1.1 Basic physics

Units and quantities

- Can you state the six base SI units (kg, m, s, A, mol and K)?
- Can you express derived units in terms of SI base units, using standard prefixes?
- Can you check equations for homogeneity using units?
- Can you distinguish between scalar and vector quantities and give examples of each?
- Can you add and subtract coplanar vectors, and calculate the resultant of two perpendicular vectors?
- Can you resolve a vector into two perpendicular components?
- Can you define density and use $\rho = m/V$ to calculate mass, density or volume?

Moments and equilibrium

- Can you explain what is meant by the turning effect (moment) of a force?
- Can you state and apply the principle of moments?
- Can you locate the centre of gravity of a uniform cylinder, sphere and cuboid (beam)?
- Can you explain the importance of centre of gravity for the stability of an object?
- Can you state the conditions for equilibrium (zero resultant force and zero resultant moment) and use them in simple calculations?

1.2 Kinematics

1.2 Kinematics

- Can you define displacement, mean speed, instantaneous speed, velocity and acceleration?
- Can you represent displacement, speed, velocity and acceleration graphically?
- Can you use the gradient of a displacement-time graph and the gradient and area under a velocity-time graph?
- Can you interpret displacement-time and velocity-time graphs for motion with non-uniform acceleration?
- Can you derive the equations for uniformly accelerated motion in a straight line?
- Can you use the equations for uniformly accelerated motion ($v = u + at$, $x = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2ax$, $x = \frac{1}{2}(u + v)t$)?

Can you describe the motion of bodies falling in a gravitational field with and without air resistance?	○ ○ ○
Can you explain terminal velocity?	○ ○ ○
Can you explain the independence of vertical and horizontal motion of a body moving freely under gravity?	○ ○ ○
Can you explain and calculate the motion of a body with uniform velocity in one direction and uniform acceleration in a perpendicular direction (projectile motion)?	○ ○ ○

1.3 Dynamics

1.3 Dynamics

Can you explain the concept of force and state Newton's third law, identifying pairs of forces?	○ ○ ○
Can you draw and use free body diagrams to represent the forces on a particle or body?	○ ○ ○
Can you use F = ma in situations where mass is constant?	○ ○ ○
Can you define linear momentum as the product of mass and velocity?	○ ○ ○
Can you explain force as the rate of change of momentum, where mass is constant?	○ ○ ○
Can you state and apply the principle of conservation of momentum in one dimension?	○ ○ ○
Can you distinguish between elastic and inelastic collisions using kinetic energy?	○ ○ ○

1.4 Energy concepts

1.4 Energy concepts

Can you define work done as force multiplied by distance moved in the direction of a constant force?	○ ○ ○
Can you calculate the work done when the force is not along the line of motion, using $W = Fx \cos \theta$?	○ ○ ○
Can you apply the principle of conservation of energy, including gravitational potential energy, elastic potential energy and kinetic energy?	○ ○ ○
Can you use the work-energy relationship (work done = change in kinetic energy, $Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$)?	○ ○ ○
Can you define power as the rate of energy transfer and use $P = W/t$?	○ ○ ○
Can you explain how dissipative forces such as friction and drag cause energy transfer to reduce efficiency?	○ ○ ○

Can you calculate efficiency as (useful energy output / total energy input) x 100%?

1.5 Circular motion

1.5 Circular motion

Can you define the period of rotation and frequency for circular motion?

Can you define the radian as a unit of angle?

Can you use the radian as a measure of angle, including converting from degrees?

Can you define angular velocity, ω, for circular motion and simple harmonic motion?

Can you explain that a centripetal force is the resultant force needed for a body to move in a circle at constant speed?

Can you explain why the centripetal acceleration and force are directed towards the centre of the circle?

Can you use $v = r\omega$, $a = r\omega^2$, $a = v^2/r$, $F = mv^2/r$ and $F = mr\omega^2$?

1.6 Vibrations

Simple harmonic motion

Can you define simple harmonic motion in words?

Can you use $a = -\omega^2 x$ as the defining equation of SHM?

Can you sketch and interpret the graph of acceleration against displacement for SHM?

Can you use $x = A\cos(\omega t + \varphi)$ as a solution to $a = -\omega^2 x$?

Can you define frequency, period, amplitude and phase for an oscillation?

Can you use $T = 1/f$ and $T = 2\pi/\omega$?

