

## Glossary

**absolute temperature scale** | scale, such as Kelvin, with a zero point that is absolute zero [OpenStax]

**absolute zero** | temperature at which the average kinetic energy of molecules is zero [OpenStax]

**AC current** | current that fluctuates sinusoidally with time at a fixed frequency [OpenStax]

**AC voltage** | voltage that fluctuates sinusoidally with time at a fixed frequency [OpenStax]

**adiabatic process** | process during which no heat is transferred to or from the system [OpenStax]

**alternating current (ac)** | flow of electric charge that periodically reverses direction [OpenStax]

**ammeter** | instrument that measures current [OpenStax]

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

**Ampère's law** | physical law that states that the line integral of the magnetic field around an electric current is proportional to the current [OpenStax]

**area vector** | vector with magnitude equal to the area of a surface and direction perpendicular to the surface [OpenStax]

**average power** | time average of the instantaneous power over one cycle [OpenStax]

**Avogadro's number** |  $N_A$ , the number of molecules in one mole of a substance;  $N_A = 6.02 \times 10^{23}$  particles/mole [OpenStax]

**back emf** | emf generated by a running motor, because it consists of a coil turning in a magnetic field; it opposes the voltage powering the motor [OpenStax]

**bandwidth** | range of angular frequencies over which the average power is greater than one-half the maximum value of the average power [OpenStax]

**Biot-Savart law** | an equation giving the magnetic field at a point produced by a current-carrying wire [OpenStax]

**Boltzmann constant** |  $k_B$ , a physical constant that relates energy to temperature and appears in the ideal gas law;  $k_B = 1.38 \times 10^{-23}\text{ J/K}$  [OpenStax]

**boundary** | imagined walls that separate the system and its surroundings [OpenStax]

**calorie (cal)** | energy needed to change the temperature of 1.00 g of water by  $1.00^\circ\text{C}$  [OpenStax]

**calorimeter** | container that prevents heat transfer in or out [OpenStax]

**calorimetry** | study of heat transfer inside a container impervious to heat [OpenStax]

**capacitance** | amount of charge stored per unit volt [OpenStax]

**capacitive reactance** | opposition of a capacitor to a change in current [OpenStax]

**capacitor** | device that stores electrical charge and electrical energy [OpenStax]

**Carnot cycle** | cycle that consists of two isotherms at the temperatures of two reservoirs and two adiabatic processes connecting the isotherms [OpenStax]

**Carnot engine** | Carnot heat engine, refrigerator, or heat pump that operates on a Carnot cycle [OpenStax]

**Carnot principle** | principle governing the efficiency or performance of a heat device operating on a Carnot cycle: any reversible heat device working between two reservoirs must have the same efficiency or performance coefficient, greater than that of an irreversible heat device operating between the same two reservoirs [OpenStax]

**Celsius scale** | temperature scale in which the freezing point of water is  $0^\circ\text{C}$  and the boiling point of water is  $100^\circ\text{C}$  [OpenStax]

**charging by induction** | process by which an electrically charged object brought near a neutral object creates a charge separation in that object [OpenStax]

**circuit** | complete path that an electrical current travels along [OpenStax]

**Clausius statement of the second law of thermodynamics** | heat never flows spontaneously from a colder object to a hotter object [OpenStax]

**closed system** | system that is mechanically and thermally isolated from its environment [OpenStax]

**coefficient of linear expansion** | ( $\alpha$ ) material property that gives the change in length, per unit length, per  $1^\circ\text{C}$  change in temperature; a constant used in the calculation of linear expansion; the coefficient of linear expansion depends to some degree on the temperature of the material [OpenStax]

**coefficient of performance** | measure of effectiveness of a refrigerator or heat pump [OpenStax]

**coefficient of volume expansion** | ( $\beta$ ) similar to  $\alpha$  but gives the change in volume, per unit volume, per  $1^\circ\text{C}$  change in temperature [OpenStax]

