Glossary

A

absolute scale temperature scale in kelvins (K) defined in terms of *absolute zero*, 0 K, and the triple point of water, 273.16 K, which is the temperature at which ice, water and water vapour are in thermal equilbrium.

absolute zero the lowest possible temperature, the temperature at which an object has minimum internal energy.

absolute temperature *T* in kelvin = temperature in °C + 273(.15).

activity *A* of a radioactive isotope, the number of nuclei of the isotope that disintegrate per second. The unit of activity is the becquerel (Bq), equal to 1 disintegration per second.

alpha (α) decay change in an unstable nucleus when it emits an α particle which is a particle consisting of two protons and two neutrons.

alpha radiation particles that are each composed of two protons and two neutrons. An alpha (α) particle is emitted by a heavy unstable nucleus which is then less unstable as a result. Alpha radiation is easily absorbed by paper, has a range in air of no more than a few centimetres and is more ionising than beta (β) or gamma (γ) radiation.

angular displacement the angle an object in circular motion turns through. If its time period is T and its frequency is f, its angular displacement in time t, in radians $= 2\pi ft = 2\pi t/T$.

angular speed ω the rate of change of angular displacement of an object in circular (or orbital or spinning) motion.

angular frequency ω for an object oscillating at frequency f in simple harmonic motion, its angular frequency $= 2\pi f$.

antiquark antiparticle of a quark.

atomic mass unit u correctly referred to as the unified atomic mass constant; $\frac{1}{12}$th of the mass of an atom of the carbon isotope $^{12}_{6}\mathrm{C}$, equal to 1.661×10^{-27} kg.

atomic number *Z* of an atom of an element is the number of protons in the nucleus of the atom. It is also the order number of the element in the Periodic Table.

Avogadro constant N_A the number of atoms in 12 g of the carbon isotope $^{12}_{6}\mathrm{C}$.

N_A is used to define the mole. Its value is 6.02×10^{23} mol^{-1}.

B

back emf emf induced in the spinning coil of an electric motor or in any coil in which the current is changing (e.g., the primary coil of a transformer). A back emf acts against the change of applied pd.

background radiation radiation due to naturally occurring radioactive substances in the environment (e.g., in the ground or in building materials or elsewhere in the environment). Background radiation is also caused by cosmic radiation.

beta (β) decay change in a nucleus when a neutron changes into a proton and a β^- particle and an antineutrino are emitted if the nucleus is neutronrich or a proton changes to a neutron and a β^+ particle and a neutrino are emitted if the nucleus is proton-rich.

beta-minus (β^-) radiation electrons (β^-) emitted by unstable neutron-rich nuclei (i.e., nuclei with a neutron/proton ratio greater than for stable nuclei). β^- radiation is stopped by about 5 mm of aluminium, has a range in air of up to a metre and is less ionising than alpha (α) radiation and more ionising than gamma (γ) radiation.

beta-plus (β^+) radiation *positrons* (β^+) emitted by unstable proton-rich nuclei (i.e., nuclei with a neutron/proton ratio smaller than for stable nuclei). Positrons emitted in solids or liquids travel no further than about 2 mm before they are annihilated.

binding energy of a nucleus the work that must be done to separate a nucleus into its constituent neutrons and protons. Binding energy = mass defect × c^2. Binding energy in MeV = mass defect in u × 931.3.

binding energy per nucleon the average work done per nucleon to separate a nucleus into its constituent parts. The binding energy per nucleon of a nucleus = the binding energy of a nucleus/mass number *A*. The binding energy per nucleon is greatest for iron nuclei of mass number about 56. The binding energy curve is a graph of binding energy per nucleon against mass number *A*.

boiling point the temperature at which a pure liquid at atmospheric pressure boils.

Boyle's law for a fixed mass of gas at constant temperature, its pressure × its volume is constant. A gas that obeys Boyle's law is said to be an *ideal gas*.

