}$

relativistic velocity addition | the method of adding velocities of an object moving at a relativistic speed; v , where v is the relative velocity between two observers, u is the velocity of an object relative to one observer, and u' is the velocity relative to the other observer

relativity | the study of objects moving at speeds greater than about 1% of the speed of light, or of objects being affected by a strong gravitational field

relativity | the study of how different observers measure the same event

resistance | the electric property that impedes current; for ohmic materials, it is the ratio of voltage to current, $R = V/I$

resistance | causing a loss of electrical power in a circuit

resistor | a component that provides resistance to the current flowing through an electrical circuit

resonance | the phenomenon of driving a system with a frequency equal to the system's natural frequency

resonant | a system that displays enhanced oscillation when subjected to a periodic disturbance of the same frequency as its natural frequency

resonate | a system being driven at its natural frequency

rest energy | the energy stored in an object at rest: $E_0 = mc^2$

rest mass | the mass of an object as measured by a person at rest relative to the object

restoring force | force acting in opposition to the force caused by a deformation

reversible process | a process in which both the heat engine system and the external environment theoretically can be returned to their original states

right hand rule 1 (RHR-1) | the rule to determine the direction of the magnetic force on a positive moving charge: when the thumb of the right hand points in the direction of the charge's velocity \mathbf{v} and the fingers point in the direction of the magnetic field \mathbf{B} , then the force on the charge is perpendicular and away from the palm; the force on a negative charge is perpendicular and into the palm

right hand rule 2 (RHR-2) | a rule to determine the direction of the magnetic field induced by a current-carrying wire: Point the thumb of the right hand in the direction of current, and the fingers curl in the direction of the magnetic field loops

right-hand rule | direction of angular velocity ω and angular momentum \mathbf{L} in which the thumb of your right hand points when you curl your fingers in the direction of the disk's rotation

rms | a type of average taken for a time-varying quantity by squaring it, taking the mean of the square, and then taking the square-root of the mean.

roentgen equivalent man (rem) | a dose unit more closely related to effects in biological tissue

rotational inertia | resistance to change of angular velocity; also called moment of inertia; for a point mass, $I = mr^2$

rotational kinetic energy | the kinetic energy due to the rotation of an object. This is part of its total kinetic energy

Rydberg constant | a physical constant related to the atomic spectra with an established value of $1.097 \times 10^7 \text{ m}^{-1}$

scalar | a quantity that is described by magnitude, but not direction

scientific method | a method that typically begins with an observation and question that the scientist will research; next, the scientist typically performs some research about the topic and then devises a hypothesis; then, the scientist will test the hypothesis by performing an experiment; finally, the scientist analyzes the results of the experiment and draws a conclusion

scintillators | a radiation detection method that records light produced when radiation interacts with materials

second | the SI unit for time, abbreviated (s)

second law of motion | physical law that states that the net external force equals the change in momentum of a system divided by the time over which it changes

second law of thermodynamics | heat transfer flows from a hotter to a cooler object, never the reverse, and some heat energy in any process is lost to available work in a cyclical process

second law of thermodynamics stated in terms of entropy | the total entropy of a system either increases or remains constant; it never decreases

second postulate of special relativity | the idea that the speed of light c is a constant, independent of the source

series | a sequence of resistors or other components wired into a circuit one after the other

shielding | a technique to limit radiation exposure

shock hazard | when electric current passes through a person

short circuit | also known as a "short," a low-resistance path between terminals of a voltage source

SI units | the international system of units that scientists in most countries have agreed to use; includes units such as meters, liters, and grams

sievert | the SI equivalent of the rem

simple circuit | a circuit with a single voltage source and a single resistor

simple harmonic motion | the oscillatory motion in a system where the net force can be described by Hooke's law

simple harmonic oscillator | a device that implements Hooke's law, such as a mass that is attached to a spring, with the other end of the spring being connected to a rigid support such as a wall

single-photon-emission computed tomography (SPECT) | tomography performed with γ -emitting radiopharmaceuticals

solar sail | a spacecraft that utilizes radiation pressure due to solar radiation in its propulsion

solenoid | a thin wire wound into a coil that produces a magnetic field when an electric current is passed through it

solid-state radiation detectors | semiconductors fabricated to directly convert incident radiation into electrical current

sonic boom | a constructive interference of sound created by an object moving faster than sound

sound | a disturbance of matter that is transmitted from its source outward

south magnetic pole | the end or the side of a magnet that is attracted toward Earth's geographic south pole

special relativity | the theory that, in an inertial frame of reference, the motion of an object is relative to the frame from which it is viewed or measured

specific gravity | the ratio of the density of an object to a fluid (usually water)

specific heat | the amount of heat necessary to change the temperature of 1.00 kg of a substance by 1.00 °C

speed of light | in a vacuum, such as space, the speed of light is a constant 3×10^8 m/s

spring constant | a constant related to the rigidity of a system: the larger the spring constant, the more rigid the system; the spring constant is represented by k

standard model | combination of quantum chromodynamics and electroweak theory

standing wave | a wave that oscillates in place, with nodes where no motion happens

static electricity | a buildup of electric charge on the surface of an object

static friction | a force that opposes the motion of two systems that are in contact and are not moving relative to one another

statistical analysis | using statistics to examine data, such as counting microstates and macrostates

step-down transformer | a transformer that decreases voltage

step-up transformer | a transformer that increases voltage

strangeness | a physical quantity assigned to various particles based on decay systematics

