Cambridge Assessment International Education

Scheme of Work

Cambridge IGCSE®
Physics 0625

For examination from 2016

Version 2.0

Cambridge Pathway

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Contents

Introduction

This scheme of work has been designed to support you in your teaching and lesson planning. Making full use of this scheme of work will help you to improve both your teaching and your learners' potential. It is important to have a scheme of work in place in order for you to guarantee that the syllabus is covered fully. You can choose what approach to take and you know the nature of your institution and the levels of ability of your learners. What follows is just one possible approach you could take and you should always check the syllabus for the content of your course.

Suggestions for independent study **(I)** and formative assessment **(F)** are also included. Opportunities for differentiation are indicated as **Extension activities**; there is the potential for differentiation by resource, grouping, expected level of outcome, and degree of support by teacher, throughout the scheme of work. Timings for activities and feedback are left to the judgment of the teacher, according to the level of the learners and size of the class. Length of time allocated to a task is another possible area for differentiation.

Guided learning hours

Guided learning hours give an indication of the amount of contact time you need to have with your learners to deliver a course. Our syllabuses are designed around 130 hours for Cambridge IGCSE courses. The number of hours may vary depending on local practice and your learners' previous experience of the subject. The table below give some guidance about how many hours we recommend you spend on each topic area.

Topic	Suggested teaching time (%)	Suggested teaching order
1: Light	9 hours (7% of the course)	1
2: Electricity 1	10 hours (8% of the course)	2
3: Energy	13 hours (10% of the course)	3
4: Mechanics 1	9 hours (7% of the course)	4
5: Electromagnetism	16 hours (12% of the course)	5
6: Electricity 2	9 hours (7% of the course)	6
7: Thermal physics	18 hours (14% of the course)	7
8: Mechanics 2	20 hours (15% of the course)	8
9: Waves	6 hours (5% of the course)	9

Topic	Suggested teaching time (%)	Suggested teaching order
10: Atomic physics	16 hours (12% of the course)	10
11: Electronics	4 hours (3% of the course)	11

Resources

The up-to-date resource list for this syllabus, including textbooks endorsed by Cambridge International, is listed at www.cambridgeinternational.org
Endorsed textbooks have been written to be closely aligned to the syllabus they support, and have been through a detailed quality assurance process. As such, all textbooks endorsed by Cambridge International for this syllabus are the ideal resource to be used alongside this scheme of work as they cover each learning objective.

School Support Hub

The School Support Hub www.cambridgeinternational.org/support is a secure online resource bank and community forum for Cambridge teachers, where you can download specimen and past question papers, mark schemes and other resources. We also offer online and face-to-face training; details of forthcoming training opportunities are posted online. This scheme of work is available as PDF and an editable version in Microsoft Word format; both are available on the School Support Hub at www.cambridgeinternational.org/support. If you are unable to use Microsoft Word you can download Open Office free of charge from www.openoffice.org

Resource Plus

Throughout this scheme of work, you will find references to experiments from the *Resource Plus* platform.

Resource Plus

Experiment: Determining density

This experiment focuses on determining the density of solids and liquids.

Resource Plus provides specific information to help you to either carry out, or engage in virtual experiments with your learners. The materials include videos of experiments and accompanying *Skills Packs. The Skills Packs* have detailed lesson plans, extensive teacher advice and worksheets to guide you. If you don't have access to a lab or equipment, then the videos and materials in the *Skills Packs* can be used to provide a virtual experiment for your learners.

As well as the videos and *Skills Packs, Resource Plus* also offers a wide range of other materials for you to use in your classroom.
To try a demo, find out more, or to subscribe, visit www.cambridgeinternational.org/resourceplus

Websites

This scheme of work includes website links providing direct access to internet resources. Cambridge Assessment International Education is not responsible for the accuracy or content of information contained in these sites. The inclusion of a link to an external website should not be understood to be an endorsement of that website or the site's owners (or their products/services).

The website pages referenced in this scheme of work were selected when the scheme of work was produced. Other aspects of the sites were not checked and only the particular resources are recommended.

How to get the most out of this scheme of work – integrating syllabus content, skills and teaching strategies

We have written this scheme of work for the Cambridge IGCSE Physics 0625 syllabus and it provides some ideas and suggestions of how to cover the content of the syllabus. We have designed the following features to help guide you through your course.

Learning objectives help your learners by making it clear the knowledge they are trying to build. Pass these on to your learners by expressing them as 'We are learning to / about…'.

Suggested teaching activities give you lots of ideas about how you can present learners with new information without teacher talk or videos. Try more active methods which get your learners motivated and practising new skills.

Independent study (I) gives your learners the opportunity to develop their own ideas and understanding with direct input from you.

Extension activities provide your abler learners with further challenge beyond the basic content of the course. Innovation and independent learning are the basis of these activities.

Supplement (extended syllabus) is highlighted throughout the scheme of work for both the learning objectives and the suggested teaching activities.

Syllabus ref.	Learning objectives	Suggested teaching activities
2.1.4 Pressure changes	• Describe qualitatively, in terms of molecules, the effect on the pressure of a gas of: ○ a change of temperature at constant volume ○ a change of volume at constant temperature	A direct measuring Boyle's Law apparatus can be used here. Useful graph plotting and interpretation skills are included. **(I)** Place a partially inflated balloon in a bell-jar and reduce the pressure in the jar. **Extension activity:** extend this work by using the practical experiment about the temperature and pressure of a gas: www.youtube.com/watch?v=BxUS1K7xu30 Boyle's law: www.youtube.com/watch?v=N5xft2flqQU Charles' law: www.youtube.com/watch?v=HxSPdmvqstQ
changes	Recall and use the equation pV = constant for a fixed mass of gas at constant temperature	Values from the graph can be used to illustrate the constancy of the product pV. Also use phrases such as 'doubling the pressure halves the volume'. An interesting interactive experience for a more able learner to explore the ideas around the gas laws – Welcome to the Pressure Chamber: www.jersey.uoregon.edu/vlab/Piston/index.html

Past and specimen papers
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)** Past Paper Questions (Core 1)

Past papers, **specimen papers** and **mark schemes** are available for you to download at: www.cambridgeinternational.org/support

Using these resources with your learners allows you to check their progress and give them confidence and understanding.

Formative assessment (F) is on-going assessment which informs you about the progress of your learners. Don't forget to leave time to review what your learners have learnt, you could try question and answer, tests, quizzes, 'mind maps', or 'concept maps'. These kinds of activities can be found in the scheme of work.

1: Light

Syllabus ref.	Learning objectives	Suggested teaching activities
3.2.1 Reflection of light	• Describe the formation of an optical image by a plane mirror, and give its characteristics • Recall and use the law angle of incidence = angle of reflection	Use simple experiments with optical pins to find the position of the image in a plane mirror. Use ray box experiments to investigate the relationship angle of incidence = angle of reflection. How to make a simple periscope: www.lightwave.soton.ac.uk/experiments/periscope/periscope.html
3.2.1 Reflection of light	• Recall that the image in a plane mirror is virtual • Perform simple constructions, measurements and calculations for reflection by plane mirrors	Extend to draw simple ray diagrams. Explain that the brain assumes that light has travelled in straight lines and locate the position of an image in a mirror. If time allows, the behaviour of mirrors at 45°, 60° or 90° to each other may be investigated. Lateral inversion is difficult to understand and a full explanation involves a discussion on the symmetry of the human body. The wording on the front of emergency vehicles is often written in mirror writing so that lateral inversion in a driving mirror corrects it. If someone stands on a horizontal mirror, they are vertically inverted. Stereoscopic vision: www.vision3d.com/stereo.html Lateral inversion: www.bbc.co.uk/learningzone/clips/lateral-inversion-in-a-mirror/251.html
3.2.2 Refraction of light	• Describe an experimental demonstration of the refraction of light • Use the terminology for the angle of incidence *i* and angle of refraction *r* and describe the passage of light through parallel-sided transparent material • Give the meaning of critical angle	Use rectangular transparent blocks (Perspex or glass) with optical pins or ray boxes to investigate refraction. The refraction of light in air that has been heated, explains the phenomenon of a heat haze. Develop this to experiments with a semi-circular transparent block to investigate critical angle and total internal reflection. Instructions for a demonstration of total internal reflection: www.youtube.com/watch?v=NAaHPRsveJkzc Experiments on refraction, reflection and total internal reflection: www.youtube.com/watch?v=gDA_nDXM-ck Further experiments related to total internal reflection and more: http://galileo.phys.virginia.edu/outreach/8thGradeSOL/ActivitiesList.htm#9

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Describe internal and total internal reflection	
3.2.2 Refraction of light	• Recall and use the definition of refractive index *n* in terms of speed • Recall and use the equation $\frac{\sin i}{\sin r} = n$ • Recall and use $n = \frac{1}{\sin c}$ • Describe and explain the action of optical fibres particularly in medicine and communications technology	Extension activity: extend the refraction work with the rectangular block to include quantitative use of sin *i* /sin *r*. An accurate value of the refractive index can be obtained from the gradient of a graph of sin *i* against sin *r*. Encourage deeper thought with abler learners by discussing refractive index in terms of the speed of light in different materials. Use inexpensive 'novelty' light items to demonstrate optical fibres. Refractive index: www.bbc.co.uk/bitesize/higher/physics/radiation/refraction/revision/2/ To find the refractive index of a glass: www.youtube.com/watch?v=DZfqQcFV7W8 Optical cable: www.youtube.com/watch?v=0MwMkBET_5I www.youtube.com/watch?v=4i7maoqVcaY
3.2.3 Thin converging lens	• Describe the action of a thin converging lens on a beam of light • Use the terms principal focus and focal length • Draw ray diagrams for the formation of a real image by a single lens • Describe the nature of an image	Investigate converging lenses by: forming an image of a distant object, e.g. a tree or building seen from the laboratory window, bringing parallel rays from a ray box to a focus through a cylindrical lens, drawing ray diagrams to scale to show the formation of a real image. The anatomy of a lens: www.physicsclassroom.com/Class/refrn/U14L5a.html Thin lens (converging/diverging lens/mirrors): www.phy.ntnu.edu.tw/ntnujava/index.php?topic=48

