Year 12 PHYSICS Curriculum Map

Note: KS5 (Yr12-13) Topics often span half terms and can be up to 20+ lessons long, normally 2 topics are taught concurrently, for simplicity the main topics each term has been identified but may start the term before and or spill over into the following term.

<table>
<tr><th>Term</th><th>Topic/Unit title</th><th colspan="2">Essential Skills / Knowledge

(what students should know and be able to apply by the end of the unit/topic)</th></tr>
<tr><td>Aut 1</td><td>AQA Particles & Quantum

AQA Electricity</td><td rowspan="2">2.1 Particles

2.1.1 Constituents of the Atom

Simple model of the atom, including the proton, neutron and electron. Charge and mass of the proton, neutron and electron in SI units and relative units.

The atomic mass unit (amu) is included in the A-level Nuclear physics section.

Specific charge of the proton and the electron, and of nuclei and ions.

Proton number Z, nucleon number A, nuclide notation.

Students should be familiar with atomic notation.

Meaning of isotopes and the use of isotopic data.

2.1.2 Stable and Unstable Nuclei

The strong nuclear force; its role in keeping the nucleus stable; short-range attraction up to approximately 3 fm, very-short range repulsion closer than approximately 0.5 fm.

Unstable nuclei; alpha and beta decay.

Equations for alpha decay, β^- decay including the need for the neutrino.</td><td rowspan="2">5.1 Current Electricity

5.1.1 Basics of Electricity

Electric current as the rate of flow of charge; potential difference as work done per unit charge.

$I = \Delta Q / \Delta t$

$V = W / Q$

Resistance defined as: $R = V / I$

5.1.2 Current-Voltage Characteristics

IV characteristics for an ohmic conductor, semiconductor diode, and filament lamp.

Ohm's law as a special case where $I \propto V$ 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.

5.1.3 Resistivity

Resistivity: $\rho = RA / L$</td></tr>
<tr><td>Aut 2</td><td>AQA Particles & Quantum

AQA Electricity</td></tr>
</table>

		The existence of the neutrino was hypothesised to account for conservation of energy in beta decay. 2.1.3 Particles, Antiparticles and Photons For every type of particle, there is a corresponding antiparticle. Comparison of particle and antiparticle masses, charge and rest energy in MeV. Students should know that the positron, antiproton, antineutron and antineutrino are the antiparticles of the electron, proton, neutron and neutrino respectively. Photon model of electromagnetic radiation, the Planck constant. $E = hf = hc / \lambda$ Knowledge of annihilation and pair production and the energies involved. The use of E = mc2 is not required in calculations. 2.1.4 Particle Interactions Four fundamental interactions: gravity, electromagnetic, weak nuclear, strong nuclear. (The strong nuclear force may be referred to as the strong interaction.) The concept of exchange particles to explain forces between elementary particles. Knowledge of the gluon, Z0 and graviton will not be tested. The electromagnetic force; virtual photons as the exchange particle.	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 transmission of electric power. Critical field will not be assessed. 5.1.4 Circuits Resistors: in series, RT = R1 + R2 + R3 + … in parallel, 1/RT = 1/R1 + 1/R2 + 1/R3 + … Energy and power equations: E = IVt, P = IV = I2 R = V2/R 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 weak interaction is limited to β^- and β^+ decay, electron capture and electron–proton collisions; W^+ and W^- as the exchange particles. Simple diagrams to represent the above reactions or interactions in terms of incoming and outgoing particles and exchange particles. 2.1.5 Classification of Particles Hadrons are subject to the strong interaction. The two classes of hadrons:baryons (proton, neutron) and antibaryons (antiproton and antineutron) mesons (pion, kaon) Baryon number as a quantum number. Conservation of baryon number. The proton is the only stable baryon into which other baryons eventually decay. The pion as the exchange particle of the strong nuclear force. The kaon as a particle that can decay into pions. Leptons: electron, muon, neutrino (electron and muon types only) and their antiparticles. Lepton number as a quantum number; conservation of lepton number for muon leptons and for electron leptons. The muon as a particle that decays into an electron. Strange particles. Strange particles as particles that are produced through the strong interaction and decay through the weak interaction (e.g. kaons).	5.1.5 Potential Divider 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. 5.1.6 Electromotive Force and Internal Resistance $\varepsilon = E/Q$ & $\varepsilon = I(R + r)$ Terminal pd and emf Students will be expected to understand and perform calculations for circuits in which the internal resistance of the supply is not negligible.