Can you use $v = -A\omega \sin(\omega t + \varphi)$ for the velocity during SHM?

Can you sketch and interpret graphs of displacement and velocity against time for SHM?

Can you use $T = 2\pi\sqrt{(m/k)}$ for a mass oscillating on a spring of stiffness k?

Can you use $T = 2\pi\sqrt{(l/g)}$ for a simple pendulum?

Can you describe graphically the interchange between kinetic and potential energy during undamped SHM and do simple calculations on it?

Damping and resonance

- Can you explain what is meant by free oscillations and describe the effect of damping in real systems?
- Can you describe practical examples of damped oscillations?
- Can you explain the importance of critical damping, for example in vehicle suspension systems?
- Can you explain forced oscillations and resonance, giving practical examples?
- Can you describe how the amplitude of a forced oscillation varies with driving frequency, and how increased damping broadens the resonance curve?
- Can you give examples of useful and undesirable resonance, such as circuit tuning, microwave cooking and bridge design?

1.7 Kinetic theory

1.7 Kinetic theory

- Can you use the ideal gas equation in the forms pV = nRT and pV = NkT?
- Can you state the assumptions of the kinetic theory of gases, including the random distribution of energy among the molecules?
- Can you explain how molecular movement causes gas pressure and use p = (1/3)(N/V)m$\langle c^2 \rangle$?
- Can you define the Avogadro constant and the mole?
- Can you relate molar mass to relative molecular mass and use n = total mass / molar mass?
- Can you combine pV = (1/3)Nm$\langle c^2 \rangle$ with pV = nRT to show that the total translational kinetic energy of a mole of monatomic gas is (3/2)RT?
- Can you show that the mean kinetic energy of a molecule is (3/2)kT, so that absolute temperature is proportional to mean molecular kinetic energy?

1.8 Thermal physics

Internal energy and heat

- Can you define internal energy as the sum of the potential and kinetic energies of the molecules of a system?
- Can you explain absolute zero as the temperature at which the internal energy of a system is a minimum?
- Can you use U = (3/2)nRT for the internal energy of an ideal monatomic gas?

- Can you explain that heat is energy in transit across the boundary of a system due to a temperature difference?
- Can you explain thermal equilibrium as the state in which no heat flows between systems in thermal contact?

Work and the first law

- Can you explain that work is also energy in transit between a system and its surroundings?
- Can you use $W = p\Delta V$ for the work done by a gas expanding at constant pressure?
- Can you find the work done by a gas with changing pressure from the area under a p-V graph?
- Can you state and use the first law of thermodynamics, $\Delta U = Q - W$, and interpret negative values of ΔU, Q and W?
- Can you explain why W is usually negligible for solids and liquids, so that $Q = \Delta U$?
- Can you use $Q = mc\Delta\theta$ as the defining equation of specific heat capacity?

2.1 Conduction of electricity

2.1 Conduction of electricity

- Can you state that the coulomb is the unit of charge and that the charge on an electron is a very small fraction of a coulomb?
- Can you explain that charge can flow through conductors?
- Can you define electric current as the rate of flow of charge?
- Can you use $I = \Delta Q/\Delta t$ to calculate current?
- Can you state that current is measured in amperes, where $1\ A = 1\ C\ s^{-1}$?
- Can you explain conduction in metals in terms of the drift of free electrons?
- Can you derive and use $I = nAve$ for free electrons?

2.2 Resistance

Potential difference and resistance

- Can you define potential difference as the energy converted per unit charge?
- Can you state that potential difference is measured in volts ($1\ V = 1\ J\ C^{-1}$)?
- Can you sketch and explain the I-V characteristics of a filament lamp and of a metal wire at constant temperature?
- Can you state Ohm's law, use $V = IR$ and define resistance?
- Can you state that resistance is measured in ohms?
- Can you use $P = IV = I^2R = V^2/R$?

Resistivity and temperature

- Can you explain resistance in terms of collisions between free electrons and lattice ions, and why it increases with temperature?
- Can you use $R = \rho l/A$?
- Can you describe how the resistance of metals varies almost linearly with temperature over a wide range?
- Can you explain how collisions increase the vibrational energy of the ions, raising the temperature of the metal?

Superconductivity

- Can you explain what is meant by superconductivity and superconducting transition temperature?
- Can you state that most metals become superconductors only a few degrees above absolute zero?
- Can you explain that high-temperature superconductors have transition temperatures above the boiling point of nitrogen?
- Can you describe uses of superconductors, such as MRI scanners and particle accelerators?

