SAT II Physics Vocabulary

A

Absolute zero

The lowest theoretical temperature a material can have, where the molecules that make up the material have no kinetic energy. Absolute zero is reached at 0 K or -273° C.

Acceleration

A vector quantity defined as the rate of change of the velocity vector with time.

Activity

In radioactive substances, the number of nuclei that decay per second. Activity, A, will be larger in large samples of radioactive material, since there will be more nuclei.

Alpha decay

A form of radioactive decay where a heavy element emits an alpha particle and some energy, thus transforming into a lighter, more stable, element.

Alpha particle

A particle, α, which consists of two protons and two neutrons. It is identical to the nucleus of a helium atom and is ejected by heavy particles undergoing alpha decay.

Amplitude

In reference to oscillation, amplitude is the maximum displacement of the oscillator from its equilibrium position. Amplitude tells how far an oscillator is swinging back and forth. In periodic motion, amplitude is the maximum displacement in each cycle of a system in periodic motion. The precise definition of amplitude depends on the particular situation: in the case of a stretched string it would be measured in meters, whereas for sound waves it would be measured in units of pressure.

Angle of incidence

When a light ray strikes a surface, the angle of incidence is the angle between the incident ray and the normal.

Angle of reflection

The angle between a reflected ray and the normal.

Angle of refraction

The angle between a refracted ray and the line normal to the surface.

Angular acceleration

A vector quantity, α, equal to the rate of change of the angular velocity vector with time. It is typically given in units of rad/s2.

Angular displacement

The net change, θ, in a point's angular position, ϕ. It is a scalar quantity.

Angular frequency

A frequency, f, defined as the number of revolutions a rigid body makes in a given time interval. It is a scalar quantity commonly denoted in units of Hertz (Hz) or s－1.

Angular momentum

A vector quantity, L, that is the rotational analogue of linear momentum. For a single particle, the angular momentum is the cross product of the particle's displacement from the axis of rotation and the particle's linear momentum, $L = r \times p$. For a rigid body, the angular momentum is a product of the object's moment of inertia, I, and its angular velocity, ω.

Angular period

The time, T, required for a rigid body to complete one revolution.

Angular position

The position, ϕ, of an object according to a co-ordinate system measured in s of the angle of the object from a certain origin axis. Conventionally, this origin axis is the positive x-axis.

Angular velocity

A vector quantity, ω, that reflects the change of angular displacement with time, and is typically given in units of rad/s. To find the direction of the angular velocity vector, take your right hand and curl your fingers along the particle or body's direction of rotation. Your thumb then points in the direction of the body's angular velocity.

Antinode

The points midway between nodes on a standing wave, where the oscillations are largest.

Atom

The building blocks of all matter, atoms are made up of a nucleus consisting of protons and neutrons, and a number of electrons that orbit the nucleus. An electrically neutral atom has as many protons as it has electrons.

Atomic number

A number, z, associated with the number of protons in the nucleus of an atom. Every element can be defined in s of its atomic number, since every atom of a given element has the same number of protons.

Axis of rotation

The line that every particle in the rotating rigid body circles about.

B

Basis vector

A vector of magnitude 1 along one of the coordinate axes. Generally, we take the basis vectors to be $\mathbf{x}$ and $\mathbf{y}$, the vectors of length 1 along the x- and y-axes, respectively.

Beats

When two waves of slightly different frequencies interfere with one another, they produce a "beating" interference pattern that alternates between constructive (in-phase) and destructive (out-of-phase). In the case of sound waves, this sort of interference makes a "wa-wa-wa" sound, and the frequency of the beats is equal to the difference in the frequencies of the two interfering waves.

Beta decay

A form of radioactive decay where a heavy element ejects a beta particle and a neutrino, becoming a lighter element in the process.

Beta particle

A particle, β, identical to an electron. Beta particles are ejected from an atom in the process of beta decay.

Bohr atomic model

A model for the atom developed in 1913 by Niels Bohr. According to this model, the electrons orbiting a nucleus can only orbit at certain particular radii. Excited electrons may jump to a more distant radii and then return to their ground state, emitting a photon in the process.

Boiling point

The temperature at which a material will change phase from liquid to gas or gas to liquid.

Boyle's Law

For a gas held at a constant temperature, pressure and volume are inversely proportional.

C

Calorie

The amount of heat needed to raise the temperature of one gram of water by one degree Celsius. 1 cal = 4.19 J.

Celsius

A scale for measuring temperature, defined such that water freezes at 0°C and boils at 100°C. 0°C = 273 K.

Center of curvature

With spherical mirrors, the center of the sphere of which the mirror is a part. All of the normals pass through it.

Center of mass

Given the trajectory of an object or system, the center of mass is the

point that has the same acceleration as the object or system as a whole would have if its mass were concentrated at that point. In terms of force, the center of mass is the point at which a given net force acting on a

system will produce the same acceleration as if the system's mass were concentrated at that point.