		Strangeness (symbol s) as a quantum number to reflect the fact that strange particles are always created in pairs. Conservation of strangeness in strong interactions. Strangeness can change by 0, +1 or -1 in weak interactions. Appreciation that particle physics relies on the collaborative efforts of large teams of scientists and engineers to validate new knowledge. 2.1.6 Quarks and Antiquarks Properties of quarks and antiquarks: charge, baryon number and strangeness. Combinations of quarks and antiquarks required for baryons (proton and neutron only), antibaryons (antiproton and antineutron only) and mesons (pion and kaon only). Only knowledge of up (u), down (d) and strange (s) quarks and their antiquarks will be tested. The decay of the neutron should be known. 2.1.7 Applications of Conservation Laws Change of quark character in $\beta-$ and in $\beta+$ decay. Application of the conservation laws for charge, baryon number, lepton number and strangeness to particle interactions. The necessary data will be provided in questions for particles outside those specified. Students should recognise that energy and momentum are conserved in interactions	

		2.2 Electromagnetic Radiation and Quantum Phenomena 2.1 The Photoelectric Effect Threshold frequency; photon explanation of threshold frequency. Work function ϕ, stopping potential. Photoelectric equation: $hf = \phi + Ek(max)$ Ek(max) is the maximum kinetic energy of the photoelectrons. The experimental determination of stopping potential is not required. 2.2 Collisions of Electrons with atoms 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. 2.3 Energy levels and photon emissions Line spectra (eg of atomic hydrogen) as evidence for transitions between discrete energy levels in atoms. $hf = E1 - E2$ In questions, energy levels may be quoted in J or eV. 2.4 Wave Particle Duality	

		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 $\lambda=h/mv$ 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. Appreciation that such changes need to be evaluated through peer review and validated by the scientific community.	
Spr 1	AQA Mechanics AQA Waves	3.1 Progressive and Stationary waves 3.1.1 Progressive Waves Direction of oscillations of the particles in the medium. The definitions of amplitude, frequency, wavelength, speed, phase, phase difference and their units (including radians). The equations: $c = f\lambda$ and $f=1/T$ 3.1.2 Longitudinal and Transverse Waves The nature of longitudinal and transverse waves, with examples of each (sound, electromagnetic, waves on a string etc).	4.1 Force, Energy and Momentum 4.1.1 Scalars and Vectors 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.
Spr 2	AQA Mechanics AQA Waves		

		The direction of particle oscillation (if applicable) in relation to the direction of energy transfer. You 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 law will not be expected. 3.1.3 Principle of Superposition of Waves and Formation of Stationary Waves Stationary waves. Nodes and antinodes on strings. First harmonic wave equation 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.	Conditions for equilibrium for two or three coplanar forces acting at a point. Appreciation of the meaning of equilibrium in the context of an object at rest or moving with constant velocity. 4.1.2 Moments 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. 4.1.3 Motion along a Straight Line Displacement, speed, velocity, acceleration. $v = \Delta s / \Delta t$ $a = \Delta v / \Delta t$ Calculations may include average and instantaneous speeds and velocities. Representation by graphical methods of uniform and non-uniform acceleration.