Boltzmann constant *k* the molar gas constant divided by the Avogadro number $\left(\text{i.e.,}\frac{R}{N_A}\right)$. See *kinetic energy of the molecules of an ideal gas*.

Brownian motion the random and unpredictable motion of a particle such as a smoke particle caused by molecules of the surrounding substance colliding at random with the particle. Its discovery provided evidence for the existence of atoms.

C

capacitance the charge stored per unit pd of a capacitor. The unit of capacitance is the farad (*F*), equal to 1 coulomb per volt. For a capacitor of capacitance *C* at pd *V*, the charge stored, $Q = CV$.

capacitor energy energy stored by the capacitor, $E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$.

capacitor discharge through a fixed resistor of resistance *R*; time constant = *RC*; exponential decrease equation for current or charge or pd; $x = x_0 e^{\frac{-t}{RC}}$.

Celsius scale temperature, in degrees Celsius or °C, is defined as absolute temperature in kelvins –273.15. This definition means that the temperature of pure melting ice (ice point) is 0 °C, and the temperature of steam at standard atmospheric pressure (steam point) is 100 °C.

centripetal acceleration 1. For an object moving at speed *v* (or angular speed ω) in uniform circular motion, its centripetal acceleration $a = \frac{v^2}{r} = \omega^2 r$ towards the centre of the circle. 2. For a satellite in a circular orbit, its centripetal acceleration $\frac{v^2}{r} = g$.

centripetal force the resultant force on an object that moves along a circular path. For an object of mass *m* moving at speed *v* along a circular path of radius *r*, the centripetal force = $\frac{mv^2}{r}$ towards the centre of the circle.

chain reaction a series of reactions in which each reaction causes a further reaction. In a nuclear reactor, each fission event is due to a neutron colliding with a $^{235}_{92}U$ nucleus which splits and releases two or three further neutrons that can go on to produce further fission. A steady chain reaction occurs when one fission neutron on average from each fission event produces a further fission event.

Charles' law for a fixed mass of an ideal gas at constant pressure, its volume is directly proportional to its *absolute temperature*.

collisions see *elastic collision*.

conservation of momentum for a system of interacting objects is the total momentum of the objects remains constant provided no external resultant force acts on the system.

control rods rods made of a neutron-absorbing substance such as cadmium or boron that are moved in or out of the core of a nuclear reactor to control the rate of fission events in the reactor.

coolant a fluid that is used to prevent a machine or device from becoming dangerously hot. The coolant of a nuclear reactor is pumped through the core of the reactor to transfer thermal energy from the core to a heat exchanger.

Coulomb's law of force for two point charges Q_1 and Q_2 at distance apart r, the force F between the two charges is given by the equation $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$, where ε_0 is the permittivity of free space.

count rate the number of counts per unit time detected by a Geiger Müller tube. Count rates should always be corrected by measuring and subtracting the background count rate (i.e., the count rate with no radioactive source present).

critical mass the minimum mass of the fissile *isotope* (e.g., the uranium *isotope* $^{235}_{92}\mathrm{U}$) in a nuclear reactor necessary to produce a *chain reaction*. If the mass of the fissile isotope in the reactor is less than the critical mass, a chain reaction does not occur because too many fission neutrons escape from the reactor or are absorbed without fission.

D

damped oscillations oscillations that reduce in *amplitude* due to the presence of resistive forces such as friction and drag.

1. For a lightly damped system, the amplitude of oscillations decreases gradually.
2. For a heavily damped system displaced from equilibrium then released, the system slowly returns to equilibrium without oscillating.
3. For a critically damped system, the system returns to equilibrium in the least possible time without oscillating.

de Broglie wavelength a particle of matter has a wave-like nature which means that it can behave as a wave. For example, electrons directed at a thin crystal are diffracted by the crystal. The de Broglie wavelength, λ, of a matter particle

depends on its momentum, *p*, in accordance with de Broglie's equation $\lambda = \frac{h}{p} = \frac{h}{mv}$, where *h* is the Planck constant.

