UNIVERSITY of CAMBRIDGE
International Examinations

Cambridge
O Level

SYLLABUS

Cambridge O Level
Physics
5054

For examination in June and November 2014

Contents

1. Introduction

1.1 Why choose Cambridge?

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

Developed for an international audience

Cambridge O Levels have been designed for an international audience and are sensitive to the needs of different countries. These qualifications are designed for students whose first language may not be English and this is acknowledged throughout the examination process. The Cambridge O Level syllabus also allows teaching to be placed in a localised context, making it relevant in varying regions.

Recognition

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

Cambridge O Level is internationally recognised by schools, universities and employers as equivalent to UK GCSE. Learn more at **www.cie.org.uk/recognition**

Excellence in education

We understand education. We work with over 9000 schools in over 160 countries who offer our programmes 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 programmes 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**

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

We are a part of Cambridge Assessment, a department of the University of Cambridge and a not-for-profit organisation.

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

1.2 Why choose Cambridge O Level?

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

Schools worldwide have helped develop Cambridge O Levels, which provide an excellent preparation for Cambridge International AS and A Levels.

Cambridge O Level 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 O Level Physics?

Cambridge O Levels are established qualifications that keep pace with educational developments and trends. The Cambridge O Level curriculum places emphasis on broad and balanced study across a wide range of subject areas. The curriculum is structured so that students attain both practical skills and theoretical knowledge.

Cambridge O Level Physics is recognised by universities and employers throughout the world as proof of knowledge and understanding. Successful Cambridge O Level Physics 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, enquiry, 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.

Candidates may also study for a Cambridge O Level in a number of other science subjects including chemistry and biology. In addition to Cambridge O Levels, Cambridge also offers Cambridge IGCSE and Cambridge International AS & A Levels for further study in both physics as well as other science subjects.

See **www.cie.org.uk** for a full list of the qualifications you can take.

1.4 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**

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 **international@cie.org.uk** to find out how your organisation can become a Cambridge school.

2. Assessment at a glance

For the Cambridge O Level in physics, candidates take **three** components: Paper 1 **and** Paper 2 and either Paper 3 **or** Paper 4.

Paper 1: Multiple Choice	**1 hour**
40 compulsory multiple-choice questions of the direct choice type. The questions involve four response items. 40 marks	

Paper 2: Theory	**1 hour 45 minutes**
This paper has two sections: Section A has a small number of compulsory, structured questions of variable mark value. 45 marks in total are available for this section. Section B has three questions. Each question is worth 15 marks. Candidates must answer **two** questions from this section. There is no compulsory question on Section 25 of the syllabus (Electronic systems). Questions set on topics within Section 25 appear only in Paper 2 and are always set as an alternative within a question. 75 marks	

Paper 3: Practical Test	**2 hours**	**Paper 4: Alternative to Practical**	**1 hour**
This paper has two sections. Section A has three compulsory questions each carrying five marks and each of 20 minutes duration. Section B has one question of 15 marks and is of one hour's duration. 30 marks		A written paper of compulsory short-answer and structured questions designed to test familiarity with laboratory practical procedures. 30 marks	

Availability

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

This syllabus is available to private candidates. However, it is expected that private candidates learn in an environment where practical work is an integral part of the course. Candidates will not be able to perform well in this assessment or successfully progress to further study without this necessary and important aspect of science education.

Cambridge O Levels are available to Centres in Administrative Zones 3, 4 and 5. Centres in Administrative Zones 1, 2 or 6 wishing to enter candidates for Cambridge O Level examinations should contact Cambridge Customer Services.

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)
- 5129 Cambridge O Level Combined Science

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

3. Syllabus aims and assessment objectives

3.1 Aims

The aims of the syllabus, which are not listed in order of priority, are to:

1. provide, through well-designed studies of experimental and practical science, a worthwhile educational experience for all candidates, whether or not they go on to study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge
   1.1 to become confident citizens in a technological world, able to take or develop an informed interest in matters of scientific import;
   1.2 to recognise the usefulness, and limitations, of scientific method and to appreciate its applicability in other disciplines and in everyday life;
   1.3 to be suitably prepared for studies beyond Cambridge O Level in pure sciences, in applied sciences or in science-dependent vocational courses.
2. develop abilities and skills that
   2.1 are relevant to the study and practice of science;
   2.2 are useful in everyday life;
   2.3 encourage efficient and safe practice;
   2.4 encourage effective communication.
3. develop attitudes relevant to science such as
   3.1 concern for accuracy and precision;
   3.2 objectivity;
   3.3 integrity;
   3.4 enquiry;
   3.5 initiative;
   3.6 inventiveness.
4. stimulate interest in and care for the local and global environment.
5. promote an awareness that:
   5.1 the study and practice of science are co-operative and cumulative activities, that are subject to social, economic, technological, ethical and cultural influences and limitations;
   5.2 the applications of sciences may be both beneficial and detrimental to the individual, the community and the environment.

3.2 Assessment objectives

The assessment objectives describe the knowledge, skills and abilities that candidates are expected to demonstrate at the end of the course. They reflect those aspects of the aims that are assessed.

AO1 Knowledge with understanding

Candidates should be able to demonstrate knowledge with understanding in relation to:

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.

The subject content defines the factual knowledge that candidates may be required to recall and explain. Questions testing these objectives will often begin with one of the following words: *define, state, describe, explain* or *outline* (see the glossary of terms in section 6.2).

AO2 Handling information and solving problems

Candidates should be able – using visual, aural and written (including symbolic, diagrammatic, graphical and numerical) information – to:

1. locate, select, organise and present information from a variety of sources, including everyday experience;
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.

These assessment objectives cannot readily be fully specified in the syllabus content. Questions testing skills in physics may be based on information (given in the question paper) that is unfamiliar to the candidates or is based on everyday experience. In answering such questions, candidates are required to use principles and concepts that are within the syllabus and to apply them in a logical manner. Questions testing these objectives will often begin with one of the following words: *predict*, *suggest*, *calculate* or *determine* (see the glossary of terms in section 6.2).

AO3 Experimental skills and investigations

Candidates should be able to:

1. follow instructions;
2. carry out techniques, use apparatus, handle measuring devices and materials effectively and safely;
3. make and record observations, measurements and estimates with due regard to precision, accuracy and units;
4. interpret, evaluate and report upon observations and experimental data;
5. identify problems, plan and carry out investigations, including the selection of techniques, apparatus, measuring devices and materials;
6. evaluate methods and suggest possible improvements.

3.3 Weighting of assessment objectives

Theory papers (Papers 1 and 2)

AO1 Knowledge with understanding is weighted at approximately 65% of the marks for each paper, with approximately half allocated to recall.

AO2 Handling information and solving problems is weighted at approximately 35% of the marks for each paper.

Practical assessment (Papers 3 and 4)

This is designed to test appropriate skills in assessment objective AO3 and will carry approximately 20% of the marks for the qualification.

3.4 Nomenclature, units and significant figures

Nomenclature

The proposals in 'Signs, Symbols and Systematics (The Association for Science Education Companion to 16–19 Science, 2000)' will generally be adopted. 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.

Reference should also be made to the summary of key quantities, symbols and units in section 6.1.

It is intended that, in order to avoid difficulties arising out of the use of l as the symbol for litre, use of dm^3 in place of l or litre will be made.

Units, significant figures

Candidates should be aware that misuse of units and/or significant figures, e.g. failure to quote units where necessary, the inclusion of units in quantities defined as ratios or quoting answers to an inappropriate number of significant figures, is liable to be penalised.

4. Syllabus content

Certain learning outcomes of the syllabus have been marked with an asterisk (*) to indicate the possibility of the application of IT.

Section I: General Physics

1. Physical Quantities, Units and Measurement

Content

1.1 Scalars and vectors

1.2 Measurement techniques

1.3 Units and symbols

Learning outcomes

Candidates should be able to:

(a) define the terms *scalar* and *vector*.

(b) determine the resultant of two vectors by a graphical method.

(c) list the vectors and scalars from distance, displacement, length, speed, velocity, time, acceleration, mass and force.

(d) describe how to measure a variety of lengths with appropriate accuracy using tapes, rules, micrometers and calipers using a vernier as necessary.

(e) describe how to measure a variety of time intervals using clocks and stopwatches.

