

## Glossary

### A

**acceleration** The rate of change of velocity, a vector quantity

**acceleration of free fall** The rate of change of velocity of an object falling in a gravitational field, symbol  $g$

**air resistance** The drag or resistive force experienced by objects moving through air

**ammeter** A device used to measure electric current – it must be placed in series and ideally have zero resistance

**ampère** The base SI unit of electric current, symbol A, defined as the current flowing in two parallel wires in a vacuum 1 m apart such that there is an attractive force of  $2.0 \times 10^{-7}$  N per metre length of wire between them

**amplitude (waves)** The maximum displacement from the equilibrium position (can be positive or negative)

**angle of incidence** The angle between the direction of travel of an incident wave and the normal at a boundary between two media

**angle of reflection** The angle between the direction of travel of a reflected wave and the normal at a boundary between two media

**anion** A negatively charged ion, one which is attracted to an anode

**anode** A positively charged electrode

**antiparallel (vectors)** In the same line but opposite directions

**antiphase** Particles oscillating completely out of step with each other (one reaches its maximum positive displacement as the other reaches its maximum negative displacement) are in antiphase

**Archimedes' principle** The upthrust on an object in a fluid is equal to the weight of fluid it displaces

**average speed** The rate of change in distance calculated over a complete journey

**average velocity** The change in displacement  $\Delta s$  for a journey divided by the time taken  $\Delta t$ ,  
 $\Delta s / \Delta t$

### B

**base unit** One of seven units that form the building blocks of the SI measurement system

**battery** A collection of cells that transfers chemical energy into electrical energy

**braking distance** Distance travelled by a vehicle from the time the brakes are applied until the vehicle stops

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**breaking strength** The stress value at the point of fracture, calculated by dividing the breaking force by the cross-sectional area

**brittle** Property of a material that does not show plastic deformation and deforms very little (if at all) under high stress

**C**

**capacitor** A component that stores charge, consists of two plates separated by an insulator (dielectric)

**cathode** A negatively charged electrode

**cation** A positively charged ion, one which is attracted to a cathode

**cell** A device that transfers chemical energy into electrical energy

**centre of gravity** An imaginary point at which the entire weight of an object appears to act

**centre of mass** A point through which any externally applied force produces straight-line motion but no rotation

**charge carrier** A particle with charge that moves through a material to form an electric current – for example, an electron in a metal wire

**closed system** An isolated system that has no interaction with its surroundings

**coherence** Two waves sources, or waves, that are coherent have a constant phase difference

**component** One of the two perpendicular vectors obtained by resolving a vector

**compression** The decrease in length of an object when a compressive force is exerted on it

**compression (waves)** A moving region in which the medium is denser or has higher pressure than the surrounding medium

**compressive deformation** A change in the shape of an object due to compressive forces

**compressive force** Two or more forces together that reduce the length or volume of an object

**conservation of charge** A conservation law which states that electric charge can neither be created nor destroyed – the total charge in any interaction must be the same before and after the interaction

**constant speed** Motion in which the distance travelled per unit time stays the same

**constant velocity** Motion in which the change in displacement per unit time stays the same

**constructive interference** Superposition of two waves in phase so that the resultant wave has greater amplitude than the original waves

**conventional current** A model used to describe electric current in a circuit – conventional current travels from positive to negative – it is the direction in which positive charges would travel

**coulomb** The derived SI unit of electrical charge, symbol C – 1 coulomb of electric charge passes a point in one second when there is an electric current of one ampere,  $1 \text{ C} = 1 \text{ A s}$

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**couple** A pair of equal and opposite forces acting on a body but not in the same straight line

**critical angle** The angle of incidence at the boundary between two media that will produce an angle of refraction of  $90^\circ$

**crystallography** A method for determining the structure of a substance by studying the interference patterns produced by waves passing through a crystal of the substance

**D**

**de Broglie equation** An equation relating the wavelength and the momentum of a particle:

$$\lambda = \frac{h}{p}$$

**density** The mass per unit volume of a substance derived quantity A quantity that comes from a combination of base units

**derived unit** A unit used to represent a derived quantity, such as N for force

**destructive interference** Superposition of two waves in antiphase so that the waves cancel each other out and the resultant wave has smaller amplitude than the original waves