Centripetal acceleration

The acceleration of a body experiencing uniform circular motion. This acceleration is always directed toward the center of the circle.

Centripetal force

The force necessary to maintain a body in uniform circular motion. This force is always directed radially toward the center of the circle.

Chain reaction

The particles and energy released by the fission or fusion of one atom may trigger the fission or fusion of further atoms. In a chain reaction, fission or fusion is rapidly transferred to a large number of atoms, releasing tremendous amounts of energy.

Charles's Law

For a gas held at constant pressure, temperature and volume are directly proportional.

Coefficient of kinetic friction

The coefficient of kinetic friction, μ_k, for two materials is the constant of proportionality between the normal force and the force of kinetic friction. It is always a number between zero and one.

Coefficient of linear expansion

A coefficient that tells how much a material will expand or contract lengthwise when it is heated or cooled.

Coefficient of static friction

The coefficient of static friction, μ_s for two materials is the constant of proportionality between the normal force and the maximum force of static friction. It is always a number between zero and one.

Coefficient of volume expansion

A coefficient that tells how much the volume of a solid will change when it is heated or cooled.

Coherent light

Light such that all of the associated waves have the same wavelength and are in phase.

Collision

When objects collide, each object feels a force for a short amount of time. This force imparts an impulse, or changes the momentum of each of the colliding objects. The momentum of a system is conserved in all kinds of collisions. Kinetic energy is conserved in elastic collisions, but not

in inelastic collisions. In a perfectly inelastic collision, the colliding objects stick together after they collide.

Completely inelastic collision

A collision in which the colliding particles stick together.

Component
Any vector can be expressed as the sum of two mutually perpendicular component vectors. Usually, but not always, these components are multiples of the basis vectors, $\mathbf{x}$ and $\mathbf{y}$; that is, vectors along the x-axis and y-axis. We define these two vectors as the x- and y-components of the vector.
Compression
An area of high air pressure that acts as the wave crest for sound waves. The spacing between successive compressions is the wavelength of sound, and the number of successive areas of compression that arrive at the ear per second is the frequency, or pitch, of the sound.
Concave lens
Also called a diverging lens, a lens that is thinner in the middle than at the edges. Concave lenses refract light away from a focal point.
Concave mirror
A mirror that is curved such that its center is farther from the viewer than the edges, such as the front of a spoon. Concave mirrors reflect light through a focal point.
Conduction
Heat transfer by molecular collisions.
Conservation of Angular Momentum
If the net torque acting on a rigid body is zero, then the angular momentum of the body is constant or conserved.
Conservation of momentum
The principle stating that for any isolated system, linear momentum is constant with time.
Constant of proportionality
A constant in the numerator of a formula.
Constructive interference
The amplification of one wave by another, identical wave of the same sign. Two constructively interfering waves are said to be “in phase.”
Convection
Heat transfer via the mass movement of molecules.
Convex lens
Also called a converging lens, a lens that is thicker in the middle than at the edges. Convex lenses refract light through a focal point.
Convex mirror
A mirror that is curved such that its center is closer to the viewer than the edges, such as a doorknob. Convex mirrors reflect light away from a

focal point.

Cosine

The cosine of an angle in a right triangle is equal to the length of the side adjacent to the angle divided by the length of the hypotenuse.

Crest

The points of maximum displacement along a wave. In traveling waves, the crests move in the direction of propagation of the wave. The crests of standing waves, also called anti-nodes, remain in one place.

Critical angle

For two given media, the smallest angle of incidence at which total internal reflection occurs.

Cross product

A form of vector multiplication, where two vectors are multiplied to produce a third vector. The cross product of two vectors, A and B, separated by an angle, θ, is $A \times B = AB\cos\theta n$, where n is a unit vector perpendicular to both A and B. To deine which direction n points, you must use the right-hand rule.

Cycle

In oscillation, a cycle occurs when an object undergoing oscillatory motion completes a "round-trip." For instance, a pendulum bob released at angle θ has completed one cycle when it swings to $-\theta$ and then back to θ again. In period motion, a cycle is the sequence through which a system once during each oscil-lation. A cycle can consist of one trip up and down for a piece of stretched string, or of a compression followed by a rarefaction of air pressure for sound waves.

D

De Broglie wavelength

A wavelength, given by $\lambda = h/mv$, which is associated with matter. Louis de Broglie proposed the idea that matter could be treated as waves in 1923 and applied this theory successfully to small particles like electrons.

Decay constant

A constant, λ, not to be confused with wavelength, that defines the speed at which a radioactive element undergoes decay. The greater λ is, the faster the element decays.

Decibel

A logorithmic unit for measuring the volume of sound, which is the square of the amplitude of sound waves.

