Scheme of work

Cambridge IGCSE®

Physics

0625

For examination from 2016

Cambridge IGCSE

Cambridge Secondary 2

CAMBRIDGE
International Examinations

Contents

Scheme of work – Cambridge IGCSE® Physics (0625)

Overview

This scheme of work provides ideas about how to construct and deliver a course. The 2016 syllabus has been broken down into teaching units with suggested teaching activities and learning resources to use in the classroom. The scheme of work suggests teaching approaches, internet sites, references to textbooks and a variety of other ideas. It is not in itself a detailed course description but a teacher wishing to follow it in that way will discover that the entire syllabus is covered. Likewise, teachers who wish to devise other courses conducted in different orders will not find their learners disadvantaged provided their courses also cover the syllabus. An attempt has been made to place syllabus items within the unit structure in an order that is both logical and consistent. Where prior knowledge helps the teaching of a particular topic, the section dealing with the prior knowledge comes first. Teachers who wish to use the scheme of work as the basis for their courses are likely to use it in one of two ways. One approach is to teach a whole topic at once so that a learner might study only electricity for several months followed by, say, mechanics; this is a topic-based approach. Alternatively, the course can be tackled by dealing with the basic parts of each topic first and ensuring that these are understood before returning to teach some subsequent sections of the units. This approach where all topics are regularly dealt with and each subject is taught by repeatedly returning to it each time at a deeper level is commonly called the spiral curriculum approach. Teachers and Centres must make their own decisions as to how the course should be structured.

Within this scheme of work, syllabus references and learning objectives in non-bold text are from the Core syllabus and sections and learning objectives in **bold** are from the Supplement **(S)**.

Outline
The units within this scheme of work are:

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5.2.3 Radioactive decay
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Teacher support

Cambridge Teacher Support (http://teachers.cie.org.uk) 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.

An editable version of this scheme of work is available on Cambridge Teacher Support in Microsoft Word format. If you are unable to use Microsoft Word you can download Open Office free of charge from www.openoffice.org.

Resource list

An up-to-date resource list for the Cambridge IGCSE Physics can be found at
www.cie.org.uk/programmes-and-qualifications/cambridge-igcse-physics-0625/support-material/

Website links
This scheme of work includes website links providing direct access to internet resources. Cambridge International Examinations 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).

Textbooks
Those most commonly used textbooks referenced in this scheme of work include:

Cambridge IGCSE Physics Coursebook with CD-ROM Sang, D (Cambridge University Press, 2010) ISBN: 9780521757737
Cambridge IGCSE Physics Teacher's Resource CD-ROM Sang, D (Cambridge University Press, 2010) ISBN: 9780521173599
Cambridge IGCSE Physics Workbook Sang, D (Cambridge University Press, 2010) ISBN: 9780521173582

Past Paper Questions (Core, Extension and Alternative to Practical)
A sample of Cambridge IGCSE Physics past paper questions is attached to each unit of this scheme of work referred to in the learning resources column (e.g. **Unit 1: Past Paper Questions**).

Unit 1: Light

Recommended prior knowledge

Although Cambridge IGCSE Physics itself can be used as an introduction to Physics, it is likely that most learners will have studied some Physics or General Science previously.

Learners are likely to be aware that light travels from a luminous source and is reflected and scattered by an object to the human eye where it is detected on the retina. Light may also travel from a luminous source directly to the eye. Words such as *reflection, transparent*, *opaque* and *translucent* are likely to be familiar to learners embarking on this course. Learners will probably be aware that light travels in straight lines in a uniform medium and that its path is frequently represented by a *ray*. This rectilinear propagation is responsible for the formation of shadows and learners might have encountered these concepts: *umbra* and *penumbra*. These ideas can be used to explain solar and lunar eclipses. Not all learners will be aware that stereoscopic vision relies on the assumption that light travels in straight lines and that during image formation in a mirror, the eye is tricked into seeing an object that is not located where it seems to be located. Learners are likely to have seen rainbows and to have related this to the passage of light through a triangular prism; it is unlikely, however, that a learner starting the Cambridge IGCSE Physics course will understand much of the physics that underlies these phenomena. Magnifying glasses and simple focusing experiments with lenses are also likely to be within the learners' experiences but the effect of lenses on light is likely to be unfamiliar in any detail.

Context

Within the Cambridge IGCSE Physics course, *Light* can be treated as something of an isolated section and taught at any stage within the course. In particular, it does not need to be preceded by *Waves*. Mathematically it is relatively straightforward – although the Snell Law does require knowledge of the sine function. This would suggest that it is best suited to an early stage in the course.

There are many practicals that can be conducted during this section of the course and learners can be made aware that a careful and meticulous approach, involving sharpened pencils, straight-edged rulers and general tidiness and neatness, can mark the difference between an accurate experiment or drawing and a much less useful one. If sin i is to be plotted against sin r (angle of refraction) when determining the refractive index of Perspex or glass, then the exercise can also be used to accustom learners to the use of graphs and how they can be plotted accurately.

Outline

This unit contains ideas that relate to the familiar experience of many learners and the ideas are not especially challenging. It can be used to introduce skills that will be needed in the rest of the course in a context that is not in itself a challenge.

