Science Department – Year 13 Physics

Shirley High Curriculum Map

To introduce and build mastery of simple harmonic motion and systems, to introduce the phenomenon of resonance in systems.
To review Thermal energy transfers and build practical skills
To review the gas laws and introduce and build mastery of the theory of the ideal gas and the molecular kinetic theory model of a gas.
To investigate electric, gravitational and magnetic fields and build knowledge of their consequences by derivation of equations and real world examples.
To review Radioactivity and make links to the particles topic from Year 12.
To build knowledge of radioactive decay and the decay equations and their applications in the real world, to consider the operation and constraints of Nuclear fission and fusion power stations making links to Einstein's equation.
To review and increase knowledge of the physics of vision, defects and their correction using lenses
To consider the ear as a sound detection system and make links to sensitivity, frequency response and hearing defects.
To review and extend work on non- invasive diagnostic techniques, the ECG, Ultrasound scanning including A and B scans, endoscopy building on knowledge of fibre optics and MR scans.
To review and build knowledge of ionising imaging techniques, x-ray, gamma scans, CT scans and their enhancements
To investigate radionuclide imaging techniques considering, half life, common isotopes and effective, biological and physical half lives

	Autumn 1	Autumn 2	Spring 1	Spring 2	Summer 1
	Theme/Topic/Skill:	Theme/Topic/Skill:	Theme/Topic/Skill:	Theme/Topic/Skill:	Theme/Topic/Skill:
	Simple harmonic motion A Level Topic 6 Thermal Physics A Level topic 6	Gravitational and Electric Fields A level Topic 7	Magnetic fields A Level Topic 7 Nuclear Physics Part 1 A level Topic 8	Nuclear Physics part 2 A level Topic 8 Medical Physics Option Part 2	Medical Physics Option part 1
Why Now?	SHM is the completion of Topic 6 and builds on motion graphs and linear motion as well as F=ma. Vectors, Cos, sin and small angle approximations previously met in Year 12 Units 2 and 4 are revisited. Resonance and its importance are considered. Thermal Physics is the second section of the unit and builds on GCSE prior knowledge about states of matter, Heat transfer, and kinetic theory. Ideal gases and the molecular kinetic theory model are considered. RMS will be needed in Topic 7	Electric fields will be studied before gravitational fields as the practical applications make it possible to visualise and quantify field behaviour which cannot be done with gravitational fields. This unit builds on GCSE work on forces and force fields as well as static electricity. DC circuits charge and PD from AS are also needed. The gravitational fields section of this unit builds on concepts from electric fields s well as GCSE knowledge of gravity, vectors, contact and non-contact forces, work GPE and KE and from unit 6 Circular motion and centripetal force	The magnetic fields section of Topic 7 requires the prior knowledge from KS3 and GCSE of basic magnetism and electromagnetism as well as motors, induction and transformers. It requires students to be able to build DC circuits and know the difference between AC and DC Students will also need to apply knowledge of circular motion and centripetal forces. Topic 8 part 1 builds on GCSE knowledge of the Nuclear model of the atom and the properties of alpha, beta and gamma radiations and background radiation. Coulomb's law and momentum, wave particle duality and electron diffraction from A level and AS are also required.	Nuclear physics part 2 investigates mass and energy in nuclear reactions, fission and fusion. From GCSE knowledge of fission and fusion reactors is needed. Prior knowledge from part 1 is required as well concepts of the electron volt and elastic collisions from AS and A level and nuclear equations. The Medical Physics Option is chosen as being the one which is most useful to candidates from the setting. The second section of the unit is covered first as it looks at X rays and radionuclide imaging and therapies which are touched on in the Nuclear physics option just studied.	Medical physics part 1 requires prior GCSE knowledge of the eye and ear including defects of vision and their correction, ray diagrams for lenses power and focal length. Knowledge from the AS waves topic is also required. Students need GCSE knowledge of the Heart and ECG machines. This Option has excellent opportunities for revision within it
Fundamental Concepts	Conditions for SHM, Defining equation: $a = -\omega^2 x$ $x = A\cos(\omega t)$ and $v = \pm\omega\sqrt{A^2 - x^2}$ Graphical representations. SHM systems, mass spring and simple pendulum Forced vibrations and resonance, the dangers of resonance. Thermal physics Specific heat capacity, specific latent heat, ideal gas behaviour and laws, Avogadro's number and the mole, Boyle's, Charles' and the pressure laws. Brownian $pV = \frac{1}{3}N m (c_{rms})^2$ motion. Proof of Definition and proof of average $\frac{1}{2}m (c_{rms})^2 = \frac{3}{2}kT = \frac{3RT}{2N_A}$ molecular kinetic energy of a gas.	