CAMBRIDGE
International Examinations

SYLLABUS

Cambridge IGCSE®
Physics

0625

For examination in June and November 2016, 2017 and 2018.
Also available for examination in March 2016, 2017 and 2018
in India only.

This syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge
International Level 1/Level 2 Certificate (QN: 500/5660/8).

Cambridge Secondary 2

Changes to syllabus for 2016

The syllabus has been revised. You are advised to read the whole of the syllabus before planning your teaching programme. The most significant changes are outlined below.

| **Significant changes to the syllabus are indicated by black vertical lines at the side of the text.** |

Changes to the structure of the assessment

The practical option, Paper 4: Coursework has been withdrawn.

A new Multiple Choice paper for extended candidates has been included. This paper is now Paper 2.

The papers are:

Paper 1: Multiple Choice (Core)
Paper 2: Multiple Choice (Extended)
Paper 3: Theory (Core)
Paper 4: Theory (Extended)
Paper 5: Practical Test
Paper 6: Alternative to Practical

Core candidates will now take Paper 1: Multiple Choice (Core), and Paper 3: Theory (Core) and either Paper 5: Practical Test or Paper 6: Alternative to Practical.

Extended candidates will now take Paper 2: Multiple Choice (Extended) and Paper 4: Theory (Extended) and either Paper 5: Practical Test or Paper 6: Alternative to Practical.

Paper 5: Practical test will now typically consist of 4 exercises, only 3 of which will require the use of apparatus. Candidates are expected to spend about 20 minutes on each of the practical exercises.

Changes to syllabus content

The syllabus content has been revised and updated to modernise and improve the relevance of the syllabus.

The wording of some learning outcomes has been changed for clarification.

Some material has been reordered or moved from the Core to the Supplement or from the Supplement to the Core syllabus content.

Deleted topics (2014 references)

Capacitors and transistors in Electrical circuits 4.3

Cathode rays and the oscilloscope 4.6

New topics (2016 references)

1.6 Momentum

Contents

1. Introduction

1.1 Why choose Cambridge?

Recognition

Cambridge International Examinations is the world's largest provider of international education programmes and qualifications for learners aged 5 to 19. We are part of Cambridge Assessment, a department of the University of Cambridge, trusted for excellence in education. Our qualifications are recognised by the world's universities and employers.

Cambridge IGCSE® (International General Certificate of Secondary Education) is internationally recognised by schools, universities and employers as equivalent in demand to UK GCSEs. Learn more at **www.cie.org.uk/recognition**

Excellence in education

Our mission is to deliver world-class international education through the provision of high-quality curricula, assessment and services.

More than 9000 schools are part of our Cambridge learning community. We support teachers in over 160 countries who offer their learners an international education based on our curricula and leading to our qualifications. Every year, thousands of learners use Cambridge qualifications to gain places at universities around the world.

Our syllabuses are reviewed and updated regularly so that they reflect the latest thinking of international experts and practitioners and take account of the different national contexts in which they are taught.

Cambridge programmes and qualifications are designed to support learners in becoming:

confident in working with information and ideas – their own and those of others

responsible for themselves, responsive to and respectful of others

reflective as learners, developing their ability to learn

innovative and equipped for new and future challenges

engaged intellectually and socially, ready to make a difference.

Support for teachers

A wide range of materials and resources is available to support teachers and learners in Cambridge schools. Resources suit a variety of teaching methods in different international contexts. Through subject discussion forums and training, teachers can access the expert advice they need for teaching our qualifications. More details can be found in Section 2 of this syllabus and at **www.cie.org.uk/teachers**

Support for exams officers

Exams officers can trust in reliable, efficient administration of exams entries and excellent personal support from our customer services. Learn more at **www.cie.org.uk/examsofficers**

Not-for-profit, part of the University of Cambridge

We are a not-for-profit organisation where the needs of the teachers and learners are at the core of what we do. We continually invest in educational research and respond to feedback from our customers in order to improve our qualifications, products and services.

Our systems for managing the provision of international qualifications and education programmes for learners aged 5 to 19 are certified as meeting the internationally recognised standard for quality management, ISO 9001:2008. Learn more at **www.cie.org.uk/ISO9001**

1.2   Why choose Cambridge IGCSE?

Cambridge IGCSEs are international in outlook, but retain a local relevance. The syllabuses provide opportunities for contextualised learning and the content has been created to suit a wide variety of schools, avoid cultural bias and develop essential lifelong skills, including creative thinking and problem-solving.

Our aim is to balance knowledge, understanding and skills in our programmes and qualifications to enable candidates to become effective learners and to provide a solid foundation for their continuing educational journey.

Through our professional development courses and our support materials for Cambridge IGCSEs, we provide the tools to enable teachers to prepare learners to the best of their ability and work with us in the pursuit of excellence in education.

Cambridge IGCSEs are considered to be an excellent preparation for Cambridge International AS and A Levels, the Cambridge AICE (Advanced International Certificate of Education) Group Award, Cambridge Pre-U, and other education programmes, such as the US Advanced Placement program and the International Baccalaureate Diploma programme. Learn more about Cambridge IGCSEs at **www.cie.org.uk/cambridgesecondary2**

Guided learning hours

Cambridge IGCSE syllabuses are designed on the assumption that learners have about 130 guided learning hours per subject over the duration of the course, but this is for guidance only. The number of hours required to gain the qualification may vary according to local curricular practice and the learners' prior experience of the subject.