**cold reservoir** | sink of heat used by a heat engine [OpenStax]

**conduction** | heat transfer through stationary matter by physical contact [OpenStax]

**conduction electron** | electron that is free to move away from its atomic orbit [OpenStax]

**conductor** | material that allows electrons to move separately from their atomic orbits; object with properties that allow charges to move about freely within it [OpenStax]

**continuous charge distribution** | total source charge composed of so large a number of elementary charges that it must be treated as continuous, rather than discrete [OpenStax]

**convection** | heat transfer by the macroscopic movement of fluid [OpenStax]

**conventional current** | current that flows through a circuit from the positive terminal of a battery through the circuit to the negative terminal of the battery [OpenStax]

**cosmic rays** | comprised of particles that originate mainly from outside the solar system and reach Earth [OpenStax]

**coulomb** | SI unit of electric charge [OpenStax]

**Coulomb force** | another term for the electrostatic force [OpenStax]

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

**critical point** | for a given substance, the combination of temperature and pressure above which the liquid and gas phases are indistinguishable [OpenStax]

**critical pressure** | pressure at the critical point [OpenStax]

**critical temperature** | temperature at the critical point [OpenStax]

**critical temperature** |  $T_c$  at which the isotherm has a point with zero slope [OpenStax]

**critical temperature** | temperature at which a material reaches superconductivity [OpenStax]

**current density** | flow of charge through a cross-sectional area divided by the area [OpenStax]

**cyclic process** | process in which the state of the system at the end is same as the state at the beginning [OpenStax]

**cyclotron** | device used to accelerate charged particles to large kinetic energies [OpenStax]

**cylindrical symmetry** | system only varies with distance from the axis, not direction [OpenStax]

**Dalton's law of partial pressures** | physical law that states that the total pressure of a gas is the sum of partial pressures of the component gases [OpenStax]

**dees** | large metal containers used in cyclotrons that serve contain a stream of charged particles as their speed is increased [OpenStax]

**degree Celsius** | ( $^\circ\text{C}$ ) unit on the Celsius temperature scale [OpenStax]

**degree Fahrenheit** | ( $^\circ\text{F}$ ) unit on the Fahrenheit temperature scale [OpenStax]

**degree of freedom** | independent kind of motion possessing energy, such as the kinetic energy of motion in one of the three orthogonal spatial directions [OpenStax]

**diamagnetic materials** | their magnetic dipoles align oppositely to an applied magnetic field; when the field is removed, the material is unmagnetized [OpenStax]

**dielectric** | insulating material used to fill the space between two plates [OpenStax]

**dielectric breakdown** | phenomenon that occurs when an insulator becomes a conductor in a strong electrical field [OpenStax]

**dielectric constant** | factor by which capacitance increases when a dielectric is inserted between the plates of a capacitor [OpenStax]

**dielectric strength** | critical electrical field strength above which molecules in insulator begin to break down and the insulator starts to conduct [OpenStax]

**diode** | nonohmic circuit device that allows current flow in only one direction [OpenStax]

**dipole** | two equal and opposite charges that are fixed close to each other [OpenStax]

**dipole moment** | property of a dipole; it characterizes the combination of distance between the opposite charges, and the magnitude of the charges [OpenStax]

**direct current (dc)** | flow of electric charge in only one direction [OpenStax]

**disorder** | measure of order in a system; the greater the disorder is, the higher the entropy [OpenStax]

**displacement current** | extra term in Maxwell's equations that is analogous to a real current but accounts for a changing electric field producing a magnetic field, even when the real current is present [OpenStax]

**drift velocity** | velocity of a charge as it moves nearly randomly through a conductor, experiencing multiple collisions, averaged over a length of a conductor, whose magnitude is the length of conductor traveled divided by the time it takes for the charges to travel the length [OpenStax]