Deposition

The process by which a gas turns directly into a solid because it cannot exist as a liquid at certain pressures.

Destructive interference

The cancellation of one wave by another wave that is exactly out of phase with the first. Despite the dramatic name of this phenomenon, nothing is "destroyed" by this interference—the two waves emerge intact once they have passed each other.

Diffraction

The bending of light at the corners of objects or as it passes through narrow slits or apertures.

Diffraction grating

A sheet, film, or screen with a pattern of equally spaced slits. Typically the width of the slits and space between them is chosen to generate a particular diffraction pattern.

Direction

The property of a vector that distinguishes it from a scalar: while scalars have only a magnitude, vectors have both a magnitude and a direction. When graphing vectors in the xy-coordinate space, direction is usually given by the angle measured counterclockwise from the x-axis to the vector.

Directly proportional

Two quantities are directly proportional if an increase in one results in a proportional increase in the other, and a decrease in one results in a proportional decrease in the other. In a formula defining a certain quantity, those quantities to which it's directly proportional will appear in the numerator.

Dispersion

The separation of different color light via refraction.

Displacement

A vector quantity, commonly denoted by the vector s, which reflects an object's change in spatial position. The displacement vector points from the object's starting position to the object's current position in space. If an object is moved from point A to point B in space along path AB, the magnitude of the object's displacement is the separation of points A and B. Note that the path an object takes to get from point A to point B does not figure when deining displacement.

Distance

A scalar quantity. If an object is moved from point A to point B in space along path AB, the distance that the object has traveled is the length of the path AB. Distance is to be contrasted with displacement, which is simply a measure of the distance between points A and B, and doesn't take into account the path followed between A and B.

Doppler shift

Waves produced by a source that is moving with respect to the observer

will seem to have a higher frequency and smaller wavelength if the motion is towards the observer, and a lower frequency and longer wavelength if the motion is away from the observer. The speed of the waves is independent of the motion of the source.

Dot product

A form of vector multiplication, where two vectors are multiplied to produce a scalar. The dot product of two vectors, A and B, is expressed by the equation $A \cdot B = AB \cos \theta$.

Dynamics

The application of kinematics to understand why objects move the way they do. More precisely, dynamics is the study of how forces cause motion.

E

Efficiency

For a heat engine, the ratio of work done by the engine to heat intake. Efficiency is never 100%.

Elastic collision

A collision in which both kinetic energy and momentum are conserved.

Electric generator

A device that converts mechanical energy to electrical energy by rotating a coil in a magnetic field; sometimes called a "dynamo."

Electromagnetic induction

The property by which a charge moving in a magnetic field creates an electric field.

Electromagnetic spectrum

The spectrum containing all the different kinds of electromagnetic waves, ranging in wavelength and frequency.

Electromagnetic wave

A transverse traveling wave created by the oscillations of an electric field and a magnetic field. Electromagnetic waves travel at the speed of light, $c = 3.00 \times 10^8$ m/s. Examples include microwaves, X rays, and visible light.

Electron

A negatively charged particle that orbits the nucleus of the atom.

Electronvolt

A unit of measurement for energy on atomic levels. 1 eV = 1.6×10^{-19} J.

Energy

A conserved scalar quantity associated with the state or condition of an object or system of objects. We can roughly define energy as the capacity for an object or system to do work. There are many different types of energy, such as kinetic energy, potential energy, thermal energy, chemical energy, mechanical energy, and electrical energy.

Entropy

The disorder of a system.

Equilibrium

The state of a nonrotating object upon whom the net torque acting is zero.

Equilibrium position
The stable position of a system where the net force acting on the object is zero.
F
Faraday’s Law
A law, $|\mathcal{E}| = \Delta\Phi/\Delta t$, which states that the induced emf is the change in magnetic flux in a certain time.
First Law of Thermodynamics
Essentially a restatement of energy conservation, it states that the change in the internal energy of a system is equal to the heat added plus the work done on the system.
Focal length
The distance between the focal point and the vertex of a mirror or lens. For concave mirrors and convex lenses, this number is positive. For convex mirrors and concave lenses, this number is negative.
Focal point
The point of a mirror or lens where all light that runs parallel to the principal axis will be focused. Concave mirrors and convex lenses are designed to focus light into the focal point. Convex mirrors and concave lenses focus light away from the focal point.
Force
A push or a pull that causes an object to accelerate.
Free-body diagram
Illustrates the forces acting on an object, drawn as vectors originating from the center of the object.
Frequency
The number of cycles executed by a system in one second. Frequency is the inverse of period, $f = 1/T$. Frequency is measured in hertz, Hz.
Frictional force
A force caused by the roughness of two materials in contact, deformations in the materials, and a molecular attraction between the materials. Frictional forces are always parallel to the plane of contact between two surfaces and opposite the direction that the object is being pushed or pulled.
Fundamental
The standing wave with the lowest frequency that is supported by a string with both ends tied down is called the fundamental, or resonance, of the string. The wavelength of the fundamental is twice the length of the string, $\lambda_1 = 2L$.