		3.2 Refraction, Diffraction and Interference 3.2.1 Interference The definitions of path difference and 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, $w=\lambda D/s$ Production of interference patterns using white light. You are expected to show awareness of safety issues associated with using lasers. You will not be required to describe how a laser works. You 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. 3.2.2 Diffraction The patterns produced when monochromatic or white light is shone through a single slit. 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.	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 balls. SUVAT Equations Acceleration due to gravity, g. 4.1.4 Projectile Motion 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. 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. 4.1.5 Newton's Laws of Motion Knowledge and application of the three laws of motion in appropriate situations. F = ma for situations where the mass is constant. 4.1.6 Momentum

		Plane transmission diffraction grating at normal incidence. Derivation of $d\sin\theta = n\lambda$ Use of the spectrometer will not be tested. Applications of diffraction gratings. 3.2.3 Refraction at a Plane Surface Refractive index of a substance: $n = c / c_s$ Students should recall that the refractive index of air is approximately 1. Snell's law of refraction for a boundary: $n_1\sin\theta_1 = n_2\sin\theta_2$ Total internal reflection: $\sin\theta_c = n_2 / n_1$ Simple treatment of fibre optics including the function of the cladding. (Optical fibres will be limited to step index only). Material and modal dispersion. You are expected to understand the principles and consequences of pulse broadening and absorption.	momentum = mass × velocity Conservation of linear momentum. Principle applied quantitatively to problems in one dimension. Force as the rate of change of momentum: $F = \Delta mv / \Delta t$ Impulse = change in momentum $F\Delta t = \Delta mv$ Where F is constant. Significance of the area under a force–time graph. Quantitative 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. 4.1.7 Work, Energy and Power Energy transferred, $W = Fs\cos\theta$ rate of doing work = rate of energy transfer, $P = \Delta W / \Delta t = Fv$ 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.

			4.1.8 Conservation of Energy Principle of conservation of energy. $\Delta Ep = mg\Delta h$ and $Ek = \frac{1}{2} mv2$ Quantitative and qualitative application of energy conservation to examples involving gravitational potential energy, kinetic energy, and work done against resistive forces. 4.2 Materials 4.2.1 Bulk Properties of Solids Density: $\rho = m / V$ Hooke's law, elastic limit. $F = k\Delta L$ k as stiffness and spring constant. Tensile strain and tensile stress. Elastic strain energy, breaking stress. energy stored = $\frac{1}{2} F\Delta L$ = 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. 4.2.2 The Young Modulus 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 of Young Modulus required.
Sum 1	AQA Fields AQA Further Mech + Therm	7.1 Fields (A-level only) Concept of a force field as a region in which a body experiences a non- contact force. You should recognise that a force field can be represented as a vector, the direction of which must be determined by inspection. Force fields arise from the interaction of mass, of static charge, and between moving charges. Similarities between gravitational and electrostatic forces: Both have inverse-square force laws that have many characteristics in common, e.g. use of field lines, use of potential concept, equipotential surfaces etc Differences between gravitational and electrostatic forces: masses always attract, but charges may attract or repel. 7.2 Gravitational fields (A-level only) Gravity as a universal attractive force acting between all matter.	6.1 Periodic Motion (A-level only) Motion in a circular path at constant speed implies there is an acceleration and requires a centripetal force. Estimate the acceleration and centripetal force in situations that involve rotation. Magnitude of angular speed $\omega = v / r = 2\pi f$ Radian as the measure of angle. Direction of angular velocity will not be considered. Centripetal acceleration $a = v2 / r = \omega 2r$ The derivation of the centripetal acceleration formula will not be examined. Centripetal force $F = mv2 / r = m\omega 2r$ Analysis of characteristics of simple harmonic motion (SHM). Condition for SHM: $a \propto - x$ Defining equation: $a = - \omega 2x$ Graphical representations linking the variations of x, v and a with time (including sketching these).
Sum 2	AQA Fields AQA Further Mech + Therm		

