Rewarding Learning

REVISED GCE AS & A Level

Scheme of Work

Physics

This is an exemplar scheme of work which supports the teaching and learning of the Physics specification

scheme of work

GCE PHYSICS

Contents

Introduction

CCEA has developed new GCE specifications for first teaching from September 2008. This scheme of work has been designed to support you in introducing the new specification and was produced by practicing teachers who will be teaching the specification.

The scheme of work provides suggestions for organising and supporting students' learning activities. It is intended to assist you in developing your own schemes of work and should not be considered as being prescriptive or exhaustive.

Please remember that this scheme of work is intended only as a pathway through the content of the specification, not as a replacement. It is the specification on which assessment is based and which details the knowledge, understanding and skills that students need to acquire during the course. This scheme of work should therefore be used in conjunction with the specification.

Published resources and web references included in the scheme of work have been checked and are correct at the date of issue but may be updated by the time that the specification is introduced. You should therefore check with publishers and websites for the latest versions. CCEA accepts no responsibility for the content of listed publications or websites.

CCEA will be making Word versions of this scheme of work available on the subject micro-site. This will enable you to use them as a foundation for developing your own schemes of work which are matched to your teaching and learning environments and the needs of your students. CCEA have developed a number of web-based support materials to support you introducing the new specification, including PowerPoint presentations, case studies and pod casts. These have been referred to throughout the scheme of work.

We hope that you find this aspect of our support package useful in your teaching.

Best wishes

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Exemplar Scheme of Work: GCE Physics

Unit AS 1
Forces, Energy and Electricity

Specification: GCE Physics

Unit: AS 1: Forces, Energy and Electricity

Introduction:

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Spec. Ref	Learning Outcomes	Suggested Teaching Strategy	Time Required	Resources	Risk Assessment Safety	Other Information
1.1.1	Describe all quantities in terms of a magnitude and unit	Teacher exposition Pupils make a list of base units and prefixes	30 mins			
1.1.2	State the 6 base units and express other quantities in terms of these units	Teacher exposition and worked examples Practice questions with peer and teacher support	60 mins	Worksheet and/or question bank		
1.2.1	Distinguish between and give examples of scalar and vector quantities	Pupil research leading to an A4 poster	30 mins	Internet and/or text books		
1.2.2	Scale diagram to find the resultant of two vectors Calculate the resultant of two perpendicular vectors	Teacher exposition and worked examples Practice questions with peer and teacher support Practical demonstration: static arrangement of two newtonmeters supporting a weight Computer simulation	60 mins	Worksheet and/or question bank ,2 newtonmeters, string, slotted masses and hanger, Data projector and computer	Avoid the use of large forces	Measure angles between the string and use to confirm results from scale diagram / calculation www.slu.edu/classes/maymk/SketchpadApplets/AddVectors.html
1.2.3	Resolving a vector into components	Teacher exposition and worked examples Practice questions with peer and teacher support Practical demonstration: static arrangement of two perpendicular newtonmeters balancing a third	60 mins	3 newtonmeters, string	Avoid the use of large forces	Two perpendicular newtonmeters balancing a third. Only invoke Newton's 3rd law if pressed!

Spec. Ref	Learning Outcomes	Suggested Teaching Strategy	Time Required	Resources	Risk Assessment Safety	Other Information
1.3.1	Define displacement, speed, velocity and acceleration;	Pupils research leading to an A4 poster	30 mins	Internet and/or text books		www.jersey.uoregon.edu/AverageVelocity/index.html
1.3.2	Recall and use the equations of motion for uniform acceleration	Activities to learn the equations Practice questions with peer and teacher support	60 mins	Worksheet and/or question bank		
1.3.3	Describe an experiment to measure acceleration of freefall	Class experiment to measure 'g' conducted. Pupils to produce an experimental report Computer simulation	60 mins	Light gates, transparent tube, squash ball or dedicated apparatus data projector and computer		
1.3.4	Interpret velocity-time and displacement-time graphs for motion with uniform and non-uniform acceleration	Teacher exposition and worked examples Practice questions with peer and teacher support	120 mins	Worksheet and/or question bank		
1.4.1	Describe projectile motion	Analysis of strobe photographs for balls with and without a horizontal component of velocity Monkey & hunter	120 mins	Digital SLR, strobe lamp Appropriate apparatus	Danger to those with light sensitive epilepsy	
1.4.2	Explain motion due to a uniform velocity in one direction and uniform acceleration in a perpendicular direction	Analysis of strobe photographs for balls with and without a horizontal component of velocity		Digital SLR, strobe lamp	Danger to those with light sensitive epilepsy	

Spec. Ref	Learning Outcomes	Suggested Teaching Strategy	Time Required	Resources	Risk Assessment Safety	Other Information
1.4.3	Apply the equations of motion to projectile motion, excluding air resistance	Teacher exposition and worked examples Practice questions with peer and teacher support	120 mins	Worksheet and/or question bank		
1.5.1	State Newton's laws of motion	Interrogate websites for statements of the laws leading to a poster	60 mins	Internet		
1.5.2	Apply the laws to simple situations	Air track demonstration of each of the laws Tug-of-war demonstration Sitting on a chair Discussion on weightlessness Discussion on mass	60 mins	Air track and accessories, light gates, Rope		
1.5.3	Recall and use *F* = *ma* where m is constant	Experiments to show a ∝ F and a ∝ 1/m	100 mins	Air track and accessories, light gates,		
1.5.4	Understand that friction is a force that opposes motion	Tilt a ramp until an object starts to move	60 mins	Dynamics runway and trolley, wooden block, glass paper	Possible danger of runway falling	
1.6.1	Define the moment of a force about a point	Pupils research leading to an A4 poster	120 mins	Internet and/or text books		
1.6.2	State the principle of moments	Pupils research leading to an A4 poster		Internet and/or text books		
1.6.3	Use the principle of moments to solve simple problems	Teacher exposition and worked examples Practice questions with peer and teacher support Verification of the principle by		Worksheet and/or question bank Metre rule, retort stand,	Danger of falling masses and swinging metre rule at eye level	