G

Gamma decay

A form of radioactivity where an excited atom releases a photon of gamma radiation, thereby returning to a lower energy state. The atomic structure itself does not change in the course of gamma radiation.

Gamma ray

An electromagnetic wave of very high frequency.

Gold foil experiment

An experiment by Ernest Rutherford that proved for the first time that atoms have nuclei.

Gravitational constant

The constant of proportionality in Newton's Law of Gravitation. It reflects the proportion of the gravitational force and $m_1 m_2 / r^2$, the product of two particles' masses divided by the square of the bodies' separation. $G = 6.67 \times 10^{-11}$ N • m2/kg2.

Gravitational Potential Energy

The energy associated with the configuration of bodies attracted to each other by the gravitational force. It is a measure of the amount of work necessary to get the two bodies from a chosen point of reference to their present position. This point of reference is usually chosen to be a point of infinite distance, giving the equation $U = -G m_1 m_2 / r$. Objects of mass m that are a height h above the surface of the earth have a gravitational potential energy of $U_g = mgh$.

Ground state

In the Bohr model of the atom, the state in which an electron has the least energy and orbits closest to the nucleus.

H

Half-life

The amount of time it takes for one-half of a radioactive sample to decay.

Harmonic series

The series of standing waves supported by a string with both ends tied down. The first member of the series, called the fundamental, has two nodes at the ends and one anti-node in the middle. The higher harmonics are generated by placing an integral number of nodes at even intervals over the length of the string. The harmonic series is very important in music.

Heat

A transfer of thermal energy. We don't speak about systems "having" heat, but about their "transferring" heat, much in the way that dynamical

systems don’t “have” work, but rather “do” work.

Heat engine

A machine that operates by taking heat from a hot place, doing some work with that heat, and then exhausting the rest of the heat into a cool place. The internal combustion engine of a car is an example of a heat engine.

Heat transfer

A transfer of thermal energy from one system to another.

Hertz (Hz)

The units of frequency, defined as inverse-seconds ($1\ \text{Hz} = 1\ \text{s}^{-1}$). "Hertz" can be used interchangeably with "cycles per second."

Hooke's Law

For an oscillating spring, the restoring force exerted by the spring is directly proportional to the displacement. That is, the more the spring is displaced, the stronger the force that will pull toward the equilibrium position. This law is expressed mathematically as $F = -kx$, where F is the restoring force and x is the displacement. The constant of proportionality, $-k$, is the spring constant.

Hypotenuse

The longest side of a right triangle, opposite to the right angle.

I

Ideal gas law

An equation, $PV = nRT$, that relates the pressure, volume, temperature, and quantity of an ideal gas. An ideal gas is one that obeys the approximations laid out in the kinetic theory of gases.

Impulse

A vector quantity defined as the product of the force acting on a body multiplied by the time interval over which the force is exerted.

Incident ray

When dealing with reflection or refraction, the incident ray is the ray of light before it strikes the reflecting or refracting surface.

Inclined plane

A wedge or a slide. The dynamics of objects sliding down inclined planes is a popular topic on SAT II Physics.

Index of refraction

The index of refraction $n = c/v$ of a substance characterizes the speed of light in that substance, v. It also characterizes, by way of Snell's Law, the angle at which light refracts in that substance.

Induced current

The current induced in a circuit by a change in magnetic flux.

Inelastic collision

A collision in which momentum is conserved but kinetic energy is not.

Inertia

The tendency of an object to remain at a constant velocity, or its resistance to being accelerated. Newton’s First Law is alternatively called the Law of Inertia because it describes this tendency.
Inertial reference frame

A reference frame in which Newton's First Law is true. Two inertial reference frames move at a constant velocity relative to one another. According to the first postulate of Einstein's theory of special relativity, the laws of physics are the same in all inertial reference frames.

Instantaneous velocity

The velocity at any given instant in time. To be contrasted with average velocity, which is a measure of the change in displacement over a given time interval.

Internal energy

The energy stored in a thermodynamic system.

Inversely proportional

Two quantities are inversely proportional if an increase in one results in a proportional decrease in the other, and a decrease in one results in a proportional increase in the other. In a formula defining a certain quantity, those quantities to which it's inversely proportional will appear in the denominator.

Isolated system

A system that no external net force acts upon. Objects within the system may exert forces upon one another, but they cannot receive any impulse from outside forces. Momentum is conserved in isolated systems.

Isotope

Atoms of the same element may have different numbers of neutrons and therefore different masses. Atoms of the same element but with different numbers of neutrons are called isotopes of the same element.

J

Joule

The joule (J) is the unit of work and energy. A joule is $_1$ N • m or $_1$ kg • m2/s2.