		Newton's Law of Gravitation (Where G is the gravitational constant). Representation of a gravitational field by gravitational field lines. 'g' as force per unit mass as defined by $g = F/m$ Magnitude of g in a radial field given by $g = GM/ r2$ Understanding of definition of gravitational potential, including zero value at infinity. Understanding of gravitational potential difference. Work done in moving mass m given by $\Delta W = m\Delta V$ Idea that no work is done when moving along an equipotential surface. V in a radial field given by $V = - GM/r$ (Considering the significance of the negative sign) Graphical representations of variations of g and V with r. V related to g by: $g = - \Delta V/ \Delta r$ ΔV from the area under the graph of g against r. Orbital period and speed related to radius of circular orbit; Derivation of $T2 \propto r3$ Energy considerations (including total energy) for an orbiting satellite. Escape velocity and synchronous orbits. Use of satellites in low orbits and geostationary orbits, to include plane and radius of geostationary orbit.	Appreciation that the v − t graph is derived from the gradient of the x − t graph and that the a − t graph is derived from the gradient of the v − t graph. Maximum speed = ωA Maximum acceleration = $\omega 2A$ Study of mass-spring systems: $T = 2\pi \sqrt{(m/k)}$ Study of simple pendulums: $T = 2\pi \sqrt{(l/g)}$ You should recognise the use of the small angle approximation ($\theta = \sin \theta$) in the derivation of the time period for these examples of SHM. Questions may involve other harmonic oscillators (e.g. liquid in U-tube) but full information will be provided in questions where necessary. Variation of Ek, Ep and total energy with both displacement and time. Effects of damping on oscillations. Qualitative treatment of free and forced vibrations. Resonance and the effects of damping on the sharpness of resonance. Examples of these effects in mechanical systems and situations involving stationary waves.

Year 13 PHYSICS Curriculum Map

Note: KS5 (Yr12-13) Topics often span half terms and can be up to 20+ lessons long, normally 2 topics are taught concurrently, for simplicity the main topics each term has been identified but may start the term before and or spill over into the following term.

Term	Topic/Unit title	Essential knowledge (what students should know and understand by the end of the unit/topic)	
Aut 1	AQA Fields AQA Further Mech + Therm	Recap of 7.1 Fields (A-level only) and 7.2 Gravitational fields (A-level only) during the first 4-6 weeks.	Recap of 6.1 Periodic Motion (A-level only) during the first 4-6 weeks.
Aut 2	AQA Particles & Quantum AQA Electricity	7.3 Electric fields (A-level only) Coulomb's Law of electrostatic Force Permittivity of free space, $\varepsilon 0$ Appreciation that air can be treated as a vacuum when calculating force between charges. For a charged sphere, charge may be considered to be at the centre. Comparison of magnitude of gravitational and electrostatic forces between subatomic particles. Representation of electric fields by electric field lines. Electric field strength, E, as force per unit charge defined by $E = F/Q$ Magnitude of E in a uniform field given by $E = V/d$ Derivation from work done moving charge between plates: $Fd = Q\Delta V$ Trajectory of moving charged particle entering a uniform electric field initially at right angles. Magnitude of E in a radial field & corresponding formula.	6.2 Thermal Physics (A-level only) Internal energy is the sum of the randomly distributed kinetic energies and potential energies of the particles in a body. The internal energy of a system is increased when energy is transferred to it by heating or when work is done on it (and vice versa), e.g. a qualitative treatment of the first law of thermodynamics. Appreciation that during a change of state the potential energies of the particle ensemble are changing but not the kinetic energies. Calculations involving transfer of energy. For a change of temperature: $Q = mc\,\Delta\,\theta$ where c is specific heat capacity. Calculations including continuous flow. For a change of state $Q = ml$ where l is the specific latent heat. Gas laws as experimental relationships between p, V, T and the mass of the gas. Concept of absolute zero of temperature.

		Understanding of definition of absolute electric potential, including zero value at infinity, and of electric potential difference. Work done in moving charge Q given by ΔW = QΔ V No work done moving charge along an equipotential surface. Magnitude of V in a radial field and corresponding formula. Graphical representations of variations of E and V with r. V related to E by E = Δ V/ Δ r ΔV from the area under the graph of E against r. 7.4 Capacitance (A-level only) Definition of capacitance: C = Q/V Dielectric action in a capacitor: Relative permittivity and dielectric constant. You should be able to describe the action of a simple polar molecule that rotates in the presence of an electric field. Interpretation of the area under a graph of charge against pd. E = ½ QV = ½ CV2 = ½ Q2/C Graphical representation of charging and discharging of capacitors through resistors. Corresponding graphs for Q, V and I against time for charging and discharging. Interpretation of gradients and areas under graphs where appropriate. Time constant RC. Calculation of time constants including their determination from graphical data.	Ideal gas equation: pV = nRT for n moles and pV = NkT for N molecules. Work done = pΔV Avogadro constant NA, molar gas constant R, Boltzmann constant k Molar mass and molecular mass. Brownian motion as evidence for the existence of atoms. Explanation of relationships between p, V and T in terms of a simple molecular model. Students should understand that the gas laws are empirical in nature whereas the kinetic theory model arises from theory. Assumptions leading to pV = ⅓Nm (crms)2 including derivation of the equation and calculations. A simple algebraic approach involving conservation of momentum is required. Appreciation that for an ideal gas internal energy is kinetic energy of the atoms. Use of average molecular kinetic energy = ½ m (crms)2 = 3/2 kT = 3RT / 2NA Appreciation of how knowledge and understanding of the behaviour of a gas has changed over time.

