Cambridge Secondary 2

Cambridge IGCSE

Learner Guide

Cambridge IGCSE® (9–1)
Physics **0972**

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Contents

How to use this guide

This Learner Guide can be used to help you to plan your revision programme for the theory exams and will explain what we're looking for in the answers you write. It can also be used to help you revise by using the revision checklist in section 4. You can check what you know, which topic areas you have covered and the topics you need to spend more time on.

The guide contains the following sections:

1: How will you be tested?
This section will give you information about the different types of theory and practical exam papers that are available.

2: Exam advice
This section gives you advice to help you do as well as you can. Some of the ideas are general advice and some are based on the common mistakes that candidates make in exams.

3: What will be tested?
This section describes the areas of knowledge, understanding and skills that you will be tested on.

4: What you need to know
This shows the syllabus content in a simple way so that you can check:

- the topics you need to know about
- how the Extended syllabus (Supplement) differs from the Core syllabus
- details about each topic in the syllabus
- how much of the syllabus you have covered

5: Mathematical skills

6: Appendices
This section covers the other things you need to know, including:

- information about terminology, units and symbols, and the presentation of data
- the importance of the command words the examiners use in the exam papers

Not all the information will be relevant to you. For example, you will need to select what you need to know in Sections 1 and 3, by finding out from your teacher which exam papers you're taking.

1: How will you be tested?

About the papers

You will be entered for **three** exam papers, **two** theory papers and **one** practical paper.

You will need to ask your teacher which practical paper you're taking. Nearer the time of the exam, you will also need to ask which theory papers you're being entered for:

- If your teacher thinks that you should enter for the exam based on the Core syllabus, you will take Paper 1 (theory), Paper 3 (theory) and **one** of the practical Papers (5 or 6).
- If your teacher thinks that you should enter for the exam based on the Extended syllabus, you will take Paper 1 (theory), Paper 4 (theory) and **one** of the practical Papers (5 or 6).

Whether you take the Core or Extended papers will depend on the progress your teacher thinks you have made and which option most suits your particular strengths. You should discuss this with your teacher.

About the theory papers

The table gives you information about the theory papers.

Paper	How long and how many marks?	What's in the paper?	What's the % of the total marks?
Paper 1 (Core)	45 minutes	40 multiple-choice questions. You choose one answer you consider correct from a choice of four possible answers. The paper tests the Core syllabus.	30% (you do either Paper 1 or Paper 2)
Paper 2 (Extended)	45 minutes	40 multiple-choice questions. You choose one answer you consider correct from a choice of four possible answers. The paper tests the Extended syllabus (Core plus Supplement topics).	30% (you do either Paper 1 or Paper 2)
Paper 3 (Core)	1 hour 15 minutes	Short-answer questions and structured questions. You should write your answers in the spaces provided. The paper tests the Extended syllabus (Core plus Supplement topics).	50% (you do either Paper 3 or Paper 4)
Paper 4 (Extended)	1 hour 15 minutes	Short-answer questions and structured questions. Questions will be based on the Extended syllabus content (Core and Supplement).	50% (you do either Paper 3 or Paper 4)

About the practical papers

Twenty per cent of the marks for Cambridge IGCSE Physics are for practical work. Practical work is not based on specific syllabus content. You will need to practise the experimental skills listed in the syllabus, and any other information you need will be given in the questions.

You will do **one** of the practical papers shown in the table. Your teacher will tell you which practical paper you will do.

Paper	How long and what it's marked out of?	What's in the test/paper?
Paper 5 Practical Test	1 hour 15 minutes	You do a practical exam, which is supervised by a teacher. There are usually two questions testing five skill areas.
Paper 6 Alternative to Practical	1 hour	You answer a written paper about practical work. There are usually two or three questions, which test the same skill areas as Paper 5.

Here is some more detail about each of the practical papers. If you're unsure of anything, ask your teacher.