Syllabus ref.	Learning objectives	Suggested teaching activities
	using the terms enlarged/same size/diminished and upright/inverted	
3.2.3 Thin converging lens	• Draw and use ray diagrams for the formation of a virtual image by a single lens • Use and describe the use of a single lens as a magnifying glass • Show understanding of the terms real image and virtual image	Extend the ray diagram work to include the formation of a virtual image and use a magnifying glass. **(I)** Remember that a virtual image produced by a lens (or by a mirror) relies on the brain assuming that the light is travelling to the eye in a straight line. Virtual image: www.physicsclassroom.com/class/refln/Lesson-2/Image-Characteristics www.youtube.com/watch?v=IBKGP6Fh9vs
3.2.4 Dispersion of light	• Give a qualitative account of the dispersion of light as shown by the action on light of a glass prism including the seven colours of the spectrum in their correct order	Use a simple experiment, or demonstration, to show that white light from a ray box or slide projector is dispersed by a prism. A single slit can be cut from a piece of stiff card and inserted in the slide carrier of the projector to produce a ray that can be shone through the prism onto a screen. Although not part of the syllabus, learners will find it interesting to learn a little about mixing coloured lights at this stage. When light passes into a parallel-sided glass block, the dispersion occurring at the first face is reversed at the second face and so dispersion in glass blocks is usually ignored. In a prism, the second face exaggerates the dispersion and so the effect is much more obvious and cannot be ignored. Colour mixing: www.youtube.com/watch?v=LCs8mK1rzc0 For prism work: www.mistupid.com/science/prism.htm
3.2.4 Dispersion of light	• Recall that light of a single frequency is described as monochromatic	This is a simple fact and the definition of the syllabus word. Use of the word monochromatic: http://sentence.yourdictionary.com/monochromatic

Past and specimen papers
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**

2: Electricity 1

Syllabus ref.	Learning objectives	Suggested teaching activities
4.2.2 Current	• State that current is related to the flow of charge • Use and describe the use of an ammeter, both analogue and digital • State that current in metals is due to a flow of electrons	Use simple circuits to measure current and use both analogue and digital meters. Digital meters are easier to read if the reading is stable, but when the digits keep changing, this can be a source of difficulty. Generally, the inertia of the needles ensures that analogue meters give a more stable reading. A series of useful pages relating to electricity and magnetism: www.galaxy.net/~k12/electric/index.shtml Using a digital meter: www.youtube.com/watch?v=Ftc3EQGZowk
4.2.2 Current	• Show understanding that a current is a rate of flow of charge and recall and use the equation $I = Q/t$ • Distinguish between the direction of flow of electrons and conventional current	A Van de Graaff generator can be used with a micro ammeter or nanometer and a shuttling ball to show that current is a flow of charge. Interesting information about static electricity and how the Van de Graaff generator works: www.engr.uky.edu/~gedney/courses/ee468/expmnt/vdg.html www.wonderhowto.com/how-to-experiment-with-van-de-graaff-generator-272678/ Shuttling ball experiment: www.youtube.com/watch?v=2Rh8fJnvisA At the mention of the Van de Graaff generator, learners are likely to ask about lightning – try this site about the work of Benjamin Franklin. Franklin survived but some of those who tried to duplicate this experiment were killed. www.history.com/this-day-in-history/franklin-flies-kite-during-thunderstorm
4.2.3 Electro-motive force	• State that the e.m.f. of an electrical source of energy is measured in volts	Give specific examples: cells, batteries with the e.m.f. written on them. Emphasise that it is the e.m.f. (in volts) that is written, not the current which depends on the circuit. Sources with a variable e.m.f. are also worth mentioning.

Syllabus ref.	Learning objectives	Suggested teaching activities
4.2.3 Electro-motive force	• Show understanding that e.m.f. is defined in terms of energy supplied by a source in driving charge round a complete circuit	An analogy with water being pumped around a closed system, e.g. central heating, can be useful here to enable the learners to have a mental picture which helps them to distinguish between current (the water) and e.m.f. (the energy from the water pump). Electric current can be compared to the moving chain of a bicycle. The bicycle analogy: www.youtube.com/watch?v=ecMM9z39irg
4.2.4 Potential difference	• State that the potential difference (p.d.) across a circuit component is measured in volts • Use and describe the use of a voltmeter, both analogue and digital	Continue the circuit work, measuring potential differences with a voltmeter. Show that the e.m.f. of the source is equal to the sum of the p.d.s across series components and equal to the p.d. across parallel components. Voltmeters in parallel with the component: www.bbc.co.uk/bitesize/ks3/science/energy_electricity_forces/electric_current_voltage/revision/5/
4.2.4 Potential difference	• Recall that 1 V is equivalent to 1 J/C	This is a statement of a fact – the definition of the volt. Abler learners might wish to be told that in a cell, the number of ions reacting increases in proportion with the number of electrons entering and leaving the cell. If twice the charge flows, then twice the number of electrons enter the cell, twice the number of ions react and twice the energy is liberated. Hence a given number of coulombs always releases a given quantity of energy. The volt: www.schoolphysics.co.uk/age14-16/Electricity%20and%20magnetism/Current%20electricity/text/Volts_amps_and_joules/index.html
4.2.5 Resistance	• State that resistance = p.d./current and understand qualitatively how changes in p.d. or resistance affect current • Recall and use the equation $R = V / I$ • Describe an experiment to determine resistance using a voltmeter and an ammeter • Relate (without calculation) the	**Extension activity:** extend the circuit work using an ammeter and a voltmeter to measure I and V and so calculate resistance of a resistor. **(I)** By using samples of nichrome or constantan wire of different lengths and diameters suitable resistance comparisons can be made. There are many practicals that can be performed using this topic. **Resource Plus** **Experiment:** Factors affecting the resistance of a wire This experiment focuses on the factors affecting the resistance of a wire.

Syllabus ref.	Learning objectives	Suggested teaching activities
	resistance of a wire to its length and to its diameter	Why not create a vocabulary quiz at this stage to test knowledge in a different way? A unit quiz highlights areas of uncertainty. Resistance: www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_gateway/radiation/safeelectricalsrev3.shtml Measuring voltage and current: www.youtube.com/watch?v=z6-c4jLXkMo
4.2.5 Resistance	• Sketch and explain the current-voltage characteristic of an ohmic resistor and a filament lamp • Recall and use quantitatively the proportionality between resistance and length, and the inverse proportionality between resistance and cross-sectional area of a wire	**Extension activity:** extend the experimental resistance work to give quantitative results. **(I)** Resistance of a filament lamp: www.youtube.com/watch?v=qbhoGefCUiA Resistance, length and area: www.physicsclassroom.com/class/circuits/Lesson-3/Resistance
4.2.6 Electrical working	• Understand that electric circuits transfer energy from the battery or power source to the circuit components then into the surroundings	This point can be made whenever a circuit is used; there is always an energy transfer from the source to elsewhere. Energy in a circuit: www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_pre_2011/electric_circuits/mainselectricityrev1.shtml
4.2.6 Electrical working	• Recall and use the equations $P = IV$ and $E = IVt$	Both of these equations relate to the definition of potential difference and electromotive force. Formulas: http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elepow.html

Past and specimen papers
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3: Energy

Syllabus ref.	Learning objectives	Suggested teaching activities
1.7.1 Energy	• Identify changes in kinetic, gravitational potential, chemical, elastic (strain), nuclear and internal energy that have occurred as a result of an event or process • Recognise that energy is transferred during events and processes, including examples of transfer by forces (mechanical working), by electrical currents (electrical working), by heating and by waves • Apply the principle of conservation of energy to simple examples	A number of devices which convert energy from one form to another, e.g. loudspeaker, steam engine, solar-powered motor, candle can be used. A circus of simple experiments can be set up for learners to identify the energy conversions. Kits are available which enable falling weights to power generators or cells to turn motors which lift weights. It is worth driving home the point with many different examples but ensure that the focus of the demonstration is energy conversion. Unusual and fun energy change experiments: www.childrensuniversity.manchester.ac.uk/interactives/science/energy/what-is-energy/ www.physicsclassroom.com/class/energy www.brightstorm.com/science/physics/energy-and-momentum/conservation-of-energy/
1.7.1 Energy	• Recall and use the expressions kinetic energy = $\frac{1}{2}mv^2$ and change in gravitational potential energy = $mg\Delta h$ • Apply the principle of conservation of energy to examples involving multiple stages • Explain that in any event or process the energy tends to become more spread out among the objects and	The gravitational potential energy formula can be deduced in terms of work done and it seems likely that the greater the height and the greater the weight, the greater is the gravitational potential energy stored. The kinetic energy formula is probably best quoted although again the relationship to the mass is highly likely. Similarly, since an object moving backwards (velocity negative) has positive energy and can be used to do work, the presence of the square can be justified. Hydroelectric power stations are usually a good example of a multi-stage energy conversion. The last part of this section is essentially the second law of thermodynamics but there is no need, at this level, to go beyond what is stated in the syllabus. Pumped storage schemes: www.bbc.co.uk/bitesize/standard/physics/energy_matters/generation_of_electricity/revision/3/

Syllabus ref.	Learning objectives	Suggested teaching activities
	surroundings (dissipated)	
1.7.2 Energy resources	• Describe how electricity or other useful forms of energy may be obtained from: ○ chemical energy stored in fuel ○ water, including the energy stored in waves, in tides, and in water behind hydroelectric dams ○ geothermal resources ○ nuclear fission ○ heat and light from the Sun (solar cells and panels) ○ wind • Give advantages and disadvantages of each method in terms of renewability, cost, reliability, scale and environmental impact • Show a qualitative understanding of efficiency	Examples of both renewable and non-renewable sources of energy can be considered along with their advantages and disadvantages. Be careful with categorising wood; wood is a renewable resource, as is all biomass, although we sometimes use it in a non-sustainable way (deforestation). Important discussions here to consolidate the learners' understanding of energy processes both in physical and environmental impact terms. A significant disadvantage of many renewable sources is their intermittency and because electrical energy is difficult to store on a large scale, the problem of energy storage to cover the times when little or no electricity is being generated is a significant aspect to the discussion. This website provides a useful investigation into alternative energy: www.altenergy.org/ Power generation: www.bbc.co.uk/bitesize/standard/physics/energy_matters/generation_of_electricity/revision/1/ www.open.edu/openlearn/science-maths-technology/science/environmental-science/energy-resources-introduction-energy-resources/content-section-0 Energy storage: http://science.howstuffworks.com/environmental/energy/question247.htm
1.7.2 Energy resources	• Understand that the Sun is the source of energy for all our energy resources except geothermal, nuclear and tidal • Show an understanding that energy is released by nuclear fusion in the Sun • Recall and use the equations: efficiency =	The solar origin of solar energy is obvious. The other origins can be explained in outline by describing how the Sun heats the sea which leads to evaporation and hence rainfall (hydroelectric power) and how the expansion of air above land and sea drives the winds and hence causes waves at sea. The transformation of solar energy by photosynthesis can lead to the use of wood or peat as a fuel source and after many hundreds of millions of years, living things can be turned to fossil fuels. Many learners will be aware that on a hot day, it is cooler under a tree than under an artificial shade because the tree transfers solar energy into chemical energy by photosynthesis. The concept of efficiency is readily understood by many learners. It can be tackled through specific numerical examples. The use of the expression output/input should be discouraged as it disguises the link with the Principle of the Conservation of Energy.