Time to halve: $T_{½} = 0.69RC$

Quantitative treatment of capacitor discharge $Q = Q_0 e^{-t/RC}$

Use of the corresponding equations for V and I.

Quantitative treatment of capacitor charge:

$Q = Q_0 (1 - e^{-t/RC})$

7.5 Magnetic fields (A-level only)

Force on a current-carrying wire in a magnetic field: $F = BIL$ when field is perpendicular to current.

Fleming’s left hand rule.

Magnetic flux density B and definition of the tesla.

Force on charged particles moving in a magnetic field, $F = BQv$ when the field is perpendicular to velocity.

Direction of force on positive and negative charged particles

Circular path of particles; application in devices such as the cyclotron.

Magnetic flux defined by $\Phi = BA$ where B is normal to A.

Flux linkage as $N\Phi$ where N is the number of turns cutting the flux.

Flux and flux linkage passing through a rectangular coil rotated in a magnetic field:

Flux linkage $N\Phi = BAN\cos\theta$

Faraday’s and Lenz’s laws.

Magnitude of induced emf = rate of change of flux linkage $\varepsilon = N \Delta\Phi/\Delta t$

		Applications such as a straight conductor moving in a magnetic field. emf induced in a coil rotating uniformly in a magnetic field: $\varepsilon = BAN\omega \sin \omega t$ Sinusoidal voltages and currents only; root mean square, peak and peak-to- peak values for sinusoidal waveforms only. Application to the calculation of mains electricity peak and peak-to-peak voltage values. Use of an oscilloscope as a dc and ac voltmeter, to measure time intervals and frequencies, and to display ac waveforms. No details of the structure of the oscilloscope are required but familiarity with the operation of the controls is expected. The transformer equation: $N_s/N_p = V_s/V_p$ Transformer efficiency = I_SV_S/I_PV_P Production of eddy currents and causes of inefficiencies in a transformer. Transmission of electrical power at high voltage including calculations of power loss in transmission lines.	
Core **Spr 1 & Spr2**	AQA Nuclear	8.1 Radioactivity 8.1.1 Rutherford Scattering Qualitative study of Rutherford scattering. Appreciation of how knowledge and understanding of the structure of the nucleus has changed over time. 8.1.2 α, β and γ Radiation Their properties and experimental identification using simple absorption experiments; applications e.g. to relative hazards of exposure to humans.	

Applications also include thickness measurements of aluminium foil paper and steel.

Inverse-square law for γ radiation: $I = k / x^2$

Experimental verification of inverse-square law.

Applications e.g. to safe handling of radioactive sources.

Background radiation; examples of its origins and experimental elimination from calculations.

Appreciation of balance between risk and benefits in the uses of radiation in medicine.

8.1.3 Radioactive Decay

Random nature of radioactive decay; constant decay probability of a given nucleus: $\Delta N / \Delta t = -\lambda N$

Use of halflife: $N = N_0 e^{-\lambda t}$

Use of activity: $A = \lambda N$

Modelling with constant decay probability.

Questions may be set which require students to use: $A = A_0 e^{-\lambda t}$

Questions may also involve use of molar mass or the Avogadro constant.

Half-life equation: $T_{½} = \ln 2 / \lambda$

Determination of half-life from graphical decay data including decay curves and log graphs.