1.3   Why choose Cambridge IGCSE Physics?

Cambridge IGCSE Physics is accepted by universities and employers as proof of essential knowledge and ability. As well as a subject focus, the physics syllabus enables learners to:

- better understand the technological world, with an informed interest in scientific matters
- recognise the usefulness (and limitations) of scientific method, and how to apply this to other disciplines and in everyday life
- develop relevant attitudes, such as a concern for accuracy and precision, objectivity, integrity, enquiry, initiative and inventiveness
- develop an interest in, and care for, the environment
- better understand the influence and limitations placed on scientific study by society, economy, technology, ethics, the community and the environment
- develop an understanding of the scientific skills essential for both further study and everyday life.

Prior learning

Learners in England who are beginning this course should normally have followed the Key Stage 3 programme of study within the National Curriculum for England.

Other candidates beginning this course should have achieved an equivalent level of general education.

Progression

Cambridge IGCSE Certificates are general qualifications that enable candidates to progress either directly to employment, or to proceed to further qualifications.

Candidates who are awarded grades A* to C for this qualification are well prepared to follow courses leading to Level 3 AS and A Level GCE Physics, Cambridge Pre-U Physics, IB Certificates in Physics or the Cambridge International AS and A Level Physics.

1.4 Cambridge ICE (International Certificate of Education)

Cambridge ICE is a group award for Cambridge IGCSE. It gives schools the opportunity to benefit from offering a broad and balanced curriculum by recognising the achievements of learners who pass examinations in at least seven subjects. To qualify for the Cambridge ICE award, learners are required to have studied subjects from five groups: two languages from Group 1, and one subject from each of the remaining four groups. The seventh subject can be taken from any of the five subject groups.

Physics is in Group 3, Science.

Learn more about Cambridge ICE at **www.cie.org.uk/cambridgesecondary2**

The Cambridge ICE is awarded from examinations administered in the June and November series each year. In India, the Cambridge ICE is also awarded from examinations administered in the March series each year.

1.5 How can I find out more?

If you are already a Cambridge school

You can make entries for this qualification through your usual channels. If you have any questions, please contact us at info@cie.org.uk

If you are not yet a Cambridge school

Learn about the benefits of becoming a Cambridge school at **www.cie.org.uk/startcambridge**. Email us at info@cie.org.uk to find out how your organisation can register to become a Cambridge school.

2. Teacher support

2.1 Support materials

Cambridge syllabuses, past question papers and examiner reports to cover the last examination series are on the *Syllabus and Support Materials* DVD, which we send to all Cambridge schools.

You can also go to our public website at **www.cie.org.uk/igcse** to download current and future syllabuses together with specimen papers or past question papers and examiner reports from one series.

For teachers at registered Cambridge schools a range of additional support materials for specific syllabuses is available from Teacher Support, our secure online support for Cambridge teachers. Go to **http://teachers.cie.org.uk** (username and password required).

2.2 Resource lists

We work with publishers providing a range of resources for our syllabuses including textbooks, websites, CDs, etc. Any endorsed, recommended and suggested resources are listed on both our public website and on Teacher Support.

The resource lists can be filtered to show all resources or just those which are endorsed or recommended by Cambridge. Resources endorsed by Cambridge go through a detailed quality assurance process and are written to align closely with the Cambridge syllabus they support.

2.3 Training

We offer a range of support activities for teachers to ensure they have the relevant knowledge and skills to deliver our qualifications. See **www.cie.org.uk/events** for further information.

3.   Syllabus content at a glance

Candidates study the following topics.

1. General physics

1.1 Length and time
1.2 Motion
1.3 Mass and weight
1.4 Density
1.5 Forces
1.6 Momentum (Extended candidates only)
1.7 Energy, work and power
1.8 Pressure

2. Thermal physics

2.1 Simple kinetic molecular model of matter
2.2 Thermal properties and temperature
2.3 Thermal processes

3. Properties of waves, including light and sound

3.1 General wave properties
3.2 Light
3.3 Electromagnetic spectrum
3.4 Sound

4. Electricity and magnetism

4.1 Simple phenomena of magnetism
4.2 Electrical quantities
4.3 Electric circuits
4.4 Digital electronics (Extended candidates only)
4.5 Dangers of electricity
4.6 Electromagnetic effects

5. Atomic physics

5.1 The nuclear atom
5.2 Radioactivity

4. Assessment at a glance

All candidates must enter for three papers.

Core candidates take:		Extended candidates take:	
Paper 1	45 minutes	**Paper 2**	45 minutes
A multiple-choice paper consisting of 40 items of the four-choice type.		A multiple-choice paper consisting of 40 items of the four-choice type.	
This paper will test assessment objectives AO1 and AO2. Questions will be based on the Core syllabus content.		This paper will test assessment objectives AO1 and AO2. Questions will be based on the Extended syllabus content (Core and Supplement).	
This paper will be weighted at 30% of the final total mark.		This paper will be weighted at 30% of the final total mark.	
and:		**and:**	
Paper 3	1 hour 15 minutes	**Paper 4**	1 hour 15 minutes
A written paper consisting of short-answer and structured questions.		A written paper consisting of short-answer and structured questions.	
This paper will test assessment objectives AO1 and AO2. Questions will be based on the Core syllabus content.		This paper will test assessment objectives AO1 and AO2. Questions will be based on the Extended syllabus content (Core and Supplement).	
80 marks		80 marks	
This paper will be weighted at 50% of the final total mark.		This paper will be weighted at 50% of the final total mark.	