Experimental skills tested in Paper 5: Practical Test and Paper 6: Alternative to Practical

You may be asked questions on the following experimental contexts:

- measurement of physical quantities such as length or volume or force
- cooling and heating
- springs and balances
- timing motion or oscillations
- electric circuits
- optics equipment such as mirrors, prisms and lenses
- procedures using simple apparatus, in situations where the method may not be familiar to you. You may be required to do the following:
    - use, or describe the use of, common techniques, apparatus and materials, for example ray-tracing equipment or the connection of electric circuits
    - select the most appropriate apparatus or method for a task and justify the choice made
    - draw, complete or label diagrams of apparatus
- explain the manipulation of the apparatus to obtain observations or measurements, for example:
    - when determining a derived quantity, such as the extension per unit load for a spring
    - when testing/identifying the relationship between two variables, such as between the p.d. across a wire and its length
    - when comparing physical quantities, such as two masses using a balancing method
- make estimates or describe outcomes which demonstrate their familiarity with an experiment, procedure or technique
- take readings from an appropriate measuring device or from an image of the device (for example thermometer, rule, protractor, measuring cylinder, ammeter, stopwatch), including:
    - reading analogue and digital scales with accuracy and appropriate precision
    - interpolating between scale divisions when appropriate
    - correcting for zero errors, where appropriate
- plan to take a sufficient number and range of measurements, repeating where appropriate to obtain an average value
- describe or explain precautions taken in carrying out a procedure to ensure safety or the accuracy of observations and data, including the control of variables
- identify key variables and describe how, or explain why, certain variables should be controlled
- record observations systematically, for example in a table, using appropriate units and to a consistent and appropriate degree of precision
- process data, using a calculator where necessary

- present and analyse data graphically, including the use of best-fit lines where appropriate, interpolation and extrapolation, and the determination of a gradient, intercept or intersection
- draw an appropriate conclusion, justifying it by reference to the data and using an appropriate explanation
- comment critically on a procedure or point of practical detail and suggest an appropriate improvement
- evaluate the quality of data, identifying and dealing appropriately with any anomalous results
- identify possible causes of uncertainty, in data or in a conclusion
- plan an experiment or investigation including making reasoned predictions of expected results and suggesting suitable apparatus and techniques.

2: Exam advice

This section highlights some common mistakes made by learners. They are collected under various subheadings to help you when you revise a particular topic.

General advice

- Read the questions carefully and fully.
- Look for details that indicate how to answer or the depth of answer required. For example the question 'Describe, in terms of the movement and energies of the water molecules, how evaporation takes place' is allocated two marks on a paper. This shows that you must make two valid points and you must refer to movement and energy of the molecules. So wording such as 'some molecules have more energy than others and these leave the surface' will gain both marks.
- Make sure you are confident with your calculator – particularly using powers of 10.
- Always show your working in calculations so that you can gain marks for your method even if you make a mistake with the final answer.
- Always include units where appropriate.
- Avoid vague descriptions – try to write clearly and concisely using the correct physics terms.
- Use a sharp pencil for graph work, taking care to plot each point with a small, neat cross and to draw a thin best fit line.
- At the end of a calculation ask yourself 'is this answer sensible?'
- Make sure you answer the question set. You will gain no marks for merely repeating the facts given in the question.

Paper 1 and Paper 2 advice

This is the multiple-choice test.

- Work through the paper with care. Do not miss out a question for any reason – you may then start placing your answers in the wrong places.
- Do not attempt to look for any pattern, or any lack of pattern in the answers. In other words, do not worry about how many questions have been answered A, B, C or D and do not worry about the distribution of As, Bs, Cs and Ds.

Paper 3 and Paper 4 advice

These are the papers that test your knowledge and understanding of physics theory and the ability to apply your knowledge to situations described on the paper. The following includes some tips on how to read the questions and advice on particular items in the syllabus that often seem to be poorly understood or applied. (This does not mean that other parts of the syllabus require any less revision of course!).

Reading the questions

- It is very easy when presented with a diagram question to look at the diagram and then try to answer the question. You **must** read and understand the introductory sentences above the diagram first before trying to answer the question. There may be a part of the question near the end which requires you to use a piece of information that is included in the introductory sentences in your answer.
- Be careful how you answer your questions. An explanation of some physics (even if correct) that does not answer the question set does not score marks.
- If there are three marks available for a calculation, two of the three marks are for showing your working.
- If a question states 'accurately mark' or 'accurately draw', we expect points (e.g. a centre of gravity) to be carefully positioned and lines to be drawn with care using a ruler. In the case of ray diagrams it is expected that rays drawn should pass at least within 1 mm of the relevant point (e.g. principal focus).

- When reading the questions, decide which area of physics you are being asked about. Do not just look at a few words as you may then misunderstand the question. For example a question that mentions heat radiation is not about radioactivity (just because the word 'radiation' is seen). If you are asked for a convection current diagram do not draw a circuit just because the word 'current' is in the question!