**diffraction** The phenomenon in which waves passing through a gap or around an obstacle spread out

**diode** A semiconductor component that allows current only in one particular direction

**displacement** The distance travelled in a particular direction – it is a vector with magnitude and a direction

**displacement (waves)** The distance from the equilibrium position in a particular direction – displacement is a vector, so it has a positive or a negative value

**drag force** The resistive force exerted by a fluid on an object moving through it

**ductile** Property of a material that has a large plastic region in a stress-strain graph, so can be drawn into wires

**E**

**efficiency** The ratio of useful output energy to total input energy, often expressed as a percentage

**elastic deformation** A reversible change in the shape of an object due to a compressive or tensile force – removal of stress or force will return the object to its original shape and size (no permanent strain)

**elastic limit** The value of stress or force beyond which elastic deformation becomes plastic deformation, and the material or object will no longer return to its original shape and size when the stress or force is removed

**elastic potential energy** The energy stored in an object because of its deformation

**electric charge** A physical property, symbol  $q$  or  $Q$ , either positive or negative, measured in coulombs, C, or as a relative charge

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**electric current** The rate of flow of charge, symbol  $I$ , measured in ampères, A; normally a flow of electrons in metals or a flow of ions in electrolytes

**electricity meter** A device that measures the electrical energy supplied in kWh to a house from the grid

**electrolyte** A liquid containing ions that are free to move and so to conduct electricity

**electromagnetic spectrum** The full range of frequencies of electromagnetic waves, from gamma rays to radio waves

**electromagnetic wave** Transverse waves with oscillating electric and magnetic field components, such as light and X-rays, that do not need a medium to propagate – they travel at a speed of  $3.0 \times 10^8 \text{ m s}^{-1}$  in a vacuum

**electromotive force (e.m.f.)** The work done on the charge carriers per unit charge, symbol  $V$ , unit volt, V, measured across a cell, battery or power supply

**electron gun** A device that uses a large accelerating potential difference to produce a narrow beam of electrons

**electronvolt** A derived unit of energy used for subatomic particles and photons, defined as the energy transferred to or from an electron when it passes through a potential difference of 1 volt; 1 eV is equivalent to  $1.60 \times 10^{-19} \text{ J}$

**elementary charge** The electric charge equivalent to the charge on a proton,  $1.60 \times 10^{-19} \text{ C}$ ; symbol  $e$

**energy** The capacity for doing work, measured in joules, J

**equilibrium** A body is in equilibrium when the net force and net moment acting on it are zero

**equilibrium position (waves)** The resting position for particles in the medium

**extension** The increase in length of an object when a tensile force is exerted on it

**F**

**filament lamp** An electrical component containing a narrow filament of wire that transfers electrical energy into heat and light

**fluid** A substance that can flow, including liquids and gases

**force** A push or pull on an object, measured in newtons, N

**force constant** A quantity determined by dividing force by extension (or compression) for an object obeying Hooke's law – called constant of proportionality  $k$  in Hooke's law, measured in  $\text{N m}^{-1}$

**force–extension graph** A graph of force against extension (or compression), with the area under the graph equal to the work done on the material

**force–time graph** A graph of net force against time, with the area under the graph equal to the impulse

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**free electron** An electron in a metal that is not bound to an atom and is free to move – sometimes called a delocalised electron

**free fall** The motion of an object accelerating under gravity with no other force acting on it

**free-body diagram** A diagram that represents the forces acting on a single object

**frequency (waves)** The number of wavelengths passing a given point per unit time

**fundamental frequency** The lowest frequency at which an object (e.g., an air column in a pipe or a string fixed at both ends) can vibrate

**fundamental mode of vibration** A vibration at the fundamental frequency

**G**

**gamma rays** Short-wavelength electromagnetic waves, with wavelengths from  $10^{-10}$  m to  $10^{-16}$  m

**gold-leaf electroscope** A device with a metallic stem and a gold leaf that can be used to identify and measure electric charge – a device that was historically used as a voltmeter for measuring large voltages

**gradient** In a graph, the change in the vertical axis quantity divided by the corresponding change in the horizontal axis quantity