All candidates take:			
either:		**or:**	
Paper 5	1 hour 15 minutes	**Paper 6**	1 hour
Practical Test		Alternative to Practical	
This paper will test assessment objective AO3. Questions will be based on the experimental skills in Section 7.		This paper will test assessment objective AO3. Questions will be based on the experimental skills in Section 7.	
The paper is structured to assess grade ranges A*–G.		The paper is structured to assess grade ranges A*–G.	
40 marks		40 marks	
This paper will be weighted at 20% of the final total mark.		This paper will be weighted at 20% of the final total mark.	

Candidates who have studied the Core syllabus content, or who are expected to achieve a grade D or below should be entered for Paper 1, Paper 3 and either Paper 5 or Paper 6. These candidates will be eligible for grades C to G.

Candidates who have studied the Extended syllabus content (Core and Supplement), and who are expected to achieve a grade C or above should be entered for Paper 2, Paper 4 and either Paper 5 or Paper 6. These candidates will be eligible for grades A* to G.

Availability

This syllabus is examined in the June and November examination series. This syllabus is also available for examination in March for India only.

This syllabus is available to private candidates.

Detailed timetables are available from **www.cie.org.uk/examsofficers**

Combining this with other syllabuses

Candidates can combine this syllabus in an examination series with any other Cambridge syllabus, except:

- syllabuses with the same title at the same level
- 0652 Cambridge IGCSE Physical Science
- 0653 Cambridge IGCSE Combined Science
- 0654 Cambridge IGCSE Co-ordinated Sciences (Double Award)
- 5129 Cambridge O Level Combined Science

Please note that Cambridge IGCSE, Cambridge International Level 1/Level 2 Certificate and Cambridge O Level syllabuses are at the same level.

5. Syllabus aims and assessment objectives

5.1 Syllabus aims

The syllabus aims listed below describe the educational purposes of a course based on this syllabus. These aims are not intended as assessment criteria but outline the educational context in which the syllabus content should be viewed. These aims are the same for all learners and are not listed in order of priority. Some of these aims may be delivered by the use of suitable local, international or historical examples and applications, or through collaborative experimental work.

The aims are:

1. to provide an enjoyable and worthwhile educational experience for all learners, whether or not they go on to study science beyond this level

2. to enable learners to acquire sufficient knowledge and understanding to:
   - become confident citizens in a technological world and develop an informed interest in scientific matters
   - be suitably prepared for studies beyond Cambridge IGCSE

3. to allow learners to recognise that science is evidence based and understand the usefulness, and the limitations, of scientific method

4. to develop skills that:
   - are relevant to the study and practice of physics
   - are useful in everyday life
   - encourage a systematic approach to problem-solving
   - encourage efficient and safe practice
   - encourage effective communication through the language of science

5. to develop attitudes relevant to physics such as:
   - concern for accuracy and precision
   - objectivity
   - integrity
   - enquiry
   - initiative
   - inventiveness

6. to enable learners to appreciate that:
   - science is subject to social, economic, technological, ethical and cultural influences and limitations
   - the applications of science may be both beneficial and detrimental to the individual, the community and the environment

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5.2   Assessment objectives

AO1: Knowledge with understanding

Candidates should be able to demonstrate knowledge and understanding of:

1.   scientific phenomena, facts, laws, definitions, concepts and theories
2.   scientific vocabulary, terminology and conventions (including symbols, quantities and units)
3.   scientific instruments and apparatus, including techniques of operation and aspects of safety
4.   scientific and technological applications with their social, economic and environmental implications.

Syllabus content defines the factual material that candidates may be required to recall and explain. Candidates will also be asked questions which require them to apply this material to unfamiliar contexts and to apply knowledge from one area of the syllabus to another.

Questions testing this objective will often begin with one of the following words: *define*, *state*, *describe*, *explain (using your knowledge and understanding)* or *outline* (see the *Glossary of terms used in science papers*).

AO2: Handling information and problem solving

Candidates should be able, in words or using other written forms of presentation (i.e. symbolic, graphical and numerical), to:

1.   locate, select, organise and present information from a variety of sources
2.   translate information from one form to another
3.   manipulate numerical and other data
4.   use information to identify patterns, report trends and draw inferences
5.   present reasoned explanations for phenomena, patterns and relationships
6.   make predictions and hypotheses
7.   solve problems, including some of a quantitative nature.

Questions testing these skills may be based on information that is unfamiliar to candidates, requiring them to apply the principles and concepts from the syllabus to a new situation, in a logical, deductive way.

Questions testing these skills will often begin with one of the following words: *predict*, *suggest*, *calculate* or *determine* (see the *Glossary of terms used in science papers*).

AO3: Experimental skills and investigations

Candidates should be able to:

1.   demonstrate knowledge of how to safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)
2.   plan experiments and investigations
3.   make and record observations, measurements and estimates
4.   interpret and evaluate experimental observations and data
5.   evaluate methods and suggest possible improvements.

5.3   Relationship between assessment objectives and components

The approximate weightings allocated to each of the assessment objectives are summarised in the table below.