**eddy current** | current loop in a conductor caused by motional emf [OpenStax]

**efficiency (e)** | output work from the engine over the input heat to the engine from the hot reservoir [OpenStax]

**electric charge** | 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 electric force [OpenStax]

**electric dipole** | system of two equal but opposite charges a fixed distance apart [OpenStax]

**electric dipole moment** | quantity defined as  $\vec{p} = q\vec{d}$  for all dipoles, where the vector points from the negative to positive charge [OpenStax]

**electric field** | physical phenomenon created by a charge; it “transmits” a force between a two charges [OpenStax]

**electric flux** | dot product of the electric field and the area through which it is passing [OpenStax]

**electric force** | noncontact force observed between electrically charged objects [OpenStax]

**electric generator** | device for converting mechanical work into electric energy; it induces an emf by rotating a coil in a magnetic field [OpenStax]

**electric potential** | potential energy per unit charge [OpenStax]

**electric potential difference** | the change in potential energy of a charge  $q$  moved between two points, divided by the charge. [OpenStax]

**electric potential energy** | potential energy stored in a system of charged objects due to the charges [OpenStax]

**electrical conductivity** | measure of a material’s ability to conduct or transmit electricity [OpenStax]

**electrical current** | rate at which charge flows,  $I = \frac{dQ}{dt}$  [OpenStax]

**electrical power** | time rate of change of energy in an electric circuit [OpenStax]

**electromotive force (emf)** | energy produced per unit charge, drawn from a source that produces an electrical current [OpenStax]

**electron** | particle surrounding the nucleus of an atom and carrying the smallest unit of negative charge [OpenStax]

**electron-volt** | energy given to a fundamental charge accelerated through a potential difference of one volt [OpenStax]

**electrostatic attraction** | phenomenon of two objects with opposite charges attracting each other [OpenStax]

**electrostatic force** | amount and direction of attraction or repulsion between two charged bodies; the assumption is that the source charges have no acceleration [OpenStax]

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

**electrostatic repulsion** | phenomenon of two objects with like charges repelling each other [OpenStax]

**electrostatics** | study of charged objects which are not in motion [OpenStax]

**emissivity** | measure of how well an object radiates [OpenStax]

**energy density** | energy stored in a capacitor divided by the volume between the plates [OpenStax]

**entropy** | state function of the system that changes when heat is transferred between the system and the environment [OpenStax]

**entropy statement of the second law of thermodynamics** | entropy of a closed system or the entire universe never decreases [OpenStax]

**environment** | outside of the system being studied [OpenStax]

**equation of state** | describes properties of matter under given physical conditions [OpenStax]

**equilibrium** | thermal balance established between two objects or parts within a system [OpenStax]

**equipartition theorem** | theorem that the energy of a classical thermodynamic system is shared equally among its degrees of freedom [OpenStax]

**equipotential line** | two-dimensional representation of an equipotential surface [OpenStax]

**equipotential surface** | surface (usually in three dimensions) on which all points are at the same potential [OpenStax]

**equivalent resistance** | resistance of a combination of resistors; it can be thought of as the resistance of a single resistor that can replace a combination of resistors in a series and/or parallel circuit [OpenStax]

**extensive variable** | variable that is proportional to the amount of matter in the system [OpenStax]

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

**Faraday’s law** | induced emf is created in a closed loop due to a change in magnetic flux through the loop [OpenStax]

**ferromagnetic materials** | contain groups of dipoles, called domains, that align with the applied magnetic field; when this field is removed, the material is still magnetized [OpenStax]

**field line** | smooth, usually curved line that indicates the direction of the electric field [OpenStax]

**field line density** | number of field lines per square meter passing through an imaginary area; its purpose is to indicate the field strength at different points in space [OpenStax]

**first law of thermodynamics** | the change in internal energy for any transition between two equilibrium states is  $\Delta E_{int} = Q - W$  [OpenStax]

**flux** | quantity of something passing through a given area [OpenStax]

**free electrons** | also called conduction electrons, these are the electrons in a conductor that are not bound to any particular atom, and hence are free to move around [OpenStax]