**gravitational potential energy** The capacity for doing work as a result of an object's position in a gravitational field

**H**

**harmonic** A whole-number multiple of the fundamental frequency

**Hooke's law** The force applied is directly proportional to the extension of the spring unless the limit of proportionality is exceeded

**hysteresis loop** A loop-shaped plot obtained when, for example, loading and unloading a material produce different deformations

**I**

**impulse** The area under a force-time graph – the product of force and the time for which the force acts

**in phase** Particles oscillating perfectly in time with each other (reaching their maximum positive displacement at the same time) are in phase

**inelastic collision** A collision in which kinetic energy is lost

**infrared waves** Electromagnetic waves, with wavelengths from  $10^{-3}$  m to  $7 \times 10^{-7}$  m

**instantaneous speed** The speed at the moment it is measured – speed over an infinitesimal interval of time

**intensity (waves)** The radiant power passing through a surface per unit area

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**interference** Superposition of two progressive waves from coherent sources to produce a resultant wave with a displacement equal to the sum of the individual displacements from the two waves

**interference pattern** A pattern of constructive and destructive interference formed as waves overlap

**internal resistance** The resistance of a source of e.m.f. (e.g a cell) due to its construction, which causes a loss in energy/voltage as the charge passes through the source, symbol  $r$ , SI unit ohm  $\Omega$

**ion** An atom that has either lost or gained electrons and so has a net charge

**ionic solution** An ionic compound dissolved in a liquid to form an electrolyte

**I–V characteristic** A description of the relationship between the electric current in a component and the potential difference across it – in most cases this is usually in the form of a simple graph of  $I$  against  $V$

**K**

**kilowatt-hour** A derived unit of energy, most often associated with paying for electrical energy, symbol kWh (1 kWh = 3.6 MJ). Energy in kWh can be calculated by multiplying the power in kW by the time in hours

**kinetic energy** The energy associated with an object as a result of its motion

**Kirchhoff's first law** At any point in an electrical circuit, the sum of currents into that point is equal to the sum of currents out of that point, electrical charge is conserved

**Kirchhoff's second law** In a closed loop of an electrical circuit, the sum of the e.m.f.s is equal to the sum of the p.d.s

**L**

**law of reflection** The angle of incidence is equal to the angle of reflection

**light-dependent resistor** An electrical component with a resistance that decreases as the light intensity incident on it increases

**light-emitting diode** A type of diode that emits light when it conducts electricity

**limit of proportionality** The value of stress or force beyond which stress is no longer directly proportional to strain

**linear momentum** A property of an object travelling in a straight line, the product of its mass and velocity, measured in  $\text{kg m s}^{-1}$  or  $\text{N s}$

**loading (electrical circuits)** Connecting a component or a device across the terminals of a source of e.m.f. or across another component

**loading curve** A force-extension graph

**longitudinal wave** A wave in which the medium is displaced in the same line as the direction of energy transfer – oscillations of the medium particles are parallel to the direction of the wave travel

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**lost volts** The potential difference across the internal resistor of a source of e.m.f.

**M**

**mass** Amount of matter, a base quantity measured in kilograms, kg

**maximum (waves)** The point of greatest amplitude in an interference pattern, produced by constructive interference

**mean drift velocity** The average velocity of electrons as they move through a wire, symbol  $v$ , unit  $\text{ms}^{-1}$

**microwaves** Long-wavelength electromagnetic waves, with wavelengths from  $10^{-1}$  m to  $10^{-3}$  m

**minimum (waves)** The point of least amplitude in an interference pattern, produced by destructive interference

**moment** The product of force and perpendicular distance from a pivot or stated point

**monochromatic light** Light of a single frequency

**N**

**negative (charge)** One type of electric charge; negatively charged objects attract positively charged ones, and repel other negative charges

**negative temperature coefficient (NTC)** A relationship in which a variable decreases as temperature increases, for example the resistance of NTC thermistors

**Newton's first law of motion** A body will remain at rest or continue to move with constant velocity unless acted upon by a resultant force

**Newton's second law of motion** The rate of change of momentum of an object is directly proportional to the resultant force and takes place in the direction of the force

