

## Glossary

### A

**absolute scale of temperature** a scale for measuring temperature based on absolute zero and the triple point of pure water, with gradations equal in size to those of the Celsius scale; unit kelvin (K).

**absolute zero** the lowest possible temperature, the temperature at which substances have minimum internal energy.

**absorption coefficient** a measure of the absorption of X-ray photons by a substance, also known as attenuation coefficient – SI unit  $\text{m}^{-1}$ .

**absorption line spectrum** a set of specific frequencies of electromagnetic radiation, visible as dark lines in an otherwise continuous spectrum on spectroscopy. They are absorbed by atoms as their electrons are excited between energy states by absorbing the corresponding amount of energy in the form of photons – every element has a characteristic line spectrum.

**acoustic impedance** the product of the density  $\rho$  of a substance and the speed  $c$  of ultrasound in that substance – symbol  $Z$ , SI unit  $\text{kg m}^{-2} \text{s}^{-1}$ .

**acoustic matching** (or impedance matching) the use of two substances with similar acoustic impedance to minimise reflection of ultrasound at the boundary between them.

**activity** the rate at which nuclei decay or disintegrate in a radioactive source, measured in becquerels (Bq) or decays per second.

**alpha radiation** ionising radiation consisting of particles comprising two protons and two neutrons (a helium nucleus), with a charge of  $+2e$ .

**amount of substance** a measure of the amount of matter in moles.

**angular frequency** a quantity used in oscillatory motion – equal to the product of frequency  $f$  and  $2\pi$ .

**angular velocity** the rate of change of angle for an object moving in a circular path – symbol  $\omega$ .

**annihilation** the complete destruction of a particle and its antiparticle in an interaction that releases energy in the form of identical photons.

**antiparticle** the antimatter counterpart of a particle, with the opposite charge to the particle (if the particle has charge) and exactly the same rest mass as the particle.

**aphelion** the furthest point from the Sun in an orbit.

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**arcminute** a minute of arc;  $1^\circ = 60$  arcminutes.

**arcsecond** a second of arc; 1 arcminute = 60 arcseconds.

**astronomical unit** the mean distance from the Earth to the Sun, i.e.

150 million km or  $1.50 \times 10^{11}$  m.

**atomic mass unit** one atomic mass unit (1 u) is one-twelfth the mass of a neutral carbon-12 atom.

**atomic number** the number of protons in a nucleus – symbol  $Z$ .

**attenuation** the decrease in the intensity of electromagnetic radiation as it passes through matter and/or space attenuation coefficient  $A$  a measure of the absorption of X-ray photons by a substance, also known as absorption coefficient – SI unit  $\text{m}^{-1}$ .

**Avogadro constant**  $6.02 \times 10^{23}$ , the number of atoms in 0.012 kg (12 g) of carbon-12; symbol  $N_A$ .

**B**

**background radiation** the radiation emitted by the surroundings, which must be measured before radiation produced in an experiment can usefully be measured.

**baryon** any hadron made with a combination of three quarks.

**becquerel** a unit of activity – one becquerel is an activity of one decay per second.

**beta decay** a neutron in an unstable nucleus decays into a proton, an electron, and an electron antineutrino ( $\beta^-$  decay), or a proton into a neutron, a positron, and an electron neutrino ( $\beta^+$  decay).

**beta radiation** ionising radiation consisting of fast-moving electrons ( $\beta^-$ ) or ( $\beta^+$ ) emitted from unstable nuclei, with a charge of  $-e$  or  $+e$ , respectively.

**Big Bang** the theory that at a moment in the past all the matter in the Universe was contained in a singularity (a single point), the beginning of space and time, that expanded rapidly outwards.

**binding energy** the minimum energy required to completely separate a nucleus into its constituent protons and neutrons.

**binding energy per nucleon** the binding energy divided by the number of protons and neutrons in the nucleus; the greater the binding energy per nucleon, the more tightly bound are the nucleons within the nucleus.