Electric fields Topic 7 part 2 Electric fields and their representation, Coulomb's law, electric field strength in a uniform and radial field and magnitude, derivation of work done moving charges in uniform field. Fd= QΔV. Definition of absolute electric potential, and why it is 0 at infinity, equipotential and the definition of the volt. Magnitude of V in a radial field and the way E, V and r vary. Capacitance, definition, dielectrics and their actions. Equations and proof for Energy, charge and PD of a capacitor during charge and discharge. The definition and importance of the time constant RC. Gravitational fields Newton's law of gravitation, G as the universal gravitational constant, gravitational fields representation and definition of g. Gravitational potential, definition, why it is 0 at infinity, gravitational potential difference and equipotentials, V in a uniform and radial field. Graphical representations of V,g and r, Orbits of planets and satellites, types and uses, escape velocity. Comparison of G and E fields.	Magnetic fields Magnetic flux density Definition of the Tesla, Fleming's left hand rule, Force on charged particles moving in a B field. Flux and flux linkage in a coil cutting a B field. NØ=BAN cosθ. Faraday's and Lenz's laws of induction.. Magnitude of induced EMF in a straight conductor. $\varepsilon = N\Delta\phi/\Delta t$ Emf induced in a rotating coil $\varepsilon = BAN\omega\sin\omega t$ Ac currents, the concept of rms current and voltage and its definition from power in a DC circuit. The operation, equations of and efficiency of transformers, definition of eddy currents and uses. Nuclear Physics part 1 Rutherford scattering, identification and properties of αβγ radiations, inverse square law for gamma radiation. Safe handling of sources. Random nature of radioactive decay, the decay constant and activity, half life. The equations $\frac{\Delta N}{\Delta t} = -\lambda N$ $N = N_o e^{-\lambda t}$ $A = \lambda N$ $T_{½} = \frac{\ln 2}{\lambda}$ $A = A_o e^{-\lambda t}$ NZ graphs, decay equations, excited emission and Technetium production $R = R0A^{1/3}$ derived from experimental data. Calculation of the nuclear radius and links to nucleon number. Derivation of Nuclear density calculation. .	Nuclear Physics part 2 $E=mc^2$ use and importance of AMU, binding energy and its links to fission and fusion. How fission is induced, safety in nuclear reactors. Fusion reactions and reactors. Medical physics part 2 The production of x rays,, rotating tube and flat panel detectors, dosage, barium meals. Absorption of x rays, principles of CT scanners. Radionuclide imaging and therapies, gamma tracers, PET scans, biological and effective half lives, the gamma camera.	Medical physics part 1 Physics of the eye, properties of lenses nd the lens equations, eye defects, corrective lenses and ray diagrams, astigmatism. Physics of the ear, the ear as a sound detection system, sensitivity and frequency response, defects of hearing and correction. Definition of sound intensity. Biological measurements, ECG machines and waveforms. Ultrasound and ultrasound Imaging, reflection, transmission and absorption at tissue boundaries acoustic impedance and attenuation. A and B scans and relevant equations $Z = \rho c$ and $I_t / I_i = [(Z_2 - Z_1)/(Z_2 + Z_1)]^2$ Fibre optics, endoscopy and MR scanners. The principles and operation of the endoscope. Principles of MR imaging
Students will…	Demonstrate knowledge and understanding of the conditions for SHM, analyse and interpret data to reach conclusions on relationships of variables, use ICT for modelling. Apply knowledge and understanding to derive equations for mass spring systems and simple pendulum, analyse and interpret data to understand the connections between variables. Demonstrate knowledge and understanding of resonance. Demonstrate knowledge and understanding of specific het and latent heat, identify errors, Demonstrate knowledge and understanding of the Ideal Gas	Apply knowledge and understanding of electric fields and circular motion to explain charged particle trajectories in a magnetic field, correctly construct circuits. Apply knowledge and understanding of capacitors to solve problems, design, construct and check DC circuits. Demonstrate knowledge and understanding of capacitor charge and discharge by sketching graphs. Demonstrate knowledge and understanding of Newton's law of gravitation. Demonstrate knowledge and understanding of the concept of gravitational fields and gravitational field strength and gravitational potential when solving problems.	Apply knowledge and understanding to predict the behaviour of a spinning motor. Demonstrate and apply knowledge and understanding of forces on charges particles in magnetic fields to explain the operation of machines guiding the motion of charges particles. Demonstrate knowledge and understanding of magnetic flux and changing flux linkage and emf production. Apply knowledge and understanding of scientific issues to explain electromagnetic braking. Demonstrate knowledge and understanding of rms and peak values and use an oscilloscope to find the values. Demonstrate knowledge of the construction and operation of a	Demonstrate and apply knowledge and understanding of binding energy, fission and fusion and calculate energy released in nuclear reactions. Demonstrate and apply knowledge and understanding of fission and fusion and nuclear power stations and demonstrate knowledge of safety considerations, analyse, interpret and evaluate information, ideas and evidence and make judgements and reach conclusions about the development of nuclear power. Apply knowledge and understanding of photons in x ray production and detection. Apply knowledge and understanding of half life to explain calculate effective half life.	Apply knowledge and understanding of lenses to explain corrections to eye defects. Demonstrate knowledge and understanding of the structure of the ear. Demonstrate knowledge of the ECG waveform. Demonstrate knowledge and understanding of A and B ultrasound scans. Demonstrate knowledge and understanding of endoscopy and MR scanning.