(Note: **(S)** denotes material in the Supplement only.)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
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 *IGCSE Physics Coursebook* CD-ROM Activity Sheet 13.1 **Unit 1: Past Paper Questions (Core 3)**
3.2.1(S) 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 Describe internal and total internal reflection	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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 13.2

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
			IGCSE Physics Coursebook CD-ROM Activity Sheet 13.3 **Unit 1: Past Paper Questions (Core 1)** **Unit 1: Past Paper Questions (Alternative to Practical 1)**
3.2.2(S) Refraction of light	**Recall and use the definition of refractive index *n* in terms of speed** **Recall and use the equation** $\frac{\sin i}{\sin r} = n$	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 more able 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 **Unit 1: Past Paper Questions (Extension 2)**
	Recall and use $n = \frac{1}{\sin c}$		
	Describe and explain the action of optical fibres particularly in medicine and communications technology		
3.2.3 Thin converging lens	Describe the action of a thin converging lens on a beam of light Use the terms principal focus	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

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	and focal length Draw ray diagrams for the formation of a real image by a single lens Describe the nature of an image using the terms enlarged/same size/diminished and upright/inverted		lens/mirrors): www.phy.ntnu.edu.tw/ntnujava/index.php?topic=48 *IGCSE Physics CD-ROM* Activity Sheet 13.4
3.2.3(S) 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. 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=lBKGP6Fh9vs **Unit 1: Past Paper Questions (Extension 1)**
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 *IGCSE Physics Coursebook* CD-ROM Activity Sheet 15.1 **Unit 1: Past Paper Questions (Core 2)**

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
3.2.4(S) 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 word monochromatic: http://sentence.yourdictionary.com/monochromatic

Unit 2: Electricity 1

Recommended prior knowledge

Although Cambridge IGCSE Physics itself can be used as an introduction to Physics, it is likely that most learners will have studied some Physics or general Science previously. The use of electricity will, almost certainly, have been within the experience of all learners although, since it is very commonly misunderstood or not understood at all, there might be misconceptions that need to be addressed early on. The media rarely distinguish between voltage, current and power and the ideas that current diminishes as it progresses through a circuit is curiously attractive and difficult to erase.

Learners are likely to be aware that electricity is an enormously useful mechanism for transferring energy and are also likely to be aware that mains voltage electricity can be dangerous or even fatal. They might not realise how this relates to the human nervous system which is essentially electrical. The idea that electricity is solely industrial and not natural will also be difficult to counter but some learners will have encountered electric eels or be aware of the electrical nature of lightning. Many learners will have met simple experiments with light bulbs and simple cells and will know that a closed circuit is required before any energy can be transferred within the circuit. The fundamental effects of electricity – the heating, lighting, motor and chemical effects – might be within the experience of most learners. Those who have not previously come across ammeters might at least be familiar with fuses, trip switches and residual current circuit breakers. Similarly, they will probably have experienced various electrostatic effects. These might include making a balloon stick to the ceiling or hearing the crackling as a comb is pulled through hair that is dry and clean. The recharging of a mobile phone battery is one example of the chemical effect of an electric current.

Context

Electricity is both a fundamental and a major component of many Physics courses and this is true of the Cambridge IGCSE Physics course. It is also one that learners find hard to understand. That electricity can be neither seen nor heard nor smelt, renders it somehow less accessible. This, then, is unlikely to be the first unit taught. Simple practical experiments and the kinaesthetic experience of handling equipment might assist in overcoming the difficulties many learners encounter; there are many practical experiments that can be demonstrated or performed in class. The relationship between current and charge can be used to distinguish between a rate of change and the original quantity that is changing. This is an idea that has more general application within the course. The concept of electric current is one that learners are likely to find more accessible that the concept underlying the two types of voltage (e.m.f. and p.d.).

Outline

This unit contains ideas that do not immediately and directly relate to the familiar experience of many learners and the concepts are ones that learners tend to find somewhat hard to grasp. The teacher is likely to concentrate here on the basic ideas of the subject but experiments can be used to acquire the skills of graph plotting and calculations can be used to ensure that learners are adept at rearranging equations. There are likely to be several unfamiliar units encountered properly for the first time here, and learners can be encouraged to be meticulous in ensuring that the correct units are invariably included with numerical answers.

(Note: **(S)** denotes material in the Supplement only.)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 18.1
4.2.2(S) 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. At the mention of the Van de Graaff generator, learners are likely to ask about lightning – try this site also about the work of Benjamin Franklin. Franklin survived but some of those who tried to duplicate this experiment were killed.	Interesting information about static electricity and how the Van de Graaff 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 Franklin: www.history.com/this-day-in-history/franklin-flies-kite-during-thunderstorm
4.2.3 Electromotive 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.	
4.2.3(S) Electromotive 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.	A good introductory lesson on current and e.m.f: www.mos.org/live-presentations/lightning The bicycle analogy: www.youtube.com/watch?v=ecMM9z39irg
4.2.4	State that the potential	Continue the circuit work, measuring potential differences with a	Voltmeters in parallel with the component:

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
Potential difference	difference (p.d.) across a circuit component is measured in volts Use and describe the use of a voltmeter, both analogue and digital	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.	www.bbc.co.uk/bitesize/ks3/science/energy_electricity_forces/electric_current_voltage/revision/5/
4.2.4(S) Potential difference	**Recall that 1 V is equivalent to 1 J / C**	This is a statement of a fact – the definition of the volt. More able 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 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 resistance of a wire to its length and to its diameter	Extend the circuit work using an ammeter and a voltmeter to measure I and V and so calculate resistance of a resistor. 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. 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 Resistance depends on length: www.youtube.com/watch?v=KWAJNkX0c04 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 18.2 **Unit 2: Past Paper Questions (Core 1 and 2)** **Unit 2: Past Paper Questions (Alternative to Practical 1 and 2)**
4.2.5(S) Resistance	**Sketch and explain the current-voltage characteristic of an ohmic**	Extend the experimental resistance work to give quantitative results.	Resistance of filament lamp: www.youtube.com/watch?v=qbhoGefCUiA

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	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**		Resistance, length and area: www.physicsclassroom.com/class/circuits/Lesson-3/Resistance **Unit 2: Past Paper Questions (Extension 1)** **Unit 2: Past Paper Questions (Alternative to Practical 3)**
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(S) 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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 18.3