**black body** an idealised object that absorbs all the electromagnetic radiation incident on it and, when in thermal equilibrium, emits a characteristic distribution of

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wavelengths at a specific temperature.

**black hole** the remnant core of a massive star after it has gone supernova and the core has collapsed so far that in order to escape it an object would need an escape velocity greater than the speed of light, and therefore nothing, not even photons, can escape.

**blue shift** the shortening of observed wavelength that occurs when a wave source is moving towards the observer – in astronomy, if a galaxy is moving towards the Earth, the absorption lines in its spectrum will be blue-shifted, that is, moved towards the blue end of the spectrum.

**Boltzmann constant** the molar gas constant  $R$  divided by the Avogadro constant  $N_A$ , a constant that relates the mean kinetic energy of the atoms or molecules in a gas to the gas temperature – symbol  $k$ .

**Boyle's Law** the pressure of an ideal gas is inversely proportional to its volume, provided that the mass of gas and the temperature do not vary.

**Brownian motion** the continuous random motion of small particles suspended in a fluid, visible under a microscope.

**C**

**capacitance** the charge stored per unit potential difference across a capacitor.

**carbon dating** a method for determining the age of organic material, by comparing the activities, or the ratios, of carbon-14 to carbon-12 nuclei of the dead material of interest and similar living material.

**Celsius scale** a temperature scale with 100 degrees between the freezing point and the boiling point of pure water (at atmospheric pressure  $1.01 \times 10^5$  Pa),  $0^\circ\text{C}$  and  $100^\circ\text{C}$ .

**centripetal acceleration** the acceleration of any object travelling in a circular path at constant speed, which always acts towards the centre of the circle.

**centripetal force** a force that keeps a body moving with a constant speed in a circular path.

**chain reaction** a reaction in which the neutrons from an earlier fission stage are responsible for further fission reactions leading to an exponential growth in the rate of the reactions.

**Chandrasekhar limit** the mass of a star's core beneath which the electron degeneracy pressure is sufficient to prevent gravitational collapse, 1.44 solar masses.

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

**cloud chamber** a detector of ionising radiation consisting of a chamber filled with air saturated with vapour at a very low temperature so that droplets of liquid condense around ionised particles left along the path of radiation.

**collimator** part of a gamma camera, a honeycomb of long, thin tubes made from lead that absorbs any photons arriving at an angle to the axis of the tubes so that a clear picture is obtained.

**comet** a small, irregular body made of ice, dust, and small pieces of rock in an (often highly eccentric elliptical) orbit around the Sun – as they approach the Sun, some comets develop spectacular tails.

**conical pendulum** a simple pendulum that, instead of swinging back and forth, rotates in a horizontal circle at constant speed.

**continuous spectrum** a spectrum in which all visible frequencies or wavelengths are present (a heated solid metal such as a lamp filament will produce this type of spectrum).

**control rods** rods made of a material whose nuclei readily absorb neutrons (commonly boron or cadmium), which can be moved into or out of a reactor core to ensure that exactly one slow neutron survives per fission reaction or to completely stop the fission reaction.

**coolant** a substance that removes the thermal energy produced from reactions within a fission reactor.

**corrected count rate** the radiation count rate measured in an experiment minus the background count rate.

**cosmological principle** the assumption that, when viewed on a large enough scale, the Universe is homogeneous and isotropic, and the laws of physics are universal.

**Coulomb's law** any two point charges exert an electrostatic (electrical) force on each other that is directly proportional to the product of their charges and inversely proportional to the square of their separation.

**coupling gel** a gel with acoustic impedance similar to that of skin smeared onto the transducer and the patient's skin before an ultrasound scan in order to fill air gaps and ensure that almost all the ultrasound enters the patient's body.

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**D**

**damping** an oscillation is damped when an external force that acts on the oscillator has the effect of reducing the amplitude of its oscillations.

**dark energy** a hypothetical form of energy that fills all of space and would explain the accelerating expansion of the Universe.

