Curriculum Map – Year 13 – Physics (Teacher 2)

Topic name	Term	Skills developed	Link to subject content	Prior learning	Next link in curriculum
3.7 Fields and their consequences	Autumn	MS 0.4 Students can estimate the gravitational force between a variety of objects. MS 3.8, 3.9 Students use graphical representations to investigate relationships between v, r and g. 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. MS 0.3, 2.3 Students can estimate the magnitude of the electrostatic force between various charge configurations. PS 1.2, 2.2 / AT b	3.7.1 Fields 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 Gravitational fields 3.7.2.1 Newton's law 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 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 potential 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 = −	Links from KS4: 4.7 Magnetism and Electromagnetism Domestic Electricity Links from AS 3.4.1.4 Projectile motion 3.4.1.2 Moments 3.4.1.7 Work, energy and power 3.5 Electricity	Electric field strength and potential

		Students can investigate the patterns of various field configurations using conducting paper (2D) or electrolytic tank (3D). 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. MS 3.8, 3.10, 3.11 / PS 2.2, 2.3 / AT f, k 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	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. 3.7.2.4 Orbits of planets and satellites Orbital period and speed related to radius of circular orbit; derivation of T2 ∝ 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 Electric fields 3.7.3.1 Coulomb's law Force between point charges in a vacuum: F = k Q1Q2 /r 2 Permittivity of free space. 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 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 = k Q/ r 2 3.7.3.3 Electric potential 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		

		Required practical 10: Investigate how the force on a wire varies with flux density, current and length of wire using a top pan balance. MS 4.3 Convert between 2D representations and 3D situations. 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. MS 0.3 / AT b, h Investigate relationships between currents, voltages and numbers of coils in transformers.	Equipotential surfaces. No work done moving charge along an equipotential surface. Magnitude of V in a radial field given by V = k 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. 3.7.4 Capacitance 3.7.4.1 Definition of capacitance C=Q/V 3.7.4.2 Parallel plate capacitor Dielectric action in a capacitor C = A x permittivity x 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. 3.7.4.3 Energy stored by a capacitor Interpretation of the area under a graph of charge against pd. E = 0.5 QV = 0.5 CV2 = 0.5 Q2/ C 3.7.4.4 Capacitor charge and discharge 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 = 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) 3.7.5 Magnetic fields 3.7.5.1 Magnetic flux density 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.		

			3.7.5.2 Moving charges in a magnetic field 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 Magnetic flux defined by $_{\varphi}= BA$ where B is normal to A. Flux linkage as N_{φ} 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 $N_{\varphi}= BAN\cos\Theta$ 3.7.5.4 Electromagnetic induction Simple experimental phenomena. Faraday's and Lenz's laws. Magnitude of induced emf = rate of change of flux linkage $E = N \Delta_{\varphi}/ \Delta t$ Applications such as a straight conductor moving in a magnetic field. emf induced in a coil rotating uniformly in a magnetic field: $E = BAN\Omega\sin\Omega t$ 3.7.5.5 Alternating currents Sinusoidal voltages and currents only; root mean square, peak and peak-to-peak values for sinusoidal waveforms only. $I_{rms} = I0/\sqrt{2}$; $V_{rms} = V0/\sqrt{2}$ 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. 3.7.5.6 The operation of a transformer 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.		
3.8 Nuclear physics	Spring	Required practical 12: Investigation of the inverse-square law for gamma radiation. 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. MS 1.4 Make order of magnitude calculations of the radius of different atomic nuclei.	3.8.1 Radioactivity 3.8.1.1Rutherford scattering 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 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 / x2 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. 3.8.1.3 Radioactive decay Random nature of radioactive decay; constant decay probability of a given nucleus Modelling with constant decay probability. Questions may also involve use of molar mass or the Avogadro constant. Half-life equation. 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. 3.8.1.4 Nuclear instability	Links from KS4 Y10/11 Atomic structure Nuclear Fission and fusion Links from AS 3.2 Particles and radiation	Turning points – special relativity

			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 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 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 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		

			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. 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 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.		
3.12 Turning points in physics	Summer		3.12.1 The discovery of the electron 3.12.1.1 Cathode rays Production of cathode rays in a discharge tube. 3.12.1.2 Thermionic emission of electrons 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 Determination of the specific charge of an electron, e/ me , by any one method. Significance of Thomson's determination of e me Comparison with the specific charge of the hydrogen ion. 3.12.1.4 Principle of Millikan's determination of the electronic charge, e 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.	Links from AS 3.2.2.1 Wave-particle duality 3.2.2 Radiation 3.3.1 Progressive and stationary waves 3.3.2 Refraction, diffraction and interference	

			Significance of Millikan's results. Quantisation of electric charge. 3.12.2 Wave-particle duality 3.12.2.1 Newton's corpuscular theory of light 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. Explanation for fringes in general terms, no calculations are expected. Delayed acceptance of Huygens' wave theory of light. 3.12.2.3 Electromagnetic waves Nature of electromagnetic waves. Maxwell's formula for the speed of electromagnetic waves in a vacuum c = 1 ⍰0⍰0 where ⍰0 is the permeability of free space and ⍰0 is the permittivity of free space. Students should appreciate that ⍰0 relates to the electric field strength due to a charged object in free space and ⍰0 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 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 de Broglie's hypothesis. 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 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 Special relativity 3.12.3.1 The Michelson-Morley experiment 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 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 Proper time and time dilation as a consequence of special relativity. Time dilation equation. Evidence for time dilation from muon decay. 3.12.3.4 Length contraction Length of an object having a speed v l = l0 1 − v 2 c 2 3.12.3.5 Mass and energy 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.		