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# SYLLABUS

Cambridge IGCSE®

Physics (US)

0443

For examination in June and November 2014

**This syllabus is available only to Centers taking part in the  
Board Examination Systems (BES) Pilot.**

**If you have any questions about this syllabus, please contact Cambridge at  
[international@cie.org.uk](mailto:international@cie.org.uk) quoting syllabus code 0443.**

**Note**

**The subject content of this syllabus is the same as the international version. The alternative to practical paper is not included to ensure that coursework or the practical paper is a mandatory part of the syllabus.**

**Please read the *Cambridge Glossary* alongside this syllabus. This is available from our website. Administration materials appear in UK English and are standard for all our international customers.**

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# Contents

1. Introduction.....	2
1.1 Why Choose Cambridge?	
1.2 Why Choose Cambridge IGCSE?	
1.3 Why Choose Cambridge IGCSE Physics?	
1.4 Cambridge International Certificate of Education (ICE)	
1.5 How Can I Find Out More?	
2. Assessment at a Glance .....	5
3. Syllabus Goals and Objectives .....	6
3.1 Goals	
3.2 Assessment Objectives	
3.3 Scheme of Assessment	
3.4 Weightings	
3.5 Conventions (e.g., Signs, Symbols, Terminology, and Nomenclature)	
4. Curriculum Content.....	11
5. Practical Assessment.....	25
5.1 Paper 4: Coursework	
5.2 Paper 5: Practical Test	
6. Appendix A .....	32
6.1 Grade Descriptions	
6.2 Symbols, Units, and Definitions of Physical Quantities	
6.3 Glossary of Terms Used in Science Papers	
6.4 Mathematical Requirements	
6.5 ICT	
6.6 Procedures for External Moderation	
6.7 Forms	
7. Appendix B: Additional Information.....	45
7.1 Guided Learning Hours	
7.2 Recommended Prerequisites	
7.3 Progression	
7.4 Component Codes	
7.5 Grading and Reporting	
7.6 Access	
7.7 Support and Resources	

# 1. Introduction

## 1.1 Why Choose Cambridge?

University of Cambridge International Examinations is the world's largest provider of international education programs and qualifications for 5 to 19 year olds. We are part of the University of Cambridge, trusted for excellence in education. Our qualifications are recognized by the world's universities and employers.

### Recognition

Every year, hundreds of thousands of learners gain the Cambridge qualifications they need to enter the world's universities.

Cambridge IGCSE® (International General Certificate of Secondary Education) is internationally recognized by schools, universities, and employers as equivalent to UK GCSE. Learn more at [www.cie.org.uk/recognition](http://www.cie.org.uk/recognition)

### Excellence in Education

We understand education. We work with over 9,000 schools in over 160 countries that offer our programs and qualifications. Understanding learners' needs around the world means listening carefully to our community of schools, and we are pleased that 98% of Cambridge schools say they would recommend us to other schools.

Our mission is to provide excellence in education, and our vision is that Cambridge learners become confident, responsible, innovative, and engaged.

Cambridge programs and qualifications help Cambridge learners to become:

- **confident** in working with information and ideas—their own and those of others
- **responsible** for themselves, responsive to and respectful of others
- **innovative** and equipped for new and future challenges
- **engaged** intellectually and socially, ready to make a difference.

### Support in the Classroom

We provide a world-class support service for Cambridge teachers and exams officers. We offer a wide range of teacher materials to Cambridge schools, plus teacher training (online and face-to-face), expert advice, and learner support materials. Exams officers can trust in reliable, efficient administration of exams entry and excellent, personal support from our customer services. Learn more at [www.cie.org.uk/teachers](http://www.cie.org.uk/teachers)

### Nonprofit, Part of the University of Cambridge

We are a part of Cambridge Assessment, a department of the University of Cambridge and a nonprofit organization.

We invest constantly in research and development to improve our programs and qualifications.

## 1.2 Why Choose Cambridge IGCSE?

Cambridge IGCSE helps your school improve learners' performance. Learners develop not only knowledge and understanding, but also skills in creative thinking, inquiry, and problem solving, helping them perform well and prepare for the next stage of their education.

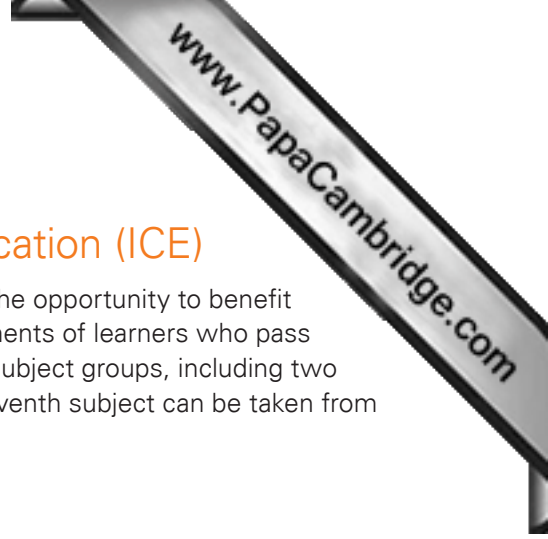
Cambridge IGCSE is the world's most popular international curriculum for 14 to 16 year olds, leading to globally recognized and valued Cambridge IGCSE qualifications. It is part of the Cambridge Secondary 2 stage.

Schools worldwide have helped develop Cambridge IGCSE, which provides an excellent preparation for Cambridge International AS and A Levels, Cambridge Pre-U, Cambridge AICE (Advanced International Certificate of Education), and other education programs, such as the US Advanced Placement Program and the International Baccalaureate Diploma. Cambridge IGCSE incorporates the best in international education for learners at this level. It develops in line with changing needs, and we update and extend it regularly.

## 1.3 Why Choose Cambridge IGCSE Physics?

Cambridge IGCSE Physics is accepted by universities and employers as proof of knowledge and understanding of physics. Successful candidates gain lifelong skills, including:

- confidence in a technological world with an informed interest in scientific matters
- an understanding of how scientific theories and methods have developed, and continue to develop, as a result of groups and individuals working together
- an understanding that the study and practice of science are affected and limited by social, economic, technological, ethical, and cultural factors
- an awareness that the application of science in everyday life may be both helpful and harmful to the individual, the community, and the environment
- knowledge that science overcomes national boundaries and that the language of science, used correctly and thoroughly, is universal
- an understanding of the usefulness (and limitations) of scientific method and its application in other subjects and in everyday life
- a concern for accuracy and precision
- an understanding of the importance of safe practice
- improved awareness of the importance of objectivity, integrity, inquiry, initiative, and inventiveness
- an interest in, and care for, the environment
- an excellent foundation for advanced study in pure sciences, in applied science, or in science-dependent vocational courses



## 1.4 Cambridge International Certificate of Education (ICE)

Cambridge ICE is the group award of Cambridge IGCSE. It gives schools the opportunity to benefit from offering a broad and balanced curriculum by recognizing the achievements of learners who pass examinations in at least seven subjects. Learners take subjects from five subject groups, including two languages, and one subject from each of the other subject groups. The seventh subject can be taken from any of the five subject groups.

Physics falls into Group III, Science.

Learn more about Cambridge IGCSE and Cambridge ICE at [www.cie.org.uk/cambridgesecondary2](http://www.cie.org.uk/cambridgesecondary2)

## 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 [international@cie.org.uk](mailto:international@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](http://www.cie.org.uk/startcambridge).  
Email us at [international@cie.org.uk](mailto:international@cie.org.uk) to find out how your organization can become a Cambridge school.

## 2. Assessment at a Glance

Cambridge IGCSE Physics candidates are awarded grades ranging from A\* to G.

Candidates expected to achieve grades D, E, F, or G study the Core Curriculum only and are eligible for grades C to G.

Candidates expected to achieve grade C or higher should study the Extended Curriculum, which consists of the Core and Supplement Curriculums; these candidates are eligible for all grades from A\* to G.

All candidates must enter for **three** papers.

All candidates take:			
<b>Paper 1</b>		45 minutes	
Multiple-choice question paper			
Weighted at 30% of total available marks			
and either:		or:	
<b>Paper 2</b>	1 hour, 15 minutes	<b>Paper 3</b>	1 hour, 15 minutes
Core theory paper		Extended theory paper	
Weighted at 50% of total available marks		Weighted at 50% of total available marks	
and either:		or:	
<b>Paper 4</b>		<b>Paper 5</b>	1 hour, 15 minutes
Coursework		Practical test	
Weighted at 20% of total available marks		Weighted at 20% of total available marks	

### Availability

This syllabus is examined in the May/June examination series and the October/November examination series.