Spec. Ref	Learning Outcomes	Suggested Teaching Strategy	Time Required	Resources	Risk Assessment Safety	Other Information
		determining the weight of a metre rule which is balanced by a single suspended weight		boss head, clamp, string, slotted masses & hanger, string, scales		
1.7.1	Define work done, potential energy, kinetic energy, efficiency and power	Interrogate websites or textbooks for definitions leading to a poster	120 mins	Internet and/or text books		
1.7.2	Recognise that when work is done energy is transferred	Drop ball bearings into sand and measure the penetration distance Teacher exposition and worked examples Practice questions with peer and teacher support	60 mins	Sand trough, ball bearings Worksheet and/or question bank		
1.7.3	Calculate the work done for constant forces, including force not along the line of motion	Teacher exposition and worked examples to include force-displacement graphs	60 mins	Worksheet and/or question bank		
1.7.4	Recall and use the equations $\Delta PE = mg\,\Delta h$ and $KE = \frac{1}{2}mv^2$		120 mins	Worksheet and/or question bank		
1.7.5	State the principle of conservation of energy and use it to calculate exchanges between GPE and KE	Class experiment to verify this using a suspended mass attached to a truck Teacher exposition and worked examples	120 mins	Air track and accessories, light gates Data projector and computer		www.jersey.uoregon.edu/PotentialEnergy/index.html
1.7.6	Recall and use P = work done/time taken	Practice questions with peer and teacher support		Worksheet and/or		

Spec. Ref	Learning Outcomes	Suggested Teaching Strategy	Time Required	Resources	Risk Assessment Safety	Other Information
	$P = Fv$ Efficiency = useful energy(power)output energy (power) input			question bank		
1.8.1	State Hooke's law and use $F = kx$ to solve simple problems	Class experiment to verify Hooke's law for a spring and a wire	120 mins			
1.8.2	Understand the terms elastic and plastic deformation and elastic limit	Group research leading to a PPT presentation	60 mins	Data projector & computer		
1.8.3	Distinguish between limit of proportionality and elastic limit					
1.8.4	Define the terms stress, strain and ultimate tensile stress	Teacher exposition and worked examples Practice questions with peer and teacher support	60 mins	Worksheet and/or question bank		
1.8.5	Define the Young modulus	Pupils research leading to an A4 poster	40 mins	Copper wire (~ 30 swg) slotted masses	Danger of falling weights and a wire under tension snapping	www.matter.org.uk/Schools/Content/YoungModulus/experiment_1.html
1.8.6	Perform and describe an experiment to determine the Young modulus	Class experiment to measure the Young modulus of copper Computer simulation	60 mins	& hangers, G-clamp, bench pulley, metre		
1.9.1	Describe current as the rate of flow of charge	Modelling or visualisation using tennis balls in a tube	40 mins	rule, micrometer, data projector		

Spec. Ref	Learning Outcomes	Suggested Teaching Strategy	Time Required	Resources	Risk Assessment Safety	Other Information
1.9.2	Recall and use the equation $I = \Delta Q / \Delta t$	Teacher exposition and worked examples Practice questions with peer and teacher support	60 mins	and computer Tennis balls, transparent tubing Worksheet and/or question bank		
1.10.1	Recall and use the equations $V = W / q$ and $V = P / I$	Teacher exposition and worked examples Practice questions with peer and teacher support	60 mins	Worksheet and/or question bank		
1.10.2 1.10.3 1.10.4	Define the volt Define electromotive force Distinguish between emf and pd	Group research leading to a presentation	60 mins	Data projector & computer		
1.11.1	Describe the relationship between current, voltage and resistance in series and parallel circuits	Class experiments to reveal relationship. Circuit software (Crocodile Physics) to create and analyse circuits	120 mins	PSU, resistors, ammeters, voltmeters, ohmmeters Computer + software		
1.11.3	Recall and use the equations $R = V / I$ and $P = I^2 R$	Teacher exposition and worked examples Practice questions with peer and teacher support	60 mins	Worksheet and/or question bank		
1.11.4 1.11.5	Define resisivity Recall and use the equation $R=\rho l/A$	Pupils research leading to a poster. Experiments leading to R α l, and R $\alpha \frac{1}{a}$ Practice questions with peer and teacher support	40 mins 60 mins	 Ohmmeter, micrometer, wire samples of different		

Spec. Ref	Learning Outcomes	Suggested Teaching Strategy	Time Required	Resources	Risk Assessment Safety	Other Information
				swg and length or conducting putty		
1.11.6	Perform and describe an experiment to measure resistivity	Class experiment to measure resistivity of different materials	60 mins	Worksheet and/or question bank Power supply, variable resistor, leads, metre rule, micrometer screw gauge, ammeter, voltmeter, wires of different resistivity	Beware of possible overheating of wires and use of electrical appliances near water taps	
1.11.7	Demonstrate knowledge and simple understanding of superconductivity	Interrogate websites to explore and research the principles/definition of superconductivity, examples of how it is used and potential advantages	60 mins			
1.11.8	Distinguish between ohmic and non-ohmic behaviour	Class experiment to determine V-I characteristics for constantan wire at constant temperature, filament lamp and an ntc thermistor. Class discussion of results	100 mins	Power supply, ntc thermistor, constantan wire, filament lamp, variable	Beware of possible overheating of wires and use of electrical	

Spec. Ref	Learning Outcomes	Suggested Teaching Strategy	Time Required	Resources	Risk Assessment Safety	Other Information
1.11.9	Perform experiments to determine the current voltage characteristics for a metallic conductor and a negative temperature coefficient thermistor -			resistor, ammeter, voltmeter,	appliances near water taps	
1.11.10	Sketch and explain the variation with temperature of the resistance of a pure metallic conductor and a negative temperature coefficient (ntc) thermistor	Demonstration experiment to measure resistance and temperature for a metallic conductor and an ntc thermistor	60 mins	Ohmmeter, water bath, wire sample, thermistor, thermometer		
1.11.11	Appreciate the existence of internal resistance of sources and understand the simple consequences of internal resistance for external circuits	Research followed by a discussion of the consequences of internal resistance	40 mins			
1.11.12	Use the equation $V = E - IR$	Class experiment to verify the equation Practice questions with peer and teacher support	60 mins	Battery, resistors, voltmeter, ammeter, switch Worksheet and/or question bank		
1.11.13	Perform and describe experiments to measure internal resistance	Class experiment to measure internal resistance supported by an experimental report	60 mins	Battery, lamps, voltmeter, ammeter, switch		

Spec. Ref	Learning Outcomes	Suggested Teaching Strategy	Time Required	Resources	Risk Assessment Safety	Other Information
1.12.1	Use conservation of charge and energy in simple d.c. circuits	Teacher exposition and worked examples Practice questions with peer and teacher support	60 mins	Worksheet and/or question bank		
1.12.2	Recall and use the equations for resistors in series and in parallel	Derive the formulae using ohmmeters and resistors Practice questions with peer and teacher support	60 mins	Ohmmeters, resistors Worksheet and/or question bank		
1.12.3	Understand the use of a potential divider as a source of variable p.d.	Demonstration experiment to view the set-up and action of a potentiometer	60 mins	PSU, resistors, voltmeters		
1.12.4	*Use* $V_o = R_1 V_{in} / (R_1 + R_2)$	Demonstration experiment to verify the equation	60 mins	PSU, resistors, voltmeters		

