AS Level Physics HEAD

3.1 Measurements and their errors	**3.1.1 Use of SI units and their prefixes** Recall fundamental (base) units. Use, and derive where necessary, appropriate SI units for mass, length, time, amount of substance, temperature, electric current. Use SI prefixes, values and standard form appropriately. Use the prefixes: T, G, M, k, c, m, μ, n, p, f. Convert between different units of the same quantity, e.g. J and eV, J and kW h.	**3.1.2 Limitation of physical measurements** Identify random and systematic errors. Define: precision; repeatability; reproducibility; resolution and accuracy. Calculate absolute, fractional and percentage uncertainties represent uncertainty in the final answer for a quantity. Combine absolute and percentage uncertainties. Represent uncertainty in a data point on a graph using error bars. Determine the uncertainties in the gradient and intercept of a straight-line graph.	**3.1.3 Estimation of physical quantities** Use orders of magnitude appropriately. Estimate approximate values of physical quantities.

AS Level Physics HEAD

3.2 Particles and radiation	**3.2.1 Particles**	**3.2.1.1 Constituents of the atom** Describe a simple model of the atom. Recall charge and mass of the proton, neutron and electron in SI units and relative units. Outline the meaning of proton number Z, nucleon number A, nuclide notation. Be familiar with the ZX A notation. Explain what isotopes and use isotopic data.	**3.2.1.2 Stable and unstable nuclei** Explain the role of the strong nuclear force in keeping the nucleus stable. Describe how alpha and beta decay arises. Construct equations for alpha decay, β− decay including the need for the neutrino.	**3.2.1.3 Particles, antiparticles and photons** Compare particle and antiparticle masses, charge and rest energy in MeV. Recall the names of the antiparticles to the electron, proton, neutron and neutrino. Use the Planck constant when describing the photon model of electromagnetic radiation. Apply knowledge of annihilation and pair production and the energies involved.	**3.2.1.4 Particle interactions** Describe the four fundamental interactions: gravity, electromagnetic, weak nuclear, strong nuclear. Apply the concept of exchange particles to explain forces between elementary particles. Describe the electromagnetic force and the role of virtual photons as the exchange particle. Explain the weak interaction limited to β− and β+ decay, electron capture and electron–proton collisions; W+ and W− as the	**3.2.1.5 Classification of particles** Describe the two classes of hadrons: baryons and antibaryons; mesons. Define baryon number. Explain conservation of baryon number. Describe the proton is the only stable baryon into which other baryons eventually decay. Describe the pion as the exchange particle of the strong nuclear force. Describe the kaon as a particle that can decay into pions. Recall the names of leptons and their antiparticles. Use lepton number as a quantum number; conservation of lepton number for muon leptons and for electron leptons. Describe the muon as a particle that decays into an electron. Explain how strange particles are produced.	**3.2.1.6 Quarks and antiquarks** Describe properties of quarks and antiquarks. Recall the combinations of quarks and antiquarks required for baryons, antibaryons and mesons.. Describe neutron decay.	**3.2.1.7 Applications of conservation laws** Describe the change of quark character in β− and in β+ decay. Apply the conservation laws for charge, baryon number, lepton number and strangeness to particle interactions. Recognise that energy and momentum are conserved in interactions.

AS Level Physics HEAD

					exchange particles. Construct simple diagrams to represent the above reactions or interactions in terms of incoming and outgoing particles and exchange particles.	Use strangeness as a quantum number to reflect the fact that strange particles are always created in pairs. Describe strangeness in weak and strong interactions. Conservation of strangeness in strong interactions. Appreciate that particle physics relies on the collaborative efforts of large teams of scientists and engineers to validate new knowledge.		
3.2.2 Electromagnetic radiation and quantum phenomena		**3.2.2.1 The photoelectric effect**		**3.2.2.2 Collisions of electrons with atoms**	**3.2.2.3 Energy levels and photon emission**	**3.2.2.4 Wave-particle duality**		