Answering the questions

Here are some examples that show the type of understanding that is required to answer questions successfully.

- You must understand the turning effect of a force and that it is called the moment of the force.
- You must be clear about the names given to types of energy and use them appropriately.
- You should know the circuit symbols required for use in describing electrical circuits. The symbol for a fuse is often not known and the symbols for a thermistor and a variable resistor are commonly confused with each other.
- You must know how to connect a voltmeter in parallel with the component across which you are measuring the potential difference.
- You must have a clear understanding of electromagnetic induction. For example, you must know that when a magnet is moved in or out of a solenoid that is part of a circuit, a current will be induced. It is the movement of the magnet in the solenoid that causes the current as its magnetic field lines cut the coil.
- You must understand the difference between mass and weight.
- You must understand basic radioactivity. You should know about the characteristics of the three types of emission (alpha, beta and gamma), half-life and safety precautions.

Paper 5 and Paper 6 advice

You will take one of these papers that test practical physics. There are some particular points that are relevant to answering the questions here.

- When plotting a graph it is important to choose the scales so that the plots occupy more than half of the graph grid. Careless, rushed graph plotting can lose several marks. You should always use a sharp pencil and plot small, neat, accurately placed crosses. Then draw a neat thin best-fit line.
- You should understand that if y is proportional to x then the graph will be a straight line through the origin.
- Diagrams should be drawn with care using a sharp pencil.
- It is important to be able to set up a circuit from a diagram, draw a circuit diagram of a circuit already set up and also to draw a circuit diagram from a written description.
- You need to know that to read the current through a component (e.g. a lamp or a resistor) and the voltage across it, the ammeter is placed in series with the component but the voltmeter must be connected in parallel with the component.
- Column headings in tables of readings must be headed with the quantity and unit as in these examples: I/A, or t/s, or y/m. Graph axes are labelled in the same way.
- Final answers should be given to two or three significant figures.
- When carrying out practical work there are usually measurements that are in some way difficult to take in spite of taking great care. You should comment about these difficulties when asked about precautions taken to improve accuracy.
- You should understand that the control of variables is an important aspect of practical work. You should be able to comment on the control of variables in a particular experiment.
- You should understand the significance of wording such as 'within the limits of experimental accuracy'.
- If you are asked to justify a statement that you have made it must be justified by reference to the readings. A theoretical justification in a practical test will not gain marks.

3: What will be tested?

The examiners will take account of the following areas in your exam papers:

- your knowledge (what you remember) and understanding (how you use what you know and apply it to unfamiliar situations).
- how you handle information and solve problems.
- your use of experimental skills.

These areas of knowledge and skills are called assessment objectives. The theory papers (Papers 1 and 3, or Papers 2 and 4) test mainly Assessment Objective 1 (knowledge with understanding) and Assessment Objective 2 (handling information and problem solving). The purpose of the practical paper (Paper 5 or 6) is to test Assessment Objective 3 (experimental skills). Your teacher will be able to give you more information about how each of these is used in the exam papers.

The table shows you the range of skills you should try to develop:

Assessment Objective	What the skill means?	What you need to be able to do?
AO1 Knowledge with understanding	remembering facts and applying these facts to new situations	1. use scientific ideas, facts and theories 2. know scientific definitions e.g. centre of mass 3. know about apparatus and how it works 4. know about S I units, quantities (e.g. mass and weight) and symbols (e.g. kg and N) 5. understand the importance of science in everyday life
AO2 Handling information and problem solving	how you extract information and rearrange it in a sensible pattern and how you carry out calculations and make predictions	1. select and organise information from graphs, tables and written text 2. change information from one form to another, e.g. draw graphs 3. arrange data and carry out calculations 4. identify patterns from information given and draw conclusions 5. explain scientific relationships, e.g. use the moving (kinetic) particle theory to explain ideas about solids, liquids and gases 6. make predictions and develop scientific ideas 7. solve problems
AO3 Experimental skills	planning and carrying out experiments and recording and analysing information	1. set up and use apparatus safely 2. make observations and measurements and record them 3. analyse experimental results and suggest how valid they are 4. plan and carry out your own experiment and describe to what extent your plan worked and suggest improvements

4: What you need to know

The table describes the things you may be tested on in the exam. It is arranged in 21 topic areas. If you're studying only the Core material (Papers 1 and 3), you will need to refer **only** to the column headed Core material. If you're studying the Extended syllabus (Papers 2 and 4), you will need to refer to both the Core and Supplement material columns. Read Section 1 if you're unsure about which material to use.