Unit AS 2
Waves, Photons and Medical Physics

Specification: GCE Physics

Unit: AS 2: Waves, Photons and Medical Physics

Introduction:

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Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
2.1.1	Demonstrate a knowledge and understanding of the terms 'transverse wave' and 'longitudinal wave'	Slinky spring demonstrations Computer simulation Write a paragraph detailing the similarities and differences between transverse & longitudinal waves.	60 mins	Slinky spring Data projector & computer		www.silcom.com/~aludwig/images/snake.gif www.ngsir.netfirms.com/englishhtm/Lwave.htm
2.1.2	Be able to categorise waves as transverse or longitudinal	Pupil research Develop a mnemonic to link sound as a longitudinal wave	40 mins	Text books &/or internet		
2.1.3	Understand polarisation as a phenomenon associated with transverse waves	Group research leading to a presentation	60 mins	Text books &/or internet		
2.1.4	Recall and use $v = f\lambda$	Produce a poster explaining what the symbols represent and their SI units Practice questions with peer and teacher support	60 mins	Paper & pens Worksheet and/or question bank		
2.1.5	Recall radio waves, microwaves, infrared, visible, ultraviolet, x-rays and gamma rays as regions of the electromagnetic spectrum	Teacher exposition Develop a mnemonic to recall the seven regions in wavelength order Film clip	80 mins	TV/data projector & VCR/DVD drive Paper & pens		
2.1.6	State typical wavelengths for each of these regions	Produce a poster on which typical wavelengths are flagged				
2.1.7	Analyse graphs to obtain data on amplitude, period, frequency, wavelength and phase	Teacher exposition and worked examples Practice questions with peer and teacher support	120 mins	Worksheet and/or question bank		

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
2.2.1	Describe an experiment to verify Snell's law	Class experiment to verify Snell's law conducted. Pupils to produce an experimental report	60 mins	Rectangular transparent block, ray box, PSU, protractor, plain paper, ruler	Care with electricity	
2.2.2	Recall and use the formula sin i /sin r = n	Produce a poster explaining what the symbols represent and their SI units Practice questions with peer and teacher support	60 mins	Paper & pens Worksheet and/or question bank		
2.2.3	Perform and describe an experiment to measure refractive index	Class experiment to measure refractive index conducted. Pupils to produce an experimental report	60 mins	Rectangular transparent block, ray box, PSU, protractor, plain paper, ruler	Care with electricity	
2.2.4	Demonstrate knowledge and understanding of total internal reflection	Class experiment to observe TIR and to measure the critical angle conducted. Pupils to produce an experimental report Computer simulation	60 mins	Semi-circular transparent block, ray box, PSU, protractor, plain paper, ruler Data projector & computer	Care with electricity	www.phy.ntnu.edu.tw/ntnujava/index.php?topic=49
2.2.5	Recall and use the formula sin $C = 1 / n$	Produce a poster explaining what the symbols represent and their SI units Practice questions with peer and teacher support	60 mins	Paper & pens Worksheet and/or question bank		

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
2.3.1	Draw ray diagrams for converging and diverging lenses	Teacher exposition and worked examples Practice questions with peer and teacher support	60 mins	Worksheet and/or question bank		
3.3.2	Use the equation $1/u + 1/v = 1/f$ for converging lenses	Teacher exposition and worked examples Practice questions with peer and teacher support	60 mins	Worksheet and/or question bank		
2.3.3	Perform and describe an experiment to measure the focal length of a converging lens	Class experiment to measure the focal length conducted for both methods. Pupils to produce an experimental report	60 mins	Lens + holder, screen, ruler, PSU mirror, lamp house	Care with electricity	
2.3.4	Rrecall and use the equation $m = v/u$	Produce a poster explaining what the symbols represent and their SI units Practice questions with peer and teacher support Class experiment to verify the theoretical predictions of both the ray diagrams and the calculations.	120 mins	Paper & pens Worksheet and/or question bank Lens + holder, screen, metre rule, PSU, lamp house	Care with electricity	
2.3.5	Describe the use of the lens to correct myopia and hypermetropia	Pair research to explain what these defects are and diagrams with text to explain their correction	80 mins	Text books &/or internet		
2.3.6	Perform calculations on the correction of long sight	Teacher exposition and worked examples Practice questions with peer and teacher support	60 mins	Worksheet and/or question bank		

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
2.3.7	Perform calculations involving the lens power of converging lenses	Teacher exposition and worked examples Practice questions with peer and teacher support		Worksheet and/or question bank		
2.4.1	Illustrate the concept of superposition by the graphical addition of two sinusoidal waves	Pupil research to find a definition of superposition Teacher exposition and worked examples Practice questions with peer and teacher support Computer simulation	60 mins	Worksheet and/or question bank Data projector & computer		www.mysite.verizon.net/vzeoacw1/wave_interference.html
2.4.2	Demonstrate knowledge and understanding of the graphical representation of standing waves in stretched strings and air in pipes closed at one end	Demonstration experiments showing each phenomenon conducted. Draw a labelled diagram of a typical experimental set-up to investigate stationary waves in strings and pipes. Draw diagrams to show the THREE simplest modes of vibration in each case and for each state how the length is related to the wavelength.	120 mins	Power sig. gen, vibration generator, string, bench pulley, slotted masses + hanger, large graduated cylinder, resonance tube, metre rule, tuning forks, bung, retort stand, boss head & clamp	Too large an amplitude may damage the vibration generator Care with electricity	
2.4.3	Identify node and anti-node positions	On each of the diagrams mark the nodes and anti-nodes				

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
2.4.4	Understand the significance of coherence as applied to wave sources	Teacher exposition	40 mins			
2.4.5	State the conditions for observable interference	Pupil research to complete an extended paragraph on the conditions for observable interference	60 mins	Text books &/or internet		
2.4.6	Understand the significance of path difference and phase difference in explaining interference effects	Teacher exposition and worked examples Computer simulation	60 mins	Worksheet and/or r question bank Data projector & computer		www.phy.ntnu.edu.tw/ntnujava/index.php?topic=20.0
2.4.7	Describe Young's slits interference experiment with monochromatic light	Demonstration experiment to show Young's slits interference. Pupils to produce an experimental report	100 mins	Laser + double slit	Danger of laser light Care with electricity	
2.4.8	Use the formula $\lambda = ay / d$ applied to Young's slits experiment	Practice questions with peer and teacher support Demonstration experiment to verify the formula		Worksheet and/or question bank Laser + double slit, travelling microscope, metre rule, measuring tape	Danger of laser light Care with electricity	
2.5.1	Describe and explain simple diffraction phenomena	Pupil research leading to a mind map	60 mins	Text books &/or internet		