K

Kelvin

A scale for measuring temperature, defined such that $_0$K is the lowest theoretical temperature a material can have. $_{273}$K = $_0$°C.

Kepler's First Law

The path of each planet around the sun is an ellipse with the sun at one focus.

Kepler's Second Law

If a line is drawn from the sun to the planet, then the area swept out by this line in a given time interval is constant.

Kepler's Third Law

Given the period, T, and semimajor axis, a, of a planet's orbit, the ratio T^2/a^3 is the same for every planet.

Kinematic equations

The five equations used to solve problems in kinematics in one dimension with uniform acceleration.

Kinematics

Kinematics is the study and description of the motion of objects.

Kinetic energy

Energy associated with the state of motion. The translational kinetic energy of an object is given by the equation $KE = (1/2)mv^2$.

Kinetic friction

The force between two surfaces moving relative to one another. The frictional force is parallel to the plane of contact between the two objects and in the opposite direction of the sliding object's motion.

Kinetic theory of gases

A rough approximation of how gases work, that is quite accurate in everyday conditions. According to the kinetic theory, gases are made up of tiny, round molecules that move about in accordance with Newton's Laws, and collide with one another and other objects elastically. We can derive the ideal gas law from the kinetic theory.

L

Latent heat of fusion

The amount of heat necessary to transform a solid at a given temperature into a liquid of the same temperature, or the amount of heat needed to be removed from a liquid of a given temperature to transform it into a solid of the same temperature.

Latent heat of sublimation

The amount of heat necessary for a material undergoing sublimation to make a phase change from gas to solid or solid to gas, without a change in temperature.

Latent heat of transformation

The amount heat necessary to cause a substance to undergo a phase transition.

Latent heat of vaporization

The amount of heat necessary to transform a liquid at a given temperature into a gas of the same temperature, or the amount of heat needed to be taken away from a gas of a given temperature to transform it into a liquid of the same temperature.

Law of conservation of energy

Energy cannot be made or destroyed; energy can only be changed from one place to another or from one form to another.

Law of reflection

For a reflected light ray, $\theta_{\text{incidence}} = \theta_{\text{reflection}}$. In other words, a ray of light reflects of a surface in the same plane as the incident ray and the normal,

and at an angle to the normal that is equal to the angle between the incident ray and the normal.

Legs

The two shorter sides of a right triangle that meet at the right angle.

Lenz's Law

States that the current induced in a circuit by a change in magnetic flux is in the direction that will oppose that change in flux. Using the right-hand rule, point your thumb in the opposite direction of the change in magnetic flux. The direction your fingers curl into a fist indicates the direction of the current.

Longitudinal waves

Waves that oscillate in the same direction as the propagation of the wave. Sound is carried by longitudinal waves, since the air molecules move back and forth in the same direction the sound travels.

Loudness

The square of the amplitude of a sound wave is called the sound's loudness, or volume.

M

Magnetic flux

The dot product of the area and the magnetic field passing through it. Graphically, it is a measure of the number and length of magnetic field lines passing through that area. It is measured in Webers (Wb).

Magnification

The ratio of the size of the image produced by a mirror or lens to the size of the original object. This number is negative if the image is upside-down.

Magnitude

A property common to both vectors and scalars. In the graphical representation of a vector, the vector's magnitude is equal to the length of the arrow.

Margin of error

The amount of error that's possible in a given measurement.

Mass

A measurement of a body's inertia, or resistance to being accelerated.

Mass defect

The mass difference between a nucleus and the sum of the masses of the constituent protons and neutrons.

Mass number

The mass number, A, is the sum of the number of protons and neutrons in a nucleus. It is very close to the weight of that nucleus in atomic mass

units.

Maxima

In an interference or diffraction pattern, the places where there is the most light.

Mechanical energy

The sum of a system's potential and kinetic energy. In many systems, including projectiles, pulleys, pendulums, and motion on frictionless surfaces, mechanical energy is conserved. One important type of problem in which mechanical energy is not conserved is the class of problems involving friction.

Medium

The substance that is displaced as a wave propagates through it. Air is the medium for sound waves, the string is the medium of transverse waves on a string, and water is the medium for ocean waves. Note that even if the waves in a given medium travel great distances, the medium itself remains more or less in the same place.

Melting point

The temperature at which a material will change phase from solid to liquid or liquid to solid.

Meson

A class of elementary particle whose mass is between that of a proton and that of an electron. A common kind of meson is the pion.

Michelson-Morley experiment

An experiment in 1879 that showed that the speed of light is constant to all observers. Einstein used the results of this experiment as support for his theory of special relativity.

Minima

In an interference or diffraction pattern, the places where there is the least light.

Mole

The number of hydrogen atoms in one gram of hydrogen, equal to 6.023×10^{23}.