**dark matter** a hypothetical form of matter spread throughout the galaxy that neither emits nor absorbs light – it could explain the differences between the predicted and observed velocities of stars in galaxies.

**daughter nucleus** a new nucleus formed following a radioactive decay.

**decay constant** the probability of decay of an individual nucleus per unit time.

**diffraction grating** a glass or plastic slide on which as many as 1000 lines in a millimetre are ruled, at a spacing that diffracts visible wavelengths of light.

**Doppler effect** the change in the frequency and wavelength of waves received from an object moving relative to an observer compared with what would be observed without relative motion.

**Doppler equation**  $\frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$ , where  $\lambda$  is the source wavelength,  $\Delta\lambda$  is the

change in wavelength recorded by the observer,  $f$  is the source frequency,  $\Delta f$  is the change in frequency recorded by the observer,  $v$  is the magnitude of the relative velocity between the source and observer, and  $c$  is the speed of light through a vacuum ( $3.00 \times 10^8 \text{ m s}^{-1}$ ).

**driving frequency** the frequency with which the periodic driver force is applied to a system in forced oscillation.

**E**

**eccentricity** a measure of the elongation of an ellipse.

**electric field strength** the force experienced per unit positive charge at that point.

**electric potential** the work done by an external force per unit positive charge to bring a charge from infinity to a point in an electric field – unit volt or  $\text{J C}^{-1}$ .

**electric potential difference** the work done by an external force per unit positive charge to move a charge between two points in an electric field.

**electron degeneracy pressure** a quantum-mechanical pressure created by the electrons in the core of a collapsing star due to the Pauli exclusion principle.

**elementary particle** a fundamental particle.

**ellipse** an elongated 'circle' with two foci.

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**emission line spectrum** a set of specific frequencies of electromagnetic radiation, visible as bright lines in spectroscopy, emitted by excited atoms as their electrons make transitions between higher and lower energy states, losing the corresponding amount of energy in the form of photons as they do so – every element has a characteristic line spectrum.

**energy level** a discrete (quantised) amount of energy that an electron within an atom is permitted to possess.

**equation of state of an ideal gas**  $pV = nRT$ , where  $n$  is the number of moles of gas.

**escape velocity** the minimum velocity at which an object has just enough energy to leave a specified gravitational field.

**excited** (an atom) containing an electron or electrons that have absorbed energy and been boosted into a higher energy level.

**expanding Universe** the idea that the fabric of space and time is expanding in all directions and that as a result any point, in any part of the Universe, is moving away from every other point in the Universe, and the further the points are apart the faster their relative motion away from each other.

**exponential decay** a constant-ratio process in which a quantity decreases by the same factor in equal time intervals.

**F**

**Faraday's law** the magnitude of the induced e.m.f. is directly proportional to the rate of change of magnetic flux linkage.

**fiducial marker** a marker for a point used as a fixed basis for measurement or comparison.

**fission** a process in which a large nucleus splits into two smaller nuclei after absorbing a neutron.

**Fleming's left-hand rule** a mnemonic for the direction of the force experienced by a current-carrying wire placed perpendicular to the external magnetic field: on the left hand, the first finger gives the direction of the external magnetic field, the second finger gives the direction of the conventional current, and the thumb gives the direction of motion (force) of the wire.

**forced oscillation** an oscillation in which a periodic driver force is applied to an oscillator.

**free oscillation** the motion of a mechanical system displaced from its equilibrium

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position and then allowed to oscillate without any external forces.

**frequency (oscillations)** the number of complete oscillations per unit time – unit Hertz (Hz).

**fundamental particle** a particle that has no internal structure and hence cannot be split into smaller particles.

**fusion** a process in which two smaller nuclei join together to form one larger nucleus.

**G**

**galaxy** a collection of stars and interstellar dust and gas bound together by their mutual gravitational force.

**gamma radiation** ionising radiation consisting of high-energy photons, with wavelengths less than about  $10^{-13}$  m, which travel at the speed of light.