	equation, analyse experimental data to find absolute zero. Make links between Brownian motion and the development of the kinetic theory, apply knowledge of mechanics to derive the kinetic theory equations.	Demonstrate and apply knowledge of satellites and their orbits when considering uses and understanding of gravitational potential when considering energy and orbits.	transformer and analyse, interpret and evaluate data. Demonstrate knowledge and understanding and evaluate and interpret data from the Rutherford scattering experiment. Apply knowledge and understanding of the properties of radiation in medicine and industry, analyse, interpret and evaluate data from absorption and inverse square experiment to make judgements and reach conclusions, improve experimental design. Apply knowledge and understanding of radioactive decay processes to analyse, interpret and evaluate data on radioactive decay to make judgements. Demonstrate knowledge and understanding of the size of the nucleus and apply Coulomb's law and diffraction to calculate radii		
Language for Life (Key terms/Vocabulary)	Oscillation, systems, harmonic oscillator, damping, forced and free vibrations, resonance. Specific heat capacity, specific latent heat, state change, melt, freeze, boil, evaporate, sublimate, continuous flow calorimeter, Kelvin, Celsius, absolute zero, Boyle, Charles, Ideal gas, mole, molar mass, molecular mass, Avogadro, Boltzmann, empiricism, root mean square.	Point charge, permittivity of free space, Coulomb, electric field strength, uniform, radial, field lines, Electron deflection, electric potential, equipotential, capacitance, polar molecule, dielectric, charge, discharge, exponential, natural logs, time constant. Universal gravitational constant, point mass, gravitational field strength, gravitational potential, Kepler's laws, escape velocity, synchronous.	Magnetic field, Magnetic flux, flux density, flux linkage, Fleming's rules, Tesla, Cyclotron, Hall probe, mass spectrometer, particle accelerator, Faraday, Lenz, electromagnetic induction, em braking, back emf, alternating current, sinusoidal output, peak to peak, root mean square, transformer, eddy currents, lamination. Rutherford, nuclear model, inverse square law, background radiation correction, radioactive decay, random, protactinium, activity, half-life, radioactive waste, radiocarbon and Nitrogen 14 dating, nuclear stability, decay equations, Technetium, nuclear radius, electron diffraction by a nucleus.	Einstein, amu, mass difference, binding energy, fission, fusion, thermal neutrons, chain reaction, critical mass, moderator, coolant, control rods, Chernobyl, Fukoshima, nuclear safety, Cherenkov radiation. Rotating anode, beam intensity, photon energies, flat panel detector, x ray scintillator, photodiode, sharpness, contrast, barium meal, exponential attenuation, linear coefficient, mass attenuation coefficient, half thickness, tracer, technetium 99m, iodine 131, indium 111, gamma camera, radionuclide labelling, affinity, effective half life, photomultiplier, high energy x ray, beta implants.	Cornea, iris, lens, suspensory ligaments, vitreous, aqueous humour, retina, fovea, rods, cones, focus, focal length, power, dioptres, myopia, hypermetropia, astigmatism, pinna, ear canal, tympanum, malleus, incus, stapes, oval window, cochlea, relative intensity, decibel, logarithmic, hearing threshold, ECG, P,Q,R,S,T segments, diastole, systole, atrial, ventricular, ultrasound, piezoelectric, absorbance, impedance, attenuation, resolution, endoscope, coherent and non-coherent optical fibre bundles, Magnetic resonance, superconducting magnet, proton spin, excitation, radio frequency emissions.
Extended writing Opportunities	The development of the gas laws from an experimental and theoretical perspective	Discuss the similarities and differences between electric and gravitational fields.	Present a piece on the mass spectrometer/ particle accelerator/cyclotron/Hall probe What are the applications of radiation in medicine and industry? What is the evidence for the age of the earth?	Explain the operation and safety considerations for fission and fusion power stations What are the gamma emitting isotopes and what are their useful properties in treatments?	Defects of the eye and their corrections The effects of excessive noise and age on the ear and hearing. The history of CT scanning Compare imaging techniques in terms of safety, convenience and image resolution.