How to use the table

You can use the table throughout your course to check the topic areas you have covered. You can also use it as a revision aid. When you think you have a good knowledge of a topic, you can tick the appropriate box in the checklist column. The main headings in the topic areas are usually followed by the details of what you should know.

Test yourself as follows:

- cover up the details with a piece of paper
- try to remember the details
- when you have remembered the details correctly, put a tick in the appropriate box.

If you use a pencil to tick the boxes, you can retest yourself whenever you want by simply rubbing out the ticks. If you're using the table to check the topics you have covered, you can put a tick in the topic column next to the appropriate bullet point.

The column headed 'Comments' can be used:

- to add further information about the details for each bullet point
- to add learning aids
- to highlight areas of difficulty/things which you need to ask your teacher about.

Topic	Core material You should be able to:	Checklist	Comments	Supplement material You should be able to:	Checklist	Comments
1. General physics						
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)	☐ ☐ ☐		• Understand that a micrometre screw gauge is used to measure very small distances	☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
1.2 Motion	• Define speed and calculate speed from $\frac{\text{total distance}}{\text{time}}$ • Plot and interpret a speed-time graph or a distance-time graph • Recognise from the shape of a speed-time graph when a body is ○ At rest ○ Moving with constant speed ○ Moving with changing speed • 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	☐ ☐ ☐ ☐ ☐ ☐		• Distinguish between speed and velocity • Define and calculate acceleration using $\frac{\text{change of velocity}}{\text{time taken}}$ • Calculate speed from the gradient of a distance-time graph • Calculate acceleration from the gradient of a speed-time graph • Recognise linear motion for which the acceleration is constant • Recognise motion for which the 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)	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
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	☐ ☐ ☐ ☐ ☐		• 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	☐ ☐	
1.4 Density	• Recall and use the equation $\rho = \frac{m}{v}$ • Describe an experiment to determine the density of a liquid and of a regularly shaped solid and make the necessary calculation • Describe the determination of the density of an irregularly shaped solid by the method of displacement • Predict whether an object will float based on density data	☐ ☐ ☐ ☐				

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
1.5 Forces 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	☐ ☐ ☐ ☐ ☐ ☐ ☐		• 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 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)	☐ ☐ ☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
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	☐ ☐ ☐ ☐		• Apply the principle of moments to different situations	☐	
1.5.3 Conditions for equilibrium	• Recognise that, when there is no resultant force and no resultant turning effect, a system is in 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	☐ ☐				