Assessment objective	Paper 1 and 2	Paper 3 and 4	Paper 5 and 6	Weighting of AO in overall qualification
AO1: Knowledge with understanding	63%	63%	–	50%
AO2: Handling information and problem solving	37%	37%	–	30%
AO3: Experimental skills and investigations	–	–	100%	20%
Weighting of paper in overall qualification	30%	50%	20%	

5.4 Grade descriptions

The scheme of assessment is intended to encourage positive achievement by all candidates.

A **Grade A** candidate will be able to:

- recall and communicate precise knowledge and display comprehensive understanding of scientific phenomena, facts, laws, definitions, concepts and theories
- apply scientific concepts and theories to present reasoned explanations of familiar and unfamiliar phenomena, to solve complex problems involving several stages, and to make reasoned predictions and hypotheses
- communicate and present complex scientific ideas, observations and data clearly and logically, independently using scientific terminology and conventions consistently and correctly
- independently select, process and synthesise information presented in a variety of ways, and use it to draw valid conclusions and discuss the scientific, technological, social, economic and environmental implications
- devise strategies to solve problems in complex situations which may involve many variables or complex manipulation of data or ideas through multiple steps
- analyse data to identify any patterns or trends, taking account of limitations in the quality of the data and justifying the conclusions reached
- select, describe, justify and evaluate techniques for a large range of scientific operations and laboratory procedures.

A **Grade C** candidate will be able to:

- recall and communicate secure knowledge and understanding of scientific phenomena, facts, laws, definitions, concepts and theories
- apply scientific concepts and theories to present simple explanations of familiar and some unfamiliar phenomena, to solve straightforward problems involving several stages, and to make detailed predictions and simple hypotheses
- communicate and present scientific ideas, observations and data using a wide range of scientific terminology and conventions
- select and process information from a given source, and use it to draw simple conclusions and state the scientific, technological, social, economic or environmental implications
- solve problems involving more than one step, but with a limited range of variables or using familiar methods
- analyse data to identify a pattern or trend, and select appropriate data to justify a conclusion
- select, describe and evaluate techniques for a range of scientific operations and laboratory procedures.

A **Grade F** candidate will be able to:

- recall and communicate limited knowledge and understanding of scientific phenomena, facts, laws, definitions, concepts and theories
- apply a limited range of scientific facts and concepts to give basic explanations of familiar phenomena, to solve straightforward problems and make simple predictions
- communicate and present simple scientific ideas, observations and data using a limited range of scientific terminology and conventions
- select a single piece of information from a given source, and use it to support a given conclusion, and to make links between scientific information and its scientific, technological, social, economic or environmental implications
- solve problems involving more than one step if structured help is given
- analyse data to identify a pattern or trend
- select, describe and evaluate techniques for a limited range of scientific operations and laboratory procedures.

5.5 Conventions (e.g. signs, symbols, terminology and nomenclature)

Syllabuses and question papers conform with generally accepted international practice. In particular, the following document, produced by the Association for Science Education (ASE), should be used as guidelines.

- *Signs, Symbols and Systematics: The ASE Companion to 16–19 Science* (2000)

Decimal markers

In accordance with current ASE convention, decimal markers in examination papers will be a single dot on the line. Candidates are expected to follow this convention in their answers.

Numbers

Numbers from 1000 to 9999 will be printed without commas or spaces. Numbers greater than or equal to 10 000 will be printed without commas. A space will be left between each group of three whole numbers, e.g. 4 256 789.

6.   Syllabus content

All candidates should be taught the Core syllabus content. Candidates who are only taught the Core syllabus content can achieve a maximum of grade C. Candidates aiming for grades A* to C should be taught the Extended syllabus content. The Extended syllabus content includes both the Core and the Supplement.

In delivering the course, teachers should aim to show the relevance of concepts to the learners' everyday lives and to the world around them. The syllabus content has been designed so as to allow teachers to develop flexible programmes which meet all of the general aims of the syllabus while drawing on appropriate local and international contexts.

Scientific subjects are, by their nature, experimental. Wherever possible, learners should pursue a fully integrated course which allows them to develop their practical skills by carrying out practical work and investigations within all of the topics listed.

1. General physics	
1.1 Length and time **Core** • 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)	**Supplement** • Understand that a micrometer screw gauge is used to measure very small distances

1.2 Motion
 Core
 	
 • Define speed and calculate average speed from $\frac{\text{total distance}}{\text{total time}}$
 • Plot and interpret a speed-time graph or a distance-time graph
 • Recognise from the shape of a speed-time graph when a body is
  – at rest
  – moving with constant speed
  – moving with changing speed
 • 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
	Supplement
	
	 • 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
	
	 cont.

1.2 Motion continued	
Core	**Supplement**
• State that the acceleration of free fall for a body near to the Earth is constant	• Describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity)
1.3 Mass and weight	
Core	**Supplement**
• 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	
Core	
• Recall and use the equation $\rho = \dfrac{m}{V}$ • 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	
1.5 Forces	
1.5.1 Effects of forces	
Core	**Supplement**
• 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	• 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
• Describe the ways in which a force may change the motion of a body	• Recall and use the relation between force, mass and acceleration (including the direction), $F = ma$
• 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	• Describe qualitatively motion in a circular path due to a perpendicular force ($F = mv^2/r$ is *not* required)

1.5.2 Turning effect	
Core	**Supplement**
• 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	
Core	**Supplement**
• 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	
Core	
• 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	
1.5.5 Scalars and vectors	
	Supplement
	• 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	
	Supplement
	• 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

1.7 Energy, work and power	
1.7.1 Energy **Core** • 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	**Supplement** • 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)