Syllabus ref.	Learning objectives	Suggested teaching activities
	$\frac{\text{useful energy output}}{\text{energy input}} \times 100$ efficiency = $\frac{\text{useful power output}}{\text{power input}} \times 100$	Fusion in the Sun: www.youtube.com/watch?v=pusKlK1L5To
2.3.1 Conduction	• Describe experiments to demonstrate the properties of good and bad thermal conductors	There are many simple experiments that can be performed here. Some simple experiments can be used to compare thermal conductivity, e.g. using metal conductivity rods. There are poor conductors of heat but no true insulators; all materials conduct to some noticeable extent. **Resource Plus** **Experiment:** Heat conduction in metal rods This experiment focuses on measuring relative rates of thermal conductivity. Conduction in copper and steel: www.youtube.com/watch?v=eMGqkOTJCN0
2.3.1 Conduction	• Give a simple molecular account of conduction in solids including lattice vibration and transfer by electrons	Extend to a molecular account – a row of learners can be used to model the idea of increased vibration of particles as the process of conduction. It is important to distinguish between the vibration of atoms which only pass energy to their neighbours and the translational motion of the electrons which can transfer energy to very large distant ions provided there are no collisions on the way. How does heat travel? www.bbc.co.uk/schools/gcsebitesize/science/aqa_pre_2011/energy/heatrev1.shtml www.s-cool.co.uk/category/subjects/gcse/physics/energy-transfers

Syllabus ref.	Learning objectives	Suggested teaching activities
2.3.2 Convection	• Recognise convection as an important method of thermal transfer in fluids • Relate convection in fluids to density changes and describe experiments to illustrate convection	Use simple experiments to illustrate convection, e.g. dissolving a crystal of potassium manganate(VII) at the bottom of a large beaker that is heated by a candle flame. **(I)** Show convection in air using, for example, a mine ventilation model. Discuss heaters at ground level and air-conditioning units at ceiling level. **Resource Plus** **Experiment:** Convection currents This experiment focuses on a convection current experiment using potassium permanganate. Remember that convection is the main mechanism by which the central heating equipment (which is usually called a radiator) passes thermal energy around a room. Convection: www.edumedia-sciences.com/en/a639-thermal-convection
2.3.3 Radiation	• Identify infra-red radiation as part of the electromagnetic spectrum • Recognise that thermal energy transfer by radiation does not require a medium • Describe the effect of surface colour (black or white) and texture (dull or shiny) on the emission, absorption and reflection of radiation	The word radiation is used in many contexts in science and even in IGCSE there are two or three significantly different uses. In this topic, radiation means the infra-red radiation that is emitted by all objects at all temperatures but is emitted at the largest rate by the hottest bodies. It is worth emphasising that the boundary between infra-red radiation and microwaves is an arbitrary line drawn at a particular wavelength/frequency for convenience. Learners should be able to distinguish emission from absorption. These two features are commonly taught at the same time. When offering an explanation, learners need to be clear whether a particular behaviour is observed because of absorption or emission. What is infra-red radiation? www.bbc.co.uk/schools/gcsebitesize/science/aqa/heatingandcooling/heatingrev1.shtml www.youtube.com/watch?v=_WP2XwBhmAk www.gemini.edu/public/infrared.html
2.3.3 Radiation	• Describe experiments to show the properties of good and bad emitters and good and bad absorbers of infra-red radiation	Leslie's cube type experiments show the effect of the colour of a surface on the emission of radiation. (I) A thick (3–5 mm) sheet of copper, covered with lamp-black (powdered carbon) on one side, if heated strongly with a Bunsen burner on the other side, will emit noticeably more heat from the blackened side when the Bunsen burner is removed.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Show understanding that the amount of radiation emitted also depends on the surface temperature and surface area of a body	Absorption of infra-red radiation can be shown easily by arranging two thermometers at equal distances from a working 12 V headlamp bulb. One thermometer has a blackened bulb (use a felt-tip pen or poster paint). Leslie's cube: www.youtube.com/watch?v=D1PJQMXYiH8
2.3.4 Consequences of energy transfer	• Identify and explain some of the everyday applications and consequences of conduction, convection and radiation	A good opportunity to carry out some investigative experiments involving rate of cooling and insulation. **(I)** Discussion of the vacuum flask is a useful way to revise conduction, convection and radiation, as is discussion about the domestic refrigerator. Obtain two identical stainless steel vacuum flasks; drill a hole in the outside of one so that air enters the vacuum. Compare by data-logging the rates of fall of temperature. Vacuum flask: www.youtube.com/watch?v=mT4qZA3BAjI

Past and specimen papers
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4: Mechanics 1

Syllabus ref.	Learning objectives	Suggested teaching activities
1.1 Length and time	• Use and describe the use of rules and measuring cylinders to find a length or a volume • Use and describe the use of clocks and devices, both analogue and digital, for measuring an interval of time • Obtain an average value for a small distance and for a short interval of time by measuring multiples (including the period of a pendulum)	A circus of simple measuring experiments can work well here. When measuring the period of a pendulum, it may be pointed out that the pendulum is travelling at its fastest as it passes through the centre of the oscillation. Consequently, this moment is more precisely defined than the moment that it reaches a maximum displacement. Timing should begin and end at the centre point. The only difficulty is that learners might count half oscillations rather than full ones. Pendulums are easy to set up and learners may see the effect of changing the length, changing the mass and changing the amplitude on the period. The idea of a fiducial marker may also be suggested for this experiment. Simple activities such as wrapping a length of thread ten times round a boiling tube, measuring the length of thread and then calculating the circumference of the tube, working out the thickness of paper by the thickness of the stack and timing 20 swings of a pendulum to find the period. **(I)**
1.1 Length and time	• Understand that a micrometer screw gauge is used to measure very small distances	Both electronic and mechanical micrometer screw gauges can be used. Using a micrometer: www.youtube.com/watch?v=O8vMFFYNIfo
1.2 Motion	• Define speed and calculate average speed from $\frac{\text{total distance}}{\text{total time}}$ • Plot and interpret a speed-time graph or a distance-time graph • Recognise from the shape of a speed-time graph when a body is ○ at rest ○ moving with constant speed ○ moving with changing speed	Work with trolleys using ticker tape, light gates or ultrasound sensors and data-loggers to produce speed-time graphs for constant speed and constant acceleration. **(I)** **Resource Plus** **Experiment:** Speed-time graphs This experiment focuses on a speed-time experiment. Learners should be able to define the speed and calculate an average speed using the equation total distance / total time. Although not specifically part of the syllabus, work on thinking distance and braking distance of cars related to safety is useful and relevant here. There is a great deal that can be done here with a few simple experiments which will help learners to understand what graphs tell us.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Calculate the area under a speed-time graph to work out the distance travelled for motion with constant acceleration • Demonstrate understanding that acceleration and deceleration are related to changing speed including qualitative analysis of the gradient of a speed-time graph • State that the acceleration of free fall for a body near to the Earth is constant	Definition of velocity: www.youtube.com/watch?v=cE-bGnwTbTU What is acceleration: www.youtube.com/watch?v=I7W5pH0AKSI www.youtube.com/watch?v=_O0l3hWs5gM Stopping distances can be found from: www.bbc.co.uk/schools/gcsebitesize/science/add_gateway_pre_2011/forces/motionrev3.shtml A fun investigation involving ideas around terminal velocity: www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/forces/forcesvelocityrev1.shtml http://hyperphysics.phy-astr.gsu.edu/hbase/airfri2.html
1.2 Motion	• Distinguish between speed and velocity • Define and calculate acceleration using $\frac{\text{change of velocity}}{\text{time taken}}$ • Calculate speed from the gradient of a distance-time graph • Calculate acceleration from the gradient of a speed-time graph • Recognise linear motion for which the acceleration is constant • Recognise motion for which the	**Extension activity:** extend the trolley work to analyse the graphs further and calculate the acceleration. **(I)** Learners find it difficult to distinguish between a decreasing speed and a speed that is increasing at a decreasing rate and so this point is worth emphasising. Terminal velocity: www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/forces/forcesvelocityrev1.shtml http://hyperphysics.phy-astr.gsu.edu/hbase/airfri2.html

Syllabus ref.	Learning objectives	Suggested teaching activities
	acceleration is not constant • Understand deceleration as a negative acceleration • Describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity)	
1.3 Mass and weight	• Show familiarity with the idea of the mass of a body • State that weight is a gravitational force • Distinguish between mass and weight • Recall and use the equation $W = mg$ • Demonstrate understanding that weights (and hence masses) may be compared using a balance	It is useful to ensure that learners have a feeling for the sizes of forces (in N) by asking them to estimate, e.g. weight of a laboratory stool, force required to open a drawer, and then to measure using a spring (newton) balance. Similarly, estimation and measurement of masses (in g and kg). Gravity (for more able learners): www.qrg.northwestern.edu/projects/vss/docs/space-environment/1-what-is-gravity.html Gravitational fields: www.youtube.com/watch?v=T8nLTwIWplo
1.3 Mass and weight	• Demonstrate an understanding that mass is a property that 'resists' change in motion • Describe, and use the concept of, weight as the effect of a gravitational field on a mass	Use some 'novelty' demonstrations, e.g. pulling a sheet of paper from under a mass, without moving the mass, to show the idea of inertia. What is inertia: www.physicsclassroom.com/class/newtlaws/Lesson-1/Inertia-and-Mass Demonstrations of inertia: www.youtube.com/watch?v=T1ux9D7-O38