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
1.5.5 Scalars and vectors				• Understand that vectors have a magnitude and direction • Demonstrate an understanding of the difference between scalars and vectors and give common examples • Determine graphically the resultant of two vectors	☐ ☐ ☐	
1.6 Momentum				• Understand the concepts of momentum and impulse • Recall and use the equation momentum = mass × velocity, $p = mv$ • Recall and use the equation for impulse $Ft = mv – mu$ • Apply the principle of the conservation of momentum to solve simple problems in one dimension	☐ ☐ ☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
1.7 Energy, work and power 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	☐ ☐ ☐		• Recall and use the expressions kinetic energy = $\frac{1}{2}mv^2$ and change in gravitational potential energy = $mg\Delta h$ • Apply the principle of conservation of energy to examples involving multiple stages • Explain that in any event or process the energy tends to become more spread out among the objects and surroundings (dissipated)	☐ ☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
1.7.2 Energy resources	• Describe how electricity or other useful forms of energy may be obtained from: ○ chemical energy stored in fuel ○ water, including the energy stored in waves, in tides, ○ and in water behind hydroelectric dams ○ geothermal resources ○ nuclear fission ○ heat and light from the Sun (solar cells and panels) ○ wind • Give advantages and disadvantages of each method in terms of renewability, cost, reliability, scale and environmental impact • Show a qualitative understanding of efficiency	☐ ☐ ☐		• 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 equation: efficiency = $\frac{\text{useful energy output}}{\text{energy input}} \times 100$ • efficiency = $\frac{\text{useful power output}}{\text{power input}} \times 100$	☐ ☐ ☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
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	☐ ☐		• Recall and use $W = Fd = \Delta E$	☐	
1.7.4 Power	• Relate (without calculation) power to work done and time taken, using appropriate examples	☐		• Recall and use the equation $P = \Delta E / t$ in simple systems	☐	
1.8 Pressure	• Recall and use the equation $p = F / A$ • Relate pressure to force and area, using appropriate examples • Describe the simple mercury barometer and its use in measuring atmospheric pressure • Relate (without calculation) the pressure beneath a liquid surface to depth and to density, using appropriate examples • Use and describe the use of a manometer	☐ ☐ ☐ ☐ ☐		• Recall and use the equation $p = h\rho g$	☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
2 Thermal physics						
2.1 Simple kinetic molecular model of matter 2.1.1 States of matter	• State the distinguishing properties of solids, liquids and gases	☐				
2.1.2 Molecular mode	• 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	☐ ☐ ☐ ☐ ☐		• Relate the properties of solids, liquids and gases to the forces and distances between molecules and to the motion of the molecules • Explain pressure in terms of the change of momentum of the particles striking the walls creating a force • Show an appreciation that massive particles may be moved by light, fast-moving molecules	☐ ☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
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	☐ ☐		• 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	☐ ☐	
2.1.4 Pressure changes	• Describe qualitatively, in terms of molecules, the effect on the pressure of a gas of: ○ a change of temperature at constant volume ○ a change of volume at constant temperature	☐		• Recall and use the equation pV = constant for a fixed mass of gas at constant temperature	☐	
2.2 Thermal properties and temperature 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	☐ ☐		• Explain, in terms of the motion and arrangement of molecules, the relative order of the magnitude of the expansion of solids, liquids and gases	☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
2.2.2 Measurement of temperature	• Appreciate how a physical property that varies with temperature may be used for the measurement of temperature, and state examples of such properties • Recognise the need for and identify fixed points • Describe and explain the structure and action of liquid-in-glass thermometers	☐ ☐ ☐		• 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	☐ ☐ ☐	
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	☐ ☐		• Give a simple molecular account of an increase in internal energy • 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 = $mc\Delta T$	☐ ☐ ☐ ☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
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	☐ ☐ ☐		• Distinguish between boiling and evaporation • Use the terms latent heat of vaporisation and latent heat of fusion and give a molecular interpretation of latent heat • Define specific latent heat • Describe an experiment to measure specific latent heats for steam and for ice • Recall and use the equation energy = *ml*	☐ ☐ ☐ ☐ ☐	
2.3 Thermal processes 2.3.1 Conduction	• Describe experiments to demonstrate the properties of good and bad thermal conductors	☐		• Give a simple molecular account of conduction in solids including lattice vibration and transfer by electrons	☐	
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	☐ ☐				

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
2.3.3 Radiation	• Identify infra-red radiation as part of the electromagnetic spectrum • Recognise that thermal energy transfer by radiation does not require a medium • Describe the effect of surface colour (black or white) and texture (dull or shiny) on the emission, absorption and reflection of radiation	☐ ☐ ☐		• 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	☐ ☐	
2.3.4 Consequences of energy transfer	• Identify and explain some of the everyday applications and consequences of conduction, convection and radiation	☐				