1.7.2 Energy resources
Core
 	
• 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
	Supplement
	
	• 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:
	$$\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$$
	• $$\text{efficiency} = \frac{\text{useful power output}}{\text{power input}} \times 100\%$$

1.7.3 Work **Core** • 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	**Supplement** • Recall and use $W = Fd = \Delta E$

1.7.4 Power **Core** • Relate (without calculation) power to work done and time taken, using appropriate examples	**Supplement** • Recall and use the equation $P = \Delta E/t$ in simple systems
1.8 Pressure **Core** • 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	**Supplement** • Recall and use the equation $p = h\rho g$

2. Thermal physics

2.1 Simple kinetic molecular model of matter	
2.1.1 States of matter **Core** • State the distinguishing properties of solids, liquids and gases	
2.1.2 Molecular model **Core** • 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	**Supplement** • 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
2.1.3 Evaporation **Core** • 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	**Supplement** • 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 **Core** • 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	**Supplement** • 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 **Core** • 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	**Supplement** • Explain, in terms of the motion and arrangement of molecules, the relative order of the magnitude of the expansion of solids, liquids and gases
2.2.2 Measurement of temperature **Core** • 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	**Supplement** • 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) **Core** • 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	**Supplement** • 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 = $mc\Delta T$
2.2.4 Melting and boiling **Core** • 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	**Supplement** • 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 **Core** • Describe experiments to demonstrate the properties of good and bad thermal conductors	**Supplement** • Give a simple molecular account of conduction in solids including lattice vibration and transfer by electrons
2.3.2 Convection **Core** • Recognise convection as an important method of thermal transfer in fluids • Relate convection in fluids to density changes and describe experiments to illustrate convection	
2.3.3 Radiation **Core** • 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	**Supplement** • 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 **Core** • Identify and explain some of the everyday applications and consequences of conduction, convection and radiation	

3. Properties of waves, including light and sound	

3.1 General wave properties
Core
 	
• 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
	Supplement
	
	• 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

3.2 Light	
3.2.1 Reflection of light **Core** • 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	**Supplement** • 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 **Core** • 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	**Supplement** • Recall and use the definition of refractive index n in terms of speed • Recall and use the equation $\dfrac{\sin i}{\sin r} = n$ • Recall and use $n = \dfrac{1}{\sin c}$ • Describe and explain the action of optical fibres particularly in medicine and communications technology
3.2.3 Thin converging lens **Core** • 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	**Supplement** • 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 **Core** • 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	**Supplement** • Recall that light of a single frequency is described as monochromatic

3.3 Electromagnetic spectrum **Core**	**Supplement**
• Describe the main features of the electromagnetic spectrum in order of wavelength	• State that the speed of electromagnetic waves in a vacuum is 3.0×10^8 m/s and is approximately the same in air
• 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	
3.4 Sound **Core**	**Supplement**
• Describe the production of sound by vibrating sources	
• Describe the longitudinal nature of sound waves	• Describe compression and rarefaction
• 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	• State typical values of the speed of sound in gases, liquids and solids
• Relate the loudness and pitch of sound waves to amplitude and frequency	
• Describe how the reflection of sound may produce an echo	

4. Electricity and magnetism	
4.1 Simple phenomena of magnetism **Core** • 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	**Supplement** • 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
4.2 Electrical quantities	
4.2.1 Electric charge **Core** • 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	**Supplement** • 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

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4.2.2 Current **Core** • 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	**Supplement** • 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 **Core** • State that the e.m.f. of an electrical source of energy is measured in volts	**Supplement** • 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 **Core** • 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	**Supplement** • Recall that 1 V is equivalent to 1 J/C
4.2.5 Resistance **Core** • 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	**Supplement** • 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 **Core** • Understand that electric circuits transfer energy from the battery or power source to the circuit components then into the surroundings	**Supplement** • Recall and use the equations $P = IV$ and $E = IVt$
4.3 Electric circuits	
4.3.1 Circuit diagrams **Core** • 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	**Supplement** • Draw and interpret circuit diagrams containing diodes

4.3.2 Series and parallel circuits	
Core	**Supplement**
• 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
4.3.3 Action and use of circuit components	
Core	**Supplement**
• 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	
	Supplement
	• 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

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4.5 Dangers of electricity
Core
 	
• 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	

4.6 Electromagnetic effects	
4.6.1 Electromagnetic induction **Core** • 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.	**Supplement** • 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
4.6.2 a.c. generator **Core** • Distinguish between direct current (d.c.) and alternating current (a.c.)	**Supplement** • 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 **Core** • 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	**Supplement** • 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

4.6.4 The magnetic effect of a current **Core** • 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	**Supplement** • 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 **Core** • 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	**Supplement** • 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 **Core** • 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	**Supplement** • Relate this turning effect to the action of an electric motor including the action of a split-ring commutator
5. Atomic physics	
5.1 The nuclear atom	
5.1.1 Atomic model **Core** • Describe the structure of an atom in terms of a positive nucleus and negative electrons	**Supplement** • Describe how the scattering of α-particles by thin metal foils provides evidence for the nuclear atom
5.1.2 Nucleus **Core** • 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	**Supplement** • State the meaning of nuclear fission and nuclear fusion • Balance equations involving nuclide notation

5.2 Radioactivity	
5.2.1 Detection of radioactivity **Core** • 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$^-$)	

5.2.2 Characteristics of the three kinds of emission
Core
 	
• 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$^-$)
	Supplement
	
	• 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 **Core** • State the meaning of radioactive decay • State that during α- or β-decay the nucleus changes to that of a different element	**Supplement** • Use equations involving nuclide notation to represent changes in the composition of the nucleus when particles are emitted
5.2.4 Half-life **Core** • Use the term half-life in simple calculations, which might involve information in tables or decay curves	**Supplement** • Calculate half-life from data or decay curves from which background radiation has not been subtracted
5.2.5 Safety precautions **Core** • Recall the effects of ionising radiations on living things • Describe how radioactive materials are handled, used and stored in a safe way	

7. Practical assessment

Scientific subjects are, by their nature, experimental. It is therefore important that an assessment of a candidate's knowledge and understanding of physics should contain a practical component (see assessment objective AO3).

