(Science/KS5 Physics) Long-Term Plan

Ousedale School
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Long-term planning (LTPs) - Planning how the key concepts, knowledge, skills identified in the Progression map will be delivered termly per year group
Ensuring that end points & NC/spec are covered
Identifying what assessments are planned and when
Ensuring whole school intent priorities to be planned for

(Year 12 Physics)						
	Autumn 1	**Autumn 2**	**Spring 1**	**Spring 2**	**Summer 1**	**Summer 2**
Unit title:	Practical Skills Physics Skills 1 – Atomic Model 7 – Vectors 8 – Motion in a straight line	2 - Particle Model 3 – Energy levels 9 – Newton's Laws 10 - Energy	4 – photoelectric effect 5 – wave properties 11 – Momentum 13 - Electricity	6 – Combining Waves 14 – Electronics	13 – Astronomy Options 12 – Materials 1 – Circular Motion	2 – Simple Harmonic Motion
Unit length:	Practical Skills – 10 lessons Physics Skills – 6 lessons Atomic Model – 6 lessons Vectors – 4 lessons Motion in a straight line – 6 lessons	Particle Model – 6 lessons Energy levels – 4 lessons Newton's Laws - 4 lessons Energy – 4 lessons	Photoelectric effect – 5 lessons Wave properties – 9 lessons Momentum - 7 lessons Electricity – 9 lessons	Combining Waves – 9 lessons Electronics – 9 lessons	Astronomy - 16 lessons Materials – 7 lessons Circular Motion – 3 lessons	Simple Harmonic Motion - 6 lessons
Key concepts:	Practical Skills – Giving students hands on practical experience and knowledge of the practical criteria used in practical skills assessment Physics Skills – Learning the key skills to function well in A-level physics, Maths skills and data handling	Particle Model – The standard model of particle physics, conservation laws, Feynman diagrams and fundamental forces Energy levels – photon energys, excitation, ionization and spectra Newton's Laws - Newtons laws	Photoelectric effect – concept and calculations of the photoelectric effect Wave properties – basic properties of waves and how these can be used in calculation Momentum – conservation of momentum, inelastic and elastic collisions	Combining Waves – superposition and wave interference, youngs double slits and standing waves required practicals. Electronics – using control circuits, internal resistance and EMF	Astronomy – key aspects of how a telescope works, the life cycle of stars and the fate of the universe Materials – properties of materials, youngs modulus and hookes law. Circular motion – basics of circular motion and	Simple harmonic motion – Harmonic oscillators, damping and resonance

	Atomic Model – structure of the atom, particle decay and antiparticles. Vectors – scalars and vectors, vector addition, vector resolution and moments Motion in a straight line – Displacement and velocity time graphs, SUVAT equations, acceleration due to gravity required practical	Energy – Work, energy and efficiency, energy conservation	in one and two dimensions Electricity – Curent, Voltage and resistance.		centripetal force and accelerations	
Knowledge/ Skills:	As in specification below	As in specification below	As in specification below	As in specification below	As in specification below	As in specification below
End points covered:	As in specification below	As in specification below	As in specification below	As in specification below	As in specification below	As in specification below
NC/Spec coverage:	Skills Intro 3.1.1 Use of SI units and their prefixes Content Opportunities for skills development Fundamental (base) units. Use of mass, length, time, amount of substance, temperature, electric current and their associated SI units. SI units derived.	Particle Model 3.2.1.3 Particles, antiparticles and photons Content Opportunities for skills development For every type of particle, there is a corresponding antiparticle. Comparison of particle and antiparticle masses,	Photoelectric effect 3.2.2.1 The photoelectric effect Content Opportunities for skills development Threshold frequency; photon explanation of threshold frequency. Work function ?, stopping potential. Photoelectric equation: h f = ? + Ek (max Ek (max is the	Combining waves 3.3.1.3 Principle of superposition of waves and formation of stationary waves Content Opportunities for skills development Stationary waves. Nodes and antinodes on strings. f = 1 2l T ? for first harmonic. The formation of stationary waves by	Materials 3.4.2.1 Bulk properties of solids Content Opportunities for skills development 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 =	SHM 3.6.1.2 Simple harmonic motion (SHM) (A-level only) Content Opportunities for skills development Analysis of characteristics of simple harmonic motion (SHM). Condition for SHM: a ∝ − x Defining equation: a = − ?2 x x