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
3. Properties of waves, including light and sound						
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	☐ ☐ ☐ ☐ ☐ ☐ ☐		• Recall and use the equation $v = f\lambda$ • Describe how wavelength and gap size affects diffraction through a gap • Describe how wavelength affects diffraction at an edge	☐ ☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	**Checklist**	**Comments**	**You should be able to:**	**Checklist**	**Comments**
3.2 Light 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	☐ ☐		• Recall that the image in a plane mirror is virtual • Perform simple constructions, measurements and calculations for reflection by plane mirrors	☐ ☐	
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	☐ ☐ ☐ ☐		• Recall and use the definition of refractive index n in terms of speed • Recall and use the equation $\frac{\sin i}{\sin r} = n$ • Recall and use $n = \frac{1}{\sin c}$ • Describe and explain the action of optical fibres particularly in medicine and communications technology	☐ ☐ ☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
3.2.3 Thin converging lens	• Describe the action of a thin converging lens on a beam of light • Use the terms principal focus and focal length • Draw ray diagrams for the formation of a real image by a single lens • Describe the nature of an image using the terms enlarged/same size/ diminished and upright/ inverted	☐ ☐ ☐ ☐		• 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	☐ ☐ ☐	
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	☐		• Recall that light of a single frequency is described as monochromatic	☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
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	☐ ☐ ☐ ☐		• State that the speed of electromagnetic waves in a vacuum is 3.0×10^8 m/s and is approximately the same in air	☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
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	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐		• Describe compression and rarefaction • State typical values of the speed of sound in gases, liquids and solids	☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
4 Electricity and magnetism						
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	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐		• Explain that magnetic forces are due to interactions between magnetic fields • Describe methods of demagnetisation, to include hammering, heating and use of a.c. in a coil	☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	**Checklist**	**Comments**	**You should be able to:**	**Checklist**	**Comments**
4.2 Electrical qualities 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	☐ ☐ ☐ ☐ ☐		• State that charge is measured in coulombs • State that the direction of an electric field at a point is the direction of the force on a positive charge at that point • Describe an electric field as a region in which an electric charge experiences a force • Describe simple field patterns, including the field around a point charge, the field around a 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	☐ ☐ ☐ ☐ ☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
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	☐ ☐ ☐		• 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	☐ ☐	
4.2.3 Electromotive force	• State that the e.m.f. of an electrical source of energy is measured in volts	☐		• Show understanding that e.m.f. is defined in terms of energy supplied by a source in driving charge round a complete circuit	☐	
4.2.4 Potential difference	• State that the potential difference (p.d.) across a circuit component is measured in volts • Use and describe the use of a voltmeter, both analogue and digital	☐ ☐		• Recall that 1 V is equivalent to 1 J / C	☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
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	☐ ☐ ☐ ☐		• Sketch and explain the current-voltage characteristic of an ohmic resistor and a filament lamp • Recall and use quantitatively the proportionality between resistance and length, and the inverse proportionality between resistance and cross- sectional area of a wire	☐ ☐	
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	☐		• Recall and use the equations $P = IV$ and $E = IVt$	☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
4.3 Electric circuits 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	☐		• Draw and interpret circuit diagrams containing diodes	☐	
4.3.2 Series and parallel circuits	• Understand that the current at every point in a series circuit is the same • Give the combined resistance of two or more resistors in series • 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	☐ ☐ ☐ ☐ ☐		• Calculate the combined e.m.f. of several sources in series • Recall and use the fact that the sum of the p.d.s across the components in a series circuit is equal to the total p.d. across the 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	☐ ☐ ☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	**Checklist**	**Comments**	**You should be able to:**	**Checklist**	**Comments**
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	☐ ☐ ☐ ☐		• 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)	☐ ☐	
4.4 Digital electronics				• Explain and use the terms analogue and digital in terms of continuous variation and high/low states • Describe the action of NOT, AND, OR, NAND and NOR gates • Recall and use the symbols for logic gates • Design and understand simple digital circuits combining several logic gates • Use truth tables to describe the action of individual gates and simple combinations of gates	☐ ☐ ☐ ☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
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	☐ ☐ ☐ ☐				
4.6 Electromagnetic effects 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.	☐ ☐ ☐		• 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	☐ ☐	

Topic	Core material: You should be able to:	Checklist	Comments	Supplement material: You should be able to:	Checklist	Comments
4.6.2 a.c. generator	• Distinguish between direct current (d.c.) and alternating current (a.c.)	☐		• 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	☐ ☐ ☐	
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	☐ ☐ ☐ ☐ ☐		• Describe the principle of operation of a transformer • Recall and use the equation $I_p V_p = I_s V_s$ (for 100% efficiency) • Explain why power losses in cables are lower when the voltage is high	☐ ☐ ☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
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	☐ ☐		• 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	☐ ☐ ☐	
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	☐		• State and use the relative directions of force, field and current • Describe an experiment to show the corresponding force on beams of charged particles	☐ ☐	
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	☐		• Relate this turning effect to the action of an electric motor including the action of a split-ring commutator	☐	

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
5. Atomic physics						
5.1 The nuclear atom 5.1.1 Atomic model	• Describe the structure of an atom in terms of a positive nucleus and negative electrons	☐		• Describe how the scattering of a-particles by thin metal foils provides evidence for the nuclear atom	☐	
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 $^{A}_{Z}X$ • Use and explain the term isotope	☐ ☐ ☐ ☐ ☐ ☐		• State the meaning of nuclear fission and nuclear fusion • Balance equations involving nuclide notation	☐ ☐	
5.2 Radioactivity 5.2.1 Detection of radioactivity	• Demonstrate understanding of background radiation • Describe the detection of α-particles, β-particles and γ-rays (β^+ are not included: β-particles will be taken to refer to β^-)	☐ ☐				