2.3 D.C. circuits

2.3 D.C. circuits

- Can you explain that the current from a source equals the sum of the currents in parallel branches, as a consequence of conservation of charge?
- Can you explain that the sum of the potential differences across series components equals the supply p.d., as a consequence of conservation of energy?
- Can you state that the potential differences across components in parallel are equal?
- Can you calculate the combined resistance of resistors in series and in parallel?
- Can you analyse potential divider circuits, including those containing LDRs and thermistors?
- Can you define emf?
- Can you state that emf is measured in volts, the same unit as potential difference?
- Can you explain that sources have internal resistance and use $V = E - Ir$?
- Can you calculate the current and p.d. in circuits with a single cell or cells in series?

2.4 Capacitance

Capacitors

- Can you describe a parallel plate capacitor as two equal parallel metal plates separated by a vacuum or air?
- Can you explain how charge is transferred between the plates, leaving equal and opposite charges and zero net charge?
- Can you define capacitance and use $C = Q/V$?
- Can you use $C = \varepsilon_0 A/d$ for a parallel plate capacitor with no dielectric?

- Can you explain that a dielectric increases the capacitance of a vacuum-spaced capacitor?
- Can you explain that the field between the plates of a parallel plate capacitor is uniform and use E = V/d?
- Can you use U = ½QV (and equivalent forms) for the energy stored in a capacitor?
- Can you calculate the combined capacitance of capacitors in series and in parallel?

Charging and discharging

- Can you describe how a capacitor charges and discharges through a resistor?
- Can you use the exponential charging and discharging equations, such as $Q = Q_0 e^{-t/RC}$, with RC as the time constant?

2.5 Solids under stress

Hooke's law and Young modulus

- Can you state Hooke's law and use F = kx, where k is the spring constant?
- Can you define tensile stress, tensile strain and the Young modulus, and state when Hooke's law applies?
- Can you use the area under a force-extension graph to find the work done in deforming a solid, using W = ½Fx when Hooke's law is obeyed?

Behaviour of materials

- Can you classify solids as crystalline, amorphous (including glasses and ceramics) or polymeric?
- Can you describe the force-extension graph of a ductile metal such as copper, including elastic and plastic strain?
- Can you explain plastic deformation in terms of dislocations and how metals can be strengthened by impeding dislocation movement?
- Can you explain necking and ductile fracture in metals?
- Can you describe the behaviour of a brittle material such as glass, which obeys Hooke's law up to fracture?
- Can you explain brittle fracture in terms of crack propagation and the effect of surface imperfections?
- Can you explain how brittle materials can be strengthened by surface compression, for example toughened glass and prestressed concrete?

Can you describe the force-extension behaviour of rubber, including its approximate obedience to Hooke's law and low Young modulus?

Can you explain the extension of rubber in terms of straightening of chain molecules and explain hysteresis in rubber?

2.6 Electrostatic and gravitational fields of force

2.6 Electrostatic and gravitational fields of force

Can you state and use Coulomb's law and Newton's law of gravitation for point charges and point masses?

Can you define and use electric field strength and gravitational field strength, $E = Q/(4\pi\varepsilon_0 r^2)$ and $g = GM/r^2$?

Can you define and use electric and gravitational potential, $V = Q/(4\pi\varepsilon_0 r)$ and $V = -GM/r$?

Can you use potential energy = charge x potential (or mass x potential) and relate field strength to the potential gradient?

Can you compare the features of electric and gravitational fields, including similarities and differences?

Can you explain that the gravitational field outside a spherical body behaves as if all the mass were concentrated at its centre?

Can you use field lines to show field direction, including radial field lines for a positive point charge?

Can you explain equipotential surfaces and show that they are spherical around a point charge or mass?

Can you calculate the net potential and resultant field strength due to several point charges or point masses?

Can you use $\Delta Up = mg\Delta h$ where the variation of g is negligible?

2.7 Using radiation to investigate stars

2.7 Using radiation to investigate stars

Can you explain that a stellar spectrum is a continuous emission spectrum from the star's dense surface with a line absorption spectrum from its tenuous atmosphere?

Can you define a black body as one that absorbs all incident radiation and explain why stars approximate black bodies?

