Science

To equip our young people with the knowledge needed to understand the world and technology around them. To encourage a curiosity in the natural, physical and chemical world around them. To foster critical thinking and a provide our young people with a chance to broaden their horizons and provide multiple routes into STEM careers.

Year 13 A-Level Physics

Term	**1**
Content of study (Title)	*Fields and their consequences, Gravitational Fields, Electric Fields, Nuclear physics*
What are the aims and objectives of this term?	3.7.1 Fields (A-level only) Concept of a force field as a region in which a body experiences a non-contact force. Students 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 and differences between gravitational and electrostatic forces: Similarities: Both have inverse-square force laws that have many characteristics in common, eg use of field lines, use of potential concept, equipotential surfaces etc Differences: masses always attract, but charges may attract or repel 3.7.2.1 Newton's law (A-level only) Gravity as a universal attractive force acting between all matter. Magnitude of force between point masses: $F = Gm1m2\ r\ 2$ where G is the gravitational constant. 3.7.2.2 Gravitational field strength (A-level only) Representation of a gravitational field by gravitational field lines. g as force per unit mass as defined by $g = Fm$ Magnitude of g in a radial field given by $g = GM\ r\ 2$ 3.7.2.3 Gravitational potential (A-level only) Understanding of definition of gravitational potential, including zero value at infinity. Understanding of gravitational potential difference. Work done in moving mass m given by $\Delta W = m\Delta V$ Equipotential surfaces. Idea that no work is done when moving along an equipotential surface. V in a radial field given by $V = -\ GM\ r$ 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 area under graph of g against r. 3.7.2.4 Orbits of planets and satellites (A-level only) Orbital period and speed related to radius of circular orbit; derivation of $T\ 2 \propto r\ 3$ Energy considerations for an orbiting satellite. Total energy of an orbiting satellite. Escape velocity. Synchronous orbits. Use of satellites in low orbits and geostationary orbits, to include plane and radius of geostationary orbit. 3.7.3.1 Coulomb's law (A-level only) Force between point charges in a vacuum: $F = 1\ 4\pi\varepsilon 0\ Q1Q2\ r\ 2$ 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. 3.7.3.2 Electric field strength (A-level only)

	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 = QΔV Trajectory of moving charged particle entering a uniform electric field initially at right angles. Magnitude of E in a radial field given by E = 1 4πε0 Q r 2 3.7.3.3 Electric potential (A-level only) 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 Δ W = QΔV Equipotential surfaces. No work done moving charge along an equipotential surface. Magnitude of V in a radial field given by V = 1 4πε0 Q r Graphical representations of variations of E and V with r. V related to E by E = ΔV Δ r ΔV from the area under graph of E against r 3.8.1.1 Rutherford scattering (A-level only) Qualitative study of Rutherford scattering. Appreciation of how knowledge and understanding of the structure of the nucleus has changed over time. 3.8.1.2 α, β and γ radiation (A-level only) Their properties and experimental identification using simple absorption experiments; applications eg 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 eg 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. Required practical 12: Investigation of the inverse square law for gamma radiation.
What previous knowledge is required?	GCSE waves, space and atomic structure topics
How will this term's content help with future learning?	*The unit being studied underpin the rest of the A level and mastery of this knowledge is required to move forward in the course with any level of success.*
Resources	Revision guides, Kerboodle on-line textbook - https://www.kerboodle.com AQA | Resources | Past Papers & AQA Mark Schemes Google NotebookLM | Note Taking & Research Assistant Powered by AI https://www.briskteaching.com YouTube Crash course Physics (15) Physics - YouTube *Motion along a straight line* *https://www.youtube.com/watch?v=ZM8ECpBuQYE&list=PL8dPuuaLjXtN0ge7yDk_UA0ldZJdhwkoV&index=2* *Vectors* *https://www.youtube.com/watch?v=w3BhzYI6zXU&list=PL8dPuuaLjXtN0ge7yDk_UA0ldZJdhwkoV&index=5*