Applications e.g. relevance to storage of radioactive waste, radioactive dating etc.

8.1.4 Nuclear Instability

Graph of N against Z for stable nuclei.

Possible decay modes of unstable nuclei including α, β^+, β^- and electron capture.

Changes in N and Z caused by radioactive decay and representation in simple decay equations.

Questions may use nuclear energy level diagrams.

Existence of nuclear excited states; γ ray emission; application e.g. use of technetium-99m as a γ source in medical diagnosis.

8.1.5 Nuclear Radius

Estimate of radius from closest approach of alpha particles and determination of radius from electron diffraction.

Knowledge of typical values for nuclear radius.

Students will need to be familiar with the Coulomb equation for the closest approach estimate.

Dependence of radius on nucleon number: R = R0A1/3 derived from experimental data

Interpretation of equations as evidence for constant density of nuclear material.

Calculation of nuclear density.

Students should be familiar with the graph of intensity against angle for electron diffraction by a nucleus.

8.1.6 Mass and Energy

Appreciation that E = mc2 applies to all energy changes.

Simple calculations involving mass difference and binding energy.

Atomic mass unit, u.

Conversion of units; 1 u = 931.5 MeV.

Fission and fusion processes.

Simple calculations from nuclear masses of energy released in fission and fusion reactions.

Graph of average binding energy per nucleon against nucleon number.

Students may be expected to identify, on the plot, the regions where nuclei will release energy when undergoing fission/fusion.

Appreciation that knowledge of the physics of nuclear energy allows society to use science to inform decision making.

		8.1.7 Induced Fission Fission induced by thermal neutrons; possibility of a chain reaction; critical mass. The functions of the moderator, control rods, and coolant in a thermal nuclear reactor. Details of particular reactors are not required. Students should have studied a simple mechanical model of moderation by elastic collisions. Factors affecting the choice of materials for the moderator, control rods and coolant. Examples of materials used for these functions. 8.1.8 Safety Aspects Fuel used, remote handling of fuel, shielding, emergency shut-down. Production, remote handling, and storage of radioactive waste materials. Appreciation of balance between risk and benefits in the development of nuclear power.
Option **Spr 1 & Spr2**	Option AQA Astrophysics	3.9 Astrophysics 3.9.1 Telescopes (A-level only) Ray diagram to show the image formation in normal adjustment. Angular magnification in normal adjustment. Focal lengths of the lenses. Cassegrain arrangement using a parabolic concave primary mirror and convex secondary mirror. Ray diagram to show path of rays through the telescope up to the eyepiece. Relative merits of reflectors and refractors including a qualitative treatment of spherical and chromatic aberration Similarities and differences of radio telescopes compared to optical telescopes. Discussion should include structure, positioning and use, together with comparisons of resolving and collecting powers. Minimum angular resolution of telescope. Rayleigh criterion,

		Collecting power is proportional to diameter 2. Students should be familiar with the rad as the unit of angle. Comparison of the eye and CCD as detectors in terms of quantum efficiency, resolution, and convenience of use. No knowledge of the structure of the CCD is required. 3.9.2 Classification of stars (A-level only) Apparent magnitude, m. The Hipparcos scale. Dimmest visible stars have a magnitude of 6. Relation between brightness and apparent magnitude. Difference of 1 on magnitude scale is equal to an intensity ratio of 2.51. Brightness is a subjective scale of measurement. Parsec and light year. Definition of M , relation to m Stefan's law and Wien's displacement law. General shape of black-body curves, use of Wien's displacement law to estimate black-body temperature of sources. Experimental verification is not required. Assumption that a star is a black body. Inverse square law, assumptions in its application. Use of Stefan's law to compare the power output, temperature and size of stars Description of the main classes of stars Temperature related to absorption spectra limited to Hydrogen Balmer absorption lines: requirement for atoms in an n = 2 state. General shape: main sequence, dwarfs and giants.

Axis scales range from –10 to +15 (absolute magnitude) and 50 000 K to 2 500 K (temperature) or OBAFGKM (spectral class).