	Knowledge and use of the SI prefixes, values and standard form. The fundamental unit of light intensity, the candela, is excluded. Students are not expected to recall definitions of the fundamental quantities. Dimensional analysis is not required. Students should be able to use the prefixes: T, G, M, k, c, m, μ, n, p, f, Students should be able to convert between different units of the same quantity, eg J and eV, J and kW h. 3.1.2 Limitation of physical measurements Content Opportunities for skills development Random and systematic errors. Precision, repeatability, reproducibility, resolution and accuracy. Uncertainty: Absolute, fractional and percentage	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 = h f = hc Knowledge of annihilation and pair production and the energies involved. The use of E = mc 2 is not required in calculations. AT i Detection of gamma radiation. MS 1.1, 2.2 Students could determine the frequency and wavelength of the two gamma photons produced when a ‘slow’ electron and a ‘slow’ positron annihilate each other. The PET scanner could be used as an application of annihilation. 3.2.1.4	maximum kinetic energy of the photoelectrons. The experimental determination of stopping potential is not required. PS 3.2 / MS 2.3 Demonstration of the photoelectric effect using a photocell or an electroscope with a zinc plate attachment and UV lamp Wave properties 3.3.1.1 Progressive waves Content Opportunities for skills development 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. PS 2.3 / MS 0.1, 4.7 / AT a, b Laboratory experiment to determine the speed	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. MS 4.7 / PS 1.2, 2.1 / AT i Students can investigate the factors that determine the frequency of stationary wave patterns of a stretched string. Required practical 1: Investigation into the variation of the frequency of stationary waves on a string with length, tension and mass per unit length of the	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. MS 0.2, 4.3 / PS 3.3, 4.1 Students can compare the use of analogue and digital meters. MS 0.4, 4.3 / AT e Estimate the volume of an object leading to an estimate of its density. 3.4.2.2 The Young modulus Content Opportunities for skills development	= Acos t and v = ± A2 − x 2 Graphical representations linking the variations of x, v and a with time. 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 = A Maximum acceleration = 2 A AT i, k Data loggers can be used to produce s − t, v − t and a − t graphs for SHM. MS 3.6, 3.8, 3.9, 3.12 Sketch relationships between x, v, a and a − t for simple harmonic oscillators. 31 AS Physics (7407) and A-level Physics (7408). AS exams May/June 2016 onwards. A-level exams May/June 2017 onwards. Version 1.2 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration

	uncertainties represent uncertainty in the final answer for a quantity. Combination of 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. Individual points on the graph may or may not have associated error bars. PS 2.3 Students should be able to identify random and systematic errors and suggest ways to reduce or remove them. PS 3.3 Students should understand the link between the number of significant figures in the value of a quantity and its associated uncertainty. MS 1.5 Students should be able to combine uncertainties in cases where the	Particle interactions Content Opportunities for skills development 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. The weak interaction 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. PS 1.2 Momentum	of sound in free air using direct timing or standing waves with a graphical analysis. 3.3.1.2 Longitudinal and transverse waves Content Opportunities for skills development 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 law will not be expected. PS 2.2, 2.4 / MS 1.2,	string. 19 AS Physics (7407) and A-level Physics (7408). AS exams May/June 2016 onwards. A-level exams May/June 2017 onwards. Version 1.2 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.3.2 Refraction, diffraction and interference 3.3.2.1 Interference Content Opportunities for skills development 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	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.) MS 3.1 Required practical 4: Determination of the Young modulus by a simple method. 3.6.1.1 Circular motion (A-level only) Content Opportunities for skills development Motion in a circular path at constant speed implies there is an acceleration and requires a centripetal force. Magnitude of angular speed = v r = 2 f Radian measure of angle. Direction of angular velocity will not be considered. Centripetal acceleration a = v 2 r = 2 r The derivation of the centripetal acceleration formula will not be examined. Centripetal force F = mv2 r = m2 r MS 0.4	3.6.1.3 Simple harmonic systems (A-level only) Content Opportunities for skills development Study of mass-spring system: T = 2 m k Study of simple pendulum: T = 2 l g Questions may involve other harmonic oscillators (eg 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. MS 4.6 / AT b, c Students should recognise the use of the small-angle approximation in the derivation of the time period for examples of approximate SHM. Required practical 7: Investigation into simple harmonic motion using a mass–spring system and a simple pendulum.