Can you sketch the shape of a black body spectrum and state that the peak wavelength is inversely proportional to absolute temperature?

- Can you convert between Celsius and kelvin using $T(K) = \theta(°C) + 273.15$?
- Can you use Wien's displacement law, $\lambda_{max} = W/T$?
- Can you use Stefan's law, $P = A\sigma T^4$, to relate a star's luminosity, surface area and temperature?
- Can you use the inverse square law, $I = P/(4\pi d^2)$, to find the distance to a star?
- Can you combine these laws to determine the luminosity, size, temperature and distance of a star?
- Can you explain how multiwavelength astronomy reveals different processes occurring in a region of space?

2.8 Orbits and the wider universe

Orbits

- Can you state Kepler's three laws of planetary motion?
- Can you apply Newton's law of gravitation to the motion of planets and satellites?
- Can you derive Kepler's third law for circular orbits from Newton's law of gravitation and centripetal acceleration?
- Can you use the orbital period or orbital speed to calculate the mass of the central body?
- Can you explain how the orbital speeds of objects in spiral galaxies imply the existence of dark matter?
- Can you discuss the possible relationship between the Higgs boson and dark matter?

Double systems and the Doppler effect

- Can you find the position of the centre of mass of two spherical objects and calculate their mutual orbital period for circular orbits?
- Can you use the Doppler relationship $\Delta\lambda/\lambda = v/c$?
- Can you determine the radial velocity of a star from the Doppler shift of its spectral lines?
- Can you use radial velocity variations and orbital period to find the masses in a double system with circular orbits viewed edge-on?

The expanding universe

- Can you state and use Hubble's law, $v = H_0D$?
- Can you explain why $1/H_0$ gives an approximate age of the universe?

Can you derive the critical density of a flat universe, $\rho c = 3H0^2/(8\pi G)$, using conservation of energy?



3.1 The nature of waves

3.1 The nature of waves

- Can you explain that progressive waves transfer energy without transferring matter?
- Can you describe the differences between transverse and longitudinal waves?
- Can you explain polarisation and why only transverse waves can be polarised?
- Can you explain what is meant by oscillations being in phase and in antiphase?
- Can you define displacement, amplitude, wavelength, frequency, period and wave speed?
- Can you sketch and interpret displacement-time and displacement-position graphs for transverse waves?
- Can you use the wave equation $c = f\lambda$?
- Can you explain that points on a wavefront oscillate in phase and that rays are perpendicular to wavefronts?

3.2 Wave properties

Diffraction

- Can you describe diffraction when waves meet slits or obstacles?
- Can you explain why there is little diffraction when the wavelength is much smaller than the slit or obstacle?
- Can you describe how waves spread as roughly semicircular wavefronts when the wavelength is at least the slit width, and through less than 180° when it is smaller?

Interference and superposition

- Can you describe two-source interference?
- Can you explain the historical importance of Young's double slit experiment?
- Can you state the principle of superposition and illustrate it with sketch graphs?
- Can you state the path difference conditions for constructive and destructive interference from in-phase sources?
- Can you use $\Delta y = \lambda D/a$ for Young's double slits?
- Can you use $d \sin \theta = n\lambda$ for a diffraction grating?
- Can you explain why a small slit spacing gives widely separated orders and why many slits give sharper bright beams?

- Can you define coherent sources (monochromatic, continuous wavefronts, constant phase relationship)?
- Can you give examples of coherent and incoherent sources?
- Can you state the conditions for observable interference, including constant phase difference and oscillations in the same direction?

Stationary waves

- Can you state the differences between stationary and progressive waves?
- Can you explain the formation of a stationary wave by superposition of two progressive waves of equal amplitude and frequency travelling in opposite directions, with nodes $\lambda/2$ apart?

3.3 Refraction of light

3.3 Refraction of light

- Can you define refractive index and use $n = c/v$?
- Can you use $n_1v1 = n_2v2$ and Snell's law, $n_1 \sin \theta_1 = n_2 \sin \theta_2$?
- Can you explain how Snell's law follows from the wave model, using plane waves at a boundary?
- Can you state the conditions for total internal reflection?
- Can you use $\sin C = n_2/n_1$ for the critical angle?
- Can you apply total internal reflection to multimode optical fibres?
- Can you explain how multimode dispersion limits the data rate and transmission distance in multimode fibres?
- Can you explain why monomode fibres allow much greater data rates and transmission distances?