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
2.5.2	State qualitatively, and draw diagrams to illustrate, the effect of aperture size on diffraction	Demonstration experiment to show single slit diffraction using 1. light and 2. ripple tank	40 mins			
2.6.1	Determine the frequency of a pure note using a cathode ray oscilloscope	Demonstration experiment to measure frequency using a CRO Practice questions with peer and teacher support	60 mins	Sig. gen, CRO, Worksheet and/or question bank	Care with electricity	
2.6.2	Perform and describe an experiment to measure the speed of sound in air using a resonance tube (end correction is not required)	Class experiment to measure the speed of sound in air using a resonance tube. Pupils to produce an experimental report	100 mins	Large graduated cylinder, resonance tube, metre rule, tuning forks, bung, retort stand, boss head & clamp		
2.6.3	Use the formula Intensity level = $10 \log_{10} (I / I_0)$	Teacher exposition and worked examples Practice questions with peer and teacher support	100 mins	Worksheet and/or question bank		
2.6.4	Interpret, qualitatively, graphs of frequency and intensity response for the ear	Pupil research leading to a report on human frequency – intensity response and how it compares with other animals	100 mins	Text books &/or internet		
2.7.1	Describe the flexible endoscope in terms of structure, technique and applications	Teacher exposition supported by film clips &/or computer simulations	300 mins	TV /data projector & VCR/DVD drive		

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
2.7.2	Describe ultrasonic A-scans and B-scans in terms of physical principles, basic equipment, technique and applications	Pupils to produce a mind map summary of all the imaging techniques				
2.7.3	Describe CT scans in terms of physical principles, basic equipment, technique and applications					
2.7.4	Describe MRI scans in terms of physical principles, basic equipment, technique and applications					
2.8.1	Recall and use the formula $E = hf$	Produce a poster explaining what the symbols represent and their SI units Practice questions with peer and teacher support	60 mins	Pens & paper Worksheet and/or question bank		
2.8.2	Use the photon model to explain the photoelectric effect qualitatively using the terms 'photon energy' and 'work function'	Demonstration experiment to show photoelectric effect Computer simulation Teacher exposition	120 mins	Polished zinc plate, coloumb meter or electroscope, polythene rod and duster, uv light , data projector & computer	Danger with uv light	www.usd.edu/phys/courses/phys431/notes/notes5g/photoelectric.html

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
2.9.1	Understand that electrons exist in energy levels in atoms	Teacher exposition	100 mins			
2.9.2	recall and use the formula $hf = E_1 - E_2$	Produce a poster explaining what the symbols represent and their SI units Practice questions with peer and teacher support		Worksheet and/or question bank		
2.9.3	Provide a simple explanation of laser action	Pair research leading to a presentation on laser action Computer simulation	120 mins	Worksheet and/or question bank Data projector and computer		www.colorado.edu/physics/2000/lasers/index.html
2.10.1	Categorise electromagnetic wave phenomena as being explained by the wave model, the photon model or both	Group research leading to an oral report	60 mins	Worksheet and/or question bank		
2.10.2	Describe electron diffraction	Pupil research leading to a report	60 mins	Worksheet and/or question bank		
2.10.3	Use the Broglie formula $\lambda = h / p$	Practice questions with peer and teacher support	60 mins	Worksheet and/or question bank		

Unit A2 1
Momentum, Thermal Physics, Circular Motions, Oscillations and Atomic and Nuclear Physics

Specification: AS Physics

Unit: A2 1: Momentum, Thermal Physics, Circular Motions, Oscillations and Atomic and Nuclear Physics

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4.1.1	Define momentum	Discuss the two aspects of motion – mass and velocity and define momentum as the product of these.	1 hour			
4.1.2	Calculate Momentum	Explain the importance of momentum as a vector. Use examples of change in momentum when an object's direction is reversed. Practise questions using the equation p=mv				
4.1.3	Demonstrate an appreciation of the conservation of linear momentum	Experiments to demonstrate conservation of linear momentum using linear air track & trolleys Simulation of linear air track can be found at www.sciencejoywagon.com/explrsci/media/airtrack.htm	1 ½ hours	Linear air track, trolleys, light gates	Care when moving equipment	
4.1.4	Perform calculations involving collisions in 1 dimension	Practise calculations using the principle of conservation of momentum Examine video footage of collisions, explosions etc and discuss in terms of conservation of momentum Some conservation of momentum animations at www.glenbrook.k12.il.us/gbssci/phys/mmedia/index.html#momentum	1 hour			

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
4.1.5	Use the terms 'elastic' and 'inelastic' to describe collisions	Discuss practical applications of collisions and calculate the kinetic energy before and after collisions. Use examples to explain why some collisions are elastic Use of linear air track to show elastic collisions using trolleys with repelling magnets or elastic bands Use of linear air track to show inelastic collisions using attracting magnets or cork and needle Links with section 4.2 – Reference to the collisions of molecules in ideal gases being elastic	1 ½ hours	Linear air track, trolleys, light gates	Care when moving equipment	
4.2.1	Describe simple experiments on the behaviour of gases to show that *pV*=constant for a fixed mass of gas at constant temperature, and *p*/*T*=constant for a fixed mass of gas at a constant volume, leading to the equation $\frac{pV}{T}$ = constant	Boyle's law experiment to demonstrate pV relationship. Pupils plot graphs of p against V & discuss relationship from shape of graph. Plot p against 1/V Experiment described at: www.practicalphysics.org/go/Collection_57.html?topic_id=4&collection_id=57 Charles Law experiment Pressure Law experiment. www.practicalphysics.org/go/Collection_87.	1 hours 1 hour 1 hour	Bourdon gauge or similar, foot pump V-T commercial apparatus or dry air trapped with mercury thread, oil or conc sulphuric acid in tube sealed at 1 end	check the compression joint holding the tube and any tube supports before use. Care using mercury/ using conc	

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
		html?topic_id=4&collection_id=87 Simulation of gas properties: www.phet.colorado.edu/new/simulations/sims.php?sim=Gas_Properties Students predict the relationships Extrapolate graphs to find temp at which P or V falls to zero Practise using equation Simulations of the experiments: www.aspire.cosmic-ray.org/javalabs/java12/gaslaws/index.htm	1 hour		sulphuric acid, tube must be stored in closed container with silica & clearly labelled	
4.2.2	Recall and use the ideal gas equation $pV=nRT$	Assumptions of ideal gases, discuss conditions under which real gases behave as ideal gases	1 ½ hours			
4.2.3	Recall and use the ideal gas equation in the form $pV=NkT$	Practise using the equation Practise calculating number of moles from mass of sample and molar mass Use Avogadro constant to find N from n and vice versa				
4.2.4	Use the equation $pV = \frac{1}{3}Nm < c^2 >$	Discuss the meaning of mean square speed and root mean square speed Perform calculations using the equation By considering what N and m are, pupils should be able to conclude that Nm is the total mass of the sample	1 hour			