(f) recognise and use the conventions and symbols contained in 'Signs, Symbols and Systematics', Association for Science Education, 2000.

Section II: Newtonian Mechanics

2. Kinematics

Content

2.1 Speed, velocity and acceleration

2.2 Graphical analysis of motion

2.3 Free-fall

Learning outcomes

Candidates should be able to:

(a) state what is meant by *speed* and *velocity*.

(b) calculate average speed using distance travelled/time taken.

(c) state what is meant by *uniform acceleration* and calculate the value of an acceleration using change in velocity/time taken.

(d) discuss non-uniform acceleration.

(e) *plot and *interpret speed-time and distance-time graphs.

(f) *recognise from the shape of a speed-time graph when a body is

(1) at rest,

(2) moving with uniform speed,

(3) moving with uniform acceleration,

(4) moving with non-uniform acceleration.

(g) calculate the area under a speed-time graph to determine the distance travelled for motion with uniform speed or uniform acceleration.

(h) state that the acceleration of free-fall for a body near to the Earth is constant and is approximately $10\ m/s^2$.

(i) describe qualitatively the motion of bodies with constant weight falling with and without air resistance (including reference to terminal velocity).

3. Dynamics

Content

3.1 Balanced and unbalanced forces
3.2 Friction
3.3 Circular motion

Learning outcomes

Candidates should be able to:

(a) state Newton's third law.
(b) describe the effect of balanced and unbalanced forces on a body.
(c) describe the ways in which a force may change the motion of a body.
(d) do calculations using the equation *force* = *mass* × *acceleration*.
(e) explain the effects of friction on the motion of a body.
(f) discuss the effect of friction on the motion of a vehicle in the context of tyre surface, road conditions (including skidding), braking force, braking distance, thinking distance and stopping distance.
(g) describe qualitatively motion in a circular path due to a constant perpendicular force, including electrostatic forces on an electron in an atom and gravitational forces on a satellite. ($F = mv^2/r$ is **not** required.)
(h) discuss how ideas of circular motion are related to the motion of planets in the solar system.

4. Mass, Weight and Density

Content

4.1 Mass and weight
4.2 Gravitational fields
4.3 Density

Learning outcomes

Candidates should be able to:

(a) state that mass is a measure of the amount of substance in a body.
(b) state that the mass of a body resists change from its state of rest or motion.
(c) state that a gravitational field is a region in which a mass experiences a force due to gravitational attraction.
(d) calculate weight from the equation *weight* = *mass* × *gravitational field strength*.
(e) explain that weights, and therefore masses, may be compared using a balance.
(f) describe how to measure mass and weight by using appropriate balances.
(g) describe how to use a measuring cylinder to measure the volume of a liquid or solid.
(h) describe how to determine the density of a liquid, of a regularly shaped solid and of an irregularly shaped solid which sinks in water (volume by displacement).
(i) make calculations using the formula *density* = *mass/volume*.

5. Turning Effect of Forces

Content

5.1 Moments

5.2 Centre of mass

5.3 Stability

Learning outcomes

Candidates should be able to:

(a) describe the moment of a force in terms of its turning effect and relate this to everyday examples.

(b) state the principle of moments for a body in equilibrium.

(c) make calculations using *moment of a force* = *force* × *perpendicular distance from the pivot* and the principle of moments.

(d) describe how to verify the principle of moments.

(e) describe how to determine the position of the centre of mass of a plane lamina.

(f) describe qualitatively the effect of the position of the centre of mass on the stability of simple objects.

6. Deformation

Content

6.1 Elastic deformation

Learning outcomes

Candidates should be able to:

(a) state that a force may produce a change in size and shape of a body.

(b) *plot, draw and interpret extension-load graphs for an elastic solid and describe the associated experimental procedure.

(c) *recognise the significance of the term "limit of proportionality" for an elastic solid.

(d) calculate extensions for an elastic solid using proportionality.

7. Pressure

Content

7.1 Pressure

7.2 Pressure changes

Learning outcomes

Candidates should be able to:

(a) define the term *pressure* in terms of force and area, and do calculations using the equation *pressure* = *force/area*.

(b) explain how pressure varies with force and area in the context of everyday examples.