3.4 Photons

Photoelectric effect

- Can you explain that light consists of discrete packets of energy called photons, with $E = hf$?
- Can you describe how the photoelectric effect can be demonstrated?
- Can you describe how a vacuum photocell is used to measure Ek max, expressed in eV and J?

- Can you sketch and interpret a graph of Ek max against frequency?
- Can you use Einstein's equation Ek max = hf - φ and relate it to the Ek max-frequency graph?

Spectra and energy levels

- Can you state the wavelength range of the visible spectrum (about 700 nm to 400 nm) and orders of magnitude of wavelengths in other regions of the EM spectrum?
- Can you state typical photon energies for each region of the EM spectrum?
- Can you explain how line emission and line absorption spectra are produced?
- Can you describe how emission and absorption spectra appear when viewed through a diffraction grating?
- Can you use simple energy level diagrams with the photon hypothesis to explain spectra?
- Can you determine ionisation energies from energy level diagrams?

Wave-particle duality

- Can you explain how electron diffraction provides evidence for the wave nature of particles?
- Can you use the de Broglie relationship $\lambda = h/p$ for both particles and photons?
- Can you explain and calculate radiation pressure on absorbing and reflecting surfaces?

3.5 Lasers

3.5 Lasers

- Can you explain stimulated emission and how it produces coherent light?
- Can you explain why a population inversion ($N_2 > N_1$) is needed for laser action?
- Can you explain why a population inversion is usually not possible in a 2-level system?
- Can you explain how a population inversion is achieved in 3-level and 4-level systems?
- Can you explain what is meant by pumping and its purpose?
- Can you describe the basic structure of a laser, with an amplifying medium between two mirrors, one partially transmitting?
- Can you state the advantages and uses of semiconductor lasers (small, cheap, efficient; CDs, DVDs, telecommunications)?

3.6 Nuclear decay

3.6 Nuclear decay

- Can you explain the spontaneous nature of nuclear decay and describe the nature of α, β and γ radiation?
- Can you write nuclear equations using A/Z X notation?
- Can you describe methods to distinguish between α, β and γ radiation and link their nature to their penetrating power and range?
- Can you allow for background radiation in measurements?
- Can you define half-life, $T_{½}$?
- Can you define activity, A, and the becquerel?
- Can you define the decay constant λ and use $A = \lambda N$?
- Can you use the exponential decay law, $N = N_0 e^{-\lambda t}$ and $A = A_0 e^{-\lambda t}$, in graphical and algebraic form, including non-integer numbers of half-lives?
- Can you derive and use $T_{½} = \ln 2/\lambda$?

3.7 Particles and nuclear structure

Nuclear structure

- Can you explain the significance of the results of Rutherford's alpha scattering experiment?
- Can you estimate the maximum Coulomb repulsion between an alpha particle and a gold nucleus for the plum pudding and Rutherford models?

Particles and interactions

- Can you state that matter is made of quarks and leptons in three generations, and work with first-generation particles?
- Can you explain that antiparticles have the same properties as particles but opposite charge, and describe particle-antiparticle annihilation?
- Can you use symbols for the positron, antiquarks and hadrons?
- Can you explain that quarks are never found in isolation but form hadrons (baryons, antibaryons and mesons)?
- Can you state the quark compositions of the proton and neutron?
- Can you use a particle data table to deduce the quark make-up of less familiar first-generation baryons and charged pions?

Can you compare the gravitational, weak, electromagnetic and strong interactions in terms of the particles they act on, range and relative strength?

Can you apply conservation of charge, lepton number and baryon (quark) number to particle reactions?

Can you explain that neutrino involvement and changes of quark flavour occur only in weak interactions?

3.8 Nuclear energy

3.8 Nuclear energy

Can you use mass-energy equivalence, $E = mc^2$?

Can you define binding energy and binding energy per nucleon, using the unified atomic mass unit (u)?

Can you calculate binding energy and binding energy per nucleon from nuclear masses?

Can you apply conservation of mass-energy to particle interactions, including fission and fusion?

Can you use the binding energy per nucleon curve to explain why energy is released in fission and fusion?

3.9 Magnetic fields

Magnetic forces

Can you predict the direction of the force on a current-carrying conductor in a magnetic field?

Can you define B and use $F = BIl \sin\theta$?

Can you use $F = Bqv \sin\theta$ for the force on a moving charge?