**Newton's third law of motion** When two objects interact, each exerts an equal but opposite force on the other during the interaction

**node** For a stationary wave, a point where the amplitude is always zero

**non-ohmic component** A component that does not obey Ohm's law, e.g. filament lamp and diode

**normal** An imaginary line perpendicular to a surface such as the boundary between one medium and another (e.g., air and glass)

**normal contact force** The force exerted by a surface on an object, which acts perpendicularly to the surface

**number density** The number of free electrons per cubic metre of a material, symbol  $n$ , unit  $\text{m}^{-3}$

**O**

**ohm** The derived SI unit of resistance, symbol  $\Omega$  – defined as the resistance of a component that has a potential difference of 1 V per unit ampere

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**Ohm's law** The potential difference across a conductor is directly proportional to the current in the component as long as its temperature remains constant

**ohmic conductor** A conductor that obeys Ohm's law

**optical fibre** A fibre made of glass designed with a varying refractive index in order to totally internally reflect pulses of visible or infrared light travelling through it

**oscilloscope** An instrument that displays an electrical signal as a voltage against time trace on a screen

**out of phase** Particles that are neither in phase, nor in antiphase, are out of phase

**P**

**parallel (vectors)** In the same line and direction

**parallel circuit** A type of branching electrical circuit in which there is more than one path for the current – components in parallel have the same potential difference

**partially polarised** Description of a transverse wave in which there are more oscillations in one particular plane, but the wave is not completely plane polarised – occurs when transverse waves reflect off a surface

**path difference** The difference in the distance travelled by two waves from the source to a specific point

**peak** The maximum positive amplitude of a transverse wave

**perfectly elastic collision** A collision in which no kinetic energy is lost

**period (waves)** The time taken for one complete wavelength to pass a given point

**phase difference** The difference between the displacements of particles along a wave, or the difference between the displacements of particles on different waves, measured in degrees or radians, with each complete cycle or a difference of one wavelength representing  $360^\circ$  or  $2\pi$  radians

**photoelectric effect** The emission of photoelectrons from a metal surface when electromagnetic radiation above a threshold frequency is incident on the metal

**photoelectric effect equation** Einstein's equation relating the energy of a photon, the work function of a metal, and the maximum kinetic energy of any emitted photoelectrons:

$$hf = \phi + EK_{\text{MAX}}$$

**photoelectrons** Electrons emitted from the surface of a metal by the photoelectric effect

**photon** A quantum of electromagnetic energy – photon energy  $E$  is given by  $E = hf$ , where  $h$  is the Planck constant and  $f$  is the frequency of the electromagnetic radiation

**pivot** A point about which a body can rotate

**Planck constant** Symbol  $h$ , an important constant in quantum mechanics,  $6.63 \times 10^{-34}$  J s

**plane polarised** Description of a transverse wave in which the oscillations are limited to only one plane



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**plastic deformation** An irreversible change in the shape of an object due to a compressive or tensile force – removal of the stress or force produces permanent deformation

**plumb-line** A string with a weight used to provide a vertical reference line

**polarisation** The phenomenon in which oscillation of a transverse wave are limited to only one plane

**polarity** The type of charge (positive or negative) or the orientation of a cell relative to a component

**polycrystalline graphite** Thin layers of graphite with regularly arranged carbon atoms in different orientations

**polymeric** Description of a material comprising of long-chain molecules, such as rubber, which may show large strains

**positive (charge)** One type of electric charge – positively charged objects attract negatively charged ones, and repel other positive charges

**potential difference (pd)** Defined as the energy transferred from electrical energy to other forms (heat, light, etc.) per unit charge.