AS Level Physics HEAD

	Threshold frequency; photon explanation of threshold frequency. Work function ⍰, stopping potential. Photoelectric equation: h f = ⍰ + Ek (max Ek (max is the maximum kinetic energy of the photoelectrons. The experimental determination of stopping potential is not required.	Ionisation and excitation; understanding of ionisation and excitation in the fluorescent tube. The electron volt. Students will be expected to be able to convert eV into J and vice versa.	Line spectra (eg of atomic hydrogen) as evidence for transitions between discrete energy levels in atoms. h f = E1 − E2 In questions, energy levels may be quoted in J or eV.	Students should know that electron diffraction suggests that particles possess wave properties and the photoelectric effect suggests that electromagnetic waves have a particulate nature. Details of particular methods of particle diffraction are not expected. de Broglie wavelength ⍰ = h mv where mv is the momentum. Students should be able to explain how and why the amount of diffraction changes when the momentum of the particle is				

				changed. Appreciation of how knowledge and understanding of the nature of matter changes over time.				
3.3 Waves	**3.3.1 Progressive and stationary waves**							
	3.3.1.1 Progressive waves	**3.3.1.2 Longitudinal and transverse waves**	**3.3.1.3 Principle of superposition of waves and formation of stationary waves**					

	Oscillation of the particles of the medium; amplitude, frequency, wavelength, speed, phase, phase difference, c = f ⍰ f = 1 T Phase difference may be measured as angles (radians and degrees) or as fractions of a cycle.	Nature of longitudinal and transverse waves. Examples to include: sound, electromagnetic waves, and waves on a string. Students will be expected to know the direction of displacement of particles/fields relative to the direction of energy propagation and that all electromagnetic waves travel at the same speed in a vacuum. Polarisation as evidence for the nature of transverse waves. Applications of polarisers to include Polaroid material and the alignment of aerials for transmission and reception. Malus's	Stationary waves. Nodes and antinodes on strings. f = 1 2l T ⍰ for first harmonic. The formation of stationary waves by two waves of the same frequency travelling in opposite directions. A graphical explanation of formation of stationary waves will be expected. Stationary waves formed on a string and those produced with microwaves and sound waves should be considered. Stationary waves on strings will be described in terms of harmonics. The terms fundamental (for first harmonic) and overtone will not be used.					

		law will not be expected.						
3.3.2 Refraction, diffraction and interference	**3.3.2.1 Interference**	**3.3.2.2 Diffraction**	**3.3.2.3 Refraction at a plane surface**					

	Path difference. Coherence. Interference and diffraction using a laser as a source of monochromatic light. Young's double-slit experiment: the use of two coherent sources or the use of a single source with double slits to produce an interference pattern. Fringe spacing, w = D s Production of interference pattern using white light. Students are expected to show awareness of safety issues associated with using lasers. Students will not be required to describe how a laser works. Students will be expected to describe and explain interference produced with sound and electromagnetic waves. Appreciation of how knowledge and understanding of nature of electromagnetic radiation has changed over time.	Appearance of the diffraction pattern from a single slit using monochromatic and white light. Qualitative treatment of the variation of the width of the central diffraction maximum with wavelength and slit width. The graph of intensity against angular separation is not required. Plane transmission diffraction grating at normal incidence. Derivation of dsin = n Use of the spectrometer will not be tested. Applications of diffraction gratings.	Refractive index of a substance, n = c cs Students should recall that the refractive index of air is approximately 1. Snell's law of refraction for a boundary n1sin 1 = n2sin 2 Total internal reflection sin c = n2 n1 Simple treatment of fibre optics including the function of the cladding. Optical fibres will be limited to step index only. Material and modal dispersion. Students are expected to understand the principles and consequences of pulse broadening and absorption.					
3.4 Mechanics and materials	**3.4.1 Force, energy and momentum**							