**gas laws** the laws governing the behaviour of ideal gases, like Boyle's law.

**gas pressure** in stars, the pressure of the nuclei in the star's core pushing outwards and counteracting the gravitational force pulling the matter in the star inwards.

**geostationary satellite** a satellite that remains in the same position relative to a spot on the Earth's surface, by orbiting in the direction of the Earth's rotation over the equator with a period of 24 hours.

**grating equation** an equation that can be used to determine accurately the wavelength of monochromatic light sent through a diffraction grating,  $d\sin\theta = n\lambda$ .

**grating spacing** the separation between adjacent lines or slits in a diffraction grating.

**gravitational constant, G** the constant in Newton's law of gravitation

$$F = -\frac{GMm}{r^2}, \text{ with a value determined from experiment of } 6.67 \times 10^{-11} \text{ N kg}^{-2} \text{ m}^2.$$

**gravitational field** a field created around any object with mass, extending all the way to infinity, but diminishing as the distance from the centre of mass of the object increases.

**gravitational field lines** lines of force used to map the gravitational field pattern around an object having mass.

**gravitational field strength, g** the gravitational force exerted per unit mass at a point within a gravitational field.

**gravitational potential** the work done per unit mass to bring an object from

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infinity to a point in the gravitational field – unit  $\text{J kg}^{-1}$ .

**ground state** the energy level with the most negative value possible for an electron within an atom – the most stable energy state of an electron.

**H**

**hadron** a particle or antiparticle that is affected by the strong nuclear force, and, if charged, by the electromagnetic force – for example, a proton.

**half-life** the average time it takes for half the number of active nuclei in a sample of an isotope to decay.

**heavy damping** damping that occurs when the damping forces are large and the period of the oscillations increases slightly with the rapid decrease in amplitude.

**Hertzsprung–Russell diagram** a graph showing the relationship between the luminosity of stars in our galaxy (on the  $y$ -axis) and their average surface temperature (on the  $x$ -axis, with temperature increasing from right to left).

**homogeneous** uniform in terms of the distribution of matter across the Universe when viewed on a sufficiently large scale.

**Hubble constant** the gradient of a best-fit line for a plot of recessional speed against distance from Earth of other galaxies.

**Hubble's law** the recessional speed  $v$  of a galaxy is almost directly proportional to its distance  $d$  from the Earth.

**I**

**ideal gas** a model of a gas including assumptions that simplify the behaviour of real gases.

**impedance matching** (or acoustic matching) the use of two substances with similar acoustic impedance to minimise reflection of ultrasound at the boundary between them.

**induced fission** nuclear fission occurring when a nucleus becomes unstable on absorbing another particle (such as a neutron)

**inflation** A phase of astonishing acceleration of the expansion of the Universe thought to have occurred 10–35 s after the Big Bang.

**intensity reflection coefficient** the ratio of reflected intensity over incident intensity for ultrasound incident at a boundary.

**internal energy** the sum of the randomly distributed kinetic and potential energies of the atoms, ions, or molecules within the substance.



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**ionising radiation** any form of radiation that can ionise atoms by removing an electron to leave a positive ion.

**isochronous oscillator** an oscillator that has the same period regardless of amplitude.

**isotherm** a line on a pressure–volume graph that connects points at the same temperature.

**isotopes** nuclei of the same element that have the same atomic number (number of protons) but different nucleon numbers (numbers of neutrons).

**isotropic** the same in all directions (for example the Universe, appearing the same to any observer regardless of position).

**K**

**kelvin** the SI base unit of the absolute (thermodynamic) scale of temperature.

**Kepler's first law of planetary motion** the orbit of a planet is an ellipse with the Sun at one of the two foci.

**Kepler's second law of planetary motion** a line segment connecting a planet to the Sun sweeps out equal areas during equal intervals of time.