decay constant λ the probability of an individual nucleus decaying per second.

decay curve an exponential decrease curve showing how the mass or activity of a radioactive isotope decreases with time.

dielectric material that increases the capacity of a parallel-plate capacitor to store charge when placed between the plates of the capacitor. Polythene and waxed paper are examples of dielectrics.

differentiation mathematical process of finding the gradient of a line from its equation.

diffraction the spreading of waves when they pass through a gap or round an obstacle. X-ray diffraction is used to determine the structure of crystals, metals and long molecules. Electron diffraction is used to probe the structure of materials. High-energy electron scattering is used to determine the diameter of the nucleus.

dissipative forces forces that transfer energy which is wasted.

dose equivalent a comparative measure of the effect of each type of *ionising radiation*, defined as the energy that would need to be absorbed per unit mass of matter from 250 k of X-radiation to have the same effect as a certain 'dose' of the *ionising radiation*. The unit of dose equivalent is the sievert (Sv).

E

eddy currents induced currents in the metal parts of ac machines.

elastic collision an elastic collision is one in which the total kinetic energy after the collision is equal to the total kinetic energy before the collision.

electrical conductor an object that can conduct electricity.

electrically insulating materials an electrical insulator is a material that cannot conduct electricity; a thermal insulator is a material that is a poor conductor of heat.

electric field strength *E* at a point in an electric field, is the force per unit charge on a small positively charged object at that point in the field.

electric potential *V* at a point in an electric field is the work done per unit charge on a small positively charged object to move it from infinity to that point in the field.

electromagnetic induction the generation of an emf when the *magnetic flux linkage* through a coil changes or a conductor cuts across magnetic field lines.

electromagnetic wave an electric and magnetic wavepacket or *photon* that can travel through free space.

electromotive force (emf) the amount of electrical energy per unit charge produced inside a source of electrical energy.

electron a *lepton* of rest mass 9.11×10^{-31} kg and electric charge -1.60×10^{-19} C (to 3 significant figures).

electron capture a proton-rich *nucleus* captures an inner-shell electron to cause a *proton* in the nucleus to change into a *neutron*. An electron *neutrino* is emitted by the nucleus. An X-ray *photon* is subsequently emitted by the atom when the inner shell vacancy is filled.

equipotential a line or surface in a field along which the electric or gravitational potential is constant.

escape velocity the minimum velocity an object must be given to escape from the planet when projected vertically from the surface.

excited state an atom which is not in its ground state (i.e., its lowest energy state).

explosion when two objects fly apart, the two objects carry away equal and opposite momentum.

exponential change exponential change happens when the change of a quantity is proportional to the quantity itself. For an exponential decrease of a quantity x, $\frac{dx}{dt} = -\lambda x$, where λ is referred to as the decay constant. The solution of this equation is $x = x_0 e^{-\lambda t}$ where x_0 is an initial value of x.

F

Faraday's law of electromagnetic induction the induced emf in a circuit is equal to the rate of change of *magnetic flux linkage* through the circuit. For a changing magnetic field in a fixed coil of area A and N turns, the induced emf $= -NA\frac{\Delta B}{\Delta t}$.

field line see *line of force*.

fission the splitting of a ${}^{235}_{92}\mathrm{U}$ *nucleus* or a ${}^{235}_{94}\mathrm{Pu}$ nucleus into two approximately equal fragments. Induced fission is fission caused by an incoming *neutron* colliding with a ${}^{235}_{92}\mathrm{U}$ nucleus or a ${}^{235}_{94}\mathrm{Pu}$ nucleus.

fission neutrons neutrons released when a nucleus undergoes fission and which

may collide with nuclei to cause further fission.

Fleming's left-hand rule rule that relates the directions of the force, magnetic field and current on a current-carrying conductor in a magnetic field.