### Combining This with Other Syllabi

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

- syllabi with the same title at the same level
- 0652 Cambridge IGCSE Physical Science
- 0653 Cambridge IGCSE Combined Science
- 0442 Cambridge IGCSE Coordinated Sciences (Double Award)

## 3. Syllabus Goals and Objectives

### 3.1 Goals

The goals of the syllabus listed below describe the educational purposes of this examination. The aims of the syllabus are the same for all candidates and are not listed in order of priority. The aims are:

1. to provide a worthwhile educational experience for all candidates, through well-designed studies of experimental and practical science, whether or not they go on to study science beyond this level
2. to enable candidates to acquire sufficient understanding and knowledge to:
  - become confident citizens in a technological world, to take or develop an informed interest in scientific matters
  - recognize the usefulness, and limitations, of scientific method and to appreciate its applicability in other disciplines and in everyday life
  - be suitably prepared for studies beyond Cambridge IGCSE in pure sciences, in applied sciences, or in science-dependent vocational courses
3. to develop abilities and skills that
  - are relevant to the study and practice of physics
  - are useful in everyday life
  - encourage safe practice
  - encourage effective communication
4. to develop attitudes relevant to physics such as
  - concern for accuracy and precision
  - objectivity
  - integrity
  - inquiry
  - initiative
  - inventiveness
5. to stimulate interest in, and care for, the environment
6. to promote an awareness that
  - scientific theories and methods have developed, and continue to develop, as a result of cooperative activities of groups and individuals
  - the study and practice of science are 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
  - science transcends national boundaries and that the language of science, correctly and rigorously applied, is universal



## 3.2 Assessment Objectives

The three assessment objectives in Cambridge IGCSE Physics are:

- A: Knowledge with understanding
- B: Handling information and problem solving
- C: Experimental skills and investigations

A description of each assessment objective follows.

### A: Knowledge with Understanding

Candidates should be able to demonstrate knowledge and understanding of:

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

Curriculum content defines the factual material that candidates may be required to recall and explain.

Candidates will also be asked questions that require them to apply this material to unfamiliar contexts and to apply knowledge from one area of the syllabus to knowledge of a different syllabus area.

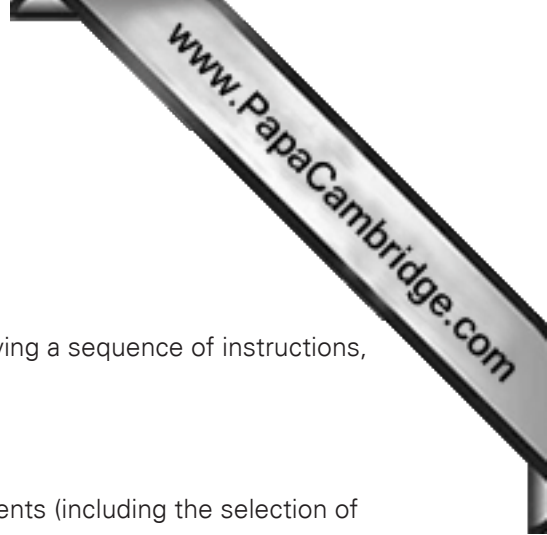
Questions testing these objectives will often begin with one of the following words: *define*, *state*, *describe*, *explain* (using your knowledge and understanding), or *outline* (see Glossary of Terms Used in Science Papers).

### B: Handling Information and Problem Solving

In words or using other written forms of presentation (e.g., symbolic, graphical and numerical), candidates should be able to:

1. locate, select, organize, 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 of 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, reasoned, or deductive way. Questions testing these skills will often begin with one of the following words: *predict*, *suggest*, *calculate*, or *determine* (see Glossary of Terms Used in Science Papers).



## C: Experimental Skills and Investigations

Candidates should be able to:

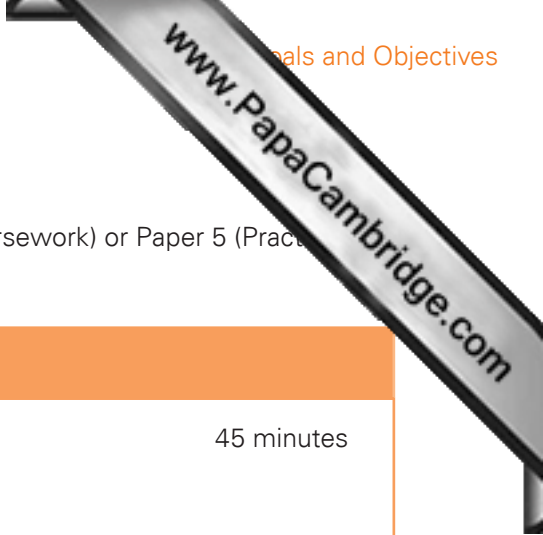
1. know how to use techniques, apparatus, and materials (including following a sequence of instructions, where appropriate)
2. make and record observations and measurements
3. interpret and evaluate experimental observations and data
4. plan investigations, evaluate methods, and suggest possible improvements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

### 3.3 Scheme of Assessment

All candidates must enter for three papers: Paper 1; one from either Paper 2 or Paper 3; and one from either Paper 4 or Paper 5.

Candidates who have studied only the Core curriculum, or who are expected to achieve a grade D or below, should normally be entered for Paper 2.

Candidates who have studied the Extended curriculum, and who are expected to achieve a grade C or above, should be entered for Paper 3.



All candidates must take a practical paper chosen from either Paper 4 (Coursework) or Paper 5 (Practical Test).

<b>All candidates take:</b>	
<p><b>Paper 1</b> <span style="float: right;">45 minutes</span>                  A multiple-choice paper consisting of 40 items of the four-choice type.                  This paper will test skills mainly in Assessment Objectives A and B.                  Questions will be based on the Core Curriculum and will be of a difficulty appropriate to grades C to G.                  This paper will be weighted at 30% of the final total marks available.</p>	
<b>and either:</b>	<b>or:</b>
<p><b>Paper 2</b> <span style="float: right;">1 hour, 15 minutes</span>                  Written paper consisting of short-answer and structured questions                  Questions will be based on the Core Curriculum and will be of a difficulty appropriate to grades C to G.                  Questions will test skills mainly in Assessment Objectives A and B.</p> <p>80 marks                  This paper will be weighted at 50% of the final total marks available.</p>	<p><b>Paper 3</b> <span style="float: right;">1 hour, 15 minutes</span>                  Written paper consisting of short-answer and structured questions                  Questions will be based on the Extended Curriculum and will be of a difficulty appropriate to the higher grades.                  Questions will test skills mainly in Assessment Objectives A and B.                  A quarter of the marks available will be based on Core material and the remainder on the Supplement.</p> <p>80 marks                  This paper will be weighted at 50% of the final total marks available.</p>
<b>and either:</b>	<b>or:</b>
<p><b>Paper 4*</b>                  Coursework                  Internal assessment of practical skills**                  This paper will be weighted at 20% of the final total marks available.</p>	<p><b>Paper 5*</b> <span style="float: right;">1 hour, 15 minutes</span>                  Practical Test                  Questions covering experimental skills.                  This paper will be weighted at 20% of the final total marks available.</p>

\* The purpose of this component is to test appropriate skills in Assessment Objective C. Candidates will not be required to use knowledge outside the Core Curriculum.

\*\* At least one teacher in each Center offering a subject including coursework must be accredited by Cambridge. Accreditation is given only to teachers who satisfy Cambridge requirements concerning moderation and who have undergone special training in assessment.

### 3.4 Weightings

Assessment objective	Weighting
<b>A:</b> Knowledge with understanding	50% (not more than 25% recall)
<b>B:</b> Handling information and problem solving	30%
<b>C:</b> Experimental skills and investigations	20%

Teachers should note that there is an equal weighting of 50% for skills (including handling information; problem solving; practical, experimental, and investigative skills) and for knowledge and understanding. Teachers' schemes of work (unit lesson plans) and the sequence of learning activities should reflect this balance, so that the goals of the syllabus may be met and the candidates fully prepared for the assessment.