**gamma ray** ( $\gamma$  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  $\gamma$ -ray frequency range overlaps the upper end of the X-ray range, but  $\gamma$  rays can have the highest frequency of any electromagnetic radiation [OpenStax]

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

**Gaussian surface** | any enclosed (usually imaginary) surface [OpenStax]

**greenhouse effect** | warming of the earth that is due to gases such as carbon dioxide and methane that absorb infrared radiation from Earth’s surface and reradiate it in all directions, thus sending some of it back toward Earth [OpenStax]

**grounding** | process of attaching a conductor to the earth to ensure that there is no potential difference between it and Earth [OpenStax]

**Hall effect** | creation of voltage across a current-carrying conductor by a magnetic field [OpenStax]

**heat** | energy transferred solely due to a temperature difference [OpenStax]

**heat engine** | device that converts heat into work [OpenStax]

**heat of fusion** | energy per unit mass required to change a substance from the solid phase to the liquid phase, or released when the substance changes from liquid to solid [OpenStax]

**heat of sublimation** | energy per unit mass required to change a substance from the solid phase to the vapor phase [OpenStax]

**heat of vaporization** | energy per unit mass required to change a substance from the liquid phase to the vapor phase [OpenStax]

**heat pump** | device that delivers heat to a hot reservoir [OpenStax]

**heat transfer** | movement of energy from one place or material to another as a result of a difference in temperature [OpenStax]

**helical motion** | superposition of circular motion with a straight-line motion that is followed by a charged particle moving in a region of magnetic field at an angle to the field [OpenStax]

**henry (H)** | unit of inductance,  $1H = 1\Omega \cdot s$ ; it is also expressed as a volt second per ampere [OpenStax]

**hot reservoir** | source of heat used by a heat engine [OpenStax]

**hysteresis** | property of ferromagnets that is seen when a material’s magnetic field is examined versus the applied magnetic field; a loop is created resulting from sweeping the applied field forward and reverse [OpenStax]

**ideal gas** | gas at the limit of low density and high temperature [OpenStax]

**ideal gas law** | physical law that relates the pressure and volume of a gas, far from liquefaction, to the number of gas molecules or number of moles of gas and the temperature of the gas [OpenStax]

**impedance** | ac analog to resistance in a dc circuit, which measures the combined effect of resistance, capacitive reactance, and inductive reactance [OpenStax]

**induced dipole** | typically an atom, or a spherically symmetric molecule; a dipole created due to opposite forces displacing the positive and negative charges [OpenStax]

**induced electric field** | created based on the changing magnetic flux with time [OpenStax]

**induced electric-dipole moment** | dipole moment that a nonpolar molecule may acquire when it is placed in an electrical field [OpenStax]

**induced electrical field** | electrical field in the dielectric due to the presence of induced charges [OpenStax]

**induced emf** | short-lived voltage generated by a conductor or coil moving in a magnetic field [OpenStax]

**induced surface charges** | charges that occur on a dielectric surface due to its polarization [OpenStax]

**inductance** | property of a device that tells how effectively it induces an emf in another device [OpenStax]

**inductive reactance** | opposition of an inductor to a change in current [OpenStax]

**inductive time constant** | denoted by  $\tau$ , the characteristic time given by quantity  $L/R$  of a particular series RL circuit [OpenStax]

**inductor** | part of an electrical circuit to provide self-inductance, which is symbolized by a coil of wire [OpenStax]

**infinite straight wire** | straight wire whose length is much, much greater than either of its other dimensions, and also much, much greater than the distance at which the field is to be calculated [OpenStax]

**infrared radiation** | 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  $0.74\mu\text{m}$  to  $300\mu\text{m}$  [OpenStax]