Unit 3: Energy

Recommended prior knowledge

Although Cambridge IGCSE Physics itself can be used as an introduction to Physics, it is likely that most learners will have studied some Physics or General Science previously. The word *energy*, with a whole host of meanings and many subtle shades of emphasis, is likely to be part of a Cambridge IGCSE Physics learner's vocabulary. When commencing the course, however, the learner is unlikely to be especially exact in distinguishing between words such as *force*, *energy*, *power* and *work*. Part of this course must be to help learners use these terms appropriately and accurately when the context is purely scientific and to ensure that they realise that the terms are not simply interchangeable. It might be argued that *energy* is the most basic idea in Physics and that every branch of Physics is the study of a corresponding energy. Again this idea is found by many learners to be vague, intangible and inaccessible. In many ways, the ideas of this unit are going to be constantly revisited in every other unit of the course.

It is likely that most learners will have encountered the concept of energy sources and will realise that the maintenance of many aspects of modern life relies on readily available energy sources. The ideas of renewable and non-renewable energy sources and of the benefits and problems associated with the use of fossil fuels are almost certain to be familiar to learners at this stage. Likewise they will be aware of the concepts of *heat* and *heating* but might not think of it as a form of energy. The way in which *energy* relates to the other sciences, might also be understood to some extent. Learners might have heard of units such as the *calorie* or *kilowatt-hour*, but are less likely to have come across the *joule.*

Context

The concept of energy is hard to grasp, despite it being so crucial to the understanding of Physics. It is an idea that is best taught by using the term correctly and frequently throughout the course; examples of energy transfers could be included in almost any lesson. The section of this unit on renewable and non-renewable energy sources is an area where individual learners can investigate the issues through project work and personal research either through the internet or by the use of periodicals, textbooks or television programmes. The topics on thermal energy transfer, however, are much more easily taught in a conventional way with the usual experiments that show the distinction between transfer by conduction, convection and radiation.

Outline

This unit contains ideas that, although superficially familiar to many learners, are unlikely to be properly understood by all. They are, however, ideas that are fundamental to this course and any proper understanding of the subject. They will need constant revisiting and the learners will need to become familiar with them in a thoroughly convincing fashion. In one sense, the whole course is the study of energy and it is very difficult to teach this unit on its own without reference to other units. The study of energy is never really completed.

(Note: **(S)** denotes material in the Supplement only.)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
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, etc. 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.youtube.com/watch?v=btLU2lb3-xs www.brightstorm.com/science/physics/energy-and-momentum/conservation-of-energy/ *IGCSE Physics Coursebook CD-ROM* Activity Sheet 6.1 **Unit 3: Past Paper Questions (Core 2)**
1.7.1(S) Energy	**Recall and use the expressions kinetic energy = ½*mv*^{2} and change in gravitational potential energy = *mg*Δ*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 surroundings (dissipated)**	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/ *IGCSE Physics Coursebook CD-ROM* Activity Sheet 6.2 **Unit 3: Past Paper Questions (Extension 1)**
1.7.2	Describe how electricity or	Examples of both renewable and non-renewable sources of	This website provides a useful investigation

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
Energy resources	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	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.	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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 7.1, 7.2
1.7.2(S) 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 by 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 transforms energy into chemical energy by photosynthesis. The concept of efficiency is readily understood by many learners.	Fusion in the Sun: www.youtube.com/watch?v=pusKlK1L5To

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	$\frac{\text{useful energy output}}{\text{energy input}} \times 100\%$ efficiency = $\frac{\text{useful power output}}{\text{power input}} \times 100\%$	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.	
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.	Conduction in copper and steel: www.youtube.com/watch?v=eMGqkOTJCN0 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 11.1
2.3.1(S) 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
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. Show convection in air using, for example, a mine ventilation model. Discuss heaters at ground level and air-conditioning units at ceiling level. 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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 11.2 **Unit 3: Past Paper Questions (Core 3)**
2.3.3 Radiation	Identify infra-red radiation as part of the electromagnetic spectrum Recognise that thermal energy transfer by 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	What is infra-red radiation? www.bbc.co.uk/schools/gcsebitesize/science/aqa/heatingandcooling/heatingrev1.shtml www.youtube.com/watch?v=_WP2XwBhmAk

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	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	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.	www.gemini.edu/public/infrared.html *IGCSE Physics Coursebook CD-ROM* Activity Sheet 11.3 **Unit 3: Past Paper Questions (Core 1)**
2.3.3(S) Radiation	**Describe experiments to show the properties of good and bad emitters and good and bad absorbers of infra-red radiation** **Show understanding that the amount of radiation emitted also depends on the surface temperature and surface area of a body**	Leslie's cube type experiments show the effect of the colour of a surface on the emission of radiation. 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. Absorption of infra-red can be easily shown 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 Infra-red radiation: www.youtube.com/watch?v=TjiIPQuU0H0
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. 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 **Unit 3: Past Paper Questions (Alternative to Practical 1)**

Unit 4: Mechanics 1

Recommended prior knowledge

It is highly likely that many learners will have studied some Physics or General Science previously and it is almost certain that many of the ideas of this unit will have been met in this way by the learners following this course. The measuring cylinder is not that different from a kitchen measuring jug, and watches and clocks – both digital and analogue – along with rules are likely to be very commonly encountered by the learners even outside the classroom.