Fleming's right-hand rule rule that relates the directions of the induced current, magnetic field and velocity of the conductor when the conductor cuts across magnetic field lines and an emf is induced in it.

force = rate of change of *momentum*

$$= \frac{\text{change of momentum}}{\text{time taken}}$$

(= mass × acceleration for fixed mass).

forced vibrations vibrations (oscillations) of a system subjected to an external periodic force.

free electrons electrons in a conductor that move about freely inside the metal because they are not attached to a particular atom.

free vibrations vibrations (oscillations) where there is no damping and no periodic force acting on the system, so the amplitude of the oscillations is constant.

fusion (nuclear) the fusing together of light nuclei to form a heavier nucleus.

fusion (thermal) the fusing together of metals by melting them together.

G

geostationary satellite a satellite that stays above the same point on the Earth's equator as it orbits the Earth because its orbit is in the same plane as the equator, its period is exactly 24 h and it orbits in the same direction as the Earth's direction of rotation.

gold leaf electroscope a device used to detect electric charge.

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

gravitational field the region surrounding an object in which it exerts a gravitational force on any other object.

gravitational field strength *g* the force per unit mass on a small mass placed in the field.

1. $g = \frac{F}{m}$, where F is the gravitational force on a small mass m.

2. At distance r from a point mass M, $g = \frac{GM}{r^2}$

3. At or beyond the surface of a sphere of mass M, $g = \frac{GM}{r^2}$ where r is the distance to the centre.

4. At the surface of a sphere of mass M and radius R, $g_s = \frac{GM}{R^2}$.

gravitational force an attractive force that acts equally on any two objects due to their mass.

gravitational potential *V* at a point in a gravitational field is the work done per unit mass to move a small object from infinity to that point. At distance r from the centre of a spherical object of mass M,

$V = -\frac{GM}{r}$.

gravitational potential energy at a point in a gravitational field is the work done to move a small object from infinity to that point. The change of gravitational potential energy of a mass m moved through height h near the Earth's surface, $\Delta E_p = mg\,\Delta h$.

grid system the network of transformers and cables that is used to distribute electrical power from power stations to users.

H

half-life $T_{½}$ the time taken for the mass of a radioactive isotope to decrease to half the initial mass or for its activity to halve. This is the same as the time taken for the number of nuclei of the isotope to decrease to half the initial number.

Hall probe a device used to measure *magnetic flux density*.

heat *Q* energy transfer due to a difference of temperature.

heat capacity the energy needed to raise the temperature of an object by 1 K.

heat exchanger a steel vessel containing pipes through which hot coolant in a sealed circuit is pumped, causing water passing through the steel vessel in separate pipes to turn to steam which is used to drive turbines.

I

ideal gas a gas under conditions such that it obeys *Boyle's law*.

ideal gas equation $pV = nRT$, where p is the gas pressure, V is the gas volume, n is the number of moles of gas, T is the absolute temperature and R is the *molar gas constant*.

impulse of a force acting on an object, force × time for which the force acts.

integration mathematical process of finding the area under a curve from its mathematical equation.

intensity of radiation at a surface is the radiation energy per second per unit area at normal incidence to the surface. The unit of intensity is J $^{s-1}$ m^{-2} or W $^{m-2}$.

internal energy of an object is the sum of the random distribution of the kinetic and potential energies of its molecules.

ionising radiation radiation that produces ions in the substances it passes through. It destroys cell membranes and damages vital molecules such as DNA directly or indirectly by creating 'free radical' ions which react with vital molecules.

inverse-square laws 1. Force: *Newton's law of gravitation* and *Coulomb's law* of force between electric charges are inverse-square laws because the force between two point objects (masses in the case of gravitation and charge in the case of charges) is inversely proportional to the square of the distance between the two objects. Because these two laws are inverse-square laws, the field strength due to a point mass or a point charge varies with distance according to the inverse of the square of the distance to the point object.

2. Intensity: the intensity of *γ* radiation from a point source varies with the inverse of the square of the distance from the source. The same rule applies to radiation from any point source that spreads out equally in all directions and is not absorbed.