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
4.2.5	Demonstrate an understanding of the concept of absolute zero	Discuss from previous extrapolation of V-T graph	1 - 2 hours			
4.2.6	Demonstrate and understanding of the concept of internal energy as the random distribution of potential and kinetic energy among molecules temperature	Possible internet research into reaching absolute zero or the behaviour of substances as they approach absolute zero Pupils describe what internal energy is and explain why in an ideal gas a change is only due to the kinetic energy changing				
4.2.7	Use the equations for average molecular kinetic energy $= \frac{1}{2} m < c^2 > = \frac{3}{2} kT$	Explain shape of graph of Number of gas molecules against speed – discussion of how shape of graph changes as T increases. Practise using equation and calculating kinetic energy of a molecule and kinetic energy of a sample when mass and molar mass is given	1 hour			
4.2.8	Perform and describe an electrical method for determination of specific heat capacity	Experimental determination of specific heat capacity of different metals. Comparison with values of SHC leading to class discussion of sources of error in experiment Experiment description: www.practicalphysics.org/go/Experiment_504.html?topic_id=39&collection_id=71	1 ½ hours	Electric Heaters, 1kg metal blocks, Thermometers, Insulation, Ammeter, Voltmeter, powerpack	Handle hot apparatus with care, Risk with electrical appliances near water	
4.2.9	Use the equation $Q = mc\Delta\theta$	Practise using the equation	1 hour			

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
4.3.1	Demonstrate an understanding of the concept of angular velocity	Pupils observe circular motion and understand that linear velocity of a point changes with r while angular velocity is constant Discussion of what a radian is. Pupils show with string that approx 6.28 (2π) lengths of the radius fit around the circumference of a circle, use to define radian Measure the angular velocity of some objects moving with circular motion Calculating angular velocity of objects eg model powered plane or object on thread flying in circle at constant speed	1 ½ hours			
4.3.2	Recall and use the equation $v = r\omega$	Model powered plane (or similar) on a thread flying in a circle at constant speed – Measure T and work out ω, measure r (a large error in this) , Find v using circumference/period and show that the equation is correct				
4.3.3	Apply the relationship $F = ma = \frac{mv^2}{r}$	Candle placed on turntable will show direction of centripetal force Useful question on what happens when centripetal force is removed. 4 animations shown of possible situations, students analyse each www.webphysics.davidson.edu/physletprob/ch7_in_class/in_class7_1/mechanics7_1_2.ht	1 hour	Glass tube, bung tied to string, paperclip on string at base of tube to keep r constant for each reading, stop clock	Care that bung is secured tightly on string; radius of circle not too large; Safety goggles must be worn	

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
		ml Model powered plane (or similar) on a thread flying in a circle at constant speed – various measurements & calculations can be done using F=mgcosθ, v, r Investigation – using rubber bung tied to string & passed through glass tube with mass at end to supply centripetal force F (investigate relationship between F and r, F and v or r and v or ω)	1 – 2 hours hour			
4.4.1	Define simple harmonic motion using the equation $a = -\omega^2 x$ where $\omega = 2\pi f$	Demonstrate mass-spring system & pendulum. Discuss values of displacement, velocity & acceleration at extremities and centre of motion leading to relationship between displacement and acceleration and definition of SHM Pupils explore website www.acoustics.salford.ac.uk/feschools/waves/shm.htm	1 hour	Mass on spring, simple pendulum, motion sensor, datalogger, oscilloscope connected to suitable transducer		
4.4.2	Perform calculations using $x = A\cos\omega t$	Use motion sensor to illustrate SHM Pupils could use computer modelling to investigate the effects of changing A and f	1 hour			
4.4.3	Demonstrate an understanding of s.h.m. graphs to include	Pupils derive graphs of velocity and acceleration against time for SHM given the graph of displacement against time	1 hour			

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
	measuring velocity from the gradient of a displacement time graph	www.edumedia-sciences.com/a266_l2-shm.html If data logger used for previous section, should be able to obtain velocity and acceleration time graphs				
4.4.4	Know and be able to use the terms free vibrations, forced vibrations, resonance and damping in this context	Use a vibration generator & mass spring system to investigate how the frequency at which resonance occurs depends on mass. Determine the natural frequency of the system at each mass leading pupils to the conclusion that for resonance forcing freq = natural freq Hacksaw blade clamped to desk & vibration generator against the blade will also show resonance – length of blade could be varied Demonstrate Barton's pendulums	1 ½ hours	Signal generator, Vibration generator, Mass on spring, Barton's pendulums Hacksaw blade, clamp	Safety goggles, care with mass-spring when resonance reached	
4.4.5	Understand the concepts of light damping, over damping and critical damping	Demonstrate light and heavy damping and discuss corresponding displacement time graph using for example mass-spring system oscillating in air, with card attached to increase air resistance and in oil or trolleys on linear air track connected with springs. Use magnets to increase damping Can be done using motion sensor & data logger	1 hour	Linear air track, trolleys with magnets attached		

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
4.4.6	Describe mechanical examples of resonance and damping	Pupils research and discuss problems & applications of resonance Discuss examples of light damping, critical damping and overdamping Pupils describe ways of increasing and decreasing damping	1 ½ hours 1 hour			
4.5.1	Be able to describe evidence for the existence of atomic nuclei, to include alpha particle scattering	Students to research Rutherford Scattering Pupils discuss the reasons for abandoning the plum pudding model www.particleadventure.org – How do we know any of this Demonstrate plum pudding model by rolling marbles down a track towards an aluminium or plastic 'hill' – marbles follow tracks similar to α particles near a gold nucleus Described at: www.practicalphysics.org/go/Experiment_572.html?topic_id=40&collection_id=76 Pupils describe the structure of an atom and know the relative charges and masses of protons, neutrons and electrons	2 hours	Plastic 'hill', marbles		
4.5.2	Know and interpret the variation of nuclear radius with nucleon number	Pupils analyse graph of nuclear radius against nucleon number Use of data on nuclear radii to show that r is proportional to $A^{1/3}$ Pupils plot r against $A^{1/3}$	1 hour			