**Kepler's third law of planetary motion** the square of the orbital period  $T$  of a planet is directly proportional to the cube of its average distance  $r$  from the Sun.

**kinetic model** a model that describes all substances as made of atoms, ions, or molecules, arranged differently depending on the phase of the substance.

**kinetic theory of matter** see kinetic model.

**L**

**Lenz's law** the direction of the induced e.m.f. or current is always such as to oppose the change producing it.

**lepton** a fundamental particle or antiparticle that is not affected by the strong nuclear force – for example, an electron

**light damping** damping that occurs when the damping forces are small and the period of the oscillations is almost unchanged.

**light-year** the distance travelled by light in a vacuum in a time of one year ( $9.46 \times 10^{15}$  m).

**luminosity** the total radiant power output of a star – symbol  $L$ , unit  $W$ .

**M**

**magnetic field lines** lines of force drawn to represent a magnetic field pattern.

**magnetic field patterns** visual representations used in interpreting the direction and strength of magnetic fields

**magnetic flux** The product of the component of the magnetic flux density perpendicular to a given area and that cross-sectional area:  $\phi = BA\cos\theta$ .

**magnetic flux density** the strength of a magnetic field – defined by the equation  $F/IL$ , where  $F$  is the force acting on current-carrying conductor placed at right angles to a magnetic field,  $I$  is the current in the conductor and  $L$  is the length of the conductor in the magnetic field – symbol  $B$ , unit tesla (T).

**magnetic flux linkage** the product of the number of turns in a coil  $N$  and the magnetic flux  $\phi$ .

**main sequence** the main period in a star's life, during which it is stable.

**mass defect** the difference between the mass of a nucleus and the mass of its completely separated constituent nucleons.

**Maxwell–Boltzmann distribution** the distribution of the speeds of particles in a gas.

**mean square speed** the mean of the squared velocities (of all the particles in a gas).

**medical tracer** a radiopharmaceutical, that is, a compound labelled with a radioisotope that can be traced inside the body using a gamma camera.

**meson** any hadron comprising a combination of a quark and an anti-quark.

**microwave background radiation** the microwave signal of uniform intensity detected from all directions of the sky, which fits the profile for a black body at a temperature of 2.7 K.

**moderator** a substance used to slow down the fast neutrons produced in fission reactions so that they can propagate the fission reaction.

**molar gas constant** the constant in the equation of state of an ideal gas – symbol  $R$ ,  $8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ .

**molar mass** the mass of one mole of a substance.

**mole** the amount of substance that contains as many elementary entities as there are atoms in 0.012 kg (12 g) of carbon-12.

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**N**

**natural frequency** the frequency of a free oscillation.

**nebula (plural nebulae)** a cloud of dust and gas (mainly hydrogen), often many hundreds of times larger than our Solar System.

**neutrino** a lepton (a fundamental particle) that carries no charge and may have a tiny mass, less than a millionth the mass of an electron.

**neutron** an electrically neutral particle, a hadron, found in the nucleus of atoms.

**neutron star** the remnant core of a massive star after the star has gone supernova and (if the mass of the core is greater than the Chandrasekhar limit) the core has collapsed under gravity to an extremely high density (similar to that of an atomic nucleus,  $\sim 10^{17} \text{ kg m}^{-3}$ ), as it is almost entirely made up of neutrons.

**Newton's law of gravitation** the force between two point masses is directly proportional to the product of the masses and inversely proportional to the square

of the separation between them;  $F = -\frac{GMm}{r^2}$ .

**nuclear fusion** see fusion.

**nucleon** a particle in the nucleus of an atom, either a proton or a neutron.

**nucleon number** the total number of protons and neutrons in a nucleus (also called the mass number); symbol  $A$ .

**nucleus** the small, positively charged region at the centre of an atom where most of the mass of the atom is concentrated.

**O**

**oscillating motion** repetitive motion of an object around its equilibrium position.

**P**

**pair production** the replacement of a single photon with a particle and a corresponding antiparticle of the same total energy.