Syllabus ref.	Learning objectives	Suggested teaching activities
1.4 Density	• Recall and use the equation $\rho = \frac{m}{V}$ • Describe an experiment to determine the density of a liquid and of a regularly shaped solid and make the necessary calculation • Describe the determination of the density of an irregularly shaped solid by the method of displacement • Predict whether an object will float based on density data	Simple experiments measuring mass and volume of a liquid and calculating density. Using a solid, finding volume from height, width and depth. **(I)** Determine the density of cooking oil by putting a measuring cylinder on an electronic balance. Take the readings as more and more oil is added. Plot a graph of mass against volume; gradient can be used to obtain the density. **Extension activity:** extend to the displacement method, e.g. modelling clay of different shapes in a measuring cylinder with water. **Resource Plus** **Experiment:** Determining density This experiment focuses on determining the density of solids and liquids. Density: www.youtube.com/watch?v=Q5Sh_-pW6ho Calculate the density of an unknown solid: www.youtube.com/watch?v=nGJ_uWTmQZI Determining density of liquids – an experiment: www.youtube.com/watch?v=RnSJSSCfgPc

Past and specimen papers
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**

5: Electromagnetism

Syllabus ref.	Learning objectives	Suggested teaching activities
4.1 Simple phenomena of magnetism	• Describe the forces between magnets, and between magnets and magnetic materials • Give an account of induced magnetism • Distinguish between magnetic and non-magnetic materials • Describe methods of magnetisation, to include stroking with a magnet, use of d.c. in a coil and hammering in a magnetic field • Draw the pattern of magnetic field lines around a bar magnet • Describe an experiment to identify the pattern of magnetic field lines, including the direction • Distinguish between the magnetic properties of soft iron and steel • Distinguish between the design and use of permanent magnets and electromagnets	Simple experiments with magnets to show attraction and repulsion, leading to investigation of the field patterns around bar magnets (individually and between attracting poles and between repelling poles). **Extension activity:** extend to show the direction of the field lines using a plotting compass. Make and use a simple electromagnet. **(I)** Experiments to investigate the magnetisation of iron or steel by mechanical and electrical means. Iron is considered to be magnetically soft whilst steel is magnetically hard. It should be realised, however, that, in reality, iron is rarely pure and the term steel covers a wide range of different alloys of iron with various magnetic properties. 'Gallery of Electromagnetic Personalities' contains brief histories of 43 scientists who have made major contributions, from Ampere to Westinghouse: www.ee.umd.edu/~taylor/frame1.htm How to make an electromagnet: www.sciencebob.com/experiments/electromagnet.php
4.1 Simple phenomena of	• Explain that magnetic forces are due to interactions between	Experiments to investigate the magnetisation of iron or steel and demagnetisation of samples of steel by mechanical and electrical means. **(I)**

Syllabus ref.	Learning objectives	Suggested teaching activities
magnetism	magnetic fields • Describe methods of demagnetisation, to include hammering, heating and use of a.c. in a coil	A steel bar aligned with a magnetic field may be both magnetised by hammering it but it may also be demagnetised by hammering it when it is at right angles to a field, or better still not in a magnetic field at all. Learners who do not remember the entirety of what has been discussed might be prone to confuse these. Magnetisation and demagnetisation: http://ap-physics.david-s.org/methods-magnetisation-demagnetisation/ www.youtube.com/watch?v=Dka-cROHxBY
4.6.1 Electro-magnetic induction	• Show understanding that a conductor moving across a magnetic field or a changing magnetic field linking with a conductor can induce an e.m.f. in the conductor • Describe an experiment to demonstrate electromagnetic induction • State the factors affecting the magnitude of an induced e.m.f.	This topic really must be demonstrated by experiment. One such includes moving a permanent magnet into and out of a coil, connected to a very sensitive meter. This can be extended to show the same effect using an electromagnet moved in and out of the coil and then by simply switching the electromagnet on and off. **Extension activity:** extend the experiments above to show the effects of the strength of the field (use a stronger permanent magnet or increasing the current in the electromagnet), the speed of movement and the number of turns per metre in the coil. **Resource Plus** **Experiment:** How to make an electromagnet This experiment focuses on an investigation to measure the strength of an electromagnet. Links with 4.6.4 The magnetic effect of a current and 4.1 Simple phenomena of magnetism Electromagnetic induction: www.ndt-ed.org/EducationResources/HighSchool/Electricity/electroinduction.htm www.youtube.com/watch?v=hajIIGHPeuU
4.6.1 Electro-magnetic induction	• Show understanding that the direction of an induced e.m.f. opposes the change causing it • State and use the relative directions of force, field and induced current	Induce a current in a solenoid by inserting a known pole at one end. Then pass a current through the solenoid in the same direction as the induced current; show that the field opposes the original insertion of the magnet. There are various rules for remembering the relative directions of the force, field and induced current of which Fleming's right-hand rule is one.

Syllabus ref.	Learning objectives	Suggested teaching activities
		Lenz's law: http://hyperphysics.phy-astr.gsu.edu/hbase/electric/farlaw.html#c2l www.youtube.com/watch?v=KGTZPTnZBFE http://video.mit.edu/watch/physics-demo-lenzs-law-with-copper-pipe-10268/ www.youtube.com/watch?v=uGUsTWjWOI8
4.6.2 a.c. generator	• Distinguish between direct current (d.c.) and alternating current (a.c.)	This can be taught at more or less the same time as the a.c. generator. It is difficult to explain at first why a.c. exists but learners might well see what happens when one is displayed on a c.r.o. It might help to listen to the hum of a.c. devices and even to see the flickering (with the aid of a diode) of a lamp. a.c. and d.c.: www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/electricity/mainselectrev5.shtml
4.6.2 a.c. generator	• Describe and explain a rotating-coil generator and the use of slip rings • Sketch a graph of voltage output against time for a simple a.c. generator • Relate the position of the generator coil to the peaks and zeros of the voltage output	Make a working model generator – use a commercial science kit generator. Use a c.r.o. to show the voltage output. Make a large 'generator' with cereal packets as magnets, a soup tin as the armature and mains wiring wrapped into a coil that connects to slip rings – it does not work but is much bigger and so easier for learners to see. The working of an a.c. generator: www.pbs.org/wgbh/amex/edison/sfeature/acdc_insideacgenerator.html
4.6.3 Transformer	• Describe the construction of a basic transformer with a soft-iron core, as used for voltage transformations • Recall and use the equation (V_p / V_s) = (N_p / N_s) • Understand the terms step up and step-down	Make a working model transformer (two 'C-cores' with suitable wire windings) to introduce the ideas, and follow with a demonstration (demountable) transformer. Use the experiment from 4.6.1 but use a.c. rather than switching on and off. Use a model transmission line and show that more energy gets through at a higher voltage; do not have high voltage wires uninsulated in the laboratory. There are several persistent errors encountered when the transformer is explained. These include the idea that a current passes through the core and that this is why it is made of iron (a metal). Some learners use the term induction to describe the production of a current in the primary coil. Some learners suspect that a step-up transformer is contravening the principle of the conservation of energy

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Describe the use of the transformer in high-voltage transmission of electricity • Give the advantages of high voltage transmission	by generating an increased voltage from nothing. All of these hint at a fundamental misunderstanding by the learner. How transformers work: www.energyquest.ca.gov/how_it_works/transformer.html www.youtube.com/watch?v=VucsoEhB0NA
4.6.3 Transformer	• Describe the principle of operation of a transformer • Recall and use the equation $I_pV_p = I_sV_s$ (for 100% efficiency) • Explain why power losses in cables are lower when the voltage is high	A simple worked example using specific values is often a clear way of showing the significance of high voltage transmission. A model power line, if used with appropriate safety precautions, can help learners to see what is happening. Power line repairs: www.youtube.com/watch?v=EWbBdAeW1m8
4.6.4 The magnetic effect of a current	• Describe the pattern of the magnetic field (including direction) due to currents in straight wires and in solenoids • Describe applications of the magnetic effect of current, including the action of a relay	Use iron filings on a suitably placed card to show the field patterns around a straight wire and a solenoid. **(I)** The direction of the field can be shown with a plotting compass. If a thin sheet of Perspex is used in place of the card the apparatus can be mounted on an overhead projector to give a class demonstration. Perspex sheets with dozens of built-in plotting compasses are also available. Fields in 3D can be shown with commercially available cylinders containing floating magnetic particles in a dense oil. Use a relay mounted in a Perspex box and it can be seen and heard switching a mains circuit on and off. Plotting magnetic fields: www.bbc.co.uk/schools/gcsebitesize/science/ocr_gateway_pre_2011/living_future/5_magnetic_field1.shtml www.youtube.com/watch?v=JUZC679CwKs www.bbc.co.uk/learningzone/clips/the-3d-magnetic-field-of-a-bar-magnet/287.html

Syllabus ref.	Learning objectives	Suggested teaching activities
4.6.4 The magnetic effect of a current	• State the qualitative variation of the strength of the magnetic field over salient parts of the pattern • State that the direction of a magnetic field line at a point is the direction of the force on the N pole of a magnet at that point • Describe the effect on the magnetic field of changing the magnitude and direction of the current	**Extension activity:** extend the experiments to show the effect of changing the magnitude and direction of the current (separation of lines of iron filings and direction of plotting compass). **(I)** When drawing the field pattern around a straight wire, learners should be encouraged to draw circles whose separation increases outwards from the wire; this shows that the field gets weaker further from the wire. Magnetic and electric field lines: www.physics4kids.com/files/elec_magneticfield.html Magnetic field lines: www.boundless.com/physics/magnetism/magnetism-and-magnetic-fields/magnetic-field-lines/
4.6.5 Force on a current-carrying conductor	• Describe an experiment to show that a force acts on a current-carrying conductor in a magnetic field, including the effect of reversing: ○ the current ○ the direction of the field	Use the 'catapult' experiment or similar. Use two parallel strips of aluminium foil mounted a few mm apart vertically. Pass a current through them in the same direction and in opposite directions and watch them attract or repel; like currents attract and unlike currents repel. Force on current carrying conductor: www.youtube.com/watch?v=14SmN_7EcGY
4.6.5 Force on a current-carrying conductor	• State and use the relative directions of force, field and current • Describe an experiment to show the corresponding force on beams of charged particles	When teaching the existence of the force the actual directions relative to each other can be incorporated into the lesson. Fleming's left-hand rule is just one of the rules that can be used to remember these directions. Use a cathode-ray tube or an e/m tube to demonstrate the effect of the force on a beam of charged particles (electrons). The left-hand rule: www.bbc.co.uk/schools/gcsebitesize/science/triple_aqa/keeping_things_moving/the_motor_effect/revision/3/ Force on an electron beam: www.youtube.com/watch?v=3McFA40nP0A
4.6.6 d.c. motor	• State that a current-carrying coil in a magnetic field experiences	Make a coil from wire and position the coil in a magnetic field so that magnetic field lines lie in the plane of the coil. When it is carrying a current the coil experiences a torque.