	measurements that give rise to the uncertainties are added, subtracted, multiplied, divided, or raised to powers. Combinations involving trigonometric or logarithmic functions will not be required. 3.1.3 Estimation of physical quantities Content Opportunities for skills development Orders of magnitude. Estimation of approximate values of physical quantities. MS 1.4 Students should be able to estimate approximate values of physical quantities to the nearest order of magnitude. Students should be able to use these estimates together with their knowledge of physics to produce further derived estimates also to the nearest order of magnitude. Atomic Model	transfer of a heavy ball thrown from one person to another. 14 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.2.1.5 Classification of particles Content Opportunities for skills development 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	3.2, 3.4, 3.5 / AT i Students can investigate the factors that determine the speed of a water wave. Momentum 3.4.1.6 Momentum Content Opportunities for skills development 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 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;	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. AT i Investigation of two-source interference with sound, light and microwave radiation. Required practical 2: Investigation of interference effects to include the Young's slit experiment and interference by a diffraction grating. 3.3.2.2 Diffraction Content Opportunities for skills development Appearance of the diffraction pattern from a single slit using monochromatic and	Estimate the acceleration and centripetal force in situations that involve rotation. Astronomy 3.9.1.1 Astronomical telescope consisting of two converging lenses (A-level only) Content Ray diagram to show the image formation in normal adjustment. Angular magnification in normal adjustment. M = angle subtended by image at eye angle subtended by object at unaided eye Focal lengths of the lenses. M = f o f e 3.9.1.2 Reflecting telescopes (A-level only) Content 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	3.6.1.4 Forced vibrations and resonance (A-level only) Content Opportunities for skills development 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. AT g, i, k Investigation of the factors that determine the resonant frequency of a driven system

	3.2.1.1 Constituents of the atom Content Opportunities for skills development 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 the ZX A notation. Meaning of isotopes and the use of isotopic data. 3.2.1.2 Stable and unstable nuclei Content Opportunities for skills development The strong nuclear force; its role in keeping the nucleus stable; short-range attraction up to	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 (eg kaons). 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. AT k Use of computer	explosions. Appreciation of momentum conservation issues in the context of ethical transport design. Energy 3.4.1.7 Work, energy and power Content Opportunities for skills development 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. MS 0.3 / PS 3.3, 4.1 / AT a, b, f. Investigate the efficiency of an electric motor being used to raise a mass through a measured height. Students should be able to identify random 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. 20 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.3.2.3 Refraction at a plane surface Content Opportunities for skills development 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 =	refractors including a qualitative treatment of spherical and chromatic aberration. 3.9.1.3 Single dish radio telescopes, I-R, U-V and X-ray telescopes (A-level only) Content 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. 3.9.1.4 Advantages of large diameter telescopes (A-level only) Content Minimum angular resolution of telescope. Rayleigh criterion, D 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	