Can you explain how a Hall voltage is produced and why VH is proportional to B for a constant current?

Fields of currents

Can you sketch the magnetic field patterns of a long straight wire and a long solenoid?

Can you use $B = \mu_0 I/(2\pi a)$ for a long straight wire and $B = \mu_0 nI$ for a long solenoid?

Can you explain that an iron core increases the field strength of a solenoid?

Can you explain the forces between current-carrying conductors and predict their directions?

Charged particles in fields

Can you calculate the deflection of ion beams in uniform electric and magnetic fields?

Can you describe the motion of charged particles in linear accelerators, cyclotrons and synchrotrons?

3.10 Electromagnetic induction

3.10 Electromagnetic induction

Can you define magnetic flux, $\Phi = BA \cos \theta$, and flux linkage, $N\Phi$?

Can you state Faraday's law and Lenz's law?

Can you apply the laws using emf = -rate of change of flux linkage?

Can you calculate the emf induced in a conductor moving at right angles to a uniform magnetic field?

Can you describe qualitatively how the instantaneous emf in a rotating coil depends on its position, the flux density, coil area and angular velocity?

OptA Alternating currents OPTION

A.c. generation and rms values

Can you apply Faraday's law to a coil rotating in a uniform magnetic field?

Can you describe how the flux linkage of a rotating coil varies with time as its angle changes?

Can you use $V = BAN\omega \sin \omega t$ for the emf induced in a rotating flat coil?

Can you define frequency, period, peak value and rms value for alternating voltages and currents?

Can you relate rms values to energy dissipated per cycle and use $V_{rms} = V_0/\sqrt{2}$ and $I_{rms} = I_0/\sqrt{2}$?

Can you calculate mean power in a resistor using rms values?

Can you use an oscilloscope to measure a.c. and d.c. voltages, currents and frequencies?

Reactance and impedance

- Can you explain why the current lags the p.d. by 90° in an inductor?
- Can you define inductive reactance and use XL = ωL?
- Can you explain why the current leads the p.d. by 90° in a capacitor and use XC = 1/(ωC)?
- Can you explain why the mean power dissipated in an ideal inductor or capacitor is zero?
- Can you add p.d.s in series RC, RL and RCL circuits using phasor diagrams?
- Can you calculate the phase angle and impedance of series RC, RL and RCL circuits?

Resonance

- Can you derive and use $f_0 = 1/(2\pi\sqrt{(LC)})$ for the resonance frequency of a series RCL circuit?
- Can you define the Q factor as the ratio of the p.d. across the inductor (or capacitor) to the p.d. across the resistor at resonance?
- Can you relate the Q factor to the sharpness of the resonance curve?

OptB Medical physics

OPTION

X-rays

- Can you describe the nature and properties of X-rays?
- Can you explain how X-ray spectra are produced and how beam intensity and photon energy are controlled?
- Can you explain why high-energy X-rays are used for therapy and low-energy X-rays for diagnosis?
- Can you use the X-ray attenuation equation, $I = I_0 e^{-\mu x}$?
- Can you explain how soft tissue is imaged with X-rays and describe fluoroscopy using image intensifiers?
- Can you describe radiography techniques, including digital image receptors?
- Can you describe the principles of a rotating-beam X-ray CT scanner?

Ultrasound

- Can you explain how ultrasound is generated and detected using piezoelectric transducers?

- Can you describe ultrasound diagnostic scanning using A-scans and B-scans?
- Can you define acoustic impedance, calculate reflection and transmission at tissue boundaries and explain the need for a coupling medium?
- Can you use the Doppler equation to study blood flow?

MRI

- Can you describe the principles of MRI, including precession, resonance and relaxation, and use the Larmor frequency?
- Can you describe the diagnostic information provided by MRI?
- Can you compare the advantages and disadvantages of ultrasound, X-ray and MRI imaging?

Radiation dose and nuclear medicine

- Can you describe the effects of alpha, beta and gamma radiation on living matter?
- Can you define absorbed dose and the gray and sievert units?
- Can you use the equations for equivalent dose and effective dose?
- Can you explain the use of radionuclide tracers, with reference to Tc-99m?
- Can you describe the components of a gamma camera?
- Can you describe PET scanning and its use in detecting tumours?