When counting the number of molecules in a gas, it is often convenient to count them in moles.

Moment of inertia

A rigid body's resistance to being rotated. The moment of inertia for a single particle is $MR2$, where M is the mass of the rigid body and R is the distance to the rotation axis. For rigid bodies, calculating the moment of inertia is more complicated, but it generally takes the form of a constant multiplied by $MR2$.

Momentum

Linear momentum, p, commonly called "momentum" for short, is a vector quantity defined as the product of an object's mass, m, and its velocity, v.

Motional emf

The emf created by the motion of a charge through a magnetic field.

Mutual Induction

The property by which a changing current in one coil of wire induces an emf in another.

N

Neutrino

An almost massless particle of neutral charge that is released along with a beta particle in beta decay.

Neutron

A neutrally charged particle that, along with protons, constitutes the nucleus of an atom.

Neutron number

The number, N, of neutrons in an atomic nucleus.

Newton

A unit of force: 1 N is equivalent to a 1 kg • m/s2.

Newton’s First Law

An object at rest remains at rest, unless acted upon by a net force. An object in motion remains in motion, unless acted upon by a net force.

Newton’s Law of Universal Gravitation

The force of gravity, F, between two particles of mass m_1 and m_2, separated by a distance r, has a magnitude of $F = Gm_1m_2/r^2$, where G is the gravitational constant. The force is directed along the line joining the two particles.

Newton’s Second Law

$F = ma$. The net force, F, acting on an object causes the object to accelerate, a. The magnitude of the acceleration is directly proportional to the net force on the object and inversely proportional to the mass, m, of the object.

Newton’s Third Law

To every action, there is an equal and opposite reaction. If an object A exerts a force on another object B, B will exert on A a force equal in magnitude and opposite in direction to the force exerted by A.

Node

The points on a standing wave where total destructive interference causes the medium to remain fixed at its equilibrium position.

Normal

The line perpendicular to a surface. There is only one normal for any given surface.

Normal force

The reaction force of the ground, a table, etc., when an object is placed upon it. The normal force is a direct consequence of Newton’s Third Law: when an object is placed on the ground, the ground pushes back with the

same force that it is pushed upon. As a result, the net force of an object on the ground is zero, and the object does not move.

Nuclear fission

A nuclear reaction in which a high-energy neutron bombards a heavy, unstable atomic nucleus, causing it to split into two smaller nuclei, and releasing some neutrons and a vast amount of energy at the same time.

Nuclear fusion

A nuclear reaction that takes place only at very high temperatures. Two light atoms, often hydrogen, fuse together to form a larger single atom, releasing a vast amount of energy in the process.

Nucleus

The center of an atom, where the protons and neutrons reside. Electrons then orbit this nucleus.

O

Optics

The study of the properties of visible light, i.e., the portion of the electromagnetic spectrum with wavelengths between 360 and 780 nm (1 nm = 1×10^{-9} m/s).

Orbit

When an object is held in circular motion about a massive body, like a planet or a sun, due to the force of gravity, that object is said to be in orbit. Objects in orbit are in perpetual free fall, and so are therefore weightless.

Oscillation

A back-and-forth movement about an equilibrium position. Springs, pendulums, and other oscillators experience harmonic motion.

P

Pascals

The unit for measuring pressure. One Pascal is equal to one Newton per meter squared, 1 Pa = 1N/m2.

Pendulum

A pendulum consists of a bob connected to a rod or rope. At small angles, a pendulum's motion approximates simple harmonic motion as it swings back and forth without friction.

Period

The time it takes a system to pass through one cycle of its repetitive motion. The period, T, is the inverse of the motion's frequency, $f = 1/T$.

Phase

Two oscillators that have the same frequency and amplitude, but reach their maximum displacements at different times, are said to have different phases. Similarly, two waves are in phase if their crests and troughs line

up exactly, and they are out of phase if the crests of one wave line up with the troughs of the other.

Phase change

When a solid, liquid, or gas changes into another phase of matter.

Photoelectric effect

When electromagnetic radiation shines upon a metal, the surface of the metal releases energized electrons. The way in which these electrons are released contradicts classical theories of electromagnetic radiation and supports the quantum view according to which electromagnetic waves are treated as particles.

Photoelectron

The name of an electron released from the surface of a metal due to the photoelectric effect.

Photon

A small particle-like bundle of electromagnetic radiation.

Pitch

Another word for the frequency of a sound wave.

Planck's constant

A constant, $h = 6.63 \times 10^{-34}$ J • s, which is useful in quantum physics.

A second constant associated with Planck's constant is $\hbar = h/2\pi$.

Polarization

A process that aligns a wave of light to oscillate in one dimension rather than two.

Potential energy

Energy associated with an object's position in space, or configuration in relation to other objects. This is a latent form of energy, where the amount of potential energy reflects the amount of energy that potentially could be released as kinetic energy or energy of some other form.