K

Kepler's third law for any planet, the cube of its mean radius of orbit *r* is directly proportional to the square of its time period *T*. Using *Newton's law of gravitation*, it can be shown that $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$.

kinetic energy the energy of a moving object due to its motion. For an object of mass *m* moving at speed *v*, its kinetic energy $E_K = \frac{1}{2}mv^2$, provided $v \ll c$ (the speed of light in free space).

kinetic energy of the molecules of an ideal gas: 1. Mean kinetic energy of a molecule of an *ideal gas* = $\frac{3}{2}kT$, where the Boltzmann constant $k = \frac{R}{N_A}$.

2. Total kinetic energy of n moles of an ideal gas = $\frac{3}{2}nRT$.

kinetic theory of a gas

1. Assumptions; a gas consists of identical point molecules which do not attract one another. The molecules are in continual random motion colliding elastically with each other and with the container.

2. The pressure p of N molecules of such a gas in a container of volume V is given by the equation $pV = \frac{1}{3}Nm(c_{rms})^2$, where m is the mass of each molecule and $(c_{rms})^2$ is the mean square speed of the gas molecules.

3. Assuming that the mean kinetic energy of a gas molecule $\frac{1}{2}m(c_{rms})^2 = \frac{3}{2}kT$, where $k = \frac{R}{N_A}$, it can be shown from $pV = \frac{1}{3}Nm(c_{rms})^2$ that $pV = nRT$, which is the *ideal gas law*.

kinetic theory of gases equation $pV = \frac{1}{3}Nm(c_{rms})^2$.

L

latent heat of fusion the energy needed to change the state of a solid to a liquid without change of temperature. See *specific latent heat of fusion*.

latent heat of vaporisation the energy needed to change the state of a liquid to a vapour without change of temperature. See *specific latent heat of vaporisation*.

Lenz's law when a current is induced by electromagnetic induction, the direction of the induced current is always such as to oppose the change that causes the current.

line of force or a field line the direction of a line of force or a field line indicates the direction of the force. An electric field line is the path followed by a free positive test charge. The gravitational field lines of a single mass point towards that mass.

logarithms for a number $n = b^p$ where b is the base number, then $p = \log_b n$

$\log (nm) = \log n + \log m$,

$\log (\frac{n}{m}) = \log n - \log m$,

$\log (m^p) = p \log m$

natural logs: for $n = e^p$, then ln $n = p$

base 10 logs: for $n = 10^p$, then $\log_{10} n = p$.

logarithmic scale a scale such that equal intervals correspond to a change by a constant factor or multiple (e.g., ×10).

log graphs 1. For $y = kx^n$, $\log_{10} y = \log_{10} k + n \log 10 x$; the graph of $\log_{10} y$ (on the vertical axis) against $\log_{10} x$ is therefore a straight line of gradient n with an intercept equal to $\log_{10} k$;

2. For $x = x_0 e^{-\lambda t}$, $\ln x = \ln x_0 - \lambda t$; the graph of ln x (on the vertical axis) against t is a straight line with a gradient equal to $-\lambda$ and a y-intercept equal to $\ln x_0$.

M

magnetic flux *Φ* $\Phi = BA$ for a uniform magnetic field of flux density B that is perpendicular to an area A. The unit of magnetic flux is the weber (Wb).

magnetic flux density *B* the magnetic force per unit length per unit current on a current carrying conductor at right angles to the field lines. The unit of magnetic flux density is the tesla (T). B is sometimes referred to as the magnetic field strength.

magnetic flux linkage *NΦ* through a coil of N turns, = $N\Phi = NBA$ where B is the magnetic flux density perpendicular to area A. The unit of magnetic flux and of flux linkage is the weber (Wb), equal to 1 T m2 or 1 V s.

magnetic force 1. $F = BIl \sin\theta$ gives the force F on a current-carrying wire of length l in a uniform magnetic field B at angle θ to the field lines, where I is the current. The direction of the force is given by *Fleming's left-hand rule* where the field direction is the direction of the field component perpendicular to the wire.