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

**insulator** | material that holds electrons securely within their atomic orbits [OpenStax]

**intensive variable** | variable that is independent of the amount of matter in the system [OpenStax]

**internal energy** | average of the total mechanical energy of all the molecules or entities in the system [OpenStax]

**internal energy** | sum of the mechanical energies of all of the molecules in it [OpenStax]

**internal resistance** | amount of resistance to the flow of current within the voltage source [OpenStax]

**ion** | atom or molecule with more or fewer electrons than protons [OpenStax]

**irreversibility** | phenomenon associated with a natural process [OpenStax]

**irreversible process** | process in which neither the system nor its environment can be restored to their original states at the same time [OpenStax]

**isentropic** | reversible adiabatic process where the process is frictionless and no heat is transferred [OpenStax]

**isobaric process** | process during which the system's pressure does not change [OpenStax]

**isochoric process** | process during which the system's volume does not change [OpenStax]

**isothermal process** | process during which the system's temperature remains constant [OpenStax]

**Josephson junction** | junction of two pieces of superconducting material separated by a thin layer of insulating material, which can carry a supercurrent [OpenStax]

**junction rule** | sum of all currents entering a junction must equal the sum of all currents leaving the junction [OpenStax]

**Kelvin scale (K)** | temperature scale in which 0 K is the lowest possible temperature, representing absolute zero [OpenStax]

**Kelvin statement of the second law of thermodynamics** | it is impossible to convert the heat from a single source into work without any other effect [OpenStax]

**kilocalorie (kcal)** | energy needed to change the temperature of 1.00 kg of water between 14.5°C and 15.5°C [OpenStax]

**kinetic theory of gases** | theory that derives the macroscopic properties of gases from the motion of the molecules they consist of [OpenStax]

**Kirchhoff's rules** | set of two rules governing current and changes in potential in an electric circuit [OpenStax]

**latent heat coefficient** | general term for the heats of fusion, vaporization, and sublimation [OpenStax]

**law of conservation of charge** | net electric charge of a closed system is constant [OpenStax]

**LC circuit** | circuit composed of an ac source, inductor, and capacitor [OpenStax]

**Lenz's law** | direction of an induced emf opposes the change in magnetic flux that produced it; this is the negative sign in Faraday's law [OpenStax]

**linear charge density** | amount of charge in an element of a charge distribution that is essentially one-dimensional (the width and height are much, much smaller than its length); its units are C/m [OpenStax]

**loop rule** | algebraic sum of changes in potential around any closed circuit path (loop) must be zero [OpenStax]

**magnetic damping** | drag produced by eddy currents [OpenStax]

**magnetic dipole** | closed-current loop [OpenStax]

**magnetic dipole moment** | term  $IA$  of the magnetic dipole, also called  $\mu$  [OpenStax]

**magnetic domains** | groups of magnetic dipoles that are all aligned in the same direction and are coupled together quantum mechanically [OpenStax]

**magnetic energy density** | energy stored per volume in a magnetic field [OpenStax]

**magnetic field lines** | continuous curves that show the direction of a magnetic field; these lines point in the same direction as a compass points, toward the magnetic south pole of a bar magnet [OpenStax]

**magnetic flux** | measurement of the amount of magnetic field lines through a given area [OpenStax]

**magnetic force** | force applied to a charged particle moving through a magnetic field [OpenStax]

**magnetic susceptibility** | ratio of the magnetic field in the material over the applied field at that time; positive susceptibilities are either paramagnetic or ferromagnetic (aligned with the field) and negative susceptibilities are diamagnetic (aligned oppositely with the field) [OpenStax]

**mass spectrometer** | device that separates ions according to their charge-to-mass ratios [OpenStax]

**Maxwell-Boltzmann distribution** | function that can be integrated to give the probability of finding ideal gas molecules with speeds in the range between the limits of integration [OpenStax]

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

**mean free path** | average distance between collisions of a particle [OpenStax]

**mean free time** | average time between collisions of a particle [OpenStax]

**mechanical equivalent of heat** | work needed to produce the same effects as heat transfer [OpenStax]

**Meissner effect** | phenomenon that occurs in a superconducting material where all magnetic fields are expelled [OpenStax]