Power

Defined as the rate at which work is done, or the rate at which energy is transformed. P is measured in joules per second (J/s), or watts (W).

Pressure

A measure of force per unit area. Pressure is measured in N/m2 or Pa.

Principal axis

The straight line that runs through the focal point and the vertex of a mirror or lens.

Proton

A positively charged particle that, along with the neutron, occupies the

nucleus of the atom.

Pulley

A pulley is a simple machine that consists of a rope that slides around a disk or block.

Q

Quark

The building blocks of all matter, quarks are the constituent parts of protons, neutrons, and mesons.

R

Radian

A unit for measuring angles; also called a "rad." 2π rad = 360°.

Radiation

Heat transfer via electromagnetic waves.

Radioactive decay

The process by which unstable nuclei spontaneously release particles and/or energy so as to come to a more stable arrangement. The most common forms of radioactive decay are alpha decay, beta decay, and gamma decay.

Radioactivity

An object is called radioactive if it undergoes radioactive decay.

Radius of curvature

With spherical mirrors, the radius of the sphere of which the mirror is a part.

Rarefaction

An area of high air pressure that acts as the wave trough for sound waves. The spacing between successive rarefactions is the wavelength of sound, and the number of successive areas of rarefaction that arrive at the ear per second is the frequency, or pitch, of the sound.

Real image

An image created by a mirror or lens in such a way that light does actually come from where the image appears to be. If you place a screen in front of a real image, the image will be projected onto the screen.

Reflect

A wave on a string that is tied to a pole at one end will reflect back toward its source, producing a wave that is the mirror-image of the original and which travels in the opposite direction.

Reflected ray

The ray of light that is reflected from a mirror or other reflecting surface.

Reflection

The phenomenon of light bouncing off a surface, such as a mirror.

Refracted ray

The ray of light that is refracted through a surface into a different medium.

Refraction

The bending of light as it passes from one medium to another. Light refracts toward the normal when going from a less dense medium into a denser medium and away from the normal when going from a denser medium into a less dense medium.

Restoring force
The force that causes simple harmonic motion. The restoring force is always directed toward an object's equilibrium position.
Right-hand rule
A means of defining the direction of the cross product vector. To define the direction of the vector $(A \times B)$, position your right hand so that your fingers point in the direction of A, and then curl them around so that they point in the direction of B. The direction of your thumb shows the direction of the cross product vector.
Rigid body
An object that retains its overall shape, meaning that the particles that make up the rigid body stay in the same position relative to one another.
Rotational kinetic energy
The energy of a particle rotating around an axis.
Rotational motion
Occurs when every point in the rigid body moves in a circular path around a line called the axis of rotation.
Rutherford nuclear model
The model of the atom according to which negatively charged electrons orbit a positively charged nucleus. This model was developed by Ernest Rutherford in light of the results from his gold foil experiment.
S
Scalar
A quantity that possesses a magnitude but not a direction. Mass and length are common examples.
Second Law of Thermodynamics
There are a few versions of this law. One is that heat flows spontaneously from hot to cold, but not in the reverse direction. Another is that there is no such thing as a 100% efficient heat engine. A third states that the entropy, or disorder, of a system may increase but will never decrease spontaneously.
Significant digits
The number of digits that have been accurately measured. When combining several measurements in a formula, the resulting calculation can only have as many significant digits as the measurement that has the smallest number of significant digits.
Simple harmonic oscillator
An object that moves about a stable equilibrium point and experiences a restoring force that is directly proportional to the oscillator's

displacement.

Sine

In a right triangle, the sine of a given angle is the length of the side opposite the angle divided by the length of the hypotenuse.

Snell's Law
Relates the angle of incidence to the angle of refraction: $n_1 \sin\theta_1 = n_2 \sin\theta_2$.

Sound
Waves carried by variations in air pressure. The speed of sound waves in air at room temperature and pressure is roughly 343 m/s.

Specific heat
The amount of heat of a material required to raise the temperature of either one kilogram or one gram of that material by one degree Celsius. Different units may be used depending on whether specific heat is measured in s of grams or kilograms, and joules or calories.

Spectroscope
A device that breaks incoming light down into spectral rays, so that one can see the exact wavelength constituents of the light.

Speed
A scalar quantity that tells us how fast an object is moving. It measures the rate of change in distance over time. Speed is to be contrasted with velocity in that there is no direction associated with speed.

Spring
Objects that experience oscillatory or simple harmonic motion when distorted. Their motion is described by Hooke's Law.

Spring constant
Indicates how "bouncy" or "stiff" a spring is. More specifically, the spring constant, k, is the constant of proportionality between the restoring force exerted by the spring, and the spring's displacement from equilibrium. The greater the value of k, more resistant the spring is to being displaced.