2. $F = BQv \sin\theta$ gives the force F on a particle of charge Q moving through a uniform magnetic field B at speed v in a direction at angle θ to the field. If the velocity of the charged particle is perpendicular to the field, $F = BQv$. The direction of the force is given by Fleming's left-hand rule, provided the current is in the direction that positive charge would move in.

3. $BQv = \frac{mv^2}{r}$ gives the radius of the orbit of a charge moving in a direction at right angles to the lines of a magnetic field.

mass defect of a nucleus is the difference between the mass of the separated nucleons (i.e., protons and neutrons from which the nucleus is composed) and the nucleus.

mean kinetic energy for a molecule in a gas at absolute temperature T, its mean kinetic energy = $\frac{3}{2}kT$, where k is the Boltzmann constant $\left(=\frac{R}{N_A}\right)$.

melting point the temperature at which a pure substance melts.

metastable state an excited state of the nuclei of an isotope that lasts long enough after α or β emission for the isotope to be separated from the parent isotope (e.g., technetium $^{99}_{43}\mathrm{Tc}$).

moderator substance in a thermal nuclear reactor that slows the fission neutrons down so they can go on to produce further fission.

mole one mole of a substance consisting of identical particles is the quantity of substance that contains N_A particles of the substance.

molarity the number of moles in a certain quantity of a substance. The unit of molarity is the mol.

molar mass the mass of one mole of a substance.

motor effect the force on a current-carrying conductor due to a magnetic field.

N

natural frequency the frequency of free oscillations of an oscillating system.

neutron an uncharged particle that has a rest mass of 1.674×10^{-27} kg. Neutrons are in every atomic nucleus except that of hydrogen $^{1}_{1}\mathrm{H}$.

Newton's law of gravitation the gravitational force F between two point masses m_1 and m_2 at distance r apart is given by $F = \frac{Gm_1m_2}{r^2}$.

nucleus the relatively small part of an atom where all the atom's positive charge and most of its mass is concentrated.

nuclide of an isotope $^{A}_{Z}\mathrm{X}$ a *nucleus* composed of Z *protons* and $(A - Z)$ *neutrons*, where Z is the proton number (and also the atomic number of element X) and A is the mass number (or nucleon number, i.e., the number of protons and neutrons in a nucleus).

P

period of a wave time for one complete cycle of a wave to pass a point.

periodic force a *force* that varies regularly in magnitude with a definite time period.

permittivity of free space ε_0 the charge per unit area in coulombs per square metre on oppositely charged parallel plates in a vacuum when the *electric field strength* between the plates is 1 volt per metre. See *Coulomb's law of force*.

phase difference in radians, for two objects oscillating with the same time period, T_p, the phase difference = $\frac{2\pi\Delta t}{T_p}$, where Δt is the time between successive instants when the two objects are at maximum displacement in the same direction.

photon electromagnetic radiation consists of photons. Each photon is a wave packet of electromagnetic radiation. The energy of a photon, $E = hf$, where f is the frequency of the radiation and h is the Planck constant.

polarised the positive charge and the negative charge of a polarised molecule are displaced in opposite directions.

potential gradient at a point in a field is the change of potential per unit change of distance along the field line at that point. The potential gradient = – the field strength at any point.

pressure law for a fixed mass of an ideal gas at constant volume, its pressure is directly proportional to its absolute temperature.

principle of conservation of momentum when two or more bodies interact, the total *momentum* is unchanged, provided no external forces act on the bodies.

proton a particle that has equal and opposite charge to the electron and has a rest mass of 1.673×10^{-27} kg which is about 1836 times that of the electron. Protons are in every atomic nucleus. The nucleus of hydrogen $^{1}_{1}\mathrm{H}$ is a single proton. The proton is the only stable baryon.