Learners will need to be familiar with graphs and graph plotting here and although they are not likely to have talked much in terms of the area under a graph or its gradient, they might have met some of the ideas in other ways. Learners are bound to have some understanding of distance, speed and time and will almost certainly be able to conduct simple calculations in miles/hour or kilometres/hour even if they find metres/second trickier and do not see immediately how it all relates to the equation: $v = x/t$. They will have encountered the term *force* but might well use it interchangeably with terms such as *energy* or *pressure*. They may have encountered the unit newton but may also be measuring forces in other units; this can lead to confusion but some learners will have previously met the distinction between *mass* and *weight* and this can help. Some learners will have learnt about density but few will be aware that it is an intrinsic (intensive) property of a substance whereas mass is an extrinsic (extensive) property of an object.

Context

The ideas covered in this part of the course are conceptually straightforward and few learners will have any difficulty in understanding them. This then is an area where learners might be encouraged to perfect other skills such as graph plotting, mathematical calculation or the rearrangement of equations. It can also be used to show how an abstract mathematical construction (such as an equation) can be applied in the much more tangible area of kinematics. Again the ideas dealt with here will be revisited and investigated further in subsequent units.

Outline

This unit contains ideas that are likely to be very familiar to many learners, although the accompanying mathematics will in some cases prove to be a challenge. This is a good topic for introducing new units and for distinguishing between mass and weight.

(Note: **(S)** denotes material in the Supplement only.)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
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.	Determine the acceleration due to gravity – an experiment: www.youtube.com/watch?v=aGqMn13e19s **Unit 4: Past Paper Questions (Alternative to Practical 1)**
1.1(S) **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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 1.1
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	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. 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.	Definition of velocity: www.youtube.com/watch?v=cE-bGnwTbTU What is acceleration: www.youtube.com/watch?v=l7W5pH0AKSI 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

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	– at rest – moving with constant speed – moving with changing speed 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		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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 2.2, 2.3, 2.4 **Unit 4: Past Paper Questions (Core 2 and 3)**
1.2(S) Motion	**Distinguish between speed and velocity** **Define and calculate acceleration using** $$\frac{\textbf{change of velocity}}{\textbf{time taken}}$$ **Calculate speed from the gradient of a distance-time graph** **Calculate acceleration**	Extend the trolley work to analyse the graphs further and calculate the acceleration. 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.	Simple animations on terminal velocity: www.regentsprep.org/Regents/physics/phys01/terminal/default.htm Terminal velocity: www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/forces/forcesvelocityrev1.shtml http://hyperphysics.phy-astr.gsu.edu/hbase/airfri2.html *IGCSE Physics Coursebook CD-ROM* Activity Sheet 2.5

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	from the gradient of a speed-time graph **Recognise linear motion for which the acceleration is constant** **Recognise motion for which the 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)**		**Unit 4: Past Paper Questions (Extension 1 and 2)**
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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 3.3

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
1.3(S) **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
1.4 Density	Recall and use the equation $\rho = \frac{m}{V}$	Simple experiments measuring mass and volume of a liquid and calculating density. Using a solid, finding volume from height, width and depth. 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. Extend to the displacement method, e.g. Plasticine of different shapes in a measuring cylinder with water.	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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 1.2 **Unit 4: Past Paper Questions (Core 1)**
	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		

Unit 5: Electromagnetism

Recommended prior knowledge

The linking of magnetic fields and electrical circuits is a part of the course that learners find one of the most challenging. It is probable that learners will have encountered magnets and magnetism at a fairly young age and the basic rules of like poles repelling and so on will have been known for many years when the Cambridge IGCSE Physics course is begun. It is surprising, however, that learners are so commonly uncertain about which materials are ferromagnetic. Learners at this stage very often believe that aluminium and copper – and sometimes all metals – are ferromagnetic. The plotting of magnetic fields with iron filings, plotting compasses and other devices will probably have been dealt with earlier, although what is actually shown by the patterns is not always properly understood. That repulsion is the only true test for a magnet is also likely to have been met. Electromagnets will have been made and learners will be familiar with many standard examples of temporary, permanent and electro-magnets. Learners will need to have studied the Unit 2: Electricity 1 before embarking on this unit; they need to be familiar with current and voltage (and the distinction between them) before dealing with electromagnetism. Surprisingly, learners who might otherwise never confuse the terms *motor* and *generator* are sometimes tempted to do so when the *motor effect* and the *dynamo effect* are encountered within a short space of time. It is wise to separate them and to emphasise the distinction between what they do.

Context

Since learners find electromagnetism so challenging, it is probably best left to near to the end of the course; this ensures that they have the maximum possible understanding of most other topics and the proximity of the examination is likely to concentrate their determination and enthusiasm. Many learners are not especially clear about electromagnetic effects and, wherever possible, they should be demonstrated by the teacher or, even better, performed by the learners themselves. The progression from inserting a magnet into a solenoid, to repeating the experiment with an electromagnet, to switching the electromagnet off instead of removing it from the solenoid and then switching it back on, and finally to using the electromagnet with an a.c. supply is a clear and helpful way of introducing the transformer.

Outline

This unit contains ideas that relate directly to the way in which electricity is generated commercially, also to its transmission at high voltage and its use in motors. It can be used to tie the physics into the everyday lives of learners and to help them see the relevance and importance of the subject as a whole.