AS Level Physics HEAD

	3.4.1.1 Scalars and vectors	3.4.1.2 Moments	3.4.1.3 Motion along a straight line	3.4.1.4 Projectile motion	3.4.1.5 Newton’s laws of motion	3.4.1.6 Momentum	3.4.1.7 Work, energy and power	3.4 Cor of e
	Nature of scalars and vectors. Examples should include: velocity/speed, mass, force/weight, acceleration, displacement/distance. Addition of vectors by calculation or scale drawing. Calculations will be limited to two vectors at right angles. Scale drawings may involve vectors at angles other than 90 °. Resolution of vectors into two components at right angles to each other. Examples should include components of forces along and perpendicular to an inclined plane. Problems may be solved either by the use of resolved forces or the use of a closed triangle. Conditions for equilibrium for two or three coplanar forces acting at a point. Appreciation of the	Moment of a force about a point. Moment defined as force × perpendicular distance from the point to the line of action of the force. Couple as a pair of equal and opposite coplanar forces. Moment of couple defined as force × perpendicular distance between the lines of action of the forces. Principle of moments. Centre of mass. Knowledge that the position of the centre of mass of uniform regular solid is at its centre.	Displacement, speed, velocity, acceleration. v = Δ s Δ t a = Δ v Δ t Calculations may include average and instantaneous speeds and velocities. Representation by graphical methods of uniform and nonuniform acceleration. Significance of areas of velocity–time and acceleration–time graphs and gradients of displacement–time and velocity–time graphs for uniform and non-uniform acceleration eg graphs for motion of bouncing ball. Equations for uniform acceleration: v = u + at s = u + v 2 t s = ut	Independent effect of motion in horizontal and vertical directions of a uniform gravitational field. Problems will be solvable using the equations of uniform acceleration. Qualitative treatment of friction. Distinctions between static and dynamic friction will not be tested. Qualitative treatment of lift and drag forces. Terminal speed. Knowledge that air resistance increases with speed.	Knowledge and application of the three laws of motion in appropriate situations. F = ma for situations where the mass is constant.	momentum = mass × velocity Conservation of linear momentum. Principle applied quantitatively to problems in one dimension. Force as the rate of change of momentum, F = Δ mv Δ t Impulse = change in momentum FΔt = Δ mv , where F is constant. Significance of the area under a force–time graph. Quantitative	Energy transferred, W = Fscos ⍰ rate of doing work = rate of energy transfer, P = Δ W Δ t = Fv Quantitative questions may be set on variable forces. Significance of the area under a force–displacement graph. efficiency = useful output power input power Efficiency can be expressed as a percentage.	Prir con of e ΔEp and 2m Qua and qua app ene con to e inve gra pot ene kine ene wo aga res forc

	meaning of equilibrium in the context of an object at rest or moving with constant velocity		+ at2 2 v 2 = u 2 + 2as Acceleration due to gravity, g.	Qualitative understanding of the effect of air resistance on the trajectory of a projectile and on the factors that affect the maximum speed of a vehicle.		questions may be set on forces that vary with time. Impact forces are related to contact times (eg kicking a football, crumple zones, packaging). Elastic and inelastic collisions; explosions. Appreciation of momentum conservation issues in the context of ethical transport design.		
3.4.2 Materials	**3.4.2.1 Bulk properties of solids**	**3.4.2.2 The Young modulus**						

	Density, ⍰ = m V Hooke's law, elastic limit, F = kΔL , k as stiffness and spring constant. Tensile strain and tensile stress. Elastic strain energy, breaking stress. energy stored = 1 2FΔL = area under force–extension graph Description of plastic behaviour, fracture and brittle behaviour linked to force–extension graphs. Quantitative and qualitative application of energy conservation to examples involving elastic strain energy and energy to deform. Spring energy transformed to kinetic and gravitational potential energy. Interpretation of simple stress–strain curves. Appreciation of energy conservation issues in the context of ethical transport design.	Young modulus = tensile stress tensile strain = FL A Δ L Use of stress–strain graphs to find the Young modulus. (One simple method of measurement is required.)						
3.5 Electricity	**3.5.1 Current electricity**							
	3.5.1.1 Basics of electricity	**3.5.1.2 Current–voltage characteristics**	**3.5.1.3 Resistivity**	**3.5.1.4 Circuits**	**3.5.1.5 Potential divider**	**3.5.1.6 Electromotive force and internal resistance**		

AS Level Physics HEAD

	Electric current as the rate of flow of charge; potential difference as work done per unit charge. I = Δ Q Δ t , V = W Q Resistance defined as R = V I	For an ohmic conductor, semiconductor diode, and filament lamp. Ohm's law as a special case where I ∝ V under constant physical conditions. Unless specifically stated in questions, ammeters and voltmeters should be treated as ideal (having zero and infinite resistance respectively). Questions can be set where either I or V is on the horizontal axis of the characteristic graph.	Resistivity, ⍰ = RA L Description of the qualitative effect of temperature on the resistance of metal conductors and thermistors. Only negative temperature coefficient (ntc) thermistors will be considered. Applications of thermistors to include temperature sensors and resistance–temperature graphs. Superconductivity as a property of certain materials which have zero resistivity at and below a critical temperature which depends on the material. Applications of superconductors to include the production of strong magnetic fields and the reduction of energy loss in	The relationships between currents, voltages and resistances in series and parallel circuits, including cells in series and identical cells in parallel. Conservation of charge and conservation of energy in dc circuits.	The potential divider used to supply constant or variable potential difference from a power supply. The use of the potentiometer as a measuring instrument is not required. Examples should include the use of variable resistors, thermistors, and light dependent resistors (LDR) in the potential divider.	Terminal pd; emf Students will be expected to understand and perform calculations for circuits in which the internal resistance of the supply is not negligible.		

			transmission of electric power. Critical field will not be assessed.					