Syllabus ref.	Learning objectives	Suggested teaching activities
	a turning effect and that the effect is increased by: ○ increasing the number of turns on the coil ○ increasing the current ○ increasing the strength of the magnetic field	When the magnetic field lines are perpendicular to the plane of the coil the torques is absent. The existence of the torque can be shown to be due to motor effect and deduced mathematically. Torque: www.youtube.com/watch?v=E-3yQqgu8OA
4.6.6 d.c. motor	• Relate this turning effect to the action of an electric motor including the action of a split-ring commutator	Make a model motor and investigate the effect of changing the number of turns. **(I)** As with the generator, make a large and visible model with cereal packets and so on which does not work but is very clear to see. Make sure that learners do not confuse split-ring (commutator) with slip rings. Increase the current in the coil of an electric motor and see it speed up. How a motor works: www.youtube.com/watch?v=Xi7o8cMPI0E Explanation of how the motor works, with helpful illustrations: www.howstuffworks.com/motor.htm Model motor kits: www.practicalphysics.org/go/Experiment_334.html

Past and specimen papers
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**

6: Electricity 2

Syllabus ref.	Learning objectives	Suggested teaching activities
4.2.1 Electric charge	• State that there are positive and negative charges • State that unlike charges attract and that like charges repel • Describe simple experiments to show the production and detection of electrostatic charges • State that charging a body involves the addition or removal of electrons • Distinguish between electrical conductors and insulators and give typical examples	Electrostatics experiments are best performed in dry climates and in some areas the time of year chosen for teaching this will affect the ease with which the experiments are demonstrated. Even in relatively damp conditions, however, it is usually possible to show most of what is needed provided a hair-dryer or an industrial dryer is used regularly as the experiment is being carried out. Use simple experiments with strips of insulating material (e.g. Perspex and cellulose acetate) rubbed with a cloth to show attraction and repulsion. Balloons or cling film can also be used to give a larger scale result. Learners are always impressed when a charged rod diverts a stream of flowing water. Remember that wood can act as a conductor when discharging electrostatically charged objects. Show this and remind learners not to use wooden objects if rescuing someone from electrocution. Introductory work on static electricity: www.sciencemadesimple.com/static.html Electricity (for the teacher): www.amasci.com/emotor/sticky.html
4.2.1 Electric charge	• State that charge is measured in coulombs • State that the direction of an electric field at a point is the direction of the force on a positive charge at that point • Describe an electric field as a region in which an electric charge experiences a force • Describe simple field patterns, including the field around a point charge, the field around a	For abler learners, electric field patterns can be demonstrated, e.g. two electrodes dipped in castor oil, contained in a petri dish – the electrodes are connected to a high voltage supply and semolina grains sprinkled around the electrodes show the field pattern. Also charging by induction can be shown using a gold-leaf electroscope. In a dry environment, very small pieces of paper (roughly 2 mm) can be picked up from a table using a charged rod and may even be made to bounce between the rod and the table a few times if the rod is horizontal and just a few centimetres from the table. This behaviour is explained because the paper is a (poor) conductor and becomes charged by induction. Deals with common misconceptions about static electricity (for the teacher): www.eskimo.com/~billb/emotor/stmiscon.html An interesting way to teach about charge and current using an overhead projector demonstration: www.eskimo.com/~billb/redgreen.html

Syllabus ref.	Learning objectives	Suggested teaching activities
	charged conducting sphere and the field between two parallel plates (not including end effects) • Give an account of charging by induction • Recall and use a simple electron model to distinguish between conductors and insulators	
4.3.1 Circuit diagrams	• Draw and interpret circuit diagrams containing sources, switches, resistors (fixed and variable), heaters, thermistors, light-dependent resistors, lamps, ammeters, voltmeters, galvanometers, magnetising coils, transformers, bells, fuses and relays	Learners can be given experience of these components as parts of working circuits (perhaps a circus arrangement), setting circuits up from given diagrams and drawing circuit diagrams of actual circuits. Measure the current at different points in a series circuit. What is electricity? www.physicsclassroom.com/class/circuits/Lesson-2/What-is-an-Electric-Circuit Shows the relationship between voltage, current (called 'amperage') and resistance. Learners can change the resistance and voltage in a circuit, switch on and see the effect on the lamp: www.jersey.uoregon.edu/vlab/Voltage/
4.3.1 Circuit diagrams	• Draw and interpret circuit diagrams containing diodes	At IGCSE, a diode can be thought of as a one-way conductor. Its resistance is infinite in the reverse direction but finite in the forward direction. Its behaviour can be demonstrated with simple experiments. It can be used in battery chargers. LEDs are diodes which happen to emit visible light when conducting a current.
4.3.2 Series and parallel circuits	• Understand that the current at every point in a series circuit is the same • Give the combined resistance of two or more resistors in series	The behaviour of current in circuits is commonly misunderstood and it is very helpful to demonstrate the equality of the current in a series circuit by using more than one ammeter in a circuit. If it also includes a variable resistor, then the circuit can be used to vary the current. Learners may observe the current changing both before and after the variable resistor and they may notice that they change at the same time. If digital meters are used, then the fact that the readings are not identical can confuse and it is usually best to use a range which does not supply unnecessary significant figures which are liable to be different on different meters.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• State that, for a parallel circuit, the current from the source is larger than the current in each branch • State that the combined resistance of two resistors in parallel is less than that of either resistor by itself • State the advantages of connecting lamps in parallel in a lighting circuit	A useful class practical is to take the measurements so that a graph of V against I may be plotted for: • resistor 1 • resistor 2 • resistor 1 and resistor 2 in series. **(I)** The gradient of the graph is used to determine the resistance of the three arrangements and to show the law for resistors in series. A parallel circuit with ammeters in the appropriate positions can show how the current in two branches of different resistances compare and how a parallel pair of resistors allows a larger current to be supplied than does either resistor on its own. If available, an ohmmeter can be used to measure the resistance of various series and parallel combinations of resistors. When considering the advantages of lamps in parallel, it should be emphasised that normal, full brightness is only achieved because they are designed to operate using the full voltage supply. It is possible to design lamps that work with full brightness in series and these would burn out if connected in parallel. Series resistors: www.bbc.co.uk/bitesize/higher/physics/elect/resistors/revision/1/ Current in series circuits: www.youtube.com/watch?v=SEAxrcOaHW8 www.youtube.com/watch?v=D2monVkCkX4 Parallel resistors: www.youtube.com/watch?v=fyeBfaxwQqs Lamps in parallel: www.youtube.com/watch?v=vIicY0Y491Q
4.3.2 Series and parallel circuits	• Calculate the combined e.m.f. of several sources in series • Recall and use the fact that the sum of the p.d.s across the components in a series circuit is equal to the total p.d. across the	The core work can be extended for abler learners to a quantitative approach to series and parallel circuits. Use voltmeters and ammeters to show the relationship required. **(I)** Measurements of current in series and parallel circuits, e.g. with cells and lamps, could form the basis of the work on combinations of resistors. Demonstrate with ammeters that the current flowing into a junction equals that flowing out.

Syllabus ref.	Learning objectives	Suggested teaching activities
	supply • Recall and use the fact that the current from the source is the sum of the currents in the separate branches of a parallel circuit • Calculate the effective resistance of two resistors in parallel	
4.5 Dangers of electricity	• State the hazards of: ○ damaged insulation ○ overheating of cables ○ damp conditions • State that a fuse protects a circuit • Explain the use of fuses and circuit breakers and choose appropriate fuse ratings and circuit-breaker settings • Explain the benefits of earthing metal cases	The heating effect work can be extended to use a very thin wire, e.g. strand of iron wool in a circuit powered by two 1.5 V cells. A short piece of iron wool will 'burn out', illustrating the action of a fuse. The action of a fuse is commonly misunderstood by learners and so it should be emphasised that it does not control or just reduce the current, but reduces it to zero by breaking the circuit. Likewise, the action of an earth wire is not to divert the current away from the user but to allow so much current to be supplied that the fuse melts and breaks the circuit. A person holding a device by its metal casing when the casing becomes live is likely to be killed or severely injured as the casing would stay live until the fuse had melted. This might take several seconds. Hazards of electricity: www.youtube.com/watch?v=igK-DRB5faU

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7: Thermal physics

Syllabus ref.	Learning objectives	Suggested teaching activities
2.1.1 States of matter	• State the distinguishing properties of solids, liquids and gases	Simple experiments can show that liquids and gases flow and that solids and liquids are distinctly less compressible than gases. **(I)** Liquids are frequently described as incompressible or as having a fixed volume. This is, of course, only true to some limited extent. The use of the expansion of a liquid in a thermometer is a clearly contradictory example. Solids, liquids and gases: www.bbc.co.uk/bitesize/ks2/science/materials/solids_liquids_gases/read/1/
2.1.2 Molecular model	• Describe qualitatively the molecular structure of solids, liquids and gases in terms of the arrangement, separation and motion of the molecules • Interpret the temperature of a gas in terms of the motion of its molecules • Describe qualitatively the pressure of a gas in terms of the motion of its molecules • Show an understanding of the random motion of particles in a suspension as evidence for the kinetic molecular model of matter • Describe this motion (sometimes known as Brownian motion) in terms of random molecular bombardment	Use examples of phenomena that are explained by the particle theory to build up understanding, e.g. diffusion in liquids, diffusion of gases (bromine in air – fume cupboard required), crystal structure, etc. Learners should observe Brownian motion, e.g. using the 'smoke cell' experiment. **(I)** Get the learners to explain randomness in both speed and direction of motion but without using the word random. Models using large spheres, e.g. table tennis balls, should be used to illustrate as much as possible, e.g. crystal model. Molecules in solids, liquids and gases: www.youtube.com/watch?v=guoU_cuR8EE Pressure due to molecules: www.grc.nasa.gov/WWW/k-12/airplane/pressure.html
2.1.2 Molecular	• Relate the properties of solids,	The ordinary experiments may be explained using a more exact approach and by talking about how the