	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. The existence of the neutrino was hypothesised to account for conservation of energy in beta decay. AT i Demonstration of the range of alpha particles using a cloud chamber, spark counter or Geiger counter. MS 0.2 Use of prefixes for small and large distance measurements Vectors 3.4.1 Force, energy and momentum 3.4.1.1 Scalars and vectors Content Opportunities for skills development Nature of scalars and vectors. Examples should include:	simulations of particle collisions. ATl Cosmic ray showers as a source of high energy particles including pions and kaons; observation of stray tracks in a cloud chamber; use of two Geiger counters to detect a cosmic ray shower. 15 AS Physics (7407) and A-level Physics (7408). AS exams May/June 2016 onwards. A-level exams May/June 2017 onwards. Version 1.2 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.2.1.6 Quarks and antiquarks Content Opportunities for skills development Properties of quarks and antiquarks: charge, baryon number and strangeness. Combinations of quarks and antiquarks required for baryons (proton and neutron only), antibaryons	systematic errors in the experiment and suggest ways to remove them. 3.4.1.8 Conservation of energy Content Opportunities for skills development Principle of conservation of energy. ΔEp = mgΔh and Ek = 1 2mv 2 Quantitative and qualitative application of energy conservation to examples involving gravitational potential energy, kinetic energy, and work done against resistive forces. MS 0.4, 2.2 Estimate the energy that can be derived from food consumption. Electricity 3.5.1.1 Basics of electricity Content Opportunities for skills development Electric current as the rate of flow of charge; potential difference as work done per unit charge. I = Δ Q Δ t , V	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. MS 0.6, 4.1 Electronics 3.5.1.5 Potential divider Content Opportunities for skills development 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	efficiency, resolution, and convenience of use. No knowledge of the structure of the CCD is required. 46 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.9.2 Classification of stars (A-level only) 3.9.2.1 Classification by luminosity (A-level only) Content 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. 3.9.2.2 Absolute magnitude, M (A-level only) Content Parsec and light year. Definition of M, relation to m: m – M = 5 log d 10 3.9.2.3 Classification	

	velocity/speed, mass, force/weight, acceleration, displacement/distanc e. 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 meaning of equilibrium in the context of an object at rest or moving with constant velocity. MS 0.6, 4.2, 4.4, 4.5 / PS 1.1 Investigation of	(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. 3.2.1.7 Applications of conservation laws Content Opportunities for skills development Change of quark character in β− and in β+ 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 Energy levels	= W Q Resistance defined as R = V I AT b, f Students can construct circuits from the range of components. 3.5.1.2 Current–voltage characteristics Content Opportunities for skills development 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. 28 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.5.1.3 Resistivity	(LDR) in the potential divider. MS 3.2 / PS 4.1 / AT f Students can investigate the behaviour of a potential divider circuit. MS 3.2 / AT g Students should design and construct potential divider circuits to achieve various outcomes. 3.5.1.6 Electromotive force and internal resistance Content Opportunities for skills development ⍰ = E Q , ⍰ = I R + r 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. Required practical 6: Investigation of the emf and internal resistance of electric cells and batteries by measuring the variation of the terminal pd of the cell with current in it. MS 3.1, 3.3 / PS 2.2, 3.1 / AT f	by temperature, black-body radiation (A-level only) Content 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. ⍰maxT = constant = 2.9 × 10−3 m K 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 P = ⍰AT4 47 AS Physics (7407) and A-level Physics (7408). AS exams May/June 2016 onwards. A-level exams May/June 2017 onwards. Version 1.2 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.9.2.4 Principles of	

	the conditions for equilibrium for three coplanar forces acting at a point using a force board. 22 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.4.1.2 Moments Content Opportunities for skills development 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.	3.2.2.2 Collisions of electrons with atoms Content Opportunities for skills development 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. 3.2.2.3 Energy levels and photon emission Content Opportunities for skills development 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. AT j / MS 0.1, 0.2 Observation of line spectra using a diffraction grating. 3.2.2.4 Wave-particle duality Content Opportunities for skills development Students should know that electron	Content Opportunities for skills development 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 transmission of electric power. Critical field will not be assessed. MS 3.2, 4.3 / PS 1.2 / AT a, b, f, g		the use of stellar spectral classes (A-level only) Description of the main classes: Spectral class Intrinsic colour Temperature / K Prominent absorption lines O blue 25 000 – 50 000 He+, He, H B blue 11 000 – 25 000 He, H A blue-white 7 500 – 11 000 H (strongest) ionized metals F white 6 000 – 7 500 ionized metals G yellow-white 5 000 – 6 000 ionized & neutral metals K orange 3 500 – 5 000 neutral metals M red < 3 500 neutral atoms, TiO Temperature related to absorption spectra limited to Hydrogen Balmer absorption lines: requirement for atoms in an n = 2 state. 3.9.2.5 The Hertzsprung-Russell (HR) diagram (A-level only) Content General shape: main sequence, dwarfs and giants. Axis scales range from –10 to +15 (absolute magnitude)	