Schools' circumstances (e.g. the availability of resources) differ greatly, so two alternative ways of examining the practical component are provided. The alternatives are:

* Paper 5 – Practical Test
* Paper 6 – Alternative to Practical (written paper).

Whichever practical assessment route is chosen, the following points should be noted:

* the same assessment objectives apply
* the same practical skills are to be learned and developed
* the same sequence of practical activities is appropriate.

Candidates may not use textbooks in the practical component, nor any of their own records of laboratory work carried out during their course.

7.1 Teaching experimental skills

The best preparation for these papers is for candidates to pursue a course in which practical work is fully integrated so that it is a normal and natural part of the teaching.

Teachers are expected to identify suitable opportunities to embed practical techniques and investigative work throughout the course, rather than as an isolated aspect of preparation for examination. This approach will not only provide opportunities for developing experimental skills but will increase the appeal of the course, and the enjoyment of the subject. Practical work helps learners to acquire a secure understanding of the syllabus topics and to appreciate how scientific theories are developed and tested. It also promotes important scientific attitudes such as objectivity, integrity, co-operation, enquiry and inventiveness.

Apparatus list

The list below details the apparatus expected to be generally available for both teaching and for examination of Paper 5. The list is not exhaustive: in particular, items that are commonly regarded as standard equipment in a physics laboratory are not included. The Confidential Instructions, provided to Centres prior to the examination of Paper 5, will give the detailed requirements for the examination.

* an ammeter FSD 1 A or 1.5 A
* voltmeter FSD 1 V, 5 V
* cells and holders to enable several cells to be joined
* connecting leads and crocodile clips
* d.c. power supply, variable to 12 V
* low voltage filament lamps in holders
* various resistors and resistance wire
* switch

- metre rule
- good supply of masses and holder
- springs
- stopwatch
- newton meter
- plastic or polystyrene cup
- Plasticine or modelling clay
- thermometer, −10 °C to +110 °C at 1 °C graduations
- wooden board
- converging lens with f = 15 cm
- glass or Perspex block, rectangular and semi circular
- optics pins
- ray box
- measuring cylinder, 25 cm^3, 100 cm^3.

7.2 Description of components, Paper 5 Practical Test and Paper 6 Alternative to Practical

These papers are based on testing experimental skills. The questions do not assess specific syllabus content from Section 6: Syllabus content. Any information required to answer these questions is contained within the question paper or from the experimental context and skills listed below.

Questions are structured to assess across the grade range A* – G.

Paper 5: Practical Test will typically consist of four questions, three of which require the use of apparatus.

Paper 6: Alternative to Practical will test the same experimental skills as Paper 5, and will contain many of the same question parts.

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

Candidates 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 the candidate.

Candidates may be required to do the following:

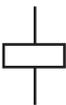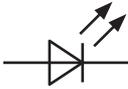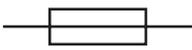- use, or describe the use of, common techniques, apparatus and materials, for example ray-tracing equipment or the connection of electric circuits
- select the most appropriate apparatus or method for a task and justify the choice made
- draw, complete or label diagrams of apparatus

- 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.

8.   Appendix

8.1   Electrical symbols

cell		switch	
battery of cells	or	earth or ground	
power supply		electric bell	
a.c. power supply		buzzer	
junction of conductors		microphone	
lamp		loudspeaker	
fixed resistor		motor	
variable resistor		generator	
thermistor		ammeter	
light dependent resistor		voltmeter	
heater		galvanometer	
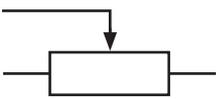
potential divider		oscilloscope	
relay coil		AND gate	
transformer		OR gate	
diode		NAND gate	
light-emitting diode		NOR gate	
fuse		NOT gate	
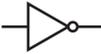
8.2 Symbols and units for physical quantities

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

Candidates 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			
			thermal capacity (heat capacity)	C	J/°C
			specific heat capacity	c	J/(g °C), J/(kg °C)

Core			Supplement		
Quantity	*Usual symbol*	*Usual unit*	*Quantity*	*Usual symbol*	*Usual unit*
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

8.3   Safety in the laboratory

Responsibility for safety matters rests with Centres. Further information can be found from the following UK association, publications and regulations.