Standing wave
A wave that interferes with its own reflection so as to produce oscillations which stand still, rather than traveling down the length of the medium. Standing waves on a string with both ends tied down make up the harmonic series.

Static friction
The force between two surfaces that are not moving relative to one another. The force of static friction is parallel to the plane of contact between the two objects and resists the force pushing or pulling on the object.

Strong nuclear force
The force that binds protons and neutrons together in the atomic nucleus.

Sublimation

The process by which a solid turns directly into gas, because it cannot exist as a liquid at a certain pressure.

Superposition

The principle by which the displacements from different waves traveling in the same medium add up. Superposition is the basis for interference.

System

A body or set of bodies that we choose to analyze as a group.

T

Tail

In the graphical representation of vectors, the tail of the arrow is the blunt end (the end without a point).

Tangent

In a right triangle, the tangent of a given angle is the length of the side opposite the angle divided by the length of the side adjacent to the triangle.

Temperature

A measure of the average kinetic energy of the molecules in a system. Temperature is related to heat by the specific heat of a given substance.

Tension force

The force transmitted along a rope or cable.

Thermal energy

The energy of the molecules that make up an object. It is related to heat, which is the amount of energy transferred from one object to another object that is a different temperature.

Thermal equilibrium

Two materials are in thermal equilibrium if they are at the same temperature.

Third Law of Thermodynamics

An object cannot be cooled to absolute zero.

Threshold frequency

A property of a metal, the minimum frequency of electromagnetic radiation that is necessary to release photoelectrons from that metal.

Tip

In the graphical representation of vectors, the tip of the arrow is the pointy end.

Torque

The effect of force on rotational motion.

Total internal reflection

The phenomenon by which light traveling from a high n to a low n material will reflect from the optical interface if the incident angle is greater than the critical angle.

Transformer

A device made of two coils, which converts current of one voltage into

current of another voltage. In a step-up transformer, the primary coil has fewer turns than the secondary, thus increasing the voltage. In a step-down transformer, the secondary coil has fewer turns than the primary, thus decreasing the voltage.

Translational kinetic energy
The energy of a particle moving in space. It is defined in s of a particle's mass, m, and velocity, v, as $(1/2)mv2$.
Translational motion
The movement of a rigid body's center of mass in space.
Transverse waves
Waves in which the medium moves in the direction perpendicular to the propagation of the wave. Waves on a stretched string, water waves, and electromagnetic waves are all examples of transverse waves.
Traveling waves
A wave with wave crests that propagate down the length of the medium, in contrast to stationary standing waves. The velocity at which a crest propagates is called the wave speed.
Trough
The points of maximum negative displacement along a wave. They are the opposite of wave crests.
U
Uncertainty principle
A principle derived by Werner Heisenberg in 1927 that tells us that we can never know both the position and the momentum of a particle at any given time.
Uniform circular motion
The motion of a body in a circular path with constant speed.
Unit vector
A unit vector is a vector with length 1.
Universal gas constant
Represented by $R = 8.31$ J/mol • K, the universal gas constant fits into the ideal gas law so as to relate temperature to the average kinetic energy of gas molecules.
V
Vector
A vector quantity, or vector, is an object possessing, and fully described by, a magnitude and a direction. Graphically a vector is depicted as an arrow with its magnitude given by the length of the arrow and its direction given by where the arrow is pointing.
Velocity
A vector quantity defined as the rate of change of the displacement vector with time. It is to be contrasted with speed, which is a scalar quantity for which no direction is specified.
Vertex

The center of a mirror or lens.

Virtual image

An image created by a mirror or lens in such a way that light does not actually come from where the image appears to be.

W

Wave

A system with many parts in periodic, or repetitive, motion. The oscillations in one part cause vibrations in nearby parts.

Wave speed

The speed at which a wave crest or trough propagates. Note that this is not the speed at which the actual medium (like the stretched string or the air particles) moves.

Wavelength

The distance between successive wave crests, or troughs. Wavelength is measured in meters and is related to frequency and wave speed by $\lambda = v/f$.

Weak nuclear force

The force involved in beta decay that changes a proton to a neutron and releases an electron and a neutrino.

Weber

The unit of magnetic flux, equal to one T • m2.

Weight

The gravitational force exerted on a given mass.

Weightlessness

The experience of being in free fall. If you are in a satellite, elevator, or other free-falling object, then you have a weight of zero Newtons relative to that object.

Work

Done when energy is transferred by a force. The work done by a force F in displacing an object by s is $W = F \cdot s$.

Work function

The amount of energy that metal must absorb before it can release a photoelectron from the metal.

Work-energy theorem

States that the net work done on an object is equal to the object's change in kinetic energy.

Z

Zeroth Law of Thermodynamics

If two systems, A and B, are in thermal equilibrium and if B and C are also in thermal equilibrium, then systems A and C are necessarily in thermal equilibrium.