	Motion in a straight line 3.4.1.3 Motion along a straight line Content Opportunities for skills development 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 + at2 2 v 2 = u 2 + 2as Acceleration due to gravity, g. MS 3.6, 3.7 / PS 1.1, 3.1	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. Appreciation that such changes need to be evaluated through peer review and validated by the scientific community. PS 1.2 Demonstration using an electron diffraction tube. MS 1.1, 2.3 Use prefixes	Investigation of the variation of resistance of a thermistor with temperature. Required practical 5: Determination of resistivity of a wire using a micrometer, ammeter and voltmeter. 3.5.1.4 Circuits Content Opportunities for skills development 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 = I 2 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.		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. 3.9.2.6 Supernovae, neutron stars and black holes (A-level only) Content 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	

	Distinguish between instantaneous velocity and average velocity. MS 3.5, 3.6 Measurements and calculations from displacement–time, velocity–time and acceleration–time graphs. MS 0.5, 2.2, 2.3, 2.4 Calculations involving motion in a straight line. Required practical 3: Determination of g by a freefall method. MS 0.3, 1.2, 3.7 / AT d Students should be able to identify random and systematic errors in the experiment and suggest ways to remove them. MS 3.9 Determine g from a graph. 24 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.4.1.4 Projectile motion Content Opportunities for skills development Independent effect of motion in horizontal	when expressing wavelength values Newtons Laws 3.4.1.5 Newton’s laws of motion Content Opportunities for skills development Knowledge and application of the three laws of motion in appropriate situations. F = ma for situations where the mass is constant. PS 4.1 / MS 0.5, 3.2 / AT a, b, d Students can verify Newton’s second law of motion. MS 4.1, 4.2 Students can use free-body diagrams.			concerning 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 Rs , Rs ≈ 2GM c 2 48 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.9.3 Cosmology (A-level only) 3.9.3.1 Doppler effect (A-level only) Content Δ f f = v c and z = Δ ⍰ ⍰ = − v c for v ≪ c applied to optical and radio frequencies. Calculations on binary stars viewed in the plane of orbit. Galaxies and quasars. 3.9.3.2 Hubble's law (A-level only) Content Red shift v = Hd Simple interpretation as expansion of	

	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. PS 2.2, 3.1 Investigation of the factors that determine the motion of an object through a fluid				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. 3.9.3.3 Quasars (A-level only) Content 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. 3.9.3.4 Detection of exoplanets (A-level only) Content 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.	
Cross-curricular links:						
Assessments:						
New experiences – broadening horizons						
Developing character – *Kind, Hard Working, Successful*						
Context specific need – diversity, inclusion; reading, literacy; mental health						
Curriculum Careers - Gatsby 4						

(Year 13 Physics)						
	Autumn 1	**Autumn 2**	**Spring 1**	**Spring 2**	**Summer 1**	**Summer 2**
Unit title:	4 – Thermal Physics 3 – Gravitational Fields 5 – Electric Fields	7 – Magnetic Fields 8 – Magnetic Flux 9 – Alternating currents 6 – capacitors	10 – nuclear physics 11 – radioactive decay 12 – Uses of nuclear energy	13 - Astronomy	Revision	N/A
Unit length:	Thermal Physics– 12 lessons Gravitational Fields– 6 lessons Electric Fields – 4 lessons	Magnetic Fields – 10 lessons Magnetic Flux– 6 lessons Alternating currents– 4 lessons Capacitors - 6 lessons	Nuclear physics – 6 lessons Radioactive decay – 4 lessons Uses of nuclear energy – 4 lessons	Astronomy – 20 lessons	N/A	N/A
Key concepts:	Thermal Physics– Gas laws, specific heat capacity and specific latent heat. Gravitational Fields– Gravitational Attraction and fields Electric Fields – attraction between electric charges and the fields they produce	Magnetic Fields – attraction between magnetic poles and the fields where they create Magnetic Flux– action of magnetic fields on devices Alternating currents– effect of alternating current on devices Capacitors – capacitance, charging and discharging capacitors	Nuclear physics – Radioactive decay – half life and calculating decay equations Uses of nuclear energy – how nuclear power plants work	Astronomy – key aspects of how a telescope works, the life cycle of stars and the fate of the universe	N/A	N/A
Knowledge/ Skills:						
End points covered:						
NC/Spec coverage:	Thermal Physics	Capacitors	Nuclear, radiation and uses of nuclear	Astronomy		