Assessment objective	Paper 1 (marks)	Papers 2 or 3 (marks)	Papers 4 or 5 (marks)	Whole assessment (%)
<b>A:</b> Knowledge with understanding	25–30	44–50	0	46–54
<b>B:</b> Handling information and problem solving	10–15	30–36	0	26–34
<b>C:</b> Experimental skills and investigations	0	0	40	20

### 3.5 Conventions (e.g., Signs, Symbols, Terminology, and Nomenclature)

The syllabus and question papers will conform with generally accepted international practice.

In particular, please note the following documents, published in the UK, which will be used as guidelines:

Reports produced by the Association for Science Education (ASE):

- *SI Units, Signs, Symbols and Abbreviations* (1981)
- *Signs, Symbols and Systematics: The ASE Companion to 16–19 Science* (2000)

#### Liter/dm<sup>3</sup>

To avoid any confusion concerning the symbol for liter, **dm<sup>3</sup>** will be used in place of *l* or liter.

#### 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.

## 4. Curriculum Content

Candidates can follow either the Core Curriculum only or they may follow the Extended Curriculum, which includes both the Core and the Supplement.

Candidates aiming for grades A\* to C must follow the Extended Curriculum.

Candidates must have adequate mathematical skills to cope with the curriculum.

Candidates should make use of the summary list of symbols, units, and definitions of quantities.

Throughout the course, teachers should aim to show the relevance of concepts to the candidates' everyday life and current technology. To encourage this approach and to allow teachers to use flexible programs to meet the course's general aims, we have limited the specified content of the syllabus. The following material should therefore be regarded as an exam syllabus rather than a teaching syllabus.

1. General Physics	
<p>1.1 Length and Time</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Use and describe the use of rules and measuring cylinders to calculate a length or a volume</li> <li>Use and describe the use of clocks and devices for measuring an interval of time</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Use and describe the use of a mechanical method for the measurement of a small distance (including use of a micrometer screw gauge)</li> <li>Measure and describe how to measure a short interval of time (including the period of a pendulum)</li> </ul>
<p>1.2 Speed, Velocity and Acceleration</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Define speed and calculate speed from <math>\frac{\text{total distance}}{\text{total time}}</math></li> <li>Plot and interpret a speed/time graph or a distance/time graph</li> <li>Recognize from the shape of a speed/time graph when a body is <ul style="list-style-type: none"> <li>at rest</li> <li>moving with constant speed</li> <li>moving with changing speed</li> </ul> </li> <li>Calculate the area under a speed/time graph to work out the distance traveled for motion with constant acceleration</li> <li>Demonstrate some understanding that acceleration is related to changing speed</li> <li>State that the acceleration of free fall for a body near to the Earth is constant</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Distinguish between speed and velocity</li> <li>Recognize linear motion for which the acceleration is constant and calculate the acceleration</li> <li>Recognize motion for which the acceleration is not constant</li> <li>Describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity)</li> </ul>

<p>1.3 Mass and Weight</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Show familiarity with the idea of the mass of a body</li> <li>State that weight is a force</li> <li>Demonstrate understanding that weights (and hence masses) may be compared using a balance</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Demonstrate an understanding that mass is a property that “resists” change in motion</li> <li>Describe, and use the concept of, weight as the effect of a gravitational field on a mass</li> </ul>
<p>1.4 Density</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe an experiment to determine the density of a liquid and of a regularly shaped solid and make the necessary calculation</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Describe the determination of the density of an irregularly shaped solid by the method of displacement and make the necessary calculation</li> </ul>
<p>1.5 Forces</p>	
<p>1.5 (a) Effects of Forces</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>State that a force may produce a change in size and shape of a body</li> <li>Plot extension/load graphs and describe the associated experimental procedure</li> <li>Describe the ways in which a force may change the motion of a body</li> <li>Find the resultant of two or more forces acting along the same line</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Interpret extension/load graphs</li> <li>State Hooke’s Law and recall and use the expression <math>F = kx</math></li> <li>Recognize the significance of the term “limit of proportionality” for an extension/load graph</li> <li>Recall and use the relation between force, mass, and acceleration (including the direction)</li> <li>Describe qualitatively motion in a curved path due to a perpendicular force (<math>F = mv^2/r</math> is <i>not</i> required)</li> </ul>
<p>1.5 (b) Turning Effect</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the moment of a force as a measure of its turning effect and give everyday examples</li> <li>Describe qualitatively the balancing of a beam about a pivot</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Perform and describe an experiment (involving vertical forces) to show that there is no net moment on a body in equilibrium</li> <li>Apply the idea of opposing moments to simple systems in equilibrium</li> </ul>
<p>1.5 (c) Conditions for Equilibrium</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>State that, when there is no resultant force and no resultant turning effect, a system is in equilibrium</li> </ul>	

<p>1.5 (d) Center of Mass</p> <p><b>Core</b></p> <ul style="list-style-type: none"><li>• Perform and describe an experiment to determine the position of the center of mass of a plane lamina</li><li>• Describe qualitatively the effect of the position of the center of mass on the stability of simple objects</li></ul>	
<p>1.5 (e) Scalars and Vectors</p>	<p><b>Supplement</b></p> <ul style="list-style-type: none"><li>• Demonstrate an understanding of the difference between scalars and vectors and give common examples</li><li>• Add vectors by graphical representation to determine a resultant</li><li>• Determine graphically the resultant of two vectors</li></ul>
<p>1.6 Energy, Work, and Power</p>	
<p>1.6 (a) Energy</p> <p><b>Core</b></p> <ul style="list-style-type: none"><li>• Demonstrate an understanding that an object may have energy due to its motion or its position, and that energy may be transferred and stored</li><li>• Give examples of energy in different forms, including kinetic, gravitational, chemical, strain, nuclear, internal, electrical, light, and sound</li><li>• Give examples of the conversion of energy from one form to another and of its transfer from one place to another</li><li>• Apply the principle of energy conservation to simple examples</li></ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"><li>• Recall and use the expressions k.e. = <math>\frac{1}{2} mv^2</math> and p.e. = <math>mgh</math></li></ul>

<p>1.6 (b) Energy Resources</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Distinguish between renewable and nonrenewable sources of energy</li> <li>• Describe how electricity or other useful forms of energy may be obtained from: <ul style="list-style-type: none"> <li>– chemical energy stored in fuel</li> <li>– water, including the energy stored in waves, in tides, and in water behind hydroelectric dams</li> <li>– geothermal resources</li> <li>– nuclear fission</li> <li>– heat and light from the Sun (solar cells and panels)</li> </ul> </li> <li>• Give advantages and disadvantages of each method in terms of cost, reliability, scale, and environmental impact</li> <li>• Show a qualitative understanding of efficiency</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Show an understanding that energy is released by nuclear fusion in the Sun</li> <li>• Recall and use the equation:  <math display="block">\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%</math> </li> </ul>
<p>1.6 (c) Work</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Relate (without calculation) work done to the magnitude of a force and the distance moved</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Describe energy changes in terms of work done</li> <li>• Recall and use <math>\Delta W = Fd = \Delta E</math></li> </ul>
<p>1.6 (d) Power</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Relate (without calculation) power to work done and time taken, using appropriate examples</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Recall and use the equation <math>P = E/t</math> in simple systems</li> </ul>
<p>1.7 Pressure</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Relate (without calculation) pressure to force and area, using appropriate examples</li> <li>• Describe the simple mercury barometer and its use in measuring atmospheric pressure</li> <li>• Relate (without calculation) the pressure beneath a liquid surface to depth and to density, using appropriate examples</li> <li>• Use and describe the use of a manometer</li> </ul>	<ul style="list-style-type: none"> <li>• Recall and use the equation <math>p = F/A</math></li> <li>• Recall and use the equation <math>p = h\rho g</math></li> </ul>