Topic	Core material			Supplement material		
	You should be able to:	Checklist	Comments	You should be able to:	Checklist	Comments
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–)	☐ ☐		• 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	☐ ☐ ☐	
5.2.3 Radioactive decay	• State the meaning of radioactive decay • State that during α- or β-decay the nucleus changes to that of a different element	☐ ☐		• Use equations involving nuclide notation to represent changes in the composition of the nucleus when particles are emitted	☐	
5.2.4 Half-life	• Use the term half-life in simple calculations, which might involve information in tables or decay curves	☐		• Calculate half-life from data or decay curves from which background radiation has not been 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	☐ ☐				

5: Mathematical skills

This is a checklist of the mathematical skills you need for your Biology exam. You should tick each box in the checklist when you know that you have learned the skill. Ask your teacher to explain any skill you're unsure about. The 'Comments' column is for extra notes and examples.

You can use a calculator for all the exam papers. If your calculator is one that can be programmed, you should make sure that any information in it is removed before the exam.

You should be able to:	Checklist	Comments
• Add, subtract, multiply and divide	☐	
• use averages • use decimals • use fractions • use percentages • use ratios • use reciprocals	☐ ☐ ☐ ☐ ☐ ☐	
• recognise standard notation (notation is putting symbols for numbers e.g. x = 2, y = 5, atomic mass, Z = 12) • use standard notation	☐ ☐	
• understand significant figures and use them appropriately	☐	
• use direct proportion (stepwise increases) • use inverse proportion (inverse means turned upside down)	☐ ☐	You should know that if you plot a graph of y against x, then a straight line through the origin shows that y is directly proportional to x. The inverse of 4 is ¼ (= 0.25).
• Use positive, whole number indices in algebraic expressions	☐	
• draw charts • draw graphs with line of best fit	☐ ☐	You will be given the data.
• interpret bar graphs • interpret pie charts • interpret line graphs • determine the gradient and intercept of a graph • select suitable scales and axes for graphs • make approximate evaluations of numerical expressions	☐ ☐ ☐ ☐ ☐ ☐	

recall and use equations for: • the area of a rectangle • the area of a triangle • the area of a circle • the volume of a rectangular block • the volume of a cylinder	☐ ☐ ☐ ☐ ☐	
• use a ruler, compasses, protractor and set square	☐	
understand the meaning of: • angle • curve • circle • radius • diameter • square • circumference • rectangle • parallelogram • diagonal	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	
• solve equations of the form $x = y + z$ and $x = yz$ for any one term when the other two are known	☐	
• Recognise and use clockwise and anticlockwise directors	☐	
• Recognise and use points of the compass (N, S, E, W)	☐	
• Use sines and inverse sines (Extended syllabus only)	☐	

6: Appendices

Symbols, units and definitions of physical quantities

You should be able to state the symbols for the following physical quantities and, where indicated, state the units in which they are measured. The list for the Extended syllabus includes both the Core and the Supplement.

You should be familiar with the following multipliers: M mega, k kilo, c centi, m milli.

Core			Supplement		
Quantity	***Usual symbol***	***Usual unit***	***Quantity***	***Usual symbol***	***Usual unit***
length	*l*, *h* …	km, m, cm, mm			
area	*A*	m^2, cm^2			
volume	*V*	m^3, cm^3			
weight	*W*	N			
mass	*m*, *M*	kg, g	mass	*m*, *M*	mg
time	*t*	h, min, s	time	*t*	ms
density	ρ	g/cm^3, kg/m^3			
speed	*u*, *v*	km/h, m/s, cm/s			
acceleration	*a*		acceleration	*a*	m/s^2
acceleration of free fall	*g*		acceleration of free fall	*g*	m/s^2
force	*F*	N			
gravitational field strength	*g*	N/kg			
			momentum	*p*	kg m/s
			impulse		N s
moment of a force		N m			
work done	*W*, *E*	J, kJ, MJ			
energy	*E*	J, kJ, MJ			
power	*P*	W, kW, MW			
pressure	*p*	N/m^2	pressure	*p*	Pa
atmospheric pressure		mm Hg			
temperature	*θ*, *T*	°C			