	3.6.2.1 Thermal energy transfer (A-level only) Content Opportunities for skills development 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), eg 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 Δ ? where c is specific heat capacity. Calculations including continuous flow. For a change of state Q = ml	3.7.4.1 Capacitance (A-level only) Content Opportunities for skills development Definition of capacitance: C = Q V 3.7.4.2 Parallel plate capacitor (A-level only) Content Opportunities for skills development Dielectric action in a capacitor C = A?0?r 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. PS 1.2, 2.2, 4.3 / AT f, g Determine the relative permittivity of a dielectric using a parallel-plate capacitor. Investigate the relationship between C and the dimensions of a parallel-plate capacitor eg using a capacitance meter. 3.7.4.3 Energy stored by a capacitor (A-level only) Content	3.8.1.1 Rutherford scattering (A-level only) Content Opportunities for skills development 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) Content Opportunities for skills development 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	3.9.1.1 Astronomical telescope consisting of two converging lenses (A-level only) Content Ray diagram to show the image formation in normal adjustment. Angular magnification in normal adjustment. M = angle subtended by image at eye angle subtended by object at unaided eye Focal lengths of the lenses. M = f o f e 3.9.1.2 Reflecting telescopes (A-level only) Content 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. 3.9.1.3 Single dish radio telescopes, I-R, U-V and X-ray telescopes (A-level		

	where l is the specific latent heat. MS 1.5 / PS 2.3 / AT a, b, d, f Investigate the factors that affect the change in temperature of a substance using an electrical method or the method of mixtures. Students should be able to identify random and systematic errors in the experiment and suggest ways to remove them. PS 1.1, 4.1 / AT k Investigate, with a data logger and temperature sensor, the change in temperature with time of a substance undergoing a phase change when energy is supplied at a constant rate. 3.6.2.2 Ideal gases (A-level only) Content Opportunities for skills development Gas laws as experimental relationships between p, V, T and the mass of the gas. Concept of absolute zero of temperature. Ideal gas equation: pV = nRT for	Opportunities for skills development Interpretation of the area under a graph of charge against pd. E = 1 2QV = 1 2CV2 = 1 2 Q2 C 38 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.7.4.4 Capacitor charge and discharge (A-level only) Content Opportunities for skills development 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, T ½ =	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. 42 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.8.1.3 Radioactive decay (A-level only) Content Opportunities for skills development Random nature of radioactive decay; constant decay probability of a given nucleus; Δ N Δ t = −⍰N N = N0e−⍰t Use of activity, A = ⍰N Modelling with constant decay probability. Questions may be set which require students to	only) Content 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. 3.9.1.4 Advantages of large diameter telescopes (A-level only) Content Minimum angular resolution of telescope. Rayleigh criterion, ⍰ ⍰ ⍰ D 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. 46 Visit aqa.org.uk/7408 for the most up-to-date specifications,		