sublimation | the transition from the solid phase to the vapor phase

supercriticality | an exponential increase in fissions

superposition | the phenomenon that occurs when two or more waves arrive at the same point

superstring theory | a theory of everything based on vibrating strings some 10^{-35} m in length

system | the object or the group of objects under consideration

tagged | process of attaching a radioactive substance to a chemical compound

tangential acceleration | the acceleration in a direction tangent to the circle at the point of interest in circular motion

tau family number | the number ± 1 that is assigned to all members of the tau family, or the number 0 that is assigned to all particles not in the tau family

temperature | the quantity measured by a thermometer

tension | the pulling force that acts along a medium, especially a stretched flexible connector, such as a rope or cable; when a rope supports the weight of an object, the force on the object due to the rope is called a tension force

tesla | T, the SI unit of the magnetic field strength;
 $1\text{ T} = \frac{1\text{ N}}{\text{A} \cdot \text{m}}$

test charge | A particle (designated q) with either a positive or negative charge set down within an electric field generated by a point charge

theory | an explanation for patterns in nature that is supported by scientific evidence and verified multiple times by various groups of researchers

thermal agitation | the thermal motion of atoms and molecules in any object at a temperature above absolute zero, which causes them to emit and absorb radiation

thermal energy | the energy within an object due to the random motion of its atoms and molecules that accounts for the object's temperature

thermal equilibrium | the condition in which heat no longer flows between two objects that are in contact; the two objects have the same temperature

thermal hazard | a hazard in which electric current causes undesired thermal effects

thrust | a reaction force that pushes a body forward; rockets, airplanes, and cars are pushed forward by a thrust, a reaction force to propellants pushed backward

time | change, or the interval over which change occurs

time dilation | the phenomenon of time passing slower to an observer who is moving relative to another observer

torque | the turning effectiveness of a force

total energy | defined as $E = \gamma mc^2$, where
 $\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$

trajectory | the path of a projectile through the air

transformer | a device that transforms voltages from one value to another using induction

transformer equation | the equation showing that the ratio of the secondary to primary voltages in a transformer equals the ratio of the number of loops in their coils;
 $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

transverse wave | a wave in which the disturbance is perpendicular to the direction of propagation

transverse wave | a wave, such as an electromagnetic wave, which oscillates perpendicular to the axis along the line of travel

TV | video and audio signals broadcast on electromagnetic waves

twin paradox | Δt_0 , the time measured by an observer at rest relative to the event being observed:

$$\Delta t = \frac{\Delta t_0}{\sqrt{1 - \frac{v^2}{c^2}}} = \gamma \Delta t_0, \text{ where } \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

twin paradox | this asks why a twin traveling at a relativistic speed away and then back towards the Earth ages less than the Earth-bound twin. The premise to the paradox is faulty because the traveling twin is accelerating, and special relativity does not apply to accelerating frames of reference

ultra-high frequency (UHF) | TV channels in an even higher frequency range than VHF, of 470 to 1000 MHz

ultracentrifuge | a centrifuge optimized for spinning a rotor at very high speeds

ultrasound | sound waves above audible frequencies (greater than 20,000 Hz)

ultraviolet catastrophe | failure of classical theory to correctly describe blackbody radiation at short wavelengths

ultraviolet radiation (UV) | electromagnetic radiation in the range extending upward in frequency from violet light and overlapping with the lowest X-ray frequencies, with wavelengths from 400 nm down to about 10 nm

uncertainty in momentum | lack of precision or lack of knowledge of precise results in measurements of momentum

uncertainty in position | lack of precision or lack of knowledge of precise results in measurements of position

uniform circular motion | an object moving in a circular path at constant speed

units | a standard used for expressing and comparing measurements

unpolarized | waves that are randomly polarized

Van de Graaff generator | a machine that produces a large amount of excess charge, used for experiments with high voltage

vector | a quantity that is described by both magnitude and direction

vector | a quantity with both magnitude and direction

vector addition | mathematical combination of two or more vectors, including their magnitudes, directions, and positions

vertically polarized | the oscillations are in a vertical plane

very high frequency (VHF) | TV channels utilizing frequencies in the two ranges of 54 to 88 MHz and 174 to 222 MHz

virtual image | image that cannot be projected

visible light | the narrow segment of the electromagnetic spectrum to which the normal human eye responds

voltage | the electrical potential energy per unit charge; electric pressure created by a power source, such as a battery

voltage drop | the loss of electrical power as a current travels through a resistor, wire or other component

watt | (W) SI unit of power, with $1\text{W} = 1\text{J/s}$

wave | a disturbance that moves from its source and carries energy

wave velocity | the speed at which the disturbance moves; also called wave speed, propagation velocity, or propagation speed

wavelength | the distance between adjacent identical parts of a wave

wavelength | the distance from one peak to the next in a wave

weight | the force due to gravity; $w = mg$ for objects on Earth

work | the transfer of energy by a force that causes an object to be displaced; the product of the component of the force in the direction of the displacement and the magnitude of the displacement

work function | the amount of energy necessary to eject an electron from a material; the binding energy in photoelectric effect

work-energy theorem | the result, based on Newton's laws, that the net work done on an object is equal to its change in kinetic energy

X-ray | invisible, penetrating form of very high frequency electromagnetic radiation, overlapping both the ultraviolet range and the γ -ray range

xerography | a dry copying process based on electrostatics

zeroth law of thermodynamics | law that states that if two objects are in thermal equilibrium, and a third object is in thermal equilibrium with one of those objects, it is also in thermal equilibrium with the other object