Links to the national curriculum/specification	AS and A-level Physics Specification Specifications for first teaching in 2015
Assessments	*End of subunit tests in Fields and their consequences, Gravitational Fields, Electric Fields, Nuclear physics. These comprise of past paper questions on these topics and are graded A-U.*
Term	**2**
Content of study (Title)	Capacitance, radioactive decay
What are the aims and objectives of this term?	3.7.4.1 Capacitance (A-level only) Definition of capacitance: C = Q/V 3.7.4.2 Parallel plate capacitor (A-level only) Dielectric action in a capacitor C = Aε0εr d Relative permittivity and dielectric constant. Students should be able to describe the action of a simple polar molecule that rotates in the presence of an electric field. 3.7.4.3 Energy stored by a capacitor (A-level only) nterpretation of the area under a graph of charge against pd. E = 1 2QV = 1 2CV2 = 1 2 Q 2 C 3.7.4.4 Capacitor charge and discharge (A-level only) 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. Time to halve, T½ = 0.69RC Quantitative treatment of capacitor discharge, Q = Q0e − t RC Use of the corresponding equations for V and I. Quantitative treatment of capacitor charge, Q = Q0 1 − e − t RC) Required practical 9: Investigation of the charge and discharge of capacitors. Analysis techniques should include log-linear plotting leading to a determination of the time constant, RC 3.8.1.3 Radioactive decay (A-level only) Random nature of radioactive decay; constant decay probability of a given nucleus; Δ N Δ t = − λN N = N0e −λt Use of activity, A = λN Modelling with constant decay probability. Questions may be set which require students to use A = A0e −λt Questions may also involve use of molar mass or the Avogadro constant. Half-life equation: T½ = ln2 λ Determination of half-life from graphical decay data including decay curves and log graphs. Applications eg relevance to storage of radioactive waste, radioactive dating etc.
What previous knowledge is required?	GCSE electricity and atomic structure topics, AS matter topic
How will this term's content help with future learning?	*The unit being studied underpin the rest of the A level and mastery of this knowledge is required to move forward in the course with any level of success.*
Resources	Revision guides, Kerboodle on-line textbook - https://www.kerboodle.com AQA | Resources | Past Papers & AQA Mark Schemes