Students should be familiar with the position of the Sun on the HR diagram.

Stellar evolution: path of a star similar to our Sun on the HR diagram from formation to white dwarf.

Defining properties: rapid increase in absolute magnitude of supernovae; composition and density of neutron stars; escape velocity > c for black holes.

Gamma ray bursts due to the collapse of supergiant stars to form neutron stars or black holes. Comparison of energy output with total energy output of the Sun.

Use of type 1a supernovae as standard candles to determine distances. Controversy concerning the accelerating Universe and dark energy.

Students should be familiar with the light curve of typical type 1a supernovae. Supermassive black holes at the centre of galaxies.

Calculation of the radius of the event horizon for a black hole, Schwarzschild radius

3.9.3 Cosmology (A-level only)

Calculation of Dopler

Calculations on binary stars viewed in the plane of orbit.

Galaxies and quasars.

Red shift v = Hd

Simple interpretation as expansion of universe; estimation of age of universe, assuming H is constant.

Qualitative treatment of Big Bang theory including evidence from cosmological microwave background radiation, and relative abundance of hydrogen and helium.

Quasars as the most distant measurable objects. Discovery of quasars as bright radio sources.

Quasars show large optical red shifts; estimation involving distance and power output. Formation of quasars from active supermassive black holes.

Difficulties in the direct detection of exoplanets.

		Detection techniques will be limited to variation in Doppler shift (radial velocity method) and the transit method. Typical light curve.
Option **Spr 1 & Spr2**	Option AQA Engineering	3.11 Engineering physics (A-level only) 3.11.1 Rotational dynamics (A-level only) I = mr2 for a point mass and calculations for an extended object. Qualitative knowledge of the factors that affect the moment of inertia of a rotating object. Expressions for moment of inertia will be given where necessary. Rotational kinetic energy Factors affecting the energy storage capacity of a flywheel. Use of flywheels in machines. Use of flywheels for smoothing torque and speed, and for storing energy in vehicles, and in machines used for production processes. Angular displacement, angular speed, angular velocity, angular acceleration, Representation by graphical methods of uniform and non-uniform angular acceleration. Equations for uniform angular acceleration (SUVAT) Torque and angular acceleration angular momentum Conservation of angular momentum. Angular impulse = change in angular momentum. Applications may include examples from sport. Work and Power Awareness that frictional torque has to be taken into account in rotating machinery. 3.11.2 Thermodynamics and engines (A-level only) Quantitative treatment of first law of thermodynamics, $Q = \Delta U + W$

		where Q is energy transferred to the system by heating, ΔU is increase in internal energy and W is work done by the system. Applications of the first law of thermodynamics. Isothermal, adiabatic, constant pressure and constant volume changes. $pV = nRT$ adiabatic change : pV^{γ} = constant isothermal change : pV = constant at constant pressure $W = p\Delta V$ Application of first law of thermodynamics to the above processes. Representation of processes on p–V diagram. Estimation of work done in terms of area below the graph. Extension to cyclic processes: work done per cycle = area of loop Expressions for work done are not required except for the constant pressure case, $W = p\Delta V$ Understanding of a four-stroke petrol engine cycle and a diesel engine cycle, and of the corresponding indicator diagrams. Comparison with the theoretical diagrams for these cycles; use of indicator diagrams for predicting and measuring power and efficiency input power Indicated power (as area of p–V loop × no. of cycles per second × no. of cylinders) Output or brake power, friction power = indicated power – brake power Engine efficiency; overall, thermal and mechanical efficiencies. A knowledge of engine constructional details is not required. Questions may be set on other cycles, but they will be interpretative and all essential information will be given. Impossibility of an engine working only by the First Law. Second Law of Thermodynamics expressed as the need for a heat engine to operate between a source and a sink. efficiency

		maximum theoretical efficiency Reasons for the lower efficiencies of practical engines. Maximising use of W and QH for example in combined heat and power schemes. Basic principles and uses of heat pumps and refrigerators. A knowledge of practical heat pumps or refrigerator cycles and devices is not required. Coefficients of performance refrigerator and heat pump