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
4.5.3	Use the equation $r = r_0 A^{\frac{1}{3}}$	Pupils explain why A is proportional to r^3 by examining model of arranging spheres in a cube shape (1 sphere, 2x2 cube, 3x3 cube) Use the equation to predict the nuclear radius of various elements				
4.6.1	Understand how the nature of alpha-particles, beta-particles and gamma-radiation determines their penetration and range	Discuss what alpha particles, beta particle & gamma radiation are Measure background radiation and discuss where it originates. Explain how to correct count rate Carry out experiments to investigate their penetration and range Descriptions of experiments at: www.practicalphysics.org/go/Collection_80.html?topic_id=40&collection_id=80 Explain ionisation www.resources.schoolscience.co.uk/pparc/16plus/partich2pg2.html Explain reasons for the difference in penetrating power & range of the three types of radiation www.colorado.edu/physics/2000/isotopes/index.html	1 hour 1 ½ hours	Sealed alpha, beta and gamma sources, GM tube,		
4.6.2	Calculate changes to nucleon number and proton number as a result	Examine graph of number of neutrons against number of protons, discuss stability & how unstable nuclei decay.	1- 2 hours			

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
	of emissions	www.ithacasciencezone.com/chemzone/lessons/11nuclear/nuclear.htm Complete radioactive decay equations, discuss the changes in nuclei after different types of decay.				
4.6.3	Appreciate the random nature of radioactive decay	Dice, tossing coins or water flow to model exponential decay Described at: www.iop.org/activity/education/Teaching_Resources/Teaching%20Advanced%20Physics/Atomic%20and%20Nuclei/Radioactivity/file_5048.doc Radioactive decay applet:	1 hour	Dice, Glass tube filled with water, Hoffmann clip, clamp, boss& stand, stopclock, container to catch water		
4.6.4	Model with constant probability of decay, leading to exponential decay	www.lectureonline.cl.msu.edu/%7Emmp/applist/decay/decay.htm				
4.6.5	Use the equations $A = \lambda N$ and $A = A_0 e^{-\lambda t}$, where A is the activity	Discuss what is meant activity and by the decay constant. Pupils define the Becquerel www.s-Cool.co.uk/physics_extra/interactions/baedecay14.htm Practise using the equations to predict activity at a given time or to calculate the original activity of a source. Discuss the properties of an exponential decay curve	1 – 2 hours			

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
4.6.6	Define half-life Use $t_{\frac{1}{2}} = \frac{0.693}{\lambda}$	Pupils take ln of each side of equation in order to calculate λ or t Discuss what half life is Work out the half life of different isotopes from activity-time graphs Explain the use of half life in radiocarbon dating & medical use www.resources.schoolscience.co.uk/pparc/16plus/partich2pg3.html Pupils use excel file to investigate half life and apply carbon dating techniques: http://www.physicssource.ca/pgs/3008_ato_emath_16.html	1 ½ hours			
4.6.7	Describe an experiment to measure half-life	Demonstration – half life of Protactinium For details of the experiment including health & safety guidance see www.practicalphysics.org/go/Experiment_577.html	1 hour	GM tube in holder, protactinium generator, scaler, stopclock or ratemeter	Follow guidelines for working with radioactive substances	
4.7.1	Appreciate the equivalence of mass and energy	Pupils carry out research into nuclear energy and Einsten's equation	1 hour			
4.7.2	Recall the equation $E = mc^2$ and understand	Discuss mass defect in nuclear reactions	2 hours			

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
	that it applies to all energy changes	Explain the energy equivalence of 1u Pupils carry out simple calculations relating mass difference to energy change				
4.7.3	Use $E = \Delta mc^2$ in nuclear calculations	Use mass defect to predict if reactions will happen spontaneously				
4.7.4	Know how the binding energy per nucleon varies with mass number	Define nuclear binding energy and discuss how this relates to the stability of the nucleus. Compare the stability of different nuclei by using binding energy per nucleon Discuss general shape of the binding energy per nucleon curve	1 hour			
4.7.5	Describe the principles of fission and fusion with reference to the binding energy per nucleon curve	Pupils research into elements that undergo fission & fusion and look at position of these on the curve Explain in terms of stability with reference to the curve why fission and fusion occur Site with useful quicktime movies on fission: www.atomicarchive.com/Fission/Fission1.shtml	2 hours			
4.8.1	Describe a fission reactor in terms of chain reaction, critical size, moderators, control rods, cooling system and reactor shielding	Pupils complete internet research on the processes inside a fission reactor and produce a presentation on fission reactors www.phet.colorado.edu/new/simulations/sims.php?sim=Nuclear_Physics	2 hours			

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
		Animations of chain reactions: www.lectureonline.cl.msu.edu/~mmp/applist/chain/chain.htm Common questions and answers on nuclear power plants www.pbs.org/wgbh/pages/frontline/shows/reaction/etc/faqs.html				
4.9.1	Understand the conditions required for nuclear fusion	Elicit the need for alternative energy sources	1 hour			
4.9.2	Estimate the temperature for fusion	Discuss the process of nuclear fusion Useful websites for pupil research in section 4.9: www.ippex.pppl.gov/ www.iter.org/ www.fusedweb.pppl.gov/CPEP/chart.html Pupils use kinetic theory to estimate the temperature required for fusion				
4.9.3	Describe the following methods of plasma confinement: gravitational, inertial and magnetic	Pupils use websites to investigate the conditions required for fusion and as a result discuss the difficulties of achieving fusion on a practical terrestrial scale	2 hours			
4.9.4	Appreciate the difficulties of achieving fusion on a practical terrestrial scale	www.splung.com/content/sid/5/page/fusion				

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4.9.5 4.9.6	Describe the JET fusion reactor State the D-T reaction and appreciate why this is most suitable for terrestrial fusion	Pupils read articles such as Fusion for the future: www.rsc.org/Education/EiC/issues/2006May/Infochem.asp leading to class discussion www.jet.efda.org/pages/jet.html Pupils explain why the D-T reaction is most suitable for terrestrial fusion from their findings	1 hour 2 hours			

Unit A2 2: Fields and their Applications

Specification: A2 Physics

Unit: A2 2: Fields and their Applications

Introduction:

This scheme of work was prepared by practising teachers and is an attempt to interpret the requirements of the specification. The scheme of work is not meant to be complete as each school has different resources, equipment and expertise within their Science Departments. It is up to each school to make this presentation a living document and add to it where necessary or amend suggested activities to meet the changing needs and resources of the school.