**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 [OpenStax]

**molar heat capacity at constant pressure** | quantifies the ratio of the amount of heat added removed to the temperature while measuring at constant pressure [OpenStax]

**molar heat capacity at constant volume** | quantifies the ratio of the amount of heat added removed to the temperature while measuring at constant volume [OpenStax]

**mole** | quantity of a substance whose mass (in grams) is equal to its molecular mass [OpenStax]

**most probable speed** | speed near which the speeds of most molecules are found, the peak of the speed distribution function [OpenStax]

**motionally induced emf** | voltage produced by the movement of a conducting wire in a magnetic field [OpenStax]

**motor (dc)** | loop of wire in a magnetic field; when current is passed through the loops, the magnetic field exerts torque on the loops, which rotates a shaft; electrical energy is converted into mechanical work in the process [OpenStax]

**mutual inductance** | geometric quantity that expresses how effective two devices are at inducing emfs in one another [OpenStax]

**net rate of heat transfer by radiation** |  $P_{\text{net}} = \sigma \epsilon A (T_2^4 - T_1^4)$  [OpenStax]

**neutron** | neutral particle in the nucleus of an atom, with (nearly) the same mass as a proton [OpenStax]

**nonohmic** | type of a material for which Ohm's law is not valid [OpenStax]

**north magnetic pole** | currently where a compass points to north, near the geographic North Pole; this is the effective south pole of a bar magnet but has flipped between the effective north and south poles of a bar magnet multiple times over the age of Earth [OpenStax]

**ohm** | ( $\Omega$ ) unit of electrical resistance,  $1\Omega = 1V/A$  [OpenStax]

**ohmic** | type of a material for which Ohm's law is valid, that is, the voltage drop across the device is equal to the current times the resistance [OpenStax]

**Ohm's law** | empirical relation stating that the current  $I$  is proportional to the potential difference  $V$ ; it is often written as  $V = IR$ , where  $R$  is the resistance [OpenStax]

**open system** | system that can exchange energy and/or matter with its surroundings [OpenStax]



**parallel combination** | components in a circuit arranged with one side of each component connected to one side of the circuit and the other sides of the components connected to the other side of the circuit [OpenStax]

**parallel-plate capacitor** | system of two identical parallel conducting plates separated by a distance [OpenStax]

**paramagnetic materials** | their magnetic dipoles align partially in the same direction as the applied magnetic field; when this field is removed, the material is unmagnetized [OpenStax]

**partial pressure** | pressure a gas would create if it occupied the total volume of space available [OpenStax]

**peak emf** | maximum emf produced by a generator [OpenStax]

**peak speed** | same as “most probable speed” [OpenStax]

**perfect engine** | engine that can convert heat into work with 100% efficiency [OpenStax]

**perfect refrigerator (heat pump)** | refrigerator (heat pump) that can remove (dump) heat without any input of work [OpenStax]

**permanent dipole** | typically a molecule; a dipole created by the arrangement of the charged particles from which the dipole is created [OpenStax]

**permeability of free space** |  $\mu_0$ , measure of the ability of a material, in this case free space, to support a magnetic field [OpenStax]

**permittivity of vacuum** | also called the permittivity of free space, and constant describing the strength of the electric force in a vacuum [OpenStax]

**phase angle** | amount by which the voltage and current are out of phase with each other in a circuit [OpenStax]

**phase diagram** | graph of pressure vs. temperature of a particular substance, showing at which pressures and temperatures the phases of the substance occur [OpenStax]

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

**planar symmetry** | system only varies with distance from a plane [OpenStax]

**polarization** | slight shifting of positive and negative charges to opposite sides of an object [OpenStax]

**potential difference** | difference in electric potential between two points in an electric circuit, measured in volts [OpenStax]