	n moles and pV = NkT for N molecules. Work done = pΔV Avogadro constant N A, molar gas constant R, Boltzmann constant k Molar mass and molecular mass. Required practical 8: Investigation of Boyle's law (constant temperature) and Charles's law (constant pressure) for a gas. MS 3.3, 3.4, 3.14 / AT a 33 AS Physics (7407) and A-level Physics (7408). AS exams May/June 2016 onwards. A-level exams May/June 2017 onwards. Version 1.2 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.6.2.3 Molecular kinetic theory model (A-level only) Content Opportunities for skills development Brownian motion as evidence for existence of atoms. Explanation of relationships between p, V and T in	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 MS 3.8, 3.10, 3.11 / PS 2.2, 2.3 / AT f, k Magnetic fields and flux 3.7.5.1 Magnetic flux density (A-level only) Content Opportunities for skills development 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	use A = A0e −t Questions may also involve use of molar mass or the Avogadro constant. Half-life equation: T ½ = ln2 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. MS 1.3, 3.10, 3.11 / PS 3.1, 3.2 Investigate the decay equation using a variety of approaches (including the use of experimental data, dice simulations etc) and a variety of analytical methods. 3.8.1.4 Nuclear instability (A-level only) Content Opportunities for skills development 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	resources, support and administration 3.9.2 Classification of stars (A-level only) 3.9.2.1 Classification by luminosity (A-level only) Content 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. 3.9.2.2 Absolute magnitude, M (A-level only) Content Parsec and light year. Definition of M, relation to m: m – M = 5 log d 10 3.9.2.3 Classification by temperature, black-body radiation (A-level only) Content Stefan's law and Wien's displacement law. General shape of black-body curves, use of Wien's		

	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 = 1 3Nm 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 = 1 2m crms 2 = 3 2 kT = 3RT 2NA Appreciation of how knowledge and understanding of the behaviour of a gas has changed over time Gravitational fields 3.7.2.1 Newton's law (A-level only) Content Opportunities for skills development Gravity as a universal	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. 39 AS Physics (7407) and A-level Physics (7408). AS exams May/June 2016 onwards. A-level exams May/June 2017 onwards. Version 1.2 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.7.5.2 Moving charges in a magnetic field (A-level only) Content Opportunities for skills development 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. MS 4.3 Convert	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. 43 AS Physics (7407) and A-level Physics (7408). AS exams May/June 2016 onwards. A-level exams May/June 2017 onwards. Version 1.2 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.8.1.5 Nuclear radius (A-level only) Content Opportunities for skills development 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	displacement law to estimate black-body temperature of sources. Experimental verification is not required. maxT = constant = 2.9 × 10−3 m K 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 P = AT4 47 AS Physics (7407) and A-level Physics (7408). AS exams May/June 2016 onwards. A-level exams May/June 2017 onwards. Version 1.2 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.9.2.4 Principles of the use of stellar spectral classes (A-level only) Description of the main classes: Spectral class Intrinsic colour Temperature / K Prominent absorption lines O		

	attractive force acting between all matter. Magnitude of force between point masses: F = Gm1m2 r 2 where G is the gravitational constant. MS 0.4 Students can estimate the gravitational force between a variety of objects. 35 AS Physics (7407) and A-level Physics (7408). AS exams May/June 2016 onwards. A-level exams May/June 2017 onwards. Version 1.2 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.7.2.2 Gravitational field strength (A-level only) Content Opportunities for skills development 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 r 2 3.7.2.3 Gravitational	between 2D representations and 3D situations. 3.7.5.3 Magnetic flux and flux linkage (A-level only) Content Opportunities for skills development Magnetic flux defined by = BA where B is normal to A. Flux linkage as N 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 = BANcos 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) Content Opportunities for skills development Simple experimental phenomena. Faraday's and Lenz's	equation for the closest approach estimate. Dependence of radius on nucleon number: R = R0A1/3 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. MS 1.4 Make order of magnitude calculations of the radius of different atomic nuclei. 3.8.1.6 Mass and energy (A-level only) Content Opportunities for skills development 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	blue 25 000 – 50 000 He+, He, H B blue 11 000 – 25 000 He, H A blue-white 7 500 – 11 000 H (strongest) ionized metals F white 6 000 – 7 500 ionized metals G yellow-white 5 000 – 6 000 ionized & neutral metals K orange 3 500 – 5 000 neutral metals M red < 3 500 neutral atoms, TiO Temperature related to absorption spectra limited to Hydrogen Balmer absorption lines: requirement for atoms in an n = 2 state. 3.9.2.5 The Hertzsprung-Russell (HR) diagram (A-level only) Content 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		