2. Thermal Physics	
2.1 Simple Kinetic Molecular Model of Matter	
2.1 (a) States of Matter <b>Core</b> <ul style="list-style-type: none"><li>State the distinguishing properties of solids, liquids, and gases</li></ul>	
2.1 (b) Molecular Model <b>Core</b> <ul style="list-style-type: none"><li>Describe qualitatively the molecular structure of solids, liquids, and gases</li><li>Interpret the temperature of a gas in terms of the motion of its molecules</li><li>Describe qualitatively the pressure of a gas in terms of the motion of its molecules</li><li>Describe qualitatively the effect of a change of temperature on the pressure of a gas at constant volume</li><li>Show an understanding of the random motion of particles in a suspension as evidence for the kinetic molecular model of matter</li><li>Describe this motion (sometimes known as Brownian motion) in terms of random molecular bombardment</li></ul>	<b>Supplement</b> <ul style="list-style-type: none"><li>Relate the properties of solids, liquids, and gases to the forces and distances between molecules and to the motion of the molecules</li><li>Show an appreciation that massive particles may be moved by light, fast-moving molecules</li></ul>
2.1 (c) Evaporation <b>Core</b> <ul style="list-style-type: none"><li>Describe evaporation in terms of the escape of more-energetic molecules from the surface of a liquid</li><li>Relate evaporation to the consequent cooling</li></ul>	<b>Supplement</b> <ul style="list-style-type: none"><li>Demonstrate an understanding of how temperature, surface area, and draught over a surface influence evaporation</li></ul>
2.1 (d) Pressure Changes <b>Core</b> <ul style="list-style-type: none"><li>Relate the change in volume of a gas to change in pressure applied to the gas at constant temperature</li></ul>	<b>Supplement</b> <ul style="list-style-type: none"><li>Recall and use the equation <math>pV = \text{constant}</math> at constant temperature</li></ul>
2.2 Thermal Properties	
2.2 (a) Thermal Expansion of Solids, Liquids, and Gases <b>Core</b> <ul style="list-style-type: none"><li>Describe qualitatively the thermal expansion of solids, liquids, and gases</li><li>Identify and explain some of the everyday applications and consequences of thermal expansion</li><li>Describe qualitatively the effect of a change of temperature on the volume of a gas at constant pressure</li></ul>	<b>Supplement</b> <ul style="list-style-type: none"><li>Show an appreciation of the relative order of magnitude of the expansion of solids, liquids, and gases</li></ul>

<p>2.2 (b) Measurement of Temperature</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Appreciate how a physical property that varies with temperature may be used for the measurement of temperature, and state examples of such properties</li> <li>• Recognize the need for and identify fixed points</li> <li>• Describe the structure and action of liquid-in-glass thermometers</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Demonstrate understanding of sensitivity, range, and linearity</li> <li>• Describe the structure of a thermocouple and show understanding of its use for measuring high temperatures and those that vary rapidly</li> </ul>
<p>2.2 (c) Thermal Capacity</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Relate a rise in the temperature of a body to an increase in internal energy</li> <li>• Show an understanding of the term thermal capacity</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Describe an experiment to measure the specific heat capacity of a substance</li> </ul>
<p>2.2 (d) Melting and Boiling</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Describe melting and boiling in terms of energy input without a change in temperature</li> <li>• State the meaning of melting point and boiling point</li> <li>• Describe condensation and solidification</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Distinguish between boiling and evaporation</li> <li>• Use the terms “latent heat of vaporization” and “latent heat of fusion” and give a molecular interpretation of latent heat</li> <li>• Describe an experiment to measure specific latent heats for steam and for ice</li> </ul>
<p>2.3 Transfer of Thermal Energy</p>	
<p>2.3 (a) Conduction</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Describe experiments to demonstrate the properties of good and bad conductors of heat</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Give a simple molecular account of heat transfer in solids</li> </ul>
<p>2.3 (b) Convection</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Relate convection in fluids to density changes and describe experiments to illustrate convection</li> </ul>	
<p>2.3 (c) Radiation</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Identify infrared radiation as part of the electromagnetic spectrum</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>• Describe experiments to show the properties of good and bad emitters and good and bad absorbers of infrared radiation</li> </ul>

<p>2.3 (d) Consequences of Energy Transfer</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Identify and explain some of the everyday applications and consequences of conduction, convection, and radiation</li> </ul>	
<b>3. Properties of Waves, Including Light and Sound</b>	
<p>3.1 General Wave Properties</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe what is meant by wave motion as illustrated by vibration in ropes and springs and by experiments using water waves</li> <li>Use the term wavefront</li> <li>Give the meaning of speed, frequency, wavelength, and amplitude</li> <li>Distinguish between transverse and longitudinal waves and give suitable examples</li> <li>Describe the use of water waves to show: <ul style="list-style-type: none"> <li>reflection at a plane surface</li> <li>refraction due to a change of speed</li> <li>diffraction produced by wide and narrow gaps</li> </ul> </li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Recall and use the equation <math>v = f\lambda</math></li> <li>Interpret reflection, refraction, and diffraction using wave theory</li> </ul>
<p>3.2 Light</p>	
<p>3.2 (a) Reflection of Light</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the formation of an optical image by a plane mirror, and give its characteristics</li> <li>Use the law angle of incidence = angle of reflection</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Perform simple constructions, measurements, and calculations</li> </ul>
<p>3.2 (b) Refraction of Light</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe an experimental demonstration of the refraction of light</li> <li>Use the terminology for the angle of incidence <math>i</math> and angle of refraction <math>r</math> and describe the passage of light through parallel-sided transparent material</li> <li>Give the meaning of critical angle</li> <li>Describe internal and total internal reflection</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Recall and use the definition of refractive index <math>n</math> in terms of speed</li> <li>Recall and use the equation <math>\sin i / \sin r = n</math></li> <li>Describe the action of optical fibers particularly in medicine and communications technology</li> </ul>

<p>3.2 (c) Thin Converging Lens</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the action of a thin converging lens on a beam of light</li> <li>Use the terms “principal focus” and “focal length”</li> <li>Draw ray diagrams to illustrate the formation of a real image by a single lens</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Draw ray diagrams to illustrate the formation of a virtual image by a single lens</li> <li>Use and describe the use of a single lens as a magnifying glass</li> </ul>
<p>3.2 (d) Dispersion of Light</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Give a qualitative account of the dispersion of light as shown by the action on light of a glass prism</li> </ul>	
<p>3.2 (e) Electromagnetic Spectrum</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the main features of the electromagnetic spectrum and state that all e.m. waves travel with the same high speed <i>in vacuo</i></li> <li>Describe the role of electromagnetic waves in: <ul style="list-style-type: none"> <li>radio and television communications (radio waves)</li> <li>satellite television and telephones (microwaves)</li> <li>electrical appliances, remote controllers for televisions, and intruder alarms (infrared)</li> <li>medicine and security (X-rays)</li> </ul> </li> <li>Demonstrate an awareness of safety issues regarding the use of microwaves and X-rays</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>State the approximate value of the speed of electromagnetic waves</li> <li>Use the term “monochromatic”</li> </ul>
<p>3.3 Sound</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the production of sound by vibrating sources</li> <li>Describe the longitudinal nature of sound waves</li> <li>State the approximate range of audible frequencies</li> <li>Show an understanding that a medium is needed to transmit sound waves</li> <li>Describe an experiment to determine the speed of sound in air</li> <li>Relate the loudness and pitch of sound waves to amplitude and frequency</li> <li>Describe how the reflection of sound may produce an echo</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Describe compression and rarefaction</li> <li>State the order of magnitude of the speed of sound in air, liquids, and solids</li> </ul>

## 4. Electricity and Magnetism

### 4.1 Simple Phenomena of Magnetism

#### Core

- State the properties of magnets
- Give an account of induced magnetism
- Distinguish between ferrous and non-ferrous materials
- Describe methods of magnetization and of demagnetization
- Describe an experiment to identify the pattern of field lines around a bar magnet
- Distinguish between the magnetic properties of iron and steel
- Distinguish between the design and use of permanent magnets and electromagnets

### 4.2 Electrical Quantities

#### 4.2 (a) Electric Charge

#### Core

- Describe simple experiments to show the production and detection of electrostatic charges
- State that there are positive and negative charges
- State that unlike charges attract and that like charges repel
- Describe an electric field as a region in which an electric charge experiences a force
- Distinguish between electrical conductors and insulators and give typical examples

#### Supplement

- State that charge is measured in coulombs
- State the direction of lines of force and describe simple field patterns, including the field around a point charge and the field between two parallel plates
- Give an account of charging by induction
- Recall and use the simple electron model to distinguish between conductors and insulators

#### 4.2 (b) Current

#### Core

- State that current is related to the flow of charge
- Use and describe the use of an ammeter

#### 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 (c) Electro-motive Force

#### Core

- State that the e.m.f. of a source of electrical 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