**potential drop** | loss of electric potential energy as a current travels across a resistor, wire, or other component [OpenStax]

**power factor** | amount by which the power delivered in the circuit is less than the theoretical maximum of the circuit due to voltage and current being out of phase [OpenStax]

**Poynting vector** | vector equal to the cross product of the electric and magnetic fields, that describes the flow of electromagnetic energy through a surface [OpenStax]

**principle of superposition** | useful fact that we can simply add up all of the forces due to charges acting on an object [OpenStax]

**proton** | particle in the nucleus of an atom and carrying a positive charge equal in magnitude to the amount of negative charge carried by an electron [OpenStax]

**pV diagram** | graph of pressure vs. volume [OpenStax]

**quality factor** | dimensionless quantity that describes the sharpness of the peak of the bandwidth; a high quality factor is a sharp or narrow resonance peak [OpenStax]

**quasi-static process** | evolution of a system that goes so slowly that the system involved is always in thermodynamic equilibrium [OpenStax]

**radar** | 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 [OpenStax]

**radiation** | energy transferred by electromagnetic waves directly as a result of a temperature difference [OpenStax]

**radiation pressure** | force divided by area applied by an electromagnetic wave on a surface [OpenStax]

**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 [OpenStax]

**rate of conductive heat transfer** | rate of heat transfer from one material to another [OpenStax]

**RC circuit** | circuit that contains both a resistor and a capacitor [OpenStax]

**refrigerator** | device that removes heat from a cold reservoir [OpenStax]

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

**resistivity** | intrinsic property of a material, independent of its shape or size, directly proportional to the resistance, denoted by  $\rho$  [OpenStax]

**resonant frequency** | frequency at which the amplitude of the current is a maximum and the circuit would oscillate if not driven by a voltage source [OpenStax]

**reversible process** | process that can be reverted to restore both the system and its environment back to their original states together [OpenStax]

**reversible process** | process in which both the system and the external environment theoretically can be returned to their original states [OpenStax]

**right-hand rule-1** | using your right hand to determine the direction of either the magnetic force, velocity of a charged particle, or magnetic field [OpenStax]

**RL circuit** | A circuit with resistance and self-inductance [OpenStax]

**RLC circuit** | circuit with an ac source, resistor, inductor, and capacitor all in series. [OpenStax]

**rms current** | root mean square of the current [OpenStax]

**rms voltage** | root mean square of the voltage [OpenStax]

**root-mean-square (rms) speed** | square root of the average of the square (of a quantity) [OpenStax]

**schematic** | graphical representation of a circuit using standardized symbols for components and solid lines for the wire connecting the components [OpenStax]

**self-inductance** | effect of the device inducing emf in itself [OpenStax]

**series combination** | components in a circuit arranged in a row one after the other in a circuit [OpenStax]

**shock hazard** | hazard in which an electric current passes through a person [OpenStax]

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

**south magnetic pole** | currently where a compass points to the south, near the geographic South Pole; this is the effective north pole of a bar magnet but has flipped just like the north magnetic pole [OpenStax]

**specific heat** | amount of heat necessary to change the temperature of 1.00 kg of a substance by 1.00°C; also called “specific heat capacity” [OpenStax]

**spherical symmetry** | system only varies with the distance from the origin, not in direction [OpenStax]

**SQUID** | (Superconducting Quantum Interference Device) device that is a very sensitive magnetometer, used to measure extremely subtle magnetic fields [OpenStax]

**static electricity** | buildup of electric charge on the surface of an object; the arrangement of the charge remains constant (“static”) [OpenStax]

**Stefan-Boltzmann law of radiation** |  $P = \sigma A e T^4$ , where  $\sigma = 5.67 \times 10^{-8} \text{ J/s} \cdot \text{m}^2 \cdot \text{K}^4$  is the Stefan-Boltzmann constant, A is the surface area of the object, T is the absolute temperature, and e is the emissivity [OpenStax]