OptC The physics of sports

OPTION

Forces, impulse and restitution

- Can you use centre of gravity to explain stability and toppling in sporting contexts?
- Can you use the principle of moments to find forces in muscle systems and other contexts such as sailing?
- Can you use Newton's second law in impulse form, Ft = mv - mu, in sporting contexts?
- Can you use the coefficient of restitution as a ratio of relative speeds and as e = √(h/H) for a bouncing ball?

Rotational dynamics

- Can you explain what is meant by moment of inertia?
- Can you use $I = (2/5)mr^2$ for a solid sphere and $I = (2/3)mr^2$ for a thin spherical shell?

- Can you define angular acceleration and use $\alpha = (\omega 2 - \omega 1)/t$?
- Can you use $\tau = I\alpha$?
- Can you use angular momentum $L = I\omega$?
- Can you apply conservation of angular momentum to sporting problems?
- Can you use rotational kinetic energy, $KE = \frac{1}{2}I\omega^2$?
- Can you apply conservation of energy including linear and rotational kinetic energy, gravitational and elastic potential energy in sporting contexts?

Projectiles and fluids

- Can you apply projectile motion theory in sporting contexts?
- Can you use Bernoulli's equation in sporting contexts?
- Can you calculate drag force using $F = \frac{1}{2}\rho v^2 AC_D$?

OptD Energy and the environment

OPTION

Global temperature and sea levels

- Can you explain how thermal equilibrium between solar energy input and energy re-radiated from the Earth affects global temperature, including the effects of global energy demand and CO2 levels?
- Can you describe the origin and transmission of solar energy, the shape of the Sun's power spectrum and the conversion of wavelengths to the near infrared in the atmosphere?
- Can you apply Wien's law (λ_{max} T = constant) and the Stefan-Boltzmann law in the context of solar power?
- Can you use the density equation and Archimedes' principle to explain why melting land ice raises sea levels but melting icebergs does not?

Energy sources

- Can you describe the proton-proton chain as the main energy mechanism of the Sun?
- Can you use I = P/A and the inverse square law for solar intensity, and explain energy conversion and efficiency in photovoltaic cells?
- Can you derive and use $P = \frac{1}{2}\rho A v^3$ for the power in a moving fluid and discuss factors affecting wind turbine efficiency?
- Can you calculate energy and power for tidal barrages, hydroelectric and pumped storage systems in terms of Ep to Ek conversion, and compare them with wind?

- Can you explain breeding and enrichment in nuclear fission reactors?
- Can you explain the difficulties of achieving sustained fusion power, including the fusion triple product?
- Can you describe the development and use of renewable and non-renewable energy sources in the UK and internationally?
- Can you explain the principles of fuel cell operation and their benefits for greenhouse gas emissions?

Thermal conduction and insulation

- Can you use the thermal conduction equation $\Delta Q/\Delta t = -kA\Delta T/\Delta x$?
- Can you explain the effect of insulation on thermal energy loss?
- Can you calculate heat loss through parallel surfaces using rate = $UA\Delta T$, including different materials in contact?

SP Specified Practicals

Specified practical work

1 Can you measure the density of solids?

2 Can you determine unknown masses using the principle of moments?

3 Can you measure g by freefall?

4 Can you investigate Newton's 2nd law?

5 Can you measure g using a simple pendulum?

6 Can you investigate the damping of a spring?

7 Can you estimate absolute zero using the gas laws?

8 Can you measure the specific heat capacity of a solid?

9 Can you investigate the I-V characteristics of a filament lamp and a metal wire at constant temperature?

10 Can you determine the resistivity of a metal?

11 Can you investigate how the resistance of a metal wire varies with temperature?

12 Can you determine the internal resistance of a cell?

13 Can you investigate the charging and discharging of a capacitor to determine the time constant?

14 Can you investigate the energy stored in a capacitor?

15 Can you determine the Young modulus of a metal in the form of a wire?

16 Can you investigate the force-extension relationship for rubber?

17 Can you measure intensity variations for polarisation?

18 Can you determine wavelength using Young's double slits?

19 Can you determine wavelength using a diffraction grating?

20 Can you determine the speed of sound using stationary waves?

21 Can you measure the refractive index of a material?

22 Can you determine the Planck constant h using LEDs?

23 Can you investigate radioactive decay using a dice analogy?

24 Can you investigate the variation of intensity of gamma radiation with distance?

25 Can you investigate the force on a current in a magnetic field?

26 Can you investigate magnetic flux density using a Hall probe?