	potential (A-level only) Content Opportunities for skills development Understanding of definition of gravitational potential, including zero value at infinity. Understanding of gravitational potential difference. Work done in moving mass m given by ΔW = mΔV 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 = − Δ V Δ r Δ V from area under graph of g against r. MS 3.8, 3.9 Students use graphical representations to investigate relationships between v, r and g. 3.7.2.4 Orbits of planets and	laws. Magnitude of induced emf = rate of change of flux linkage ? = N Δ ? Δ t Applications such as a straight conductor moving in a magnetic field. emf induced in a coil rotating uniformly in a magnetic field: ? = BAN?sin ?t Alternating currents 3.7.5.5 Alternating currents (A-level only) Content Opportunities for skills development 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	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. 44 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.8.1.7 Induced fission (A-level only) Content Opportunities for skills development Fission induced by thermal neutrons; possibility of a chain reaction; critical mass. The	evolution: path of a star similar to our Sun on the HR diagram from formation to white dwarf. 3.9.2.6 Supernovae, neutron stars and black holes (A-level only) Content 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 accelerating Universe and dark energy. Students should be familiar with the light curve of typical type 1a supernovae. Supermassive black		

	satellites (A-level only) Content Opportunities for skills development 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. MS 0.4 Estimate various parameters of planetary orbits, eg kinetic energy of a planet in orbit. MS 3.11 Use logarithmic plots to show relationships between T and r for given data Electric fields 3.7.3.1 Coulomb's law (A-level only) Content Opportunities for skills development Force between point charges in a vacuum: F	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. 3.7.5.6 The operation of a transformer (A-level only) Content Opportunities for skills development The transformer equation: $\frac{N_s}{N_p} = \frac{V_s}{V_p}$ Transformer efficiency $= \frac{I_S V_S}{I_P V_P}$ 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. MS 0.3 / AT b, h Investigate relationships between currents, voltages and numbers of coils in transformers.	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) Content Opportunities for skills development 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.	holes at the centre of galaxies. Calculation of the radius of the event horizon for a black hole, Schwarzschild radius R_s , $R_s \approx \frac{2GM}{c^2}$ 48 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.9.3 Cosmology (A-level only) 3.9.3.1 Doppler effect (A-level only) Content $\frac{\Delta f}{f} = \frac{v}{c}$ and $z = \frac{\Delta \lambda}{\lambda} = -\frac{v}{c}$ for $v \ll c$ applied to optical and radio frequencies. Calculations on binary stars viewed in the plane of orbit. Galaxies and quasars. 3.9.3.2 Hubble's law (A-level only) Content 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		

	= 1 4��0 Q1Q2 r 2 Permittivity of free space, �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. MS 0.3, 2.3 Students can estimate the magnitude of the electrostatic force between various charge configurations. 3.7.3.2 Electric field strength (A-level only) Content Opportunities for skills development 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			microwave background radiation, and relative abundance of hydrogen and helium. 3.9.3.3 Quasars (A-level only) Content 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. 3.9.3.4 Detection of exoplanets (A-level only) Content 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.		

	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 given by E = 1 4□□0 Q r 2 PS 1.2, 2.2 / AT b Students can investigate the patterns of various field configurations using conducting paper (2D) or electrolytic tank (3D). 37 AS Physics (7407) and A-level Physics (7408). AS exams May/June 2016 onwards. A-level exams May/June 2017 onwards. Version 1.2 Visit aqa.org.uk/7408 for the most up-to-date specifications, resources, support and administration 3.7.3.3 Electric potential (A-level only) Content Opportunities for skills development 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 = Q Δ V Equipotential surfaces. No work done moving charge along an equipotential surface. Magnitude of V in a radial field given by V = 1 4??0 Q r 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 graph of E against r.					
Cross-curricular links:						
Assessments:						
Other school intent priorities						
New experiences – broadening horizons						
Developing character – *Kind, Hard Working, Successful*						
Context specific need – diversity,						

inclusion; reading, literacy; mental health						
Curriculum Careers - Gatsby 4						