Syllabus ref.	Learning objectives	Suggested teaching activities
model	liquids and gases to the forces and distances between molecules and to the motion of the molecules • Explain pressure in terms of the change of momentum of the particles striking the walls creating a force • Show an appreciation that massive particles may be moved by light, fast-moving molecules	forces between the molecules act at different distances. It is not necessary to relate the pressure to the momentum change quantitatively, but the change in momentum of the colliding molecule can be seen to cause a force and hence a pressure. Pressure and molecular momentum: www.saburchill.com/physics/chapters/0099.html
2.1.3 Evaporation	• Describe evaporation in terms of the escape of more-energetic molecules from the surface of a liquid • Relate evaporation to the consequent cooling of the liquid	This is how a refrigerator works. Learners should experience the cooling effect of evaporation using a non-toxic volatile substance. The shivering sensation experienced when leaving a swimming pool is also caused by this effect and perspiration is a biological cooling mechanism that relies on it. Cooling by evaporation: www.bbc.co.uk/schools/gcsebitesize/science/aqa/heatingandcooling/heatingrev5.shtml www.youtube.com/watch?v=dt8KFgqs2A4
2.1.3 Evaporation	• Demonstrate an understanding of how temperature, surface area and draught over a surface influence evaporation • Explain the cooling of a body in contact with an evaporating liquid	Leave water in different vessels overnight and observe the rate at which evaporation occurs. **(I)**
2.1.4 Pressure changes	• Describe qualitatively, in terms of molecules, the effect on the pressure of a gas of: ○ a change of temperature at constant volume	A direct measuring Boyle's Law apparatus can be used here. Useful graph plotting and interpretation skills are included. **(I)** Place a partially inflated balloon in a bell-jar and reduce the pressure in the jar. **Extension activity:** extend this work by using the practical experiment about the temperature and

Syllabus ref.	Learning objectives	Suggested teaching activities
	○ a change of volume at constant temperature	pressure of a gas: www.youtube.com/watch?v=BxUS1K7xu30 Boyle's law: www.youtube.com/watch?v=N5xft2fIqQU Charles' law: www.youtube.com/watch?v=HxSPdmvqstQ
2.1.4 Pressure changes	• Recall and use the equation pV = constant for a fixed mass of gas at constant temperature	Values from the graph can be used to illustrate the constancy of the product pV. Also use phrases such as 'doubling the pressure halves the volume'. An interesting interactive experience for a more able learner to explore the ideas around the gas laws – Welcome to the Pressure Chamber: www.jersey.uoregon.edu/vlab/Piston/index.html
2.2.1 Thermal expansion of solids, liquids and gases	• Describe qualitatively the thermal expansion of solids, liquids, and gases at constant pressure • Identify and explain some of the everyday applications and consequences of thermal expansion	Experiments to show expansion of a metal rod and the 'bar breaker' demonstration. A large round bottom flask filled with (coloured) water and fitted with a long glass tube shows expansion of the water when heated gently. The 'fountain' experiment shows the expansion of air and brings in good discussion of the effect of pressure difference to stretch the abler learners. Thermal expansion: www.youtube.com/watch?v=EkQ2886Sxpg The fountain experiment: www.youtube.com/watch?v=AX5eVxxQgPc
2.2.1 Thermal expansion of solids, liquids and gases	• Explain, in terms of the motion and arrangement of molecules, the relative order of the magnitude of the expansion of solids, liquids and gases	Take a flask full of coloured water connected to a tube and immerse in hot water. The initial decrease in level of the water shows the expansion of the glass; the subsequent expansion of the liquid is greater and the water rises up the tube. Thermal expansion: www.bbc.co.uk/bitesize/ks3/science/chemical_material_behaviour/behaviour_of_matter/activity/
2.2.2 Measurement of temperature	• Appreciate how a physical property that varies with temperature may be used for the measurement of temperature, and state examples of such properties • Recognise the need for and	Different types of thermometer can be used e.g. resistance thermometer, thermocouple pressure of a copper sphere of gas. Calibrate an unmarked thermometer (mark 0 °C and 100 °C with rubber bands using an ice bath and a steam bath) and use it to measure an unknown temperature. Thermometric properties: www.miniphysics.com/thermometric-property.html

Syllabus ref.	Learning objectives	Suggested teaching activities
	identify fixed points • Describe and explain the structure and action of liquid-in-glass thermometers	
2.2.2 Measurement of temperature	• Demonstrate understanding of sensitivity, range and linearity • Describe the structure of a thermocouple and show understanding of its use as a thermometer for measuring high temperatures and those that vary rapidly • Describe and explain how the structure of a liquid-in-glass thermometer relates to its sensitivity, range and linearity	Sensitivity for a liquid-in-glass thermometer is measured in mm/°C. This makes it clear that it does not mean the speed of response or anything similar. A simple thermocouple can be constructed and used. State the advantages of a thermocouple thermometer over a liquid-in-glass thermometer.
2.2.3 Thermal capacity (heat capacity)	• Relate a rise in the temperature of a body to an increase in its internal energy • Show an understanding of what is meant by the thermal capacity of a body	Blocks of different metals and of different masses can be heated using identical immersion heaters to show their different thermal capacities. Many texts use the term heat capacity, and learners should also be made familiar with this term. The syllabus uses the term thermal energy for energy transferred by heating. This energy will cause an increase in the internal energy of the blocks. This is a good point to remind learners of the difference between internal energy and temperature.
2.2.3 Thermal capacity (heat capacity)	• Give a simple molecular account of an increase in internal energy • Recall and use the equation thermal capacity = mc • Define specific heat capacity	This can be extended to a quantitative determination of specific heat capacity. The word specific, when used in physics, often means per kilogram. Specific heat capacity: www.bbc.co.uk/schools/gcsebitesize/science/aqa/heatingandcooling/buildingsrev3.shtml Measuring specific heat capacity: www.youtube.com/watch?v=vMvSYIY_PxU

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Describe an experiment to measure the specific heat capacity of a substance • Recall and use the equation change in energy = $mc\Delta T$	
2.2.4 Melting and boiling	• Describe melting and boiling in terms of energy input without a change in temperature • State the meaning of melting point and boiling point • Describe condensation and solidification in terms of molecules	Heating and cooling curves can be plotted from experimental readings, e.g. timed temperature readings when heating ice until the water boils and during the solidification of stearic acid. Show that ice and water can only co-exist at the melting point, steam and water only at the boiling point. Cooling curve using data logger: www.youtube.com/watch?v=RVlf6jhVl3U
2.2.4 Melting and boiling	• Distinguish between boiling and evaporation • Use the terms latent heat of vaporisation and latent heat of fusion and give a molecular interpretation of latent heat • Define specific latent heat • Describe an experiment to measure specific latent heats for steam and for ice • Recall and use the equation energy = ml	Simple and direct experiments to determine specific latent heat, e.g. using a low voltage immersion heater. Evaporation and vapour pressure (for the teacher): www.pkwy.k12.mo.us/west/teachers/anderson/pack7/boil/boil.html Specific latent heat: www.youtube.com/watch?v=gDbo_vGOycU www.youtube.com/watch?v=EO1-yb25hYM

Past and specimen papers
Past/specimen papers and mark schemes are available to download at **www.cambridgeinternational.org/support (F)**

8: Mechanics 2

Syllabus ref.	Learning objectives	Suggested teaching activities
1.5.1 Effects of forces	• Recognise that a force may produce a change in size and shape of a body • Plot and interpret extension-load graphs and describe the associated experimental procedure • Describe the ways in which a force may change the motion of a body • Find the resultant of two or more forces acting along the same line • Recognise that if there is no resultant force on a body it either remains at rest or continues at constant speed in a straight line • Understand friction as the force between two surfaces which impedes motion and results in heating • Recognise air resistance as a form of friction	Use a simple experiment to stretch a steel spring. Further experience could be gained with a similar experiment to stretch a rubber band. Compress trapped gases in syringes; change the shape of malleable objects. Use force sensors and newton meters to add and subtract the forces acting on bodies. Friction: www.bbc.co.uk/bitesize/ks2/science/physical_processes/friction/read/1/ www.fearofphysics.com/Friction/frintro.html Air resistance: www.universetoday.com/73315/what-is-air-resistance/
1.5.1 Effects of forces	• State Hooke's Law and recall and use the expression $F = kx$, where k is the spring constant	Use a home-made copper spring or stretch a length of copper wire between two pencils and feel, measure or show the limit of proportionality. An air track can be used to show momentum effects using collisions and 'explosions' (magnets attached to the vehicles to produce repulsion). This work can be

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Recognise the significance of the 'limit of proportionality' for an extension-load graph • Recall and use the relation between force, mass and acceleration (including the direction), *F* = *ma* • Describe qualitatively motion in a circular path due to a perpendicular force ($F = mv^2/r$ is not required)	extended to investigate model rockets and Newton's cradle. Circular motion can be shown using a smooth turntable (old record player) and a marble to illustrate behaviour without centripetal force and then an object attached to the axis with cotton to provide the centripetal force. Thread a piece of string through a short length of glass tubing and attach a weight to one end of the string. Set the weight rotating by holding the glass tube vertically and rotating it in a small circle. The weight pulls the string up out of the tube. Attach another weight to the bottom end of the string; this weight can be used to exert a force on the other weight in a centripetal direction. Equilibrium can be achieved. Hooke's Law: www.youtube.com/watch?v=fYLec9q3oSw Centripetal force: www.youtube.com/watch?v=oFiXtcXRpVE
1.5.2 Turning effect	• Describe the moment of a force as a measure of its turning effect and give everyday examples • Understand that increasing force or distance from the pivot increases the moment of a force • Calculate moment using the product force × perpendicular distance from the pivot • Apply the principle of moments to the balancing of a beam about a pivot	Experiments involving balancing a rule on a pivot with a variety of different weights should be used here. Talk about everyday examples, e.g. see-saws, steelyards, crane jibs. Moment of force: www.bbc.co.uk/bitesize/ks3/science/energy_electricity_forces/forces/revision/8/ Levers: http://physics.about.com/od/simplemachines/f/HowLeverWorks.htm
1.5.2 Turning effect	• Apply the principle of moments to different situations	This can be extended quantitatively for extension learners and further extended to using a weight to balance the rule on a pivot away from the centre to introduce the concept of centre of mass.