R

radial field a field in which the *field lines* are straight and converge or diverge as if from a single point.

radian 1 radian = $\frac{360}{2\pi}$ degrees. 2π radians = 360°.

reactor core the fuel rods and the control rods together with the moderator

substance are in a steel vessel through which the coolant (which is also the moderator in 'pressurised water reactor') is pumped.

relative permittivity ratio of the charge stored by a parallel-plate capacitor with dielectric filling the space between its plates to the charge stored without the dielectric for the same pd.

renewable energy energy from a source that is continually renewed. Examples include hydroelectricity, tidal power, geothermal power, solar power, wave power, and wind power.

resonance the amplitude of vibration of an oscillating system subjected to a periodic force is largest when the periodic force has the same frequency as the resonant frequency of the system. For a lightly damped system, the frequency of the periodic force = natural frequency of the oscillating system. At resonance, the system vibrates such that its velocity is in phase with the periodic force.

resonant frequency the frequency of an oscillating system in resonance.

root mean square speed, c_{rms} square root of the mean value of the square of the molecular speeds of the molecules of a gas.

$$c_{rms} = \left(\frac{c_1^2 + c_2^2 + \ldots + c_N^2}{N} \right)^{\frac{1}{2}}$$

where c_1, c_2, c_3 … c_N represent the speeds of the individual molecules and N is the number of molecules in the gas.

Rutherford's α-particle scattering experiment demonstrated that every atom contains a positively charged nucleus which is much smaller than the atom and where all the positive charge and most of the mass of the atom is located.

S

satellite a small object in orbit round a larger object.

satellite motion for a satellite moving at speed v in a circular orbit of radius r round a planet, its centripetal acceleration, $\frac{v^2}{r}$ = g. Substituting $v = \frac{2\pi r}{T}$, where T is its time period, and $g = \frac{GM}{r^2}$, where M is the mass of the planet, $T^2 = \left(\frac{4\pi^2}{GM} \right) r^3$. See *geostationary satellite*.

simple electric motor an electric motor with an armature consisting of a single

coil of insulated wire.

simple harmonic motion motion of an object if its acceleration is proportional to the displacement of the object from equilibrium and is always directed towards the equilibrium position.

1. The acceleration, a, of an object oscillating in simple harmonic motion is given by $a = -(2\pi f)^2 x = -\omega 2x$, where x = displacement from equilibrium, and f = frequency of oscillations and ω = the angular frequency = $2\pi f$.

2. The solution of this equation depends on the initial conditions. If $x = 0$ and the object is moving in the + direction at time $t = 0$, then $x = A\sin(2\pi ft)$. If the object is at maximum displacement, $+A$, at time $t = 0$, then $x = A\cos(2\pi ft)$.

simple harmonic motion applications 1. For a simple pendulum of length L, its time period $T = 2\pi \left(\frac{L}{g}\right)^{\frac{1}{2}}$

2. For an oscillating mass m on the end of a vertical spring, its time period $T = 2\pi \left(\frac{m}{k}\right)^{\frac{1}{2}}$, where k is the spring constant.

sinusoidal curves Any curve with the same shape as a sine wave (e.g., a cosine curve).

specific heat capacity *c* of a substance is the energy needed to raise the temperature of 1 kg of the substance by 1 K without change of state. To raise the temperature of mass m of a substance from T_1 to T_2, the energy needed, $Q = mc(T_2 - T_1)$, where c is the specific heat capacity of the substance.

specific latent heat of fusion of a substance is the energy needed to change the state of unit mass of a solid to a liquid without change of temperature.

specific latent heat of vaporisation for a substance is the energy needed to change the state of unit mass of a liquid to a vapour without change of temperature. To change the state of mass m of a substance without change of temperature, the energy needed $Q = ml$, where l is the specific latent heat of fusion or vaporisation of the substance.

sublimation the change of state when a solid changes to a vapour directly.