Associations

CLEAPSS is an advisory service providing support in practical science and technology.
http://www.cleapss.org.uk

Publications

CLEAPSS Laboratory Handbook, updated 2009 (available to CLEAPSS members only)
CLEAPSS Hazcards, 2007 update of 1995 edition (available to CLEAPSS members only)

UK Regulations

Control of Substances Hazardous to Health Regulations (COSHH) 2002 and subsequent amendment in 2004
http://www.legislation.gov.uk/uksi/2002/2677/contents/made,
http://www.legislation.gov.uk/uksi/2004/3386/contents/made
A brief guide may be found at http://www.hse.gov.uk/pubns/indg136.pdf

8.4 Glossary of terms used in science papers

This glossary (which is relevant only to science subjects) will prove helpful to candidates as a guide, but it is neither exhaustive nor definitive. The glossary has been deliberately kept brief, not only with respect to the number of terms included, but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend, in part, on its context.

1. *Define* (the term(s)…) is intended literally, only a formal statement or equivalent paraphrase being required.

2. *What do you understand by/What is meant by* (the term(s)…) normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.

3. *State* implies a concise answer with little or no supporting argument (e.g. a numerical answer that can readily be obtained 'by inspection').

4. *List* requires a number of points, generally each of one word, with no elaboration. Where a given number of points is specified this should not be exceeded.

5. (a) *Explain* may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to give reasons. The candidate needs to leave the examiner in no doubt why something happens.

   (b) *Give a reason/Give reasons* is another way of asking candidates to explain why something happens.

6. *Describe* requires the candidate to state in words (using diagrams where appropriate) the main points. *Describe* and *explain* may be coupled, as may *state* and *explain*.

7. *Discuss* requires the candidate to give a critical account of the points involved.

8. *Outline* implies brevity (i.e. restricting the answer to giving essentials).

9. *Predict* implies that the candidate is expected to make a prediction not by recall but by making a logical connection between other pieces of information.

10. *Deduce* implies that the candidate is not expected to produce the required answer by recall but by making a logical connection between other pieces of information.

11. *Suggest* is used in two main contexts, i.e. either to imply that there is no unique answer (e.g. in physics there are several examples of energy resources from which electricity, or other useful forms of energy, may be obtained), or to imply that candidates are expected to apply their general knowledge of the subject to a 'novel' situation, one that may be formally 'not in the syllabus' – many data response and problem solving questions are of this type.

12. *Find* is a general term that may variously be interpreted as *calculate, measure, determine*, etc.

13. *Calculate* is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.

14. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument (e.g. length using a rule, or mass using a balance).

15. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained from a graph or by calculation.

16. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.

17. *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct, but candidates should be aware that, depending on the context, some quantitative aspects may be looked for (e.g. passing through the origin, having an intercept).

    In diagrams, *sketch* implies that simple, freehand drawing is acceptable; nevertheless, care should be taken over proportions and the clear exposition of important details.

8.5 Mathematical requirements

Calculators may be used in all parts of the examination.

Candidates should be able to:

- add, subtract, multiply and divide
- use averages, decimals, fractions, percentages, ratios and reciprocals
- use standard notation, including both positive and negative indices
- understand significant figures and use them appropriately
- recognise and use direct and inverse proportion
- use positive, whole number indices in algebraic expressions
- draw charts and graphs from given data
- interpret charts and 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 areas of a rectangle, triangle and circle and the volumes of a rectangular block and a cylinder
- use mathematical instruments (ruler, compasses, protractor and set square)
- understand the meaning of angle, curve, circle, radius, diameter, circumference, square, parallelogram, rectangle and 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 directions
- recognise and use points of the compass (N, S, E, W)
- use sines and inverse sines (Extended candidates only).

8.6   Presentation of data

The solidus (/) is to be used for separating the quantity and the unit in tables, graphs and charts, e.g. time/s for time in seconds.

(a) Tables

- Each column of a table should be headed with the physical quantity and the appropriate unit, e.g. time/s.
- The column headings of the table can then be directly transferred to the axes of a constructed graph.

(b) Graphs

- Unless instructed otherwise, the independent variable should be plotted on the *x*-axis (horizontal axis) and the dependent variable plotted on the *y*-axis (vertical axis).
- Each axis should be labelled with the physical quantity and the appropriate unit, e.g. time/s.
- Unless instructed otherwise, the scales for the axes should allow more than half of the graph grid to be used in both directions, and be based on sensible ratios, e.g. 2 cm on the graph grid representing 1, 2 or 5 units of the variable.
- The graph is the whole diagrammatic presentation, including the best-fit line when appropriate. It may have one or more sets of data plotted on it.
- Points on the graph should be clearly marked as crosses (x) or encircled dots (⊙).
- Large 'dots' are penalised. Each data point should be plotted to an accuracy of better than one half of each of the smallest squares on the grid.
- A best-fit line (trend line) should be a single, thin, smooth straight-line or curve. The line does not need to coincide exactly with any of the points; where there is scatter evident in the data, Examiners would expect a roughly even distribution of points either side of the line over its entire length. Points that are clearly anomalous should be ignored when drawing the best-fit line.
- The gradient of a straight line should be taken using a triangle whose hypotenuse extends over at least half of the length of the best-fit line, and this triangle should be marked on the graph.

(c) Bar charts

- These are drawn when one of the variables is not numerical.

(d) Numerical results

- Data should be recorded so as to reflect the precision of the measuring instrument.
- The number of significant figures given for calculated quantities should be appropriate to the least number of significant figures in the raw data used.

8.7   ICT opportunities

In order to play a full part in modern society, candidates need to be confident and effective users of ICT. This syllabus provides candidates with a wide range of opportunities to use ICT in their study of physics.