**potential divider** An electrical circuit designed to divide the potential difference across two or more components (often two resistors) in order to produce a specific output

**potential divider equation** An equation relating the output potential difference from a simple potential divider containing a pair of resistors:  $V_{\text{out}} = \frac{R_2}{(R_1 + R_2)} \times V_{\text{in}}$

**potentiometer** An electrical component with three terminals and some form of sliding contact that can be adjusted to vary the potential difference between two of the terminals

**power** The rate of work done, measured in watts, W

**prefix** A word or letter placed before another one, for example, 5.0 km is  $5.0 \times 10^3$  m

**pressure** The force exerted per unit cross-sectional area, measured in pascals, Pa

**principle of conservation of energy** The total energy of a closed system remains constant – energy cannot be created nor can it be destroyed

**principle of conservation of momentum** Total momentum of a system remains the same before and after a collision

**principle of moments** For a body in rotational equilibrium, the sum of the anticlockwise moments about a point is equal to the sum of the clockwise moments about the same point

**principle of superposition of waves** When two waves meet at a point the resultant displacement at that point is equal to the sum of the displacements of the individual waves

**progressive wave** A wave in which the peaks and troughs, or compressions and rarefactions, move through the medium as energy is transferred

**projectile** An object that is thrown or propelled on the surface of the Earth

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**P-waves** Primary waves – longitudinal waves that travel through the Earth from an earthquake

**Pythagoras' theorem** The square of the length of the hypotenuse of a right-angled triangle equals the sum of the squares of the lengths of the other two sides

**Q**

**quantisation** The availability of some quantities, such as energy or charge, only in certain discrete values

**quantity** A property of an object, substance, or phenomenon that can be measured

**quantum mechanics** The branch of physics dealing with phenomena on the very small scale, often less than the size of an atom

**R**

**radio waves** Long-wavelength electromagnetic waves, with wavelengths greater than  $10^{-1}$  m

**rarefaction (waves)** A moving region in which the medium is less dense or has less pressure than the surrounding medium

**ray** A line representing the direction of energy transfer of a wave, perpendicular to the wavefronts

**reflection** The change in direction of a wave at a boundary between two different media, so that the wave remains in the original medium

**refraction** The change in direction of a wave as it changes speed when it passes from one medium to another

**refractive index** The refractive index of a material  $n = \frac{c}{v}$ , where  $c$  is the speed of light through a vacuum and  $v$  is the speed of light through the material

**relative charge** A simplified measurement of the electric charge of a particle or object, measured as multiples of the elementary charge

**resistance** A property of a component calculated by dividing the potential difference across it by the current in it, symbol  $R$ , unit ohm,  $\Omega$

**resistivity** A property of a material, measured in  $\Omega$  m, defined as the product of the resistance of a component made of the material and its cross-sectional area divided by its length

**resistor** An electrical component that obeys Ohm's law, transferring electrical energy to thermal energy

**resistor circuit** Two or more resistors arranged to provide a specific resistance

**resolving a vector** Splitting a vector into two component vectors perpendicular to each other

**restoring force** A force that tries to return a system to its equilibrium position

**resultant vector** A single vector that has the same effect as two or more vectors added together

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**S**

**scalar quantity** A quantity with magnitude (size) but no direction

**semiconductor** A material with a lower number density than a typical conductor, for example silicon

**series** An arrangement of electrical components connected end-to-end that means that the current is the same in each component

**series circuit** A type of electrical circuit where the components are connected end-to-end

**SI** Système International d'Unités (International System of Units)

**standard form** Mathematical notation in which a number is shown with the decimal point placed after the first digit, followed by  $\times 10$  raised to an appropriate power

**standing wave** A wave that remains in a constant position with no net transfer of energy and is characterised by its nodes and antinodes – also called a stationary wave

**stationary wave** A wave that remains in a constant position with no net transfer of energy and is characterised by its nodes and antinodes – also called a standing wave

**stiffness** The ability of an object to resist deformation

**stopping distance** The total distance travelled from the time when a driver first sees a reason to stop to the time when the vehicle stops, the sum of the thinking distance and the braking distance

**strain** see 'tensile strain'

**stress** see 'tensile stress'

**strong material** A material with a large value for the ultimate tensile strength

**superconductivity** A phenomenon in which the resistivity of a material falls to almost zero when the material is cooled below a certain temperature

**superposition (waves)** Overlap of two waves at a point in space

**S-waves** Secondary waves: transverse waves that travel through the Earth from an earthquake

**T**

**tensile deformation** A change in the shape of an object due to tensile forces

**tensile force** Equal and opposite forces acting on a material to stretch it

**tensile strain** The extension per unit length, a dimensionless quantity

**tensile stress** The force per unit cross-sectional area, measured in Pa

**tension** The pulling force exerted by a string, cable, or chain on an object

**terminal p.d.** The potential difference across an electrical power source – when there is no current this is equal to the e.m.f. of the source, but if there is a current in the source this is equal to the e.m.f. minus the lost volts