This scheme of work should not be regarded as a substitute for any lesson plans and no attempt has been made to incorporate detailed lesson planning. Suggested activities or practical work, however, has been given as a possible method of meeting the requirements of the specification. The suggested activities are not prescriptive and alternative experiments/procedures may be successfully used

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Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
5.1.1	Explain the concept of a field of force	Students should be made aware that the term *field of force* is often referred to as simply *a field* and is a region where a force can be experienced Circus of experiments to illustrate fields of force as revision of GCSE Class discussion with pupils prompted to recall g as the acceleration due to gravity, the basics of electrostatics such as like charges repel, unlike charge attract, magnetic poles and field lines as a means of mapping magnetic fields The vector nature of fields should be explored.	1 hour	Bar magnets, plotting compasses and iron filings; polythene and acetate rods, a duster and an upturned watch glass; a rubber ball to drop	Make students aware of dangers of magnets with watches, bank cards etc.	
5.2.1	Define gravitational field strength	Suggested definition – The strength of a gravitational field is defined as the force acting on unit mass placed in the field	3 hours			Virtual Physical Laboratory CDROM from the National Physical Laboratory has simulations to plot gravitational field lines www.physicslab.co.uk
5.2.2	Recall and apply the equation $g = \frac{F}{m}$	Review use of this equation and complete several examples to practise its application				
5.2.3	State Newton's law of universal gravitation	Statement- Every body in the Universe attracts every other with a force which is directly proportional to the product of their masses and inversely proportional to the square of				

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
5.2.4	Recall and use the equation for the gravitational force between point masses, $F = G\frac{m_1 m_2}{r^2}$	their distance apart Discussion of Newton's observations of the Solar System leading to the law Students derive the units of G from analysis of the equation and check on data sheet Base units derived Students find value of G on data sheet and discuss with a partner the value with reference to the force between ordinary objects Students practise application of equation with several suitable examples				Stretch and Challenge:- Relate law to Newton's third law Suggest other inverse square relationships Discussion about this as a *law* but the Big Bang as a *theory*
5.2.5	Recall and apply the equation for gravitational field strength, $g = \frac{Gm}{r^2}$, and use this equation to calculate the Earth's mass	Students Combine $g = \frac{F}{m}$ and $F = G\frac{m_1 m_2}{r^2}$ and apply to suitable examples.				Stretch and Challenge Discuss how circular motion is used but orbits are elliptical
5.2.6	Apply knowledge of circular motion to planetary and satellite motion	Review Circular Motion theory and apply to example involving orbits				
5.2.7	Show that the mathematical form of Kepler's third law (t^2 proportional to r^3) is	Students research Kepler's work and laws Use centripetal force and Newton's Universal law to show Kepler's law consistent				

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	consistent with the law of universal gravitation.					
5.2.8	State the period of a geostationary satellite	Students complete historical timeline of satellite development. State meaning of geostationary and discuss origins of name In groups list uses of satellites.				
5.3.1	Define electric field strength	Suggested definition – The electric field at a point is the force per unit charge exerted on a positive charge placed at that point in the field.	4 hours			Virtual Physical Laboratory CDROM from the National Physical Laboratory has simulations to illustrate the concepts in E-field theory. www.physicslab.co.uk
5.3.2	Recall and apply the equation $E = \frac{F}{q}$	Students should justify that E can have units of N C^{-1} or V m^{-1}. Students should be given a range of examples and questions to practise the application of this equation				
5.3.3	State Coulomb's Law for the force between point charges	Suggested statement – The force between two point charges is directly proportional to the product of the charges and inversely proportional to the square of their distance apart				The Van de Graff generator is a popular lesson starter to stimulate discussion of electric charge.
5.3.4	Recall and use the equation for the force between two point charges,	Discussion that the law applies to point charges. Electrons and protons can approximate to point charges and an isolated uniformly charged sphere behaves as though the charge was concentrated at the centre				Coulomb was a

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	$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2} = \frac{kq_1 q_2}{r^2}$ where $k = \frac{1}{4\pi\varepsilon_0}$	Students should be given a range of examples and questions to practise the application of this equation				French scientist who investigated this in the 1780s
5.3.5	State that ε_0 is the permittivity of a vacuum and determine its SI base units	Discuss how the force between two charges depends on the material which separates them and how a high permittivity is one which reduces this force The units of permittivity can be given as $C^2N^{-1}m^{-2}$ and the SI base units derived. Students may be asked to find the value of ε_0 in a data sheet and note the unit is the farad per metre which will become clear later in the module				Stretch and Challenge Higher ability students may appreciate the 4π term indicating spherical symmetry
5.3.6	Recall and use the equation for the electric field strength due to a point charge, $E = \frac{q}{4\pi\varepsilon_0 r^2} = \frac{kq}{r^2}$	Students can show or be shown the development of the equation for the electric field strength due to a point charge from Coulomb's Law and the equation for the force per unit charge Students should be given a range of examples and questions to practise the application of this equation		Semolina powder suspended in castor oil with electrodes delivering high p.d. from Van der Graff shows field pattern. The experiment can be repeated with different shapes of		
5.3.7	Understand that for a uniform electric field the field strength is constant, and recall and use the	Discussion that electric field lines can be referred to as lines of force and indicate the strength of a field.				

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	equation $E = \frac{V}{d}$.	Shapes of field line patterns should be discussed. Pupils should consider why field lines do not cross Electric field lines can be demonstrated. A uniform electric field can be investigated		electrodes A home-made electroscope consisting of a charged gold-foil strip mounted at the end of a plastic ruler and held in the field produced by to metal plates connected to opposite terminals of a power supply		
5.3.8	Recognise similarities and differences in gravitational and electric fields	Students may work in pairs to identify similarities and difference in gravitational fields and electric fields. This may be stimulated by creating summary concepts maps showing their knowledge about both types of fields and making a comparison				
5.4.1	Define capacitance	Show students a range of capacitors. Introduce electrical symbol representing a capacitor and explain origins as pair of parallel metal plates Discuss the word capacitance as the ability to store charge and other uses of the word in everyday life (e.g. the capacitance to do something)	4 hours	A range of capacitors Parallel-plate capacitor Capacitor, resistor, millimetre, battery, stopcock	Electrolytic capacitor must be connected correctly to avoid damage and capacitors must be discharged	Extension More able pupils can use the exponential function to describe exponential decay Virtual Physical Laboratory CDROM from the National

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
5.4.2 5.4.3 5.4.4 5.4.5	Recall and apply the equation $C=Q/V$ Define the unit of capacitance, the farad Recall and use $\frac{1}{2}QV$ for calculating the energy of a charged capacitor Use the equation for the equivalent capacitance for capacitors in series and in parallel	Describe the action of a capacitor Suggested definition – capacitance equals the charge required to cause a change in potential of one volt of a conductor Discuss practical size of the unit the farad and ask students to examine sample capacitors to find out typical values and units Demonstrations using large electrolytic capacitors can show the energy stored in a capacitor Students practise application of equation Students can investigate the effect of different numbers of lamps and different voltage supply Students investigate capacitor networks and deduce relationship Students should be introduced to the method of calculating the equivalent capacitance for networks of capacitors by consideration of the p.d. and charge of capacitors in series and parallel		A circuit containing a capacitor, with movable connections to a battery and a lamp.	safely using a shorting lead after use.	Physical Laboratory has capacitor simulations www.physicslab.co.uk