<p>4.2 (d) Potential Difference</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>State that the potential difference across a circuit component is measured in volts</li> <li>Use and describe the use of a voltmeter</li> </ul>	
<p>4.2 (e) Resistance</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>State that resistance = p.d./current and understand qualitatively how changes in p.d. or resistance affect current</li> <li>Recall and use the equation <math>R = V/I</math></li> <li>Describe an experiment to determine resistance using a voltmeter and an ammeter</li> <li>Relate (without calculation) the resistance of a wire to its length and to its diameter</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Recall and use quantitatively the proportionality between resistance and length, and the inverse proportionality between resistance and cross-sectional area of a wire</li> </ul>
<p>4.2 (f) Electrical Energy</p>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Recall and use the equations <math>P = IV</math> and <math>E = IVt</math></li> </ul>
<p>4.3 Electric Circuits</p>	
<p>4.3 (a) Circuit Diagrams</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Draw and interpret circuit diagrams containing sources, switches, resistors (fixed and variable), lamps, ammeters voltmeters, magnetizing coils, transformers, bells, fuses, and relays</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Draw and interpret circuit diagrams containing diodes and transistors</li> </ul>
<p>4.3 (b) Series and Parallel Circuits</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Understand that the current at every point in a series circuit is the same</li> <li>Give the combined resistance of two or more resistors in series</li> <li>State that, for a parallel circuit, the current from the source is larger than the current in each branch</li> <li>State that the combined resistance of two resistors in parallel is less than that of either resistor by itself</li> <li>State the advantages of connecting lamps in parallel in a lighting circuit</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>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</li> <li>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</li> <li>Calculate the effective resistance of two resistors in parallel</li> </ul>

## 4.3 (c) Action and Use of Circuit Components

**Core**

- 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 capacitor as an energy store and show understanding of its use in time-delay circuits
- Describe the action of a relay and show understanding of its use in switching circuits

**Supplement**

- Describe the action of a diode and show understanding of its use as a rectifier
- Describe the action of a transistor as an electrically operated switch and show understanding of its use in switching circuits
- Recognize and show understanding of circuits operating as light sensitive switches and temperature-operated alarms (using a relay or a transistor)

## 4.3 (d) Digital Electronics

**Supplement**

- Explain and use the terms digital and analog
- State that logic gates are circuits containing transistors and other components
- Describe the action of NOT, AND, OR, NAND, and NOR gates
- Design and understand simple digital circuits combining several logic gates
- State and use the symbols for logic gates (candidates should use the American ANSI Y 32.14 symbols)

## 4.4 Dangers of Electricity

**Core**

- State the hazards of
  - damaged insulation
  - overheating of cables
  - damp conditions
- Show an understanding of the use of fuses and circuit-breakers

4.5 Electromagnetic Effects	
<p>4.5 (a) Electromagnetic Induction</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe an experiment that shows that a changing magnetic field can induce an e.m.f. in a circuit</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>State the factors affecting the magnitude of an induced e.m.f.</li> <li>Show understanding that the direction of an induced e.m.f. opposes the change causing it</li> </ul>
<p>4.5 (b) a.c. Generator</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe a rotating-coil generator and the use of slip rings</li> <li>Sketch a graph of voltage output against time for a simple a.c. generator</li> </ul>	
<p>4.5 (c) Transformer</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the construction of a basic iron-cored transformer as used for voltage transformations</li> <li>Recall and use the equation <math>(V_p/V_s) = (N_p/N_s)</math></li> <li>Describe the use of the transformer in high-voltage transmission of electricity</li> <li>Give the advantages of high-voltage transmission</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Describe the principle of operation of a transformer</li> <li>Recall and use the equation <math>V_p I_p = V_s I_s</math> (for 100% efficiency)</li> <li>Explain why energy losses in cables are lower when the voltage is high</li> </ul>
<p>4.5 (d) The Magnetic Effect of a Current</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the pattern of the magnetic field due to currents in straight wires and in solenoids</li> <li>Describe applications of the magnetic effect of current, including the action of a relay</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>State the qualitative variation of the strength of the magnetic field over salient parts of the pattern</li> <li>Describe the effect on the magnetic field of changing the magnitude and direction of the current</li> </ul>
<p>4.5 (e) Force on a Current-carrying Conductor</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe an experiment to show that a force acts on a current-carrying conductor in a magnetic field, including the effect of reversing:             <ol style="list-style-type: none"> <li>the current</li> <li>the direction of the field</li> </ol> </li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Describe an experiment to show the corresponding force on beams of charged particles</li> <li>State and use the relative directions of force, field, and current</li> </ul>



<p>4.5 (f) d.c. Motor</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>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</li> <li>Relate this turning effect to the action of an electric motor</li> </ul>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Describe the effect of increasing the current</li> </ul>
<p>4.6 Cathode-ray Oscilloscopes</p>	
<p>4.6 (a) Cathode Rays</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Describe the production and detection of cathode rays</li> <li>Describe their deflection in electric fields</li> <li>State that the particles emitted in thermionic emission are electrons</li> </ul>	
<p>4.6 (b) Simple Treatment of Cathode-ray Oscilloscope</p>	<p><b>Supplement</b></p> <ul style="list-style-type: none"> <li>Describe (in outline) the basic structure and action of a cathode-ray oscilloscope (detailed circuits are <b>not</b> required)</li> <li>Use and describe the use of a cathode-ray oscilloscope to display waveforms</li> </ul>
<p><b>5. Atomic Physics</b></p>	
<p>5.1 Radioactivity</p>	
<p>5.1 (a) Detection of Radioactivity</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>Show awareness of the existence of background radiation</li> <li>Describe the detection of <math>\alpha</math>-particles, <math>\beta</math>-particles, and <math>\gamma</math>-rays (<math>\beta^+</math> are not included: <math>\beta</math>-particles will be taken to refer to <math>\beta^-</math>)</li> </ul>	
<p>5.1 (b) Characteristics of the Three Kinds of Emission</p> <p><b>Core</b></p> <ul style="list-style-type: none"> <li>State that radioactive emissions occur randomly over space and time</li> <li>State, for radioactive emissions: <ul style="list-style-type: none"> <li>their nature</li> <li>their relative ionizing effects</li> <li>their relative penetrating abilities</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Describe their deflection in electric fields and magnetic fields</li> <li>Interpret their relative ionizing effects</li> </ul>

5.1 (c) Radioactive Decay <b>Core</b> <ul style="list-style-type: none"> <li>State the meaning of radioactive decay, using equations (involving words or symbols) to represent changes in the composition of the nucleus when particles are emitted</li> </ul>	
5.1 (d) Half-life <b>Core</b> <ul style="list-style-type: none"> <li>Use the term "half-life" in simple calculations, which might involve information in tables or decay curves</li> </ul>	
5.1 (e) Safety Precautions <b>Core</b> <ul style="list-style-type: none"> <li>Describe how radioactive materials are handled, used, and stored in a safe way</li> </ul>	
5.2 The Nuclear Atom	
5.2 (a) Atomic Model <b>Core</b> <ul style="list-style-type: none"> <li>Describe the structure of an atom in terms of a nucleus and electrons</li> </ul>	<b>Supplement</b> <ul style="list-style-type: none"> <li>Describe how the scattering of <math>\alpha</math>-particles by thin metal foils provides evidence for the nuclear atom</li> </ul>
5.2 (b) Nucleus <b>Core</b> <ul style="list-style-type: none"> <li>Describe the composition of the nucleus in terms of protons and neutrons</li> <li>Use the term "proton number <math>Z</math>"</li> <li>Use the term "nucleon number <math>A</math>"</li> <li>Use the term "nuclide" and use the nuclide notation <math>{}^A_ZX</math></li> </ul>	
5.2 (c) Isotopes	<b>Supplement</b> <ul style="list-style-type: none"> <li>Use the term "isotope"</li> <li>Give and explain examples of practical applications of isotopes</li> </ul>

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## 5. Practical Assessment

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Scientific subjects are, by their nature, experimental. So it is important that an assessment of a candidate's knowledge and understanding of physics should contain a practical component (see Assessment Objective C).

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

- Paper 4—Coursework (internal assessment)
- Paper 5—Practical Test

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 benefits to theoretical understanding come from all practical work
- the same motivational effect, enthusiasm, and enjoyment should be experienced
- the same sequence of practical activities is appropriate.

## 5.1 Paper 4: Coursework

At least one teacher in each Center offering a subject including coursework must be accredited by Cambridge. Accreditation will be given only to teachers who satisfy Cambridge requirements concerning moderation and they will have to undergo special training in assessment before entering candidates.