**parallax angle** the angle of the apparent shift in the position of a relatively close star against the backdrop of much more distant stars as the Earth makes a quarter an orbit around the Sun.

**parsec** the distance at which a radius of one AU subtends an angle of one arcsecond.

**perihelion** the closest point to the Sun in an orbit.

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**period (*oscillations*)** the time taken to complete one oscillation.

**phase** a phase of matter is its state (solid, liquid, or gas).

**phase difference (*for oscillating motion*)** the difference in displacement between two oscillating objects or the displacement of an oscillating object at different times – symbol  $\phi$ .

**photomultiplier tube** an apparatus that converts a photon of visible light into an electrical pulse, for example as part of a gamma camera.

**piezoelectric effect** the production of an electromotive force (e.m.f.) by some crystals, such as quartz, when they are compressed, stretched, twisted, or distorted.

**planet** an object in orbit around a star with a mass large enough for its own gravity to give it a round shape, that undergoes no fusion reactions, and that has cleared its orbit of most other objects.

**planetary nebula** the outer layers of a red giant that have drifted off into space, leaving the hot core behind at the centre as a white dwarf.

**planetary satellite** a body in orbit around a planet – it may be natural (a moon) or artificial.

**positron** the antiparticle of the electron.

**proton** a positively charged particle, a hadron, found in the nucleus of atoms.

**proton number** the atomic number, that is, the number of protons in a nucleus – symbol  $Z$ .

**protostar** a very hot, very dense sphere of condensing dust and gas that is on the way to becoming a star.

## Q

**quark** an elementary particle that can exist in six forms (plus their antiparticles) and joins with other quarks to make up hadrons.

## R

**radial field** a symmetrical field that diminishes with distance<sup>2</sup> from its centre, such as the gravitational field around a spherical mass or the electrical field around a spherical charged object.

**radian** the angle subtended by a circular arc with a length equal to the radius of the circle (approximately  $57.3^\circ$ )

**radiation pressure** pressure from the photons in the core of a star, which acts

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outwards to counteract the pressure from the gravitational force pulling the matter in the star inwards.

**radioactivity** the process by which unstable nuclei split, or decay, emitting ionising radiation (alpha particles, beta particles, and gamma rays).

**radiopharmaceutical** a radioisotope chemically combined with elements that will target particular tissues in order to ensure that the radioisotope reaches the correct organ or tumour for diagnosis or treatment.

**red giant** an expanding star at the end of its life, with an inert core in which fusion no longer takes place, but in which fusion of lighter elements continues in the shell around the core.

**red shift** the lengthening of observed wavelength that occurs when a wave source is moving away from the observer – in astronomy, if a galaxy is moving away from the Earth (receding), the absorption lines in its spectrum will be red-shifted.

**red supergiant** a huge star in the last stages of its life before it 'explodes' in a supernova.

**resonance** the increase in amplitude of a forced oscillation when the driving frequency matches the natural frequency of the oscillating system.

**rest mass** the mass of an object, such as a particle, when it is stationary.

**right-hand grip rule** for a current-carrying wire, the thumb points in the direction of the conventional current, and the direction of the field is given by the direction in which the fingers of the right hand would curl around the wire.

**root mean square speed** the square root of the mean square speed (of all the particles in a gas).

**S**

**satellite** a body orbiting around planet.

**scintillator** part of a gamma camera, often made of sodium iodide, which produces thousands of photons of visible light when struck by a single gamma photon.

**simple harmonic motion** oscillating motion for which the acceleration of the object is directly proportional to its displacement and is directed towards some fixed point – characterised by the equation  $a = -\omega^2 x$ .

**solar system** a planetary system consisting of a star and at least one planet in orbit around it – our own Solar System contains the Sun and all the objects that orbit it.

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**specific heat capacity** the energy required per unit mass to change the temperature by 1 K (or 1° C); unit  $\text{J kg}^{-1} \text{K}^{-1}$ .