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
		Students may be asked to compare equivalent capacitance in networks of capacitors, with equivalent resistance in resistor networks. Students may given a range of examples and questions to practise the application of this process				
5.4.6	Perform and describe experiments to demonstrate the charge and discharge of a capacitor	Students carry out experiments to investigate charge and discharge.				
5.4.7	Explain exponential decay using discharge curves	Use spreadsheets to plot graphs to illustrate charge and discharge.				
5.4.8	Define time constant and apply the equation $\tau = CR$	Students discuss shape of graphs with their partners and are prompted to describe exponential decay curves.				
5.4.9	Perform and describe an experiment to determine the time constant for R-C circuits	Time Constant as a measure of how long it takes a capacitor to charge through a resistor				
5.4.10	Apply knowledge and understanding of time constants and stored energy to electronic flash guns	Students determine time constant Students may be asked to recognise similarities with radioactivity decay curves. Discuss and demonstrate electronic flash guns		A camera flash gun		
5.5.1	Explain the concept of a magnetic field	Suggested explanation - the space around a magnet where a magnetic force is experienced is called a magnetic field	4 hours	Bar magnets, horseshoe magnet, iron		The historical development of discoveries in

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
		Again field lines should be demonstrated and discussed		filings. Filings suspended in glycerol show the 3D nature of the field of a bar magnet		this area of study may be explored as extension material – starting with Oersted in 1819
5.5.2	Understand that there is a force on a current-carrying conductor in a perpendicular magnetic field and be able to predict the direction of the force	Demonstration of force on current carrying conductor in magnetic field and use of Fleming's left-hand rule		A strip of aluminium foil carrying a current in the field of a large horseshoe magnet illustrates the force on a current carrying conductor		Useful websites:- www.walter-fendt.de/ph14e
5.5.3	Define magnetic flux density using the equation $F = BIl$	Demonstration of factors affecting the force				Virtual Physical Laboratory CDROM from the National Physical Laboratory has simulations to illustrate B-field concepts.
5.5.4	Define the unit of magnetic flux density, the tesla	The flux density defined as the force per unit current length – analogous to E and g Students derive the definition of the Tesla from the equation $F = BIl$ and show that the tesla is equivalent to N A^{-1} m^{-1} Students discuss the expression for the force on a current carrying conductor which is not perpendicular to the field.		Application of a.c. current shows the dependence of the direction of the force with current direction		www.physicslab.co.uk
5.5.5	Understand the concepts of magnetic flux and magnetic flux linkage	Electromagnetic induction discussed and explained		A current balance		Reference to electron flow and Fleming's Right Hand Rule

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
5.5.6 5.5.7 5.5.8 5.5.9 5.5.10 5.5.11 5.5.12	Recall and use the equation for magnetic flux, $\varphi = BA$, and flux linkage, $N\varphi$ Define the unit for magnetic flux, the weber State, use and demonstrate experimentally Faraday's and Lenz's laws of electromagnetic induction Recall and calculate induced e.m.f. as rate of change of flux linkage with time Describe how a transformer works Recall and apply the equation $\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$ for transformers Explain power losses in transformers and the	Ordering activity to arrange words correctly to describe equation Examples completed Weber defined from equation Faraday stated as - The induced emf is directly proportional to the rate of change of flux-linkage. Demonstrated with hoop of wire and diverging field lines of bar magnet.. Class experiment to show Faraday's and Lenz's Law – plunging bar magnet into solenoid Calculations illustrating concepts Discuss uses of transformers Outline differences between step-up and step-down transformers Students produce flow chart illustrating journey of electricity supply from power station to different consumers indicating transformers		Neodymium magnet in falling copper tube to illustrate electromagnetic braking em induction torch Solenoid, centre-zero galvanometer, bar magnet		The Earth's magnetic filed and magnetosphere may be discussed

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
	advantages of high voltage transmission of electricity					
5.6.1	Understand that a moving charge in a uniform, perpendicular electric field, experiences a force	Discuss streams of moving electrons as cathode rays Review Circular motion	3 hours	Cathode ray tube, Maltese cross tube, cross fields apparatus		Stretch and challenge Application to televisions Link to mass spectrometer
5.6.2	Recall and use the equation $F = Eq$ to calculate the magnitude of the force on a charged particle and determine the direction of the force	Demonstration of deflection of electron beams using cathode ray tubes Review equation and complete examples				Care using e.h.t. sources
5.6.3	Understand that a moving charge in a uniform, perpendicular magnetic field experience a force	Class discussion about Fleming's left hand and right rules depending on the charge considered				
5.6.4	Recall and use the equation $F = Bqv$ to calculate the magnitude of the force and determine its direction	Students use labelled diagrams to describe the movement of a charged particle in a B-field				
5.6.5	Outline the structure of the cathode ray oscilloscope	Students label diagram of cathode ray oscilloscope using a suitable text book				
5.6.6	Use, and explain how, the	Students use CRO to measure voltage				

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
	cathode ray oscilloscope can be used as a measuring instrument for voltage					
5.7.1	Describe the basic principles of operation of a linear accelerator, cyclotron and synchrotron	Students to research accelerators at CERN and Stanford and produces PowerPoint presentations Students apply concepts of fields to problems	2 hours			
5.7.2	Compare and contrast the three types of accelerator	Class discussion to identify similarities and differences in types of accelerators				
5.7.3	Understand the concept of antimatter and that it can be produced and observed using high energy particle accelerators	Student research antimatter using search engine and answer question sheet on production, observation and annihilation				
5.7.4	Describe the process of annihilation in terms of photon emission and conservation of energy and momentum					
5.8.1	Explain the concept of a fundamental particle	Review of protons, electrons and neutrons Students research historical development of particle theory	2 hours			www.particleadventure.org

Spec. Ref	Learning Outcomes	Suggested Teaching Strategies	Time Required	Resources	Risk Assessment Safety	Other Information
5.8.2	Identify the four fundamental forces and their associated exchange particles.	Students work in pairs to match fundamental forces with corresponding exchange particles				Stretch and Challenge Feynman diagrams
5.8.3	Classify particles as gauge bosons, leptons and hadrons (mesons and baryons).	Students research different types of quarks				
5.8.4	State examples of each class of particle.	Sorting activity with leptons and hadrons (subset to baryons and mesons)				
5.8.5	Describe the structure of hadrons in terms of quarks.	Questions on mesons and baryons are completed				
5.8.6	Understand the concept of conservation of charge, lepton number and baryon number.	Introduction to conservation laws				
5.8.7	Describe β-decay in terms of the basic quark model	Expressions and diagrams can be used to demonstrate understanding of this concept A question loop covering all aspects of particle physics can be used to summarise concepts. A matching exercise to reinforce definitions and laws.				