The experimental skills and abilities to be assessed are:

- C1 Using and organizing techniques, apparatus, and materials
- C2 Observing, measuring, and recording
- C3 Handling experimental observations and data
- C4 Planning and evaluating investigations

The four skills carry equal weighting.

All assessments must be based on experimental work carried out by the candidates.

It is expected that the teaching and assessment of experimental skills and abilities will take place throughout the course.

Teachers must ensure that they can make available to Cambridge evidence of **two** assessments of each skill for each candidate. For skills C1 to C4 inclusive, information about the tasks set and how the marks were awarded will be required. In addition, for skills C2, C3, and C4, the candidates' written work will also be required.

The assessment scores finally recorded for each skill must represent the candidate's best performances.

For candidates who miss the assessment of a given skill through no fault of their own, for example because of illness, and who cannot be assessed on another occasion, Cambridge procedure for special consideration should be followed. However, candidates who for no good reason absent themselves from an assessment of a given skill should be given a mark of zero for that assessment.

### Criteria for Assessing Experimental Skills and Abilities

Each skill must be assessed on a six-point scale, level 6 being the highest level of achievement. Each of the skills is defined in terms of three levels of achievement at scores of 2, 4, and 6.

A score of 0 is available if there is no evidence of positive achievement for a skill.

For candidates who do not meet the criteria for a score of 2, a score of 1 is available if there is some evidence of positive achievement.

A score of 3 is available for candidates who go beyond the level defined by 2, but who do not meet fully the criteria for 4.

Similarly, a score of 5 is available for those who go beyond the level defined for 4, but do not meet fully the criteria for 6.

Score	Skill C1: Using and organizing techniques, apparatus, and materials
0	No evidence of positive achievement for this skill.
1	Some evidence of positive achievement, but the criteria for a score of 2 are not met.
2	Follows written, diagrammatic, or oral instructions to perform a single practical operation. Uses familiar apparatus and materials adequately, needing reminders on points of safety.
3	Is beyond the level defined for 2, but does not meet fully the criteria for 4.
4	Follows written, diagrammatic, or oral instructions to perform an experiment involving a series of step-by-step practical operations. Uses familiar apparatus, materials, and techniques adequately and safely.
5	Is beyond the level defined for 4, but does not meet fully the criteria for 6.
6	Follows written, diagrammatic, or oral instructions to perform an experiment involving a series of practical operations where there may be a need to modify or adjust one step in the light of the effect of a previous step. Uses familiar apparatus, materials, and techniques safely, correctly, and methodically.

Score	Skill C2: Observing, measuring, and recording
0	No evidence of positive achievement for this skill.
1	Some evidence of positive achievement, but the criteria for a score of 2 are not met.
2	Makes observations or readings given detailed instructions. Records results in an appropriate manner given a detailed format.
3	Is beyond the level defined for 2, but does not meet fully the criteria for 4.
4	Makes relevant observations, measurements, or estimates given an outline format or brief guidelines. Records results in an appropriate manner given an outline format.
5	Is beyond the level defined for 4, but does not meet fully the criteria for 6.
6	Makes relevant observations, measurements, or estimates to a degree of accuracy appropriate to the instruments or techniques used. Records results in an appropriate manner given no format.

Score	Skill C3: Handling experimental observations and data
0	No evidence of positive achievement for this skill.
1	Some evidence of positive achievement, but the criteria for a score of 2 are not met.
2	Processes results in an appropriate manner given a detailed format. Draws an obvious qualitative conclusion from the results of an experiment.
3	Is beyond the level defined for 2, but does not meet fully the criteria for 4.
4	Processes results in an appropriate manner given an outline format. Recognizes and comments on anomalous results. Draws qualitative conclusions that are consistent with obtained results and deduces patterns in data.
5	Is beyond the level defined for 4, but does not meet fully the criteria for 6.
6	Processes results in an appropriate manner given no format. Deals appropriately with anomalous or inconsistent results. Recognizes and comments on possible sources of experimental error. Expresses conclusions as generalizations or patterns where appropriate.

Score	Skill C4: Planning, carrying out, and evaluating investigations
0	No evidence of positive achievement for this skill.
1	Some evidence of positive achievement, but the criteria for a score of 2 are not met.
2	Suggests a simple experimental strategy to investigate a given practical problem. Attempts "trial and error" modification in the light of the experimental work carried out.
3	Is beyond the level defined for 2, but does not meet fully the criteria for 4.
4	Specifies a sequence of activities to investigate a given practical problem. In a situation where there are two variables, recognizes the need to keep one of them constant while the other is being changed. Comments critically on the original plan and implements appropriate changes in the light of the experimental work carried out.
5	Is beyond the level defined for 4, but does not meet fully the criteria for 6.
6	Analyzes a practical problem systematically and produces a logical plan for an investigation. In a given situation, recognizes there are a number of variables and attempts to control them. Evaluates chosen procedures, suggests/implements modifications where appropriate and shows a systematic approach in dealing with unexpected results.

## Guidance on Candidate Assessment

The following notes are intended to provide teachers with information to help them to make valid and reliable assessments of the skills and abilities of their candidates.

- The assessments should be based on the principle of positive achievement: candidates should be given opportunities to demonstrate what they understand and can do.
- It is expected that candidates will have had opportunities to acquire a given skill before assessment takes place.
- It is not expected that all of the practical work undertaken by a candidate will be assessed.
- Assessments can be carried out at any time during the course. However, at whatever stage assessments are done, the standards applied must be those expected at the end of the course, as exemplified in the criteria for the skills.
- Assessments should normally be made by the person responsible for teaching the candidates.
- A given practical task is unlikely to provide opportunities for all aspects of the criteria at a given level for a particular skill to be satisfied; for example, there may not be any anomalous results (Skill C3). However, by using a range of practical work, teachers should ensure that opportunities are provided for all aspects of the criteria to be satisfied during the course.
- Extended experimental investigations are of great educational value. If such investigations are used for assessment purposes, teachers should make sure that the candidates have ample opportunity for displaying the skills and abilities required by the scheme of assessment.
- It is not necessary for all candidates within a teaching group, or within a Center, to be assessed on exactly the same practical work, although teachers can use work that is undertaken by all of their candidates.
- When assessing group work, teachers must ensure that each candidate's individual contribution is assessed.
- Skill C1 might not generate a written product from the candidates; it will often be assessed by watching the candidates carrying out practical work.
- Skills C2, C3, and C4 will usually generate a written product from the candidates; this will provide evidence for moderation.
- Raw scores for individual practical assessments should be recorded on the Individual Candidate Record Card. The final, internally moderated total score should be recorded on the Coursework Assessment Summary Form (examples of both forms, plus the Sciences Experiment Form, are at the back of this syllabus).
- Raw scores for individual practical assessments may be given to candidates as part of the normal feedback from the teacher. The final, internally moderated, total score should **not** be given to the candidate.

## Moderation

### Internal moderation

When several teachers in a Center are involved in internal assessment, arrangements must be made within the Center for all candidates to be assessed to the same standard. It is essential that the marks for each skill assigned within different teaching groups (or classes) are moderated internally for the whole Center entry. The Center assessments will then be moderated externally by Cambridge.

### External moderation

External moderation of internal assessment is carried out by Cambridge. Centers must submit candidates' internally assessed marks to Cambridge. The deadlines and methods for submitting internally assessed marks are in the *Cambridge Administrative Guide* available on our website.

Information regarding the selection of candidates for external moderation can be found in the *Cambridge Administrative Guide*. For those candidates selected, the Center must send every piece of work that has contributed towards these candidates' final marks. Individual Candidate Record Cards and Coursework Assessment Summary Forms must also be sent with the coursework. All remaining coursework and records should be kept by the Center until results are published.

Ideally, Centers should use loose-leaf letter-size filler paper for practical written work, as this is cheaper to send by mail. Original work is preferred for moderation, but authenticated photocopies can be sent if absolutely necessary.

Pieces of work for each skill should not be stapled together. Each piece of work should be clearly and securely labeled with:

- the skill being assessed
- the Center number
- the candidate's name and candidate number
- the title of the experiment
- a copy of the mark scheme used
- the mark awarded.