Maths Across the Curriculum	Apply concepts underlying calculus. Small angle approximation Sketch the relationship modelled by y=k/x	Use orders of magnitude Use graphical representations to investigate relationships between v,r and g Derivation of equations. MS3.8: ΔV from the area under graph of E against r and be able to calculate it or estimate it by graphical methods as appropriate.	Visualise and represent 2D and 3D forms 2D representations of 3D objects. Use calculators to compute sin, cos, tan x in degrees and radians. Use sin, cos, tan in problems. Understand and use $=, <, <<, >>, >, \propto, \approx, \Delta$ Calculate rate of change from a linear graph. Use ratios Analyse, interpret and evaluate data. Use simple probability Translate information between graphical, numerical and algebraic forms. Order of magnitude calculations.	Use calculators to find power, exponential and log functions. Recognise and make use of appropriate units. Translate information between graphical and numerical forms.	Inverse relationships Log scales Rearrange equations
Links to careers/ aspirations	Transportation designer, automotive engineering, heating engineer	Electrical engineer, space physicist, space program scientist, astrophysicist	Generation and transmission of electricity worker/manager, designer Tracer production	Clinical radiographer, diagnostic radiographer, nuclear industry technician, nuclear physicist/researcher.	Ophthalmologist, radiologist, medical imaging technician, paramedic.
Cultural Capital	What characteristics do all oscillating systems share? How should a suspension system operate to give the smoothest possible ride? Can a glass be shattered by a voice alone? Why can you put out a candle flame with moist fingers but putting your hand in boiling water is much more dangerous even though it is 700 degrees cooler? Which is best, Kelvin, Celsius or Fahrenheit and why? Are there any conditions under which the kinetic theory fails to explain gas behaviour?	Can Coulomb's law be confirmed in a school? Design and make a homemade capacitor and then test it. How are radioactive decay and capacitor discharge similar and different? How would a star's gravitational field change as it progresses though its life cycle? When launching a rocket is it best to go from the equator or poles?	Why do sewing needles and knitting needles become magnetised. Design and make a motor using simple household materials. How are simple motor kits similar to appliance motors and different? How do we use our knowledge of controlling the direction of movement of charged particles? What is eddy current braking and why do theme parks love it? How many uses have oscilloscopes been put to? Why was DC Edison's downfall? Should we give full body scans to everyone requiring diagnosis? What are countries around the world doing with their radioactive waste and should we be concerned?	Which has more mass the same volume of hot or cold coffee? Nuclear energy, is it the answer to all our energy issues? What went wrong at Chernobyl and why? How was disaster averted at Fukushima? How do x ray machines produce images? CT scans and xrays, what are the similarities and differences? Treating tumours, is there one gold standard treatment for all cancers?	Eyes and digital cameras, similarities and differences? Explain why the ear is most sensitive at the 3KHz frequency and why the levels of sensitivity need to be different across the hearing range. What are brachycardia, tachycardia, AF and VF and what are the ECG traces like? 3D ultrasound imaging is available but parents have to pay, is this ethical? When might Helium balloons have to be banned?
Practical Application of Skills	Observations of oscillations from IOP practical guide Required practical, investigate a mass-spring and simple pendulum system to confirm the mathematical relationship between variables. Damped systems, water in a tube or damped spring. Barton's pendulum Find the speed of sound using resonance in an air column (requires a good ear and perfect pitch!) Find the specific heat capacity of a metal and liquid Investigate the specific latent heat of fusion of water. Required practical Investigation of Boyle's law and Charles's law. Observation of Brownian motion.	Demonstration of electric field lines using EHT supply and semolina on oil and conducting paper. Use of Van de Graf and parallel plates to show displacement in a field using an aquadag ball. Demonstration of electron deflection in a tube. Virtual experiment on electric potentials. Required practical Investigation into the charge and discharge of a capacitor and a determination of the time constant.	Demonstration of kicking wire, Construct DC motors. Required practical Investigate how the force on a wire varies with flux density current and wire length using a top pan balance. Investigate the fields around magnets. Required practical Use a search coil, oscilloscope and Helmholtz coils to find the effect on magnetic flux linkage of varying the angle between the search coil and the magnetic field direction. Investigate induction using metals and a coil Investigate the period of output from a signal generator and hence determine f. Demonstration and operation of transformers if available. Absorption of alpha and beta emissions. Required practical		Dissection of the eye. Investigation of convex and concave lenses to find focal length and power. Investigation using an eye test and resolving power activity. Colour blindness test using cards. Investigation using model eye to show corrections to defects. Investigate the ear using a simulation, Range of hearing demonstration. Use of practical clinical skills tutorials to learn to read ECG. Simple piezoelectric experiment. Perform virtual colonoscopy.

			Investigation of the inverse square law for gamma radiation. Half life investigations either using modelling or a protactinium generator.		