	Google NotebookLM | Note Taking & Research Assistant Powered by AI https://www.briskteaching.com YouTube Crash course Physics (15) Physics - YouTube *Motion along a straight line* *https://www.youtube.com/watch?v=ZM8ECpBuQYE&list=PL8dPuuaLjXtN0ge7yDk_UA0ldZJdhwkoV&index=2* *Vectors* *https://www.youtube.com/watch?v=w3BhzYI6zXU&list=PL8dPuuaLjXtN0ge7yDk_UA0ldZJdhwkoV&index=5*
Links to the national curriculum/specification	AS and A-level Physics Specification Specifications for first teaching in 2015
Assessments	*End of subunit tests in Capacitance and* radioactive decay. *These comprise of past paper questions on these topics and are graded A-U.*
Term	**3**
Content of study (Title)	Magnetic fields, nuclear instability, nuclear radius
What are the aims and objectives of this term?	3.7.5.1 Magnetic flux density (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. Required practical 10: Investigate how the force on a wire varies with flux density, current and length of wire using a top pan balance. 3.7.5.2 Moving charges in a magnetic field (A-level only) 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. 3.7.5.3 Magnetic flux and flux linkage (A-level only) Magnetic flux defined by Φ = BA where B is normal to A. Flux linkage as NΦ 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 NΦ = BANcosθ Required practical 11: Investigate, using a search coil and oscilloscope, the effect on magnetic flux linkage of varying the angle between a search coil and magnetic field direction. 3.7.5.4 Electromagnetic induction (A-level only) Simple experimental phenomena. Faraday's and Lenz's laws. Magnitude of induced emf = rate of change of flux linkage ε = N ΔΦ Δ t Applications such as a straight conductor moving in a magnetic field. emf induced in a coil rotating uniformly in a magnetic field: ε = BANωsin ωt 3.7.5.5 Alternating currents (A-level only) Sinusoidal voltages and currents only; root mean square, peak and peak-to-peak values for sinusoidal waveforms only. Irms = I0 2 ; Vrms = V0 2 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 instrument are required but familiarity with the operation of the controls is expected. 3.8.1.4 Nuclear instability (A-level only) 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 eg use of technetium-99m as a γ source in medical diagnosis. 3.8.1.5 Nuclear radius (A-level only) 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 = R0A 1/3 derived from experimental data. Interpretation of equation 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. 3.8.1.6 Mass and energy (A-level only) Appreciation that E = mc 2 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. 3.8.1.7 Induced fission (A-level only) 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. 3.8.1.8 Safety aspects (A-level only) 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.
What previous knowledge is required?	GCSE topics about magnetism, atomic structure and AS topic on matter.
How will this term's content help with future learning?	*The unit being studied underpin the rest of the A level and mastery of this knowledge is required to move forward in the course with any level of success.*
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Links to the national curriculum/specification	AS and A-level Physics Specification Specifications for first teaching in 2015
Assessments	*End of subunit tests in* Magnetic fields, nuclear instability, nuclear radius. *These comprise of past paper questions on these topics and are graded A-U.*
Term	**4**
Content of study (Title)	Transformers, Option C Engineering physics, Option D Turning Points in Physics
What are the aims and objectives of this term?	3.7.5.6 The operation of a transformer (A-level only) The transformer equation: Ns Np = Vs Vp Transformer efficiency = ISVS IPVP Production of eddy currents. Causes of inefficiencies in a transformer. Transmission of electrical power at high voltage including calculations of power loss in transmission lines. 3.11.1.1 Concept of moment of inertia (A-level only) I = mr 2 for a point mass. I = Σmr 2 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 3.11.1.2 Rotational kinetic energy (A-level only) Ek = 1 2 Iω 2 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. 3.11.1.3 Rotational motion (A-level only) Angular displacement, angular speed, angular velocity, angular acceleration, ω = Δ θ Δ t , α = Δω Δ t Representation by graphical methods of uniform and non-uniform angular acceleration. Equations for uniform angular acceleration; ω2 = ω1 + αt, θ = ω1 + ω2 2 t θ = ω1 t + αt 2 2 , ω2 2 = ω1 2 + 2αθ Students should be aware of the analogy between rotational and translational dynamics. 3.11.1.4 Torque and angular acceleration (A-level only) T = Fr T = Iα 3.11.1.5 Angular momentum (A-level only) angular momentum = Iω Conservation of angular momentum. Angular impulse = change in angular momentum; T Δ t = Δ Iω where T is constant. Applications may include examples from sport. 3.11.1.6 Work and power (A-level only) W = Tθ; P = Tω Awareness that frictional torque has to be taken into account in rotating machinery.

	3.11.2.1 First law of thermodynamics (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 first law of thermodynamics. 3.11.2.2 Non-flow processes (A-level only) Isothermal, adiabatic, constant pressure and constant volume changes. $pV = nRT$ adiabatic change : $pV\gamma$ = constant isothermal change: pV = constant at constant pressure $W = p\Delta V$ Application of first law of thermodynamics to the above processes. 3.11.2.3 The p–V diagram (A-level only) 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, $W = p\Delta V$ 3.11.2.4 Engine cycles (A-level only) 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 = calorific value × fuel flow rate Indicated power as area of p−V loop × no. of cycles per second × no. of cylinders Output or brake power, $P = T\omega$ friction power = indicated power – brake power Engine efficiency; overall, thermal and mechanical efficiencies. Overall efficiency = brake power input power Thermal efficiency = indicated power input power Mechanical efficiency = brake power indicated power 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. 3.11.2.5 Second Law and engines (A-level only) mpossibility 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 = W QH = QH − QC QH maximum theoretical efficiency = TH − TC TH Reasons for the lower efficiencies of practical engines. Maximising use of W and QH for example in combined heat and power schemes. 3.11.2.6 Reversed heat engines (A-level only) 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: COPref = QC W = QC QH − QC = TC TH − TC heat pump: COPhp = QH W = QH QH − QC = TH TH – TC 3.12.1.1 Cathode rays (A-level only) Production of cathode rays in a discharge tube 3.12.1.2 Thermionic emission of electrons (A-level only) The principle of thermionic emission. Work done on an electron accelerated through a pd V ; 1 2mv 2 = eV 3.12.1.3 Specific charge of the electron (A-level only) Determination of the specific charge of an electron, eme , by any one method. Significance of Thomson's determination of eme Comparison with the specific charge of the hydrogen ion.