## 5.2 Paper 5: Practical Test

Candidates taking this paper must be able to:

- follow written instructions for the assembly and use of provided apparatus: for example, for using ray tracing equipment or for wiring up simple electrical circuits
- select, from given items, the measuring device suitable for the task
- give reasons for choosing particular items of apparatus
- draw, complete, and/or label diagrams of apparatus
- carry out the specified manipulation of the apparatus, 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 the thermal capacity of two metals
- take readings from a measuring device, including:
  - reading a scale with appropriate precision/accuracy
  - making consistent use of significant figures
  - use of appropriate units
  - interpolating between scale divisions
  - allowing for zero errors, where appropriate
- take repeated measurements to obtain an average value
- record their observations systematically, with appropriate units
- process their data as required
- present their data graphically, using suitable axes and scales (appropriately labeled) and plotting the points accurately
- take readings from a graph by interpolation and extrapolation
- determine a gradient, intercept, or intersection on a graph
- draw and report a conclusion or result clearly
- describe precautions taken in carrying out a procedure
- explain and/or comment critically on described procedures or points of practical detail
- comment on a procedure used in an experiment and suggest an improvement.
- plan an investigation, including suggesting suitable techniques and apparatus.

Candidates may not use textbooks in the exam, nor any of their own records of laboratory work carried out during their course. They must carry out the experiments from the instructions given in the paper. Candidates must answer on the question paper.

## 6. Appendix A

### 6.1 Grade Descriptions

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

<b>Grade A</b>	<b>Candidate must show mastery of the Core curriculum and the Extended curriculum</b>
A <b>Grade A</b> candidate will be able to:	<ul style="list-style-type: none"> <li>• relate facts to principles and theories and vice versa</li> <li>• state why particular techniques are preferred for a procedure or operation</li> <li>• select and collate information from a number of sources and present it in a clear logical form</li> <li>• solve problems in situations which may involve a wide range of variables</li> <li>• process data from a number of sources to identify any patterns or trends</li> <li>• generate a hypothesis to explain facts or find facts to support a hypothesis</li> </ul>
<b>Grade C</b>	<b>Candidate must show mastery of the Core curriculum, plus some ability to answer questions that are pitched at a higher level.</b>
A <b>Grade C</b> candidate will be able to:	<ul style="list-style-type: none"> <li>• link facts to situations not specified in the syllabus</li> <li>• describe the correct procedure(s) for a multistage operation</li> <li>• select a range of information from a given source and present it in a clear logical form</li> <li>• identify patterns or trends in given information</li> <li>• solve a problem involving more than one step, but with a limited range of variables</li> <li>• generate a hypothesis to explain a given set of facts or data</li> </ul>
<b>Grade F</b>	<b>Candidate must show competence in answering questions based on the Core curriculum.</b>
A <b>Grade F</b> candidate will be able to:	<ul style="list-style-type: none"> <li>• recall facts contained in the syllabus</li> <li>• indicate the correct procedure for a single operation</li> <li>• select and present a single piece of information from a given source</li> <li>• solve a problem involving one step, or more than one step if structured help is given</li> <li>• identify a pattern or trend where only minor manipulation of data is needed</li> <li>• recognize which of two given hypotheses explains a set of facts or data</li> </ul>

## 6.2 Symbols, Units, and Definitions of 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. Candidates should be able to define the items indicated by an asterisk (\*). The list for the Extended Curriculum includes both the Core and the Supplement.

Core			Supplement		
Quantity	Symbol	Unit	Quantity	Symbol	Unit
length	$l, h \dots$	km, m, cm, mm			
area	$A$	$m^2, cm^2$			
volume	$V$	$m^3, cm^3$			
weight	$W$	N			N*
mass	$m, M$	kg, g			mg
time	$t$	h, min, s			ms
density*		$g/cm^3, kg/m^3$			
speed*	$u, v$	km/h, m/s, cm/s			
acceleration	$a$		acceleration*		$m/s^2$
acceleration of free-fall	$g$				
force	$F, P \dots$	N	force*		N*
			moment of a force*		N m
work done	$W, E$	J	work done by a force*		J*
energy	$E$	J			J*, kW h*
power	$P$	W	power*		W*
pressure	$p, P$		pressure*		Pa*, $N/m^2$
			atmospheric pressure		millibar

Core			Supplement		
Quantity	Symbol	Unit	Quantity	Symbol	Unit
temperature	$\theta, T$	$^{\circ}\text{C}$			
specific heat capacity	$c$	$\text{J}/(\text{g } ^{\circ}\text{C}), \text{J}/(\text{kg } ^{\circ}\text{C})$	specific heat capacity*		
latent heat	$L$	J	specific latent heat*	$l$	$\text{J}/\text{kg}, \text{J}/\text{g}$
			frequency*	$f$	Hz
			wavelength*	$\lambda$	m, cm
focal length	$f$				
angle of incidence	$i$	degree ( $^{\circ}$ )	refractive index	$n$	
angle of reflection, refraction	$r$	degree ( $^{\circ}$ )			
critical angle	$c$	degree ( $^{\circ}$ )			
potential difference/voltage	$V$	V, mV	potential difference*		$\text{V}^*$
current	$I$	A, mA	current*		
			charge		C, A s
e.m.f.	$E$	V	e.m.f.*		
resistance	$R$	$\Omega$			

## 6.3 Glossary of Terms Used in Science Papers

The 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 numbers 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 easily 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. *Explain* may imply reasoning or some reference to theory, depending on the context.
6. *Describe* requires the candidate to state in words (using diagrams where appropriate) the main points of the topic. It is often used to refer either to particular phenomena or to particular experiments. In the former instance, the term usually implies that the answer should refer to (visual) observations associated with the phenomena.  
In other contexts, *describe* should be interpreted more generally (i.e., the candidate has greater discretion about the nature and the organization of the material to be included in the answer). *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 in the topic.
8. *Outline* implies brevity (i.e., restricting the answer to giving essentials).
9. *Predict* 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. Such information may be wholly given in the question or may depend on answers extracted in an earlier part of the question. *Predict* also implies a concise answer with no supporting statement required.
10. *Deduce* is used in a similar way to *predict* except that some supporting statement is required, e.g., reference to a law, a principle, or the necessary reasoning should be included in the answer.
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 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 in question cannot be measured directly but must be found by calculation, placing measured or known values of other quantities into a standard formula.
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.

## 6.4 Mathematical Requirements

Candidates may use calculators in all parts of the exam.

Candidates should be able to:

- add, subtract, multiply, and divide
- use averages, decimals, fractions, percentages, ratios, and reciprocals
- recognize and use scientific notation
- use direct and inverse proportion
- use positive, whole number indices
- draw charts and graphs from given data
- interpret charts and graphs
- choose suitable scales and axes for graphs
- make approximate evaluations of numerical expressions
- recognize and use the relationship between length, surface area, and volume and their units on metric scales
- use usual mathematical instruments (ruler, compasses, protractor, set square)
- understand the meaning of angle, curve, circle, radius, diameter, square, parallelogram, rectangle, and diagonal
- solve equations of the form  $x = yz$  for any one term when the other two are known
- recognize and use points of the compass (N, S, E, W).

## 6.5 ICT

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 World Wide Web 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 visualize scientific ideas;
- using software to present ideas and information on paper and on screen.

The examples listed in the table show some of the points in the syllabus where opportunities may be found.

ICT	Possible opportunities
Gathering information	Independent research into 1.6b, 3.2e, 4.5c, 4.6b, 5.1
Datalogging	Practical work associated with 1.2, 2.3
Processing data	Practical work associated with 3.2b, 4.3c, 5.1d
Visualization	Demonstration of 1.2, 2.1b, 3.3, 4.5b, 4.5e
Making presentations	Practical work or independent research in 5.1a, 1.6b, 4.2a

## 6.6 Procedures for External Moderation

1. Cambridge will send form MS1 (internally assessed mark sheet) to each Center. MS1 will list the name and candidate number of each candidate.
2. Transfer each candidate's total internally moderated mark from the Coursework Assessment Summary Form to MS1.
3. MS1 is in two parts: return the top copy to Cambridge as soon as possible, using the envelope provided. The deadlines for return are in the *Cambridge Administrative Guide*.
4. Information regarding the selection of candidates for external moderation can be found in the *Cambridge Administrative Guide*. For those candidates selected, send Cambridge:
  - the candidates' Coursework
  - their Individual Candidate Record Cards
  - the relevant Coursework Assessment Summary Form
  - the second copy of MS1
5. Label each piece of work clearly with:
  - the skill being assessed
  - the Center name
  - the candidate's name and candidate number
  - the title of the experiment
  - a copy of the marking scheme used
  - the mark awarded
6. You must supply Experiment Forms, Work Sheets, and Marking Schemes for each task **that has contributed to the final mark of these candidates**.
7. You may send photocopies of the samples **but** Cambridge prefers to see candidates' original work, with marks and comments from the teacher.
8. Do not staple pieces of work for each skill together. Do not place individual sheets in plastic wallets.