Opportunities for ICT include:

- gathering information from the internet, DVDs and CD-ROMs
- gathering data using sensors linked to data-loggers or directly to computers
- using spreadsheets and other software to process data
- using animations and simulations to visualise scientific ideas
- using software to present ideas and information on paper and on screen.

9. Other information

Equality and inclusion

Cambridge International Examinations has taken great care in the preparation of this syllabus and assessment materials to avoid bias of any kind. To comply with the UK Equality Act (2010), Cambridge has designed this qualification with the aim of avoiding direct and indirect discrimination.

The standard assessment arrangements may present unnecessary barriers for candidates with disabilities or learning difficulties. Arrangements can be put in place for these candidates to enable them to access the assessments and receive recognition of their attainment. Access arrangements will not be agreed if they give candidates an unfair advantage over others or if they compromise the standards being assessed.

Candidates who are unable to access the assessment of any component may be eligible to receive an award based on the parts of the assessment they have taken.

Information on access arrangements is found in the *Cambridge Handbook* which can be downloaded from the website **www.cie.org.uk/examsofficer**

Language

This syllabus and the associated assessment materials are available in English only.

Grading and reporting

Cambridge IGCSE results are shown by one of the grades A*, A, B, C, D, E, F or G indicating the standard achieved, A* being the highest and G the lowest. 'Ungraded' indicates that the candidate's performance fell short of the standard required for grade G. 'Ungraded' will be reported on the statement of results but not on the certificate. The letters Q (result pending), X (no results) and Y (to be issued) may also appear on the statement of results but not on the certificate.

Entry codes

To maintain the security of our examinations, we produce question papers for different areas of the world, known as 'administrative zones'. Where the component entry code has two digits, the first digit is the component number given in the syllabus. The second digit is the location code, specific to an administrative zone. Information about entry codes can be found in the *Cambridge Guide to Making Entries*.

10. Additional information for England, Wales and Northern Ireland

This syllabus appears on the Register of Regulated Qualifications (**http://register.ofqual.gov.uk**) as a Cambridge International Level 1/Level 2 Certificate. In other contexts it is known as a Cambridge IGCSE.

Cambridge International Level 1/Level 2 Certificates are approved for regulation in England, Wales and Northern Ireland and are eligible for inclusion in school and college performance tables.

For up-to-date information on the performance tables, including the list of qualifications which count towards the English Baccalaureate, please go to the Department for Education website and search on 'performance tables'.

Candidates who are awarded grades D to G will have achieved an award at Level 1 of the National Qualifications Framework. Candidates who are awarded grades A* to C will have achieved an award at Level 2 of the National Qualifications Framework.

Prior learning

Learners in England who are beginning this course should normally have followed the Key Stage 3 programme of study within the National Curriculum for England.

Other candidates beginning this course should have achieved an equivalent level of general education.

Progression

Cambridge IGCSE Certificates are general qualifications that enable candidates to progress either directly to employment, or to proceed to further qualifications.

Candidates who are awarded grades A* to C for this qualification are well prepared to follow courses leading to Level 3 AS and A Level GCE Physics, Cambridge Pre-U Physics, IB Certificates in Physics or the Cambridge International AS and A Level Physics.

Grading and reporting

Cambridge International Level 1/Level 2 Certificate results are shown by one of the grades A*, A, B, C, D, E, F or G indicating the standard achieved, A* being the highest and G the lowest. 'Ungraded' indicates that the candidate's performance fell short of the standard required for grade G. 'Ungraded' will be reported on the statement of results but not on the certificate. The letters Q (result pending), X (no results) and Y (to be issued) may also appear on the statement of results but not on the certificate.

Overlapping qualifications

Every qualification is assigned to a national classification code indicating the subject area to which it belongs. Candidates who enter for more than one qualification with the same classification code will only have one grade (the highest) counted for the purpose of the school and college performance tables. Centres may wish to advise candidates that, if they take two qualifications with the same classification code, colleges are very likely to take the view that they have achieved only one of the two qualifications. Candidates who have any doubts about their subject combinations should seek advice, either from their centre or the institution to which they wish to progress.

Spiritual, moral, ethical, social, legislative, economic and cultural issues

Learners are encouraged to develop a sense of wonder at the simplicity and universality of physical laws and how these order and give meaning to our view of the ways that nature works. They have the opportunity to study physical systems from atomic systems to the solar system, helping them to develop an appreciation of the variety and immensity of the natural world.

In the course of their practical work, learners will gain an understanding of the scientific method and the importance of integrity in reporting results. They have the chance to develop their ability to work as a team, where appropriate, and to value others' ideas. They also have the opportunity to discuss how scientific developments in the modern world (for example: nuclear power, hydroelectric dams) often pose ethical as well as technological problems.

Sustainable development, health and safety considerations, and international developments

- **Sustainable development and environmental issues**
  Learners have many opportunities to explore the role of applications of physics, for good or ill, in the community and environment. In particular, they may discuss concerns about the containment and disposal of radioactive materials, and issues regarding energy resources.

- **Health and safety**
  Learners must follow good health and safety practice in the laboratory. They also learn about the hazards associated with electricity and ionising radiations and gain an understanding of safety measures.

- **The international dimension**
  Throughout the course, learners are able to reflect on the fact that the laws and language of physics are universal and transcend national and cultural boundaries. Teachers and learners have the opportunity to discuss how international collaboration plays an important role in scientific research and the development of new ideas, and is often needed to tackle global problems, such as climate change and radioactive waste disposal.