Syllabus ref.	Learning objectives	Suggested teaching activities
		Determine the mass of a rule by balancing it away from its centre of mass with a known laboratory mass at one end. Replace the mass with an apple and determine its mass. Check by balancing the mass and the apple. Principle of moments: www.cyberphysics.co.uk/topics/forces/principleOfMoments.htm
1.5.3 Conditions for equilibrium	• Recognise that, when there is no resultant force and no resultant turning effect, a system is in equilibrium	When a bridge or trestle table is in equilibrium, the moment is zero about any point at all; it is merely convenient to take moments about one of the supports or trestles.
1.5.3 Conditions for equilibrium	• Perform and describe an experiment (involving vertical forces) to show that there is no net moment on a body in equilibrium	
1.5.4 Centre of mass	• Perform and describe an experiment to determine the position of the centre of mass of a plane lamina • Describe qualitatively the effect of the position of the centre of mass on the stability of simple objects	Avoid the term centre of gravity except to explain that at IGCSE it can be thought of as an alternative name for centre of mass. A variety of shapes of lamina should be used in experiments to find the centre of mass. Standard shapes (circle, square, etc.) can be used first and then 'non-standard' shapes, e.g. the outline of a country, where the position of the centre of mass is not so obvious. Is the point found really the centre of the country? What about mountains, islands, lakes, etc.? Extension learners can be challenged with a lamina that has its centre of mass in space, e.g. a hole in the lamina or an L-shape. Find the stability of glasses with stems, thick bases and wide bases on an inclined plane of variable slope. At what angle does the glass topple? What happens when the glass is full? Centre of mass: www.youtube.com/watch?v=hqDhW8HkOQ8 Stable and unstable objects: www.youtube.com/watch?v=muM4hhwqEwE
1.5.5 Scalars and vectors	• Understand that vectors have a magnitude and direction • Demonstrate an understanding of the difference between scalars and vectors and give	This important concept can be illustrated by a few learners attempting to pull a block of wood along the bench with strings, but pulling in a variety of directions at the same time. This could be a large-scale outdoor activity. Use a forces table with weights or newton meters and draw a scale diagram of equilibrium arrangements.

Syllabus ref.	Learning objectives	Suggested teaching activities
	common examples • Determine graphically the resultant of two vectors	Can a cable car hang from a perfectly horizontal cable? Adding vectors: www.physicsclassroom.com/class/vectors/Lesson-1/Vector-Addition www.youtube.com/watch?v=bPYLWjcY9wA This website, about Leonardo da Vinci, provides a different approach to stimulate learners: www.mos.org/leonardo click on 'Exploring Leonardo' click on 'Inventor's Workshop' click on 'The Elements of Machines'
1.6 Momentum	• Understand the concepts of momentum and impulse • Recall and use the equation momentum = mass × velocity, $p = mv$ • Recall and use the equation for impulse $Ft = mv - mu$ • Apply the principle of the conservation of momentum to solve simple problems in one dimension	Momentum can be thought of as a measurement of the difficulty of stopping a moving object. A bullet is difficult to stop because of its velocity, whereas a ship is difficult to stop because of its mass. The term impulse is usually restricted to situations where a large force is acting for a very small time. This includes a football being kicked or rocket engine firing for just a few seconds. Dynamics trolleys can be used to demonstrate the conservation of momentum and there are other more familiar examples such as colliding railway trucks, billiard balls and dodgem cars at the funfair. Momentum: www.physicsclassroom.com/class/momentum/Lesson-1/Momentum www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/forces/kineticenergyrev3.shtml www.youtube.com/watch?v=2FwhjUuzUDg Impulse: www.physicsclassroom.com/class/momentum/u4l1b.cfm Conservation of momentum: www.youtube.com/watch?v=1-s8NZ8xKW0
1.7.3 Work	• Demonstrate understanding that work done = energy transferred • Relate (without calculation) work done to the magnitude of a force and the distance moved in	In this and the following sections it may be useful to calculate (although only required for the extension paper) personal work done and power. For example, by walking up steps, recording the learner's weight, the vertical height climbed and the time taken. When rolling barrels up inclined planes the same work is done as when lifting the barrel vertically but the distance is greater and so the force is less.

Syllabus ref.	Learning objectives	Suggested teaching activities
	the direction of the force	Humans get tired holding heavy weights at a constant height but no work is done. Humans make poor shelves. Work and energy: www.youtube.com/watch?v=2WS1sG9fhOk
1.7.3 Work	• Recall and use $W = Fd = \Delta E$	Work and energy – a pulley with two weights: www.youtube.com/watch?v=vIOgL7jmz78 Examples on work done: www.tutor4physics.com/examplesworkdone.htm
1.7.4 Power	• Relate (without calculation) power to work done and time taken, using appropriate examples	Learners find rates quite hard at this stage; it is worth considering a few other examples, e.g. the rate of filling a bath and the time taken to fill it to a certain volume. Work done: http://hyperphysics.phy-astr.gsu.edu/hbase/work.html Work energy and power (for the teacher): www.tap.iop.org/mechanics/work_energy_power/index.html
1.7.4 Power	• Recall and use the equation $\boldsymbol{P = \Delta E/t}$ in simple systems	
1.8 Pressure	• Recall and use the equation $p = F/A$ • Relate pressure to force and area, using appropriate examples • Describe the simple mercury barometer and its use in measuring atmospheric pressure • Relate (without calculation) the pressure beneath a liquid surface to depth and to density, using appropriate examples	Show and discuss examples such as: drawing pins, stiletto heeled shoes, sharpened knives, cheese wire, snow shoes/skis and furniture leg cups. Demonstrate a mercury barometer (Torricelli used water). Show that the pressure under water increases with depth and if possible use a less dense liquid to show that the pressure increases at a slower rate. Use a water manometer to measure the excess pressure of the gas supply (if safe). Use a U-tube with water in one limb and ethanol in the other; the two surfaces are not level. **Resource Plus** **Experiment:** Pressure and the imploding can This experiment focuses on pressure and the imploding can experiment. Links to 1.5 Forces, 2.1.1 States of matter and 2.1.4 Pressure changes.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Use and describe the use of a manometer	Pressure: www.youtube.com/watch?v=6UC2P8Ovg_0 www.youtube.com/watch?v=fq54Ipfoh80 Liquid pressure: www.youtube.com/watch?v=oUK7agBG4KA Manometer problems: www.youtube.com/watch?v=zeNQOqr63cc Making a barometer: www.youtube.com/watch?v=GgBE8_SyQCU
1.8 Pressure	• Recall and use the equation $p = h\rho g$	Use the formula $P = F/A$ in specific cases and determine the pressure exerted on the ground by an elephant and by someone wearing stiletto heeled shoes. Calculate the pressure due to 1.0 m of mercury and show that it exceeds the atmospheric pressure; the mercury has to flow out of a barometer and leaves a vacuum above the surface in the tube.

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9: Waves

Syllabus ref.	Learning objectives	Suggested teaching activities
3.1 General wave properties	• Demonstrate understanding that waves transfer energy without transferring matter • Describe what is meant by wave motion as illustrated by vibration in ropes and springs and by experiments using water waves • Use the term wavefront • Give the meaning of speed, frequency, wavelength and amplitude • Distinguish between transverse and longitudinal waves and give suitable examples • Describe how waves can undergo: ○ reflection at a plane surface ○ refraction due to a change of speed ○ diffraction through a narrow gap • Describe the use of water waves to demonstrate reflection, refraction and diffraction	Begin with waves on ropes and a 'slinky' spring to illustrate transverse and longitudinal waves. A ripple tank can then be used to show reflection, refraction and diffraction of water waves. Sound undergoes diffraction easily but light needs special apparatus to show this property. Use 3 cm (micro)wave equipment to illustrate reflection, refraction (beeswax blocks or Perspex cubes filled with paraffin) and diffraction. A narrower slit can actually increase the intensity at some off-centre positions as the weaker signal reaches places that the stronger one (wider slit) did not diffract to. **Resource Plus** **Experiment:** Demonstrating wave phenomena This experiment focuses on demonstrating wave phenomena. Links to 3.2.1 Reflection of light and 3.2.2 Refraction of light. Demonstrations of transverse and longitudinal waves: www.youtube.com/watch?v=7cDAYFTXq3E The ripple tank: www.youtube.com/watch?v=JXaVmUvwxww Reflection: www.youtube.com/watch?v=HFckyHq594I Refraction: www.youtube.com/watch?v=stdi6XJX6gU Diffraction: www.youtube.com/watch?v=ZSF9CFsjQKg
3.1 General wave properties	• Recall and use the equation $v = f\lambda$	Find the wavelengths and frequencies for local radio stations and calculate *c*.

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Describe how wavelength and gap size affects diffraction through a gap • Describe how wavelength affects diffraction at an edge	Use a set of ripple tank projection slides to reinforce the ripple tank work and focus on more detailed discussion. Wave equation: www.youtube.com/watch?v=jEEPp0mBCdg Wave speed: www.bbc.co.uk/schools/gcsebitesize/science/aqa_pre_2011/radiation/anintroductiontowavesrev3.shtml www.gcse.com/waves/vfl.htm
3.3 Electro-magnetic spectrum	• Describe the main features of the electromagnetic spectrum in order of wavelength • State that all e.m. waves travel with the same high speed in a vacuum • Describe typical properties and uses of radiations in all the different regions of the electromagnetic spectrum including: ○ radio and television communications (radio waves) ○ satellite television and telephones (microwaves) ○ electrical appliances, remote controllers for televisions and intruder alarms (infra-red) ○ medicine and security (X-rays) • Demonstrate an awareness of safety issues regarding the use	Include plenty of examples to show learners that they already have much general knowledge regarding the uses of electromagnetic waves. Quote frequency and wavelength values and show that as f increases, λ decreases. Identify the radio wave, microwave, infra-red and X-ray regions of the e.m. spectrum. Explain that the first three can be encoded with digital or analogue signals to transmit messages remotely. Explain that X-rays can be used both diagnostically and therapeutically in medicine and discuss the risks of using and of not using X-rays in medicine. Discuss the likely dangers of using mobile phones and problems that arise when microwaves escape from faulty microwave ovens. Electromagnetic spectrum: www.schooltube.com/video/6ea0d020a582f8d6b1c1/The-Electromagnetic-Spectrum www.youtube.com/watch?v=UzI1z0u_700 www.vimeo.com/16996376