(Note: **(S)** denotes material in the Supplement only.)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
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). Extend to show the direction of the field lines using a plotting compass. Make and use a simple electromagnet. 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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 16.1, 16.2 **Unit 5: Past Paper Questions (Core 1)** **Unit 5: Past Paper Questions (Alternative to Practical 1)**
4.1(S) Simple	**Explain that magnetic forces are due to**	Experiments to investigate the magnetisation of iron or steel and demagnetisation of samples of steel by mechanical and electrical	Magnetisation and demagnetisation: http://ap-physics.david-s.org/methods-

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
phenomena of magnetism	**interactions between magnetic fields** **Describe methods of demagnetisation, to include hammering, heating and use of a.c. in a coil**	means. 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-demagnetisation/ www.youtube.com/watch?v=Dka-cROHxBY
4.6.1 Electromagnetic 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. 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.	Electromagnetic induction: www.ndt-ed.org/EducationResources/HighSchool/Electricity/electroinduction.htm www.regentsprep.org/regents/physics/phys03/dinduction/default.htm www.youtube.com/watch?v=hajlIGHPeuU *IGCSE Physics Coursebook CD-ROM* Activity Sheet 21.1 **Unit 5: Past Paper Questions (Core 2)**
4.6.1(S) Electromagnetic 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.	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	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	a.c. and d.c.: www.bbc.co.uk/schools/gcsebitesize/scienc

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	current (a.c.)	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.	e/add_aqa_pre_2011/electricity/mainselectrev5.shtml
4.6.2(S) **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 Describe the use of the transformer in high-voltage transmission of electricity Give the advantages of high voltage transmission	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 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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 21.2
4.6.3(S) **Transformer**	**Describe the principle of operation of a transformer**	A simple worked example using specific values is often a clear way of showing the significance of high voltage transmission.	Power line repairs: www.youtube.com/watch?v=EWbBdAeW1m

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	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 model power line, if used with appropriate safety precautions, can help learners to see what is happening.	8 **Unit 5: Past Paper Questions (Extension 1)**
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. 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 **Unit 5: Past Paper Questions (Extension 2)**
4.6.4(S) **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**	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). 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/

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 20.1, 20.2
4.6.5(S) 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 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	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. 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(S) 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. 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	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

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
		speed up.	**Unit 5: Past Paper Questions (Core 3)**

Unit 6: Electricity 2

Recommended prior knowledge
It is likely that this section of the course will be studied after *Electricity 1*, although there is certainly scope for dealing with electrostatics before *Electricity 1* should a teacher wish to do so. Likewise, $P = IV$ could be left until after Electricity 1 and treated almost as a topic in its own right within Electricity 2; it fits in very well with *fuses* and *RCCBs (Residual Current Circuit Breakers)* and *safety precautions* in general. The coulomb is a unit which learners are unlikely to have encountered elsewhere and might well come after meeting the idea of rates and the equation $Q = It$.

Learners commonly confuse magnetism and electrostatics and it is wise to separate the topics – perhaps by putting them into separate years in the course; it is good if the correct use of terms such as *pole, north, south* and *magnetise* can be fully understood before terms like *charge, positive, negative* and *charging* are met or vice versa.

Context
This part of the course completes the pure electricity topics that the Cambridge IGCSE syllabus requires, although the distinction between *Electricity 1* and *Electricity 2* is somewhat arbitrary and could quite happily be taught together or subdivided differently should a teacher prefer. Some teachers will prefer to deal with electricity in its entirety and then move on to other units and deal with them, whilst other teachers will teach a little electricity, move on to something else and then keep returning to it and cover it in small sections; this is a matter of taste and not one of right or wrong.

Outline
As with the previous electricity unit, it contains ideas that do not immediately and directly relate to the familiar experience of many learners, and learners tend to find the concepts somewhat vague and intangible. The teacher is likely to concentrate here on the experiments that can be used to underline the handling of information, and obtaining the correct numerical answer rather than attempting to instil a philosophical and fundamental understanding of the ideas in the abstract. Calculation and formula manipulation is likely to emphasise this. It is also a topic where the use of units and unit symbols will be important.

(Note: **(S)** denotes material in the Supplement only.)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 17.1 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 17.2 **Unit 6: Past Paper Questions (Core 2)**
4.2.1(S) 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**	For more able 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 **Unit 6: Past Paper Questions (Extension 1)**

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	charge, the field around a 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/ *IGCSE Physics Coursebook CD-ROM* Activity Sheet 19.2
4.3.1(S) 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	Understand that the current at every point in a series	The behaviour of current in circuits is commonly misunderstood and it is very helpful to demonstrate the equality of the current in	Series resistors: www.bbc.co.uk/bitesize/higher/physics/elect/

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
parallel circuits	circuit is the same Give the combined resistance of two or more resistors in series 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 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. 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. 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.	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=vlicY0Y491Q
4.3.2(S) 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 Core work can be extended for more able learners to a quantitative approach to series and parallel circuits. Use voltmeters and ammeters to show the relationship required. Measurements of current in series and parallel circuits, e.g. with cells and lamps, could form the basis of the work on combinations	**Unit 6: Past Paper Questions (Core 1 and 3)**

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	the components in a series circuit is equal to the total p.d. across the 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**	of resistors. Demonstrate with ammeters that the current flowing into a junction equals that flowing out.	
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 www.youtube.com/watch?v=Ym1a9_aXEv8 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 19.4

Unit 7: Thermal physics

Recommended prior knowledge
Many physics teachers do not like the term *heat*, preferring to refer to *heating* as a process rather than to *heat* as a form of energy. The Cambridge IGCSE Physics syllabus takes a more inclusive view. The terms *thermal energy* and *internal energy* are used commonly in the syllabus. It would be clumsy, however, to avoid the historical terms *latent heat* and *specific heat capacity* both of which appear in the syllabus.

Although heating is in many ways as intangible and abstract as electricity, it is a concept with which most learners are more comfortable. The idea of temperature is one that learners ought to have encountered by the time they embark on this course although they might use it interchangeably with the term *heat*. Likewise, liquid-in-glass thermometers should be familiar, as should digital thermometers of various sorts. Not all learners will realise that heat is a form of energy and the historically separate unit *the calorie* only re-emphasises this perceived distinction. Similarly, it is important to use the temperature unit *the degree Celsius* rather than *the degree centigrade* or *the degree*. Learners should have encountered the term *molecule* and should be aware of the microscopic structure of matter. This unit includes *evaporation* from section 2.1 of the syllabus. Evaporation is sometimes considered to be a fourth heat transfer mechanism.