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**terminal velocity** The constant speed reached by an object when the drag force (and upthrust) is equal and opposite to the weight of the object

**thermionic emission** The emission of electrons from the surface of a hot metal wire

**thermistor** An electrical component that has a resistance that decreases as the temperature increases (a negative temperature coefficient)

**thinking distance** The distance travelled by a vehicle from when the driver first perceives a need to stop to when the brakes are applied

**threshold frequency** The minimum frequency of the electromagnetic radiation that will cause the emission of an electron from the surface of a particular metal – symbol  $f_0$ , measured in Hz

**threshold voltage** The minimum potential difference at which a diode begins to conduct

**time of flight** The time taken for an object to complete its motion

**timebase** The time interval represented by one horizontal square on an oscilloscope screen

**torque (of a couple)** The product of one of the forces of a couple and the perpendicular distance between the forces

**total internal reflection** The reflection of all light hitting a boundary between two media back into the original medium when the light is travelling through the medium with the higher refractive index and the incidence angle at the boundary is greater than the critical angle

**transverse wave** A wave in which the medium is displaced perpendicular to the direction of energy transfer – the oscillations of medium particles are perpendicular to the direction of travel of the wave

**triangle of forces** Three forces acting at a point in equilibrium, represented by the sides of a triangle

**trough** The maximum negative amplitude of a transverse wave

**U**

**ultimate tensile strength** The maximum stress that a material can withstand before it breaks

**ultraviolet** Electromagnetic waves, with wavelengths from  $4 \times 10^{-7}$  m to  $10^{-8}$  m

**uniform gravitational field** A gravitational field in which the field lines are parallel and the value for  $g$  remains constant

**unpolarised** Description of a transverse wave in which the oscillations occur in many planes

**upthrust** The upward buoyant force exerted on a body immersed in a fluid

**V**

**vector quantity** A quantity with magnitude (size) and direction

**vector triangle** A triangle constructed to scale to determine the resultant of two vectors

**velocity** A vector quantity equal to the rate of change of displacement

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**visible light** Electromagnetic waves, with wavelengths from  $4 \times 10^{-7}$  m to  $7 \times 10^{-7}$  m

**volt** The derived SI unit of potential difference and electromotive force, symbol V, defined as the energy transferred per unit charge, whether energy is either transferred to or from the charges – 1 V is the p.d. across a component when 1 J of energy is transferred per 1 C passing through the component

**voltage** See 'potential difference'

**voltmeter** A device used to measure potential difference – it must be placed in parallel across components and ideally have an infinite resistance

## W

**wave equation** An equation that relates the frequency  $f$  in hertz, the wavelength  $\lambda$  in metres, and the wave speed  $v$  in  $\text{m s}^{-1}$ :  $v = f\lambda$

**wave profile** A graph showing the displacement of the particles in the wave against the distance along the wave

**wave speed** The distance travelled by the wave per unit time

**wavefront** A line of points in phase with each other in a wave, perpendicular to the direction of energy transfer

**wavelength** The minimum distance between two points oscillating in phase, for example the distance from one peak to the next or from one compression to the next

**wave–particle duality** A theory that states that matter has both particle and wave properties and also electromagnetic radiation has wave and particulate (photon) nature

**weight** The gravitational force on an object, measured in newtons, N

**work** The product of force and the distance moved in the direction of the force, measured in J

**work function** The minimum energy needed to remove a single electron from the surface of a particular metal; symbol  $\phi$ , measured in J

## X

**X-rays** Short-wavelength electromagnetic waves, with wavelengths from  $10^{-8}$  m to  $10^{-13}$  m, which can be used in medical imaging

## Y

**yield point** A point on a stress-strain graph beyond which the deformation is no longer entirely elastic

**Young modulus** The ratio of tensile stress to tensile strain when these quantities are directly proportional to each other, measured in Pa