Syllabus ref.	Learning objectives	Suggested teaching activities
	of microwaves and X-rays	
3.3 Electro-magnetic spectrum	• State that the speed of electromagnetic waves in a vacuum is 3.0×10^8 m/s and is approximately the same in air	There is no particular reason for not quoting the exact (to 2 significant figures) value 3.0×10^8 m/s here. Calculate how long it takes for an intercontinental phone call to travel to a satellite (height ~35 000 km) and back and then for the reply to make the same journey.
3.4 Sound	• Describe the production of sound by vibrating sources • Describe the longitudinal nature of sound waves • State that the approximate range of audible frequencies for a healthy human ear is 20 Hz to 20 000 Hz • Show an understanding of the term ultrasound • Show an understanding that a medium is needed to transmit sound waves • Describe an experiment to determine the speed of sound in air • Relate the loudness and pitch of sound waves to amplitude and frequency • Describe how the reflection of sound may produce an echo	Use a variety of musical instruments/vibrating rulers/pieces of card in the spokes of a bicycle wheel, etc. to introduce this section. A signal generator and loudspeaker can be used to investigate the range of audible frequencies. The usual range is considered to be ~20 Hz to ~20 kHz. Few teachers will hear frequencies as high as most of their learners and the upper limit is reduced as one gets older. A bell in a bell jar that can be evacuated can be used to show that a medium is required for the transmission of sound (at the same time showing that light travels through a vacuum). Sound can still pass through the structure holding the bell in place. Use of a c.r.o. and microphone gives a visual picture of amplitude and frequency. Extension learners can analyse the c.r.o. traces in more detail. **Resource Plus** **Experiment:** Use of a CRO to visualise sound waves This experiment focuses on an experiment to visualise sound waves using a cathode ray oscilloscope (CRO). Interesting work on resonance including a video of the Tacoma Narrows Bridge disaster: www.youtube.com/watch?v=j-zczJXSxnw This website about sound waves is informative and includes audio: www.youtube.com/watch?v=usHtqr0_HXU

Syllabus ref.	Learning objectives	Suggested teaching activities
3.4 Sound	• Describe compression and rarefaction • State typical values of the speed of sound in gases, liquids and solids	A large-scale, outdoor echo method to determine the speed of sound in air can be used. Where a long metal fence is available, it is possible to strike the fence with a hammer and for a distant observer to hear the sound twice, once through the air and once through the fence. Compressions and rarefactions: www.bbc.co.uk/schools/gcsebitesize/science/add_gateway_pre_2011/radiation/ultrasoundrev1.shtml www.youtube.com/watch?v=HISCwV8d5qM Speed of sound in differing media: http://hyperphysics.phy-astr.gsu.edu/hbase/tables/soundv.html

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10: Atomic physics

Syllabus ref.	Learning objectives	Suggested teaching activities
5.2.1 Detection of radioactivity	• Demonstrate understanding of background radiation • Describe the detection of α-particles, β-particles and γ-rays (β+ are not included: β-particles will be taken to refer to β⁻)	Use a Geiger-Müller tube to detect background radiation and α, β and γ radiations. Emphasise that these radiations are emitted from the nucleus. This website has an interesting history of Marie Curie: www.aip.org/history/curie/contents.htm Detecting background radiation: www.youtube.com/watch?v=5TCZqT7enHw
5.2.2 Characteristics of the three kinds of emission	• Discuss the random nature of radioactive emission • Identify α, β and γ-emissions by recalling ○ their nature ○ their relative ionising effects ○ their relative penetrating abilities (β⁺ are not included, β-particles will be taken to refer to β⁻)	Show the presence of background radiation using a detector and explain that it varies from location to location. Show that it varies randomly over time. Use a radiation detector with suitable absorbers to show penetrating abilities. Use a diffusion type cloud chamber to show particle tracks and lead to discussion of ionising effects. A spark counter could also be used. Properties: www.bbc.co.uk/schools/gcsebitesize/science/ocr_gateway_pre_2011/living_future/4_nuclear_radiation1.shtml www.youtube.com/watch?v=Qlb5Z8QBpcI Radioactivity: http://fiziknota.blogspot.com/2010/01/radioactivity.html www.youtube.com/watch?v=T7NhgaJCg5A
5.2.2 Characteristics of the three kinds of emission	• Describe their deflection in electric fields and in magnetic fields • Interpret their relative ionising effects	Emphasise the links between the properties (penetration, ionisation and deflection by magnetic or electric fields) and the nature (charge, relative size, particles/electromagnetic radiation). One reason why α-particles are less penetrating is that they are more strongly ionising. Magnetic deflection of α-particles: www.youtube.com/watch?v=AkO4PZn2_Vs Magnetic deflection of β-particles: www.youtube.com/watch?v=1yANM8r1WR8

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Give and explain examples of practical applications of α, β and γ-emissions	
5.2.3 Radioactive decay	• State the meaning of radioactive decay • State that during α- or β-decay the nucleus changes to that of a different element	Emphasise that a radioactive material decays nucleus by nucleus over time and not all at once.
5.2.3 Radioactive decay	• Use equations involving nuclide notation to represent changes in the composition of the nucleus when particles are emitted	The nuclide notations for α-particles and β-particles are easily learnt and the balancing of nuclear equations is best understood through practice. It can be emphasised that the 0 and the –1 from the β-particle symbol do not have the usual meaning of numbers in those places but that, following the nuclear reaction taking place, they make the equation balance.
5.2.4 Half-life	• Use the term half-life in simple calculations, which might involve information in tables or decay curves	**Extension activity:** extend to work from data involving long half-lives. Use a radioactive decay simulation exercise and if possible an experiment with a Geiger counter and short half-life isotope to plot decay curves. **Resource Plus** **Experiment:** A model to determine half-life This experiment focuses on a model to determine half-life using sweets. Radioactive half-life videos: www.youtube.com/watch?v=fToMbj3Xz2c www.youtube.com/watch?v=PYn8vFmyGPM www.youtube.com/watch?v=Tp2M9tndGG0
5.2.4 Half-life	• Calculate half-life from data or decay curves from which background radiation has not been subtracted	The principles here are the same as before except that the background radiation must be subtracted in order to obtain the count-rate due to the sample that is decaying.

Syllabus ref.	Learning objectives	Suggested teaching activities
5.2.5 Safety precautions	• Recall the effects of ionising radiations on living things • Describe how radioactive materials are handled, used and stored in a safe way	This should arise naturally from the teacher demonstrations where these are permitted, and is best integrated within the unit as a whole extending discussion to cover industrial and medical issues.
5.1.1 Atomic model	• Describe the structure of an atom in terms of a positive nucleus and negative electrons	Extension learners could discuss the limitations of the simple atomic model. Atomic structure: www.youtube.com/watch?v=IP57gEWcisY www.youtube.com/watch?v=sRPejoNktKE
5.1.1 Atomic model	• Describe how the scattering of α-particles by thin metal foils provides evidence for the nuclear atom	This important piece of understanding can be placed in its historical context and provide useful discussion on the nature of scientific research. Emphasise how the majority of the mass of an atom is concentrated in an extremely minute fraction of the whole atom's volume and that the density of nuclear matter is consequently huge. This website has interesting historical background covering Rutherford, Curie, Becquerel and Rontgen: www.accessexcellence.org/AE/AEC/CC/historical_background.html
5.1.2 Nucleus	• Describe the composition of the nucleus in terms of protons and neutrons • State the charges of protons and neutrons • Use the term proton number Z • Use the term nucleon number A • Use the term nuclide and use the nuclide notation $^{A}_{Z}X$	Explain that the proton number determines the number of electrons in the neutral atom and that this determines the chemical properties of the atom. Hence the proton number determines the chemical properties and so all atoms with the same proton number have the same chemical properties and so are atoms of the same chemical element. Nuclear reactions and decay series could be discussed to provide a focus for this section. Isotopes: www.youtube.com/watch?v=EboWeWmh5Pg

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Use and explain the term isotope	
5.1.2 Nucleus	• State the meaning of nuclear fission and nuclear fusion • Balance equations involving nuclide notation	Use many examples, concentrating on those that learners will know something about, e.g. medical treatment and diagnosis, smoke alarms, etc. Also include a few industrial examples, e.g. checking whether juice cartons are sufficiently full, checking for faulty welding joints in pipelines.

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11: Electronics

Syllabus ref.	Learning objectives	Suggested teaching activities
4.3.3 Action and use of circuit components	• Describe the action of a variable potential divider (potentiometer) • Describe the action of thermistors and light-dependent resistors and show understanding of their use as input transducers • Describe the action of a relay and show understanding of its use in switching circuits	Make a potential divider using a fixed and a variable resistor. Set up, in parallel, two voltmeters. Show that changing the resistance of the variable resistor causes one voltmeter reading to increase and the other to decrease. The larger resistor gets the larger share of the voltage. A series of straightforward circuits could be used here so that learners become familiar with the various components. The circuits could model the action of temperature sensors, light sensors, alarms, etc. Potential divider: www.bbc.co.uk/schools/gcsebitesize/design/electronics/calculationsrev2.shtml Thermistor circuit: www.youtube.com/watch?v=txGZljOfob0 Using an LDR: www.youtube.com/watch?v=29DgffpMh3k Reed relay: www.youtube.com/watch?v=kjg4Ue5wGS4
4.3.3 Action and use of circuit components	• Describe the action of a diode and show understanding of its use as a rectifier • Recognise and show understanding of circuits operating as light-sensitive switches and temperature-operated alarms (to include the use of a relay)	Set up such circuits and show how they work. Display a half-wave rectified current using a c.r.o. Explain that devices such as phone chargers always include a rectifier. Rectifier circuits: www.allaboutcircuits.com/vol_3/chpt_3/4.html
4.4 Digital electronics	• Explain and use the terms analogue and digital in terms of continuous variation and high/low states • Describe the action of NOT, AND, OR, NAND and NOR gates	Model logic gates with switches and show how two switches in series act as an AND gate – both must be on before the lamp is turned on, etc. It is worth emphasising that logic gates are active components which require their own power source. A NOT gate with a 0 input, does not generate a voltage from nothing, it diverts the power supply voltage to the output. Analogue and digital signals:

Syllabus ref.	Learning objectives	Suggested teaching activities
	• Recall and use the symbols for logic gates • Design and understand simple digital circuits combining several logic gates • Use truth tables to describe the action of individual gates and simple combinations of gates	www.youtube.com/watch?v=ubEijRkLweo www.youtube.com/watch?v=XwHXeZZf8fY

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