**specific latent heat** the energy required to change the phase per unit mass while at constant temperature – symbol  $L$ .

**specific latent heat of fusion** the energy required to change unit mass of a substance from solid to liquid while at constant temperature – symbol  $L_f$ .

**specific latent heat of vaporisation** the energy required to change unit mass of a substance from liquid to gas while at constant temperature – symbol  $L_v$ .

**spectral line** a line in an emission line spectrum or absorption line spectrum at a specific wavelength.

**spectroscopy** a technique in physics in which spectral lines are identified and measured in order to identify elements present within stars.

**standard model** the current theory of particle physics that deals with elementary particles (quarks, electrons, etc.) and their interactions.

**Stefan constant** the constant  $\sigma$  in Stefan's law,  $L = 4\pi r^2 \sigma T^4$ , relating the luminosity  $L$  of a star to its surface area  $4\pi r^2$  and its absolute surface temperature  $T$ :  $\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$ .

**stellar parallax** a technique used to determine the distance to stars that are relatively close to the Earth (less than 100 pc) by comparing their apparent positions against distant stars at times 6 months apart.

**step-down transformer** a transformer with fewer turns on the secondary than on the primary coil, and a lower output voltage than input voltage.

**step-up transformer** a transformer with more turns on the secondary than on the primary coil, and a higher output voltage than input voltage.

**strong nuclear force** one of the four fundamental forces in nature, acting on hadrons and holding nuclei together.

**supernova** the implosion of a red supergiant at the end of its life, which leads to subsequent ejection of stellar matter into space, leaving an inert remnant core.

**T**

**target metal** a metal with a high melting point used for the anode in an X-ray tube, for example tungsten.

**thermal equilibrium** a state in which there is no net flow of thermal energy between the objects involved, that is, objects in thermal equilibrium must be at the same temperature.

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**thermal neutron** a neutron in a fission reactor with mean kinetic energy similar to the thermal energy of particles in the reactor core – also known as a slow neutron.

**thermodynamic scale of temperature** see absolute scale of temperature.

**time constant** the product of capacitance and resistance,  $CR$ , for a capacitor–resistor circuit – equal to the time taken for the p.d. (or the current or the charge) to decrease to  $e^{-1}$  (about 37%) of its initial value when the capacitor discharges through a resistor – symbol  $\tau$ .

**triple point** for a given substance, one specific temperature and pressure at which all three phases of that substance can exist in thermodynamic equilibrium.

**turn-ratio equation** equation for a transformer:  $\frac{V_s}{V_p} = \frac{n_s}{n_p}$ , where output

voltage is  $V_s$ , input voltage is  $V_p$ ,  $n_s$  is the number of turns on the secondary coil and  $n_p$  is the number of turns on the primary coil.

**U**

**ultrasound transducer** a device used both to generate and to receive ultrasound, which changes electrical energy into sound and sound into electrical energy.

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

**Universe** everything that exists within space and time.

**V**

**velocity selector** a device that uses both electric and magnetic fields to select charged particles of specific velocity.

**W**

**wave source** a source of waves, such as light or sound – the object moving relative to an observer of the Doppler effect.

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

**weak nuclear force** one of the four fundamental forces in nature, responsible for inducing beta-decay within unstable nuclei.

**white dwarf** a very dense star formed from the core of a red giant, in which no fusion occurs.

**Wien's displacement law** the peak wavelength  $\lambda_{\max}$  at which the intensity of

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radiation from a black body is a maximum is inversely proportional to the absolute temperature  $T$  of the black body.

**X**

**X-rays** an electromagnetic wave with extremely short wavelength (range  $10^{-8}$  to  $10^{-13}$  m).

**X-ray tube** a piece of equipment that produces X-ray photons by firing electrons from a heated cathode across a large p.d. in an evacuated tube – X-ray photons are produced when the electrons are decelerated by hitting the target metal of the anode.