**step-down transformer** | transformer that decreases voltage and increases current [OpenStax]

**step-up transformer** | transformer that increases voltage and decreases current [OpenStax]

**sublimation** | phase change from solid to gas [OpenStax]

**superconductivity** | phenomenon that occurs in some materials where the resistance goes to exactly zero and all magnetic fields are expelled, which occurs dramatically at some low critical temperature  $T_c$  [OpenStax]

**supercritical** | condition of a fluid being at such a high temperature and pressure that the liquid phase cannot exist [OpenStax]

**superposition** | concept that states that the net electric field of multiple source charges is the vector sum of the field of each source charge calculated individually [OpenStax]

**surface charge density** | amount of charge in an element of a two-dimensional charge distribution (the thickness is small); its units are  $\text{C/m}^2$  [OpenStax]

**surroundings** | environment that interacts with an open system [OpenStax]

**temperature** | quantity measured by a thermometer, which reflects the mechanical energy of molecules in a system [OpenStax]

**terminal voltage** | potential difference measured across the terminals of a source when there is no load attached [OpenStax]

**tesla** | SI unit for magnetic field:  $1 \text{ T} = 1 \text{ N/A} \cdot \text{m}$  [OpenStax]

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

**thermal conductivity** | property of a material describing its ability to conduct heat [OpenStax]

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

**thermal expansion** | change in size or volume of an object with change in temperature [OpenStax]

**thermal hazard** | hazard in which an excessive electric current causes undesired thermal effects [OpenStax]

**thermal stress** | stress caused by thermal expansion or contraction [OpenStax]

**thermodynamic process** | manner in which a state of a system can change from initial state to final state [OpenStax]

**thermodynamic system** | object and focus of thermodynamic study [OpenStax]

**third law of thermodynamics** | absolute zero temperature cannot be reached through any finite number of cooling steps [OpenStax]

**three-wire system** | wiring system used at present for safety reasons, with live, neutral, and ground wires [OpenStax]

**toroid** | donut-shaped coil closely wound around that is one continuous wire [OpenStax]

**transformer** | device that transforms voltages from one value to another using induction [OpenStax]

**transformer equation** | equation showing that the ratio of the secondary to primary voltages in a transformer equals the ratio of the number of turns in their windings [OpenStax]

**triple point** | pressure and temperature at which a substance exists in equilibrium as a solid, liquid, and gas [OpenStax]

**ultraviolet radiation** | 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 [OpenStax]

**universal gas constant** |  $R$ , the constant that appears in the ideal gas law expressed in terms of moles, given by  $R=N_{\text{A}}k_{\text{B}}$  [OpenStax]

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

**van der Waals equation of state** | equation, typically approximate, which 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 [OpenStax]

**vapor** | gas at a temperature below the boiling temperature [OpenStax]

**vapor pressure** | pressure at which a gas coexists with its solid or liquid phase [OpenStax]

**vapor pressure** | partial pressure of a vapor at which it is in equilibrium with the liquid (or solid, in the case of sublimation) phase of the same substance [OpenStax]

**velocity selector** | apparatus where the crossed electric and magnetic fields produce equal and opposite forces on a charged particle moving with a specific velocity; this particle moves through the velocity selector not affected by either field while particles moving with different velocities are deflected by the apparatus [OpenStax]

**visible light** | narrow segment of the electromagnetic spectrum to which the normal human eye responds, from about 400 to 750 nm [OpenStax]

**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 [OpenStax]

**voltmeter** | instrument that measures voltage [OpenStax]

**volume charge density** | amount of charge in an element of a three-dimensional charge distribution; its units are  $\text{C/m}^3$  [OpenStax]

**X-ray** | invisible, penetrating form of very high frequency electromagnetic radiation, overlapping both the ultraviolet range and the  $\gamma$ -ray range [OpenStax]

**xerography** | dry copying process based on electrostatics [OpenStax]

**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 [OpenStax]