T

temperature the degree of hotness of an object. Defined in terms of 'fixed points' (e.g., the triple point of water = 273.16 K).

thermal energy the internal energy of an object due to temperature.

thermal equilibrium when no overall heat transfer occurs between two objects at the same temperature.

thermal nuclear reactor nuclear reactor which has a moderator in the core.

time constant the time taken for a quantity that decreases exponentially to decrease to 0.37 $\left(=\frac{1}{e}\right)$ of its initial value. For the discharge of a capacitor through a fixed resistor, the time constant = resistance × capacitance.

time period or period time taken for one complete cycle of oscillations.

transformer converts the amplitude of an alternating pd to a different value. It consists of two insulated coils, the primary coil and the secondary coil, wound round a soft iron laminated core; *step-down transformer*: a transformer in which the rms pd across the secondary coil is less than the rms pd applied to the primary coil; *step-up transformer*: a transformer in which the rms pd across the secondary coil is greater than the rms pd applied to the primary coil.

transformer rule the ratio of the secondary voltage to the primary voltage is equal to the ratio of the number of secondary turns to the number of primary turns.

transformer efficiency for an ideal transformer (i.e., one that is 100% efficient), the output power (= secondary voltage × secondary current) = the input power (= primary voltage × primary current). Transformer inefficiency is due to: resistance heating of the current in each coil; the heating effect of eddy currents (i.e., unwanted induced currents) in the core; and heating caused by repeated magnetisation and demagnetisation of the core.

U

uniform circular motion motion of an object moving at constant speed along a circular path.

uniform field a region where the field strength is the same in magnitude and direction at every point in the field.

1. The *electric field* between two oppositely charged parallel plates is uniform. The electric field strength $E = \frac{V}{d}$, where V is the pd between the plates and d is the

perpendicular distance between the plates.
2. The *gravitational field* of the Earth is uniform over a region which is small compared to the scale of the Earth.
3. The *magnetic field* inside a solenoid carrying a constant current is uniform along and near the axis.

X

X-rays electromagnetic radiation of wavelength less than about 1 nm. X-rays are emitted from an X-ray tube as a result of fast-moving electrons from a heated filament as the cathode being stopped on impact with the metal anode. X-rays are ionising and they penetrate matter. Thick lead plates are needed to absorb a beam of X-rays.

Glossary of practical terms

accepted value value of the most accurate measurement available, sometimes referred to as the 'true value'.
accuracy the closeness of a measurement to the true value (if known).
dependent variable a physical quantity whose value depends on the value of another physical variable.
error bar representation of an uncertainty on a graph.
errors 1. *Random* errors vary randomly with no recognisable pattern or trend or bias.
2. *Systematic* errors differ systematically and show a pattern or trend or bias.
independent variable physical quantities whose values are selected or controlled by the experimenter.
linearity an instrument that gives readings that are directly proportional to the magnitude of the quantity being measured.
mean value of a set of readings sum of the readings divided by the number of readings.

percentage uncertainty = $\frac{\text{uncertainty}}{\text{mean value}} \times 100\%$.

precision of a measurement the degree of exactness of a measurement — precise measurements have little spread around the mean value.

precision of an instrument the smallest non-zero reading that can be measured using the instrument, also sometimes referred to as the instrument sensitivity or resolution.

range of a set of readings the maximum and minimum values of the readings.

range of an instrument the maximum and minimum values that can be obtained using the instrument.

reliability an experiment or measurement is reliable if a consistent value is obtained each time it is repeated under identical conditions. The reliability of an experiment is increased if random and systematic errors have been considered and eliminated and, where appropriate, a more precise best fit line has been obtained.

repeatable an experiment or measurement that gives the same results when it is repeated by the original experimenter using the same method and equipment.

reproducible an experiment or measurement that gives the same results when it is repeated by another person or by using different equipment or techniques.

sensitivity of an instrument output response per unit input quantity.

uncertainty of a measurement half the range of the readings used to obtain the measurement.

valid measurement measurements that give the required information by an acceptable method.

zero error of an instrument a systematic error due to a non-zero reading when the quantity to be measured is zero.