3.12.1.4 Principle of Millikan's determination of the electronic charge, e (A-level only)
Condition for holding a charged oil droplet, of charge Q, stationary between oppositely charged parallel plates. QV d = mg Motion of a falling oil droplet with and without an electric field; terminal speed to determine the mass and the charge of the droplet. Stokes' Law for the viscous force on an oil droplet used to calculate the droplet radius. F = 6πηrv Significance of Millikan's results. Quantisation of electric charge.

3.12.2.1 Newton's corpuscular theory of light (A-level only)
Comparison with Huygens' wave theory in general terms. The reasons why Newton's theory was preferred.

3.12.2.2 Significance of Young's double slits experiment (A-level only)
Explanation for fringes in general terms, no calculations are expected. Delayed acceptance of Huygens' wave theory of light.

3.12.2.3 Electromagnetic waves (A-level only)
Nature of electromagnetic waves. Maxwell's formula for the speed of electromagnetic waves in a vacuum c = 1 μ0ε0 where μ0 is the permeability of free space and ε0 is the permittivity of free space. Students should appreciate that ε0 relates to the electric field strength due to a charged object in free space and μ0 relates to the magnetic flux density due to a current-carrying wire in free space. Hertz's discovery of radio waves including measurements of the speed of radio waves. Fizeau's determination of the speed of light and its implications.

3.12.2.4 The discovery of photoelectricity (A-level only)
The ultraviolet catastrophe and black-body radiation. Planck's interpretation in terms of quanta. The failure of classical wave theory to explain observations on photoelectricity. Einstein's explanation of photoelectricity and its significance in terms of the nature of electromagnetic radiation.

3.12.2.5 Wave–particle duality (A-level only)
de Broglie's hypothesis: p = h λ ; λ = h 2meV Low-energy electron diffraction experiments; qualitative explanation of the effect of a change of electron speed on the diffraction pattern.

3.12.2.6 Electron microscopes (A-level only)
Estimate of anode voltage needed to produce wavelengths of the order of the size of the atom. Principle of operation of the transmission electron microscope (TEM). Principle of operation of the scanning tunnelling microscope (STM).

3.12.3.1 The Michelson-Morley experiment (A-level only)
Principle of the Michelson-Morley interferometer. Outline of the experiment as a means of detecting absolute motion. Significance of the failure to detect absolute motion. The invariance of the speed of light.

3.12.3.2 Einstein's theory of special relativity (A-level only)
The concept of an inertial frame of reference. The two postulates of Einstein's theory of special relativity: 1. physical laws have the same form in all inertial frames 2. the speed of light in free space is invariant.

	3.12.3.3 Time dilation (A-level only) Proper time and time dilation as a consequence of special relativity. Time dilation: t = t0 1 − v 2 c 2 Evidence for time dilation from muon decay. 3.12.3.4 Length contraction (A-level only) Length of an object having a speed v l = l0 1 − v 2 c 2 3.12.3.5 Mass and energy (A-level only) Equivalence of mass and energy, E = mc 2 ; E = m0c 2 1 − v 2 c 2 Graphs of variation of mass and kinetic energy with speed. Bertozzi's experiment as direct evidence for the variation of kinetic energy with speed.
What previous knowledge is required?	GCSE topics on electricity, AS topics about forces, motion, and development of formula for nuclear physics.
How will this term's content help with future learning?	*The unit being studied underpin the rest of the A level and mastery of this knowledge is required to move forward in the course with any level of success.*
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