Context
Although the concept of energy is hard to grasp, learners seem much more comfortable with the specific example of *thermal energy* and *heating*. This is probably because of the learners' familiarity with heating. This acquaintance will have been developed from using domestic heating systems, cooking with oil or water and simple things such as adjusting the temperature of the water in a bath or from a shower. It shows the importance of practical experience in general and the pedagogic importance of practical lessons in this subject. Consequently, this unit, or at least most of it, can comfortably be taught towards the beginning of the course.

Outline
This unit contains ideas that are very familiar to many learners but their understanding is unlikely to be thorough. The relationship between macroscopic phenomena and molecular behaviour will probably be new to many but it is one of the foundations of all physics and the topics from this unit are excellent vehicles for introducing this relationship.

(Note: **(S)** denotes material in the Supplement only.)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
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. 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. 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 Brownian motion is well illustrated on this website: http://galileo.phys.virginia.edu/classes/109N/more_stuff/Applets/brownian/brownian.html Pressure due to molecules: www.grc.nasa.gov/WWW/k-12/airplane/pressure.html *IGCSE Physics Coursebook CD-ROM* Activity Sheet 9.3 **Unit 7: Past Paper Questions (Core 3)** **Unit 7: Past Paper Questions (Extension 2)**
2.1.2(S) Molecular model	**Relate the properties of solids, liquids and gases to the forces and distances between molecules and to the motion of the**	The ordinary experiments may be explained using a more exact approach and by talking about how the forces between the molecules act at different distances.	Pressure and molecular momentum: www.saburchill.com/physics/chapters/0099.html

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	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**	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.	
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(S) 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.	
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. Place a partially inflated balloon in a bell-jar and reduce the pressure in the jar.	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:

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	– a change of volume at constant temperature		www.youtube.com/watch?v=N5xft2flqQU Charles' law: www.youtube.com/watch?v=HxSPdmvqstQ *IGCSE Physics Coursebook CD-ROM* Activity Sheet 9.4
2.1.4(S) 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 more able learners.	Thermal expansion: www.youtube.com/watch?v=EkQ2886Sxpg The fountain experiment: www.youtube.com/watch?v=AX5eVxxQgPc
2.2.1(S) 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	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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 10.1

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	Recognise the need for and identify fixed points Describe and explain the structure and action of liquid-in-glass thermometers		
2.2.2(S) 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.	*IGCSE Physics Coursebook CD-ROM* Activity Sheet 10.2 **Unit 7: Past Paper Questions (Alternative to Practical 1)** **Unit 7: Past Paper Questions (Extension 1)**
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.	**Unit 7: Past Paper Questions (Core 1)**
2.2.3(S) Thermal capacity	**Give a simple molecular account of an increase in internal energy**	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

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
(heat capacity)	**Recall and use the equation** **thermal capacity = *mc*** **Define specific heat capacity** **Describe an experiment to measure the specific heat capacity of a substance** **Recall and use the equation** **change in energy = $mc\Delta T$**		Measuring specific heat capacity: www.youtube.com/watch?v=vMvSYlY_PxU
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(S) **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**	Simple and direct experiments to determine specific latent heat, e.g. using a low voltage immersion heater.	Evaporation and vapor 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 **Unit 7: Past Paper Questions (Core 2)**

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	Describe an experiment to measure specific latent heats for steam and for ice **Recall and use the equation** **energy = ml**		**Unit 7: Past Paper Questions (Extension 3)**

Unit 8: Mechanics 2

Recommended prior knowledge
By the time this stage in the course is reached, most learners will have already studied much if not all of *Mechanics 1* and will have begun to distinguish the terms *force*, *energy*, *pressure*, *work* and *mass*. By the end of the unit, these distinctions should be complete and familiar.

Mechanics is a part of physics that learners can easily understand. Most of the concepts are less abstract and relatively easily accessible and the ideas are generally straightforward. *Mechanics 2* might be dealt with earlier rather than later in the course, although it will probably be taught after *Mechanics 1*, since the idea of *force* and its corresponding unit the *newton* will need to be familiar to the learners. Learners are not always aware of the way in which forces act. Many learners are tempted to believe that a stretched spring which exerts a force of 5.0 N at one end and (inevitably) the same force at the other end is somehow subject to a tension of 10.0 N. Where learners have previously carried out experiments on springs in parallel and series, such misunderstandings are less likely to arise. Many learners will have encountered simple experiments on making things balance and will have developed ideas concerning the product *mass* × *distance*. It might be necessary to emphasise that this approach relies on the cancellation of *g* on both sides of an equation and that the important quantity is *force* × *(perpendicular) distance*. Where the distinction between mass and weight has been encountered previously, this should be easier to teach.

Pressure cannot be taught easily without having met with *force*, and pressure in a liquid will need learners to understand *density*. Learners might be aware that some units are merely special names for combinations of other units and the *pascal* and the *joule* can be used as examples of this. Graph plotting can be used in the work that deals with springs and Hooke's law.

Context
There is little in this unit that is likely to prove especially difficult; mechanics is much more related to a learner's everyday experience of the world than some other topics. It can be dealt with fairly early in the course if desired. Again practical lessons can bring the subject home to learners in a particularly direct fashion.

Outline
This unit contains ideas that are quite familiar to many learners and their understanding is likely to be reasonable. It is a unit where teaching other important skills such as accuracy, meticulousness, neatness and a systematic approach to problems can be encouraged without the danger of obscuring the topic being investigated.