Note: Cambridge reserves the right to request additional samples of Coursework as part of the external moderation process.

## 6.7 Forms

This section contains copies of the following forms, together with instructions on how to complete them: Sciences Experiment Form; Individual Candidate Record Card; Coursework Assessment Summary Form.



SCIENCES  
Experiment For  
IGCSE



Please read the instructions printed overleaf.

Centre Number					Centre Name	
Syllabus Code	0	4	4	3	Syllabus Title	<b>Physics</b>
Component Number	0		4		Component Title	<b>Coursework</b>
June/November	2	0	1	4		

Experiment Number	Experiment	Skill(s) Assessed





## Sciences experiment form – instructions

To complete the Sciences Experiment Form:

- 1 Enter the information required at the head of the form.
- 2 Use a separate form for each Syllabus.
- 3 Give a brief description of each of the experiments that your candidates performed for assessment in the Cambridge IGCSE Science Syllabus indicated. Use additional sheets as necessary.
- 4 Teachers must send to Cambridge copies of the experiment forms and the corresponding worksheets/ instructions and marking schemes for each assessed task sampled, for each of Skills C1 to C4.

**SCIENCES**  
**Individual Candidate Record Card**  
**IGCSE 2014**

**Please read the instructions printed overleaf and the General Coursework Regulations before completing this form.**

Centre number					Centre name		June/November	2	0	1	4
Candidate number					Candidate name		Teaching group/set				
Syllabus code	0	4	4	3	Syllabus title	<b>PHYSICS</b>	Component number	0	4	Component title	<b>COURSEWORK</b>

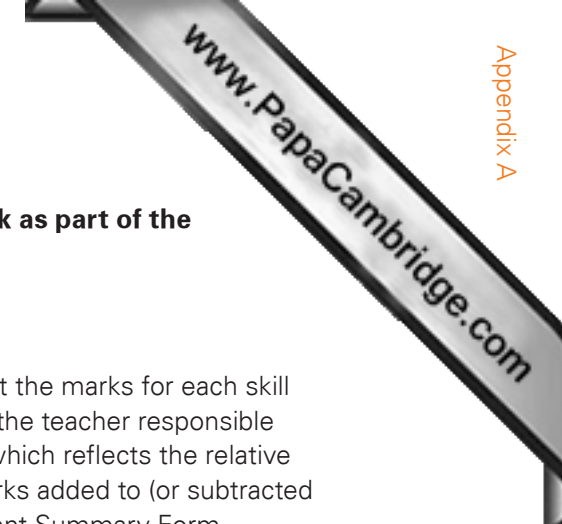
Date of Assessment	Experiment number from Sciences Experiment Form	Assess at least twice: ring highest two marks for each skill (Max 6 each assessment)				Relevant comments (for example, if help was given)
		C1	C2	C3	C4	
Marks to be transferred to						TOTAL
Coursework Assessment Summary Form		(max 12)	(max 12)	(max 12)	(max 12)	(max 48)

**WMS635**



UNIVERSITY of CAMBRIDGE  
 International Examinations

**IGCSE/PHYSICS/CW/II/14**



## Individual candidate record card – instructions

**The Individual Candidate Record Card is only for use by teachers of candidates who have undertaken Coursework as part of the Cambridge IGCSE assessment.**

### Important:

When entering candidates from different teaching groups (for example, difference classes), the Centre must make sure that the marks for each skill are moderated internally. In practice, this means that all marks within a Centre must be brought to a common standard by the teacher responsible for co-ordinating internal assessment (i.e. the internal moderator). The aim is to produce a valid and reliable set of marks, which reflects the relative attainment of all Coursework candidates in the Centre. The outcome of internal moderation, in terms of the number of marks added to (or subtracted from) the candidate's initial total, must be clearly shown when these marks are transferred onto the Coursework Assessment Summary Form.

To complete the Individual Candidate Record Form:

- 1 Enter the information required at the head of the form.
- 2 After marking each item of Coursework (see Syllabus for more information), enter the marks awarded for each Assessment Objective, and the total marks awarded, into the appropriate boxes. Make sure that the addition of marks is independently checked.
- 3 Transfer the marks to the Coursework Assessment Summary Form – see this Form for further instructions, and see the note on internal moderation above.
- 4 Keep all Individual Candidate Record Cards and Coursework, as these will be required for external moderation.

For more information at this stage please refer to the Syllabus booklet, and see the Coursework Assessment Summary Form. Further instructions on external moderation are in the *Cambridge Administrative Guide*.

Coursework Assessment Summary  
IGCSE

Please read the instructions printed overleaf and the General Coursework Regulations before completing this form.

Centre number					Centre name			June/November	2	0	1	4
Syllabus code	0	4	4	3	Syllabus title	PHYSICS	Component number	0	4	Component title	COURSEWORK	

Candidate number	Candidate name	Teaching group/ set	C1 (max 12)	C2 (max 12)	C3 (max 12)	C4 (max 12)	Total mark (max 48)	Internally moderated mark (max 48)

Name of				
Name of				

## Coursework assessment summary form – instructions

- 1 Enter the information required at the head of the form.
- 2 List candidates so that their details can be easily transferred to the computer-printed Coursework mark sheet MS1, i.e. in candidate index number order. Show the teaching group or set for each candidate – this can be done using the teacher's initials.
- 3 Transfer each candidate's marks from their Individual Candidate Record Card as follows:
  - In the columns for individual skills or assignments, enter the marks awarded before internal moderation.
  - In the column headed 'Total Mark', enter the total mark awarded before internal moderation.
  - In the column headed 'Internally Moderated Mark', enter the total mark awarded *after* internal moderation took place.
- 4 The teacher completing the form, and the internal moderator/s, must check and sign the form where indicated.

## 7. Appendix B: Additional Information

### 7.1 Guided Learning Hours

Cambridge IGCSE syllabi are designed with the assumption that candidates have about 130 guided learning hours per subject over the duration of the course. (“Guided learning hours” include direct teaching and any other supervised or directed study time. They do not include private study by the candidate.)

However, this figure is for guidance only, and the number of hours required may vary according to local curricular practice and the candidates’ prior experience with the subject.

### 7.2 Recommended Prerequisites

We recommend that candidates who are beginning this course should have previously studied a science curriculum such as that of the Cambridge Lower Secondary Programme or equivalent national educational frameworks. Candidates should also have adequate mathematical skills for the content contained in this syllabus.

### 7.3 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 C to A\* in Cambridge IGCSE Physics are well prepared to follow courses leading to Cambridge International AS and A Level Physics, or the equivalent.

### 7.4 Component Codes

Because of local variations, in some cases component codes will be different in instructions about making entries for examinations and timetables from those printed in this syllabus, but the component names will be unchanged to make identification straightforward.

### 7.5 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, Grade A\* being the highest and Grade 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.

## 7.6 Access

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments and to demonstrate what they know and what they can do. For this reason, very few candidates will have a complete barrier to the assessment. Information on reasonable adjustments is found in the *Cambridge Handbook*, which can be downloaded from the website **www.cie.org.uk**

Candidates who are unable to access part of the assessment, even after exploring all possibilities through reasonable adjustments, may still be able to receive an award based on the parts of the assessment they have taken.

## 7.7 Support and Resources

Copies of syllabi, the most recent question papers, and Principal Examiners' reports for teachers are on the Syllabus and Support Materials CD-ROM, which we send to all Cambridge International Schools. They are also on our public website—go to **www.cie.org.uk/igcse**. Click the **Subjects** tab and choose your subject. For resources, click "Resource List."

You can use the "Filter by" list to show all resources or only resources categorized as "Endorsed by Cambridge." Endorsed resources are written to align closely with the syllabus they support. They have been through a detailed quality-assurance process. As new resources are published, we review them against the syllabus and publish their details on the relevant resource list section of the website.

Additional syllabus-specific support is available from our secure Teacher Support website **http://teachers.cie.org.uk**, which is available to teachers at registered Cambridge schools. It provides past question papers and examiner reports on previous examinations, as well as any extra resources such as schemes of work (unit lesson plans) or examples of candidate responses. You can also find a range of subject communities on the Teacher Support website, where Cambridge teachers can share their own materials and join discussion groups.



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