Core			Supplement		
Quantity	***Usual symbol***	***Usual unit***	***Quantity***	***Usual symbol***	***Usual unit***
			thermal capacity (heatcapacity)	*C*	J / °C
			specific heat capacity	*c*	J / (g °C), J / (kg °C)
latent heat	*L*	J			
			specific latent heat	*l*	J / kg, J / g
frequency	*f*	Hz, kHz			
wavelength	λ	m, cm			
focal length	*f*	cm			
angle of incidence	*i*	degree (°)			
angle of reflection, refraction	*r*	degree (°)			
critical angle	*c*	degree (°)			
			refractive index	*n*	
potential difference/voltage	*V*	V, mV			
current	*I*	A, mA			
e.m.f.	*E*	V			
resistance	*R*	Ω			
			charge	*Q*	C

Command words and phrases

We use command words to help you to write down the answer they are looking for. This table explains what each of these words or phrases means and will help you to understand the kind of answer you should write. The list is in alphabetical order. You should bear in mind that the meaning of a term may vary slightly according to how the question is worded.

Command word/phrase	Meaning
Calculate	A numerical answer is needed. You should show any working, especially when there are two or more steps in a calculation. *e.g. calculate the refractive index*
Deduce	This may be used in two ways: (i) You find the answer by working out the patterns in the information given to you and drawing logical conclusions from them. You may need to use information from tables and graphs and do calculations *e.g. deduce what will happen to velocity of the vehicle if …* (ii) You have to refer to a Law or scientific theory or give a reason for your answer *e.g. use your knowledge of the kinetic theory to deduce what will happen when …*
Define	You need to state the meaning of something, *e.g. define speed*
Describe	You need to state the main points about something (using labelled diagrams if it helps you). *e.g. describe a rotating-coil generator* You may also be asked to describe observations *e.g. describe the ways in which a force may change the motion of a body* how to do particular experiments *e.g. describe an experiment to determine resistance using a voltmeter and an ammeter*
Determine	You are expected to use a formula or method that you know to calculate a quantity. *e.g. determine graphically the resultant of two vectors*
Discuss	You have to write down points **for** and **against** an argument. *e.g. discuss the energy loss in cables*
Estimate	Suggest an approximate value for a quantity based on reasons and data. You may need to make some approximations. *e.g. estimate the volume of a test tube.*
Explain	You have to give reasons for your answer OR refer to a particular theory.
Find	This is a general term meaning several similar things such as calculate, measure, determine, etc.
List	Write down a number of separate points. Where the number of points is stated in the question, you should not write more than this number. *e.g. list* ***three*** *uses of converging lenses*

Command word/phrase	Meaning
Meant (what is meant by the term…)	See 'Understand'
Measure	You are expected to find a quantity by using a measuring instrument. *e.g. length (by using a ruler), volume (by using a measuring cylinder)*
Outline	State the main points briefly. *e.g. outline a method of magnetising an iron bar*
Predict	This can be used in two ways: (i) You find the answer by working out the patterns in the information provided and drawing logical conclusions from this. You may need to use information from tables and graphs and do calculations. *e.g. predict what will happen to the direction of the resultant force if ….* (ii) It may also mean giving a short answer to a question stating what might happen next. *e.g. predict what effect an increase in temperature will have on the resistance.*
Sketch	(i) When drawing graphs, this means that you may draw the approximate shape and/or position of the graph BUT you need to make sure that important details, such as the line passing through the origin or finishing at a certain point, are drawn accurately. (ii) When drawing apparatus or other diagrams, a simple line drawing is all that is needed, but you must make sure that the proportions are correct and the most important details are shown. You should always remember to label your diagrams.
State	You should give a short answer without going into any detail. *e.g. state the hazards of damaged electrical insulation* BUT: 'state the meaning of…' is different. It is more like 'understand'.
Suggest	This may be used in two ways: (i) There may be more than one correct answer. *e.g. suggest a precaution to improve the accuracy of the experiment* (ii) You are being asked to apply your general knowledge of physics or reasoning skills to a topic area that is not on the syllabus. *e.g. applying ideas about moments to the stability of a vehicle*
Understand (what do you understand by the term.)	You should (i) define something and (ii) make a more detailed comment about it. The amount of detail depends on the number of marks awarded. *e.g. what do you understand by the term total internal reflection*

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