(Note: **(S)** denotes material in the Supplement only.)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
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/ *IGCSE Physics Coursebook CD-ROM* Activity Sheet 3.1 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 5.1 **Unit 8: Past Paper Questions (Extension 2)**
1.5.1(S) Effects of forces	**State Hooke's Law and recall and use the expression $F = kx$, where k is the spring constant** **Recognise the significance of the 'limit of**	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 extended to investigate model rockets and Newton's cradle.	Hooke's Law: www.matter.org.uk/schools/content/hookeslaw/index.html www.youtube.com/watch?v=fYLec9q3oSw Centripetal force:

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	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)**	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.	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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 4.1, 4.2 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 4.3 **Unit 8: Past Paper Questions (Core 1 and 2)** **Unit 8: Past Paper Questions (Alternative to Practical 1)**
1.5.2(S) 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. Determine the mass of a rule by balancing it away from its centre	Principle of moments: www.cyberphysics.co.uk/topics/forces/principleOfMoments.htm

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
		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.	
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(S) 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(S) Scalars and vectors	**Understand that vectors have a magnitude and direction** **Demonstrate an understanding of the difference between scalars**	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.	Adding vectors: www.physicsclassroom.com/class/vectors/Lesson-1/Vector-Addition www.youtube.com/watch?v=bPYLWjcY9wA This website, about Leonardo da Vinci,

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	and vectors and give common examples **Determine graphically the resultant of two vectors**	Can a cable car hang from a perfectly horizontal cable?	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(S) 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 the direction of the force	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. 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=482eIBArWJQ www.youtube.com/watch?v=2WS1sG9fhOk IGCSE Physics Coursebook CD-ROM Activity Sheet 3.2 IGCSE Physics Coursebook CD-ROM Activity Sheet 8.1
1.7.3(S) Work	**Recall and use $W = Fd = \Delta E$**		Work and energy – a pulley with two weights:

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
			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(S) **Power**	**Recall and use the equation $P = \Delta E / t$ in simple systems**		*IGCSE Physics Coursebook CD-ROM* Activity Sheet 8.2
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 Use and describe the use of a manometer	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.	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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 5.3 **Unit 8: Past Paper Questions (Core 3)**

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
1.8(S) Pressure	**Recall and use the equation $p = h\rho g$**	Use the formula 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.	Hydrostatic pressure: http://faculty.wwu.edu/vawter/PhysicsNet/Topics/Pressure/HydroStatic.html **Unit 8: Past Paper Questions (Extension 1)**

Unit 9: Waves

Recommended prior knowledge

Although the Cambridge IGCSE Physics course may be an introduction to Physics, it is probable that most learners will have been taught some Physics or General Science already. Both sound and light are phenomena that all learners will be aware of and will have realised that they can be understood and investigated as branches of science.

Learners might be aware that waves can be used to transfer energy from one location to another and may have been given basic definitions of wave motion. It is less likely that they will have encountered the distinction between oscillations of matter being used to transfer energy as a wave and the actual movement of matter with energy; this might be highlighted at this stage. Learners may aware of simple sound phenomena and will probably know words such as *pitch* and *loudness*. They will have seen demonstrations that show the need for a medium to transmit sound, and might know that sound travels differently in different media, that is it has different speeds and different attenuation rates in different media. They are also likely to be aware that whilst the speed of sound is large, it is very substantially less than that of light; that lightning arrives before the thunder is a widely known example of this. Similarly, a learner might be aware that sound spreads out in a way that light does not, although the precise nature of diffraction is unlikely to be understood.

Learners will have heard of infra-red radiation (and perhaps also ultraviolet radiation, although this is not separately mentioned in the syllabus) but will not necessarily follow what is meant by the phrase *invisible light* which is often applied to this component of the electromagnetic spectrum. Likewise, ultrasound might have been described *as sound which we cannot hear*.

Context

Within the Cambridge IGCSE Physics course, *waves, sound and light* are natural partners and can be dealt with early on in the course; there are few challenging concepts although some learners will find the idea of frequency more challenging than others. It is also likely that there will be those who cannot invariably rearrange $v = f\lambda$ and obtain the correct answer. Inevitably, the study of infra-red radiation will link in with the study of the transfer of thermal energy and it might help if the electromagnetic spectrum could be studied before thermal transfer. Otherwise, the term *radiation* (used in many different ways in physics and frequently confused in the media) and can easily lead to misunderstanding. Waves are often represented in diagrammatic forms and this unit can be used to emphasise the importance of clear and appropriate diagrams in explaining the subject, both generally and when answering examination questions.

Outline

This unit contains ideas that relate to the common experiences of many learners and it can be used to show that everyday phenomena can be more thoroughly understood when a scientific explanation is offered.

(Note: **(S)** denotes material in the Supplement only.)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
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.	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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 14.1 **Unit 9: Past Paper Questions (Core 1 and 3)** **Unit 9: Past Paper Questions (Extension 2)**
3.1(S) General wave properties	**Recall and use the equation $v = f\lambda$**	Find the wavelengths and frequencies for local radio stations and calculate *c*.	Wave equation: www.youtube.com/watch?v=jEEPp0mBCdg

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	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 speed: www.bbc.co.uk/schools/gcsebitesize/science/aqa_pre_2011/radiation/anintroductiontowavesrev3.shtml www.gcse.com/waves/vfl.htm
3.3 Electromagnetic 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 of microwaves and X-rays	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 **Unit 9: Past Paper Questions (Core 2)**

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
3.3(S) **Electromagnetic 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.	A good presentation of electromagnetic waves showing the link between wavelength and uses: www.colorado.edu/physics/2000/index.pl click on Science Trek click on Electromagnetic Waves
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.	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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 12.1, 12.2
3.4(S)	**Describe compression and**	A large-scale, outdoor echo method to determine the speed of	Compressions and rarefactions:

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
Sound	**rarefaction** **State typical values of the speed of sound in gases, liquids and solids**	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.	www.bbc.co.uk/schools/gcsebitesize/science/add_gateway_pre_2011/radiation/ultrasoundrev1.shtml www.youtube.com/watch?v=HlSCwV8d5qM Speed of sound in differing media: http://hyperphysics.phy-astr.gsu.edu/hbase/tables/soundv.html **Unit 9: Past Paper Questions (Extension 1)**

Unit 10: Atomic physics

Recommended prior knowledge
This unit is composed of two major sections: *radioactivity* and *atomic structure*. It is likely that learners will be aware of the existence of radioactivity but beyond the general view that it is bad and dangerous they are unlikely to be well informed. Some will know that background radiation has been an omnipresent and unavoidable factor throughout history, whilst others will believe that radioactivity is invariably man-made and a recently invented danger. Some of the course will involve the re-teaching of aspects of the subject that are firmly fixed within the learners' understanding but which are simply wrong. Many learners firmly believe that after two half-lives have passed, the radioactive sample has disappeared entirely, whilst others will be certain that one may determine the half-life by placing a radioactive sample on a set of scales and waiting for the reading to halve. It is also widely believed that the absorption of radioactive emissions such as α-particles, β-particles and γ-rays can cause a substance that was not previously radioactive to become so.

Learners might well have a much clearer view of the other part of this unit. Most will, in some way, have encountered the particle model of matter and will be aware of the distinction between elements and compounds. The distinction between atoms and molecules is much less likely to be widely understood and the importance of the structure of an atom in both chemistry and physics might not be clear.

Context
Although the particulate nature of atoms is fundamental to the study of physics, an understanding of the precise nature of those particles is not vital before other parts of the course are dealt with. When pressure or temperature is explained in terms of the particles within a substance, it doesn't immediately matter if those particles are molecules or atoms. It might be better to leave this unit until later in the course. The term *ionising* does not appear elsewhere in the syllabus and will need explanation. Some learners, however, might have met it or at least the word *ion*, elsewhere.

Outline
This unit contains ideas that are important in understanding the fundamental nature of matter and when studied it can make vague and hazy ideas much clearer to the learner. It is likely to help those who are also studying chemistry.

(Note: **(S)** denotes material in the Supplement only.)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
5.2.1 Detection of radioactivity	Demonstrate understanding of back ground 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 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 **Unit 10: Past Paper Questions (Extension 1, 2 and 3)**
5.2.2(S) Characteristics of the three kinds of emission	**Describe their deflection in electric fields and in magnetic fields** **Interpret their relative ionising effects** **Give and explain examples of practical applications of α, β and γ-emissions**	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
5.2.3 Radioactive	State the meaning of radioactive decay	Emphasise that a radioactive material decays nucleus by nucleus over time and not all at once.	*IGCSE Physics Coursebook CD-ROM* Activity Sheet 23.3

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
decay	State that during α- or β-decay the nucleus changes to that of a different element		
5.2.3(S) 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	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.	A good presentation to explain the meaning of the term 'half-life': www.colorado.edu/physics/2000/index.pl On the left-hand side click on Table of Contents. Scroll down to the bottom of the page and click on 'Meaning of half-life'. A useful half-life simulation – a graph is plotted as an isotope decays (a variety of isotopes can be chosen). Click on Half-life. www.youtube.com/watch?v=fToMbj3Xz2c www.youtube.com/watch?v=PYn8vFmyGPM www.youtube.com/watch?v=Tp2M9tndGG0 **Unit 10: Past Paper Questions (Core 3)**
5.2.4(S) Half-life	**Calculate half-life from data or decay curves from which background radiation has not been**	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	Learning resources
	subtracted		
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.	**Unit 10: Past Paper Questions (Core 1)**
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=lP57gEWcisY www.youtube.com/watch?v=sRPejoNktKE
5.1.1(S) 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 *IGCSE Physics Coursebook CD-ROM* Activity Sheet 22.1 **Unit 10: Past Paper Questions (Core 2)**

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	Use and explain the term isotope		
5.1.2(S) 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.	

Scheme of work – Cambridge IGCSE® Physics (0625)

Unit 11: Electronics

Recommended prior knowledge
Beyond seeing an old-fashioned cathode tube television set or a c.r.o. display at a hospital, learners will not have encountered much of this unit outside a physics classroom. The ideas are relatively straightforward but they build on ideas encountered earlier in the course and so this is a unit that is probably best left until the second half of the Cambridge IGCSE course.

Learners will need to know what electrons are and where they come from and they will need to know some static electricity before studying the c.r.o. Knowledge of currents and voltages should precede the study of the diode and the transistor. Likewise the study of the a.c. generator, (and inevitably the study to some limited extent of alternating currents), should precede teaching *rectification*. Learners find the potential divider surprisingly difficult, perhaps partly because they find the concept of a potential difference hard to grasp, and it is best approached through practical experimentation that allows the learner to see what is happening. It may then be dealt with theoretically.

Context
This unit groups together ideas that relate principally to the application of electricity and should not be tackled until the other electrical units have been covered. There is little in it that is genuinely difficult but without a fundamental and prior understanding of the other electrical units, confusion and misunderstanding would be inevitable.

Outline
This unit primarily deals with the application of ideas met in other units and there are few new ideas here – just the application of familiar ideas in important and new contexts.

(Note: **(S)** denotes material in the Supplement only.)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
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 **Unit 11: Past Paper Questions (Core 1)**
4.3.3(S) 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 **Unit 11: Past Paper Questions (Alternative to Practical 1)**
4.4(S) 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** **Recall and use the**	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: www.youtube.com/watch?v=ubEijRkLweo www.youtube.com/watch?v=XwHXeZZf8fY *IGCSE Physics Coursebook CD-ROM* Activity Sheet 19.3

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
	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**		