(c) describe how the height of a liquid column may be used to measure the atmospheric pressure.

(d) explain quantitatively how the pressure beneath a liquid surface changes with depth and density of the liquid in appropriate examples.

(e) do calculations using the equation for hydrostatic pressure $p = \rho gh$.

(f) describe the use of a manometer in the measurement of pressure difference.

(g) describe and explain the transmission of pressure in hydraulic systems with particular reference to the hydraulic press and hydraulic brakes on vehicles.

(h) describe how a change in volume of a fixed mass of gas at constant temperature is caused by a change in pressure applied to the gas.

(i) do calculations using $p_1V_1 = p_2V_2$.

Section III: Energy and Thermal Physics

8. Energy Sources and Transfer of Energy

Content

8.1 Energy forms

8.2 Major sources of energy

8.3 Work

8.4 Efficiency

8.5 Power

Learning outcomes

Candidates should be able to:

(a) list the different forms of energy with examples in which each form occurs.

(b) state the principle of the conservation of energy and apply this principle to the conversion of energy from one form to another.

(c) state that kinetic energy is given by $E_k = ½mv^2$ and that gravitational potential energy is given by $E_P = mgh$, and use these equations in calculations.

(d) list renewable and non-renewable energy sources.

(e) describe the processes by which energy is converted from one form to another, including reference to

(1) chemical/fuel energy (a re-grouping of atoms),

(2) hydroelectric generation (emphasising the mechanical energies involved),

(3) solar energy (nuclei of atoms in the Sun),

(4) nuclear energy,

(5) geothermal energy,

(6) wind energy.

(f) explain nuclear fusion and fission in terms of energy-releasing processes.

(g) describe the process of electricity generation and draw a block diagram of the process from fuel input to electricity output.

(h) discuss the environmental issues associated with power generation.

(i) calculate work done from the formula *work* = *force* × *distance moved in the line of action of the force*.

(j) calculate the efficiency of an energy conversion using the formula *efficiency* = *energy converted to the required form/total energy input*.

(k) discuss the efficiency of energy conversions in common use, particularly those giving electrical output.

(l) discuss the usefulness of energy output from a number of energy conversions.

(m) calculate power from the formula *power* = *work done/time taken.*

9. Transfer of Thermal Energy

Content

9.1 Conduction

9.2 Convection

9.3 Radiation

9.4 Total transfer

Learning outcomes

Candidates should be able to:

(a) describe how to distinguish between good and bad conductors of heat.

(b) describe, in terms of the movement of molecules or free electrons, how heat transfer occurs in solids.

(c) describe convection in fluids in terms of density changes.

(d) describe the process of heat transfer by radiation.

(e) describe how to distinguish between good and bad emitters and good and bad absorbers of infra-red radiation.

(f) describe how heat is transferred to or from buildings and to or from a room.

(g) state and explain the use of the important practical methods of thermal insulation for buildings.

10. Temperature

Content

10.1 Principles of thermometry

10.2 Practical thermometers

Learning outcomes

Candidates should be able to:

(a) explain how a physical property which varies with temperature may be used for the measurement of temperature and state examples of such properties.

(b) explain the need for fixed points and state what is meant by the *ice point* and *steam point*.

(c) discuss sensitivity, range and linearity of thermometers.

(d) describe the structure and action of liquid-in-glass thermometers (including clinical) and of a thermocouple thermometer, showing an appreciation of its use for measuring high temperatures and those which vary rapidly.

11. Thermal Properties of Matter

Content

11.1 Specific heat capacity

11.2 Melting and boiling

11.3 Thermal expansion of solids, liquids and gases

Learning outcomes

Candidates should be able to:

(a) describe a rise in temperature of a body in terms of an increase in its internal energy (random thermal energy).

(b) define the terms *heat capacity* and *specific heat capacity*.

(c) calculate heat transferred using the formula *thermal energy* = *mass* × *specific heat capacity* × *change in temperature*.

(d) describe melting/solidification and boiling/condensation in terms of energy transfer without a change in temperature.

(e) state the meaning of *melting point* and *boiling point*.

(f) explain the difference between boiling and evaporation.

(g) define the terms *latent heat* and *specific latent heat*.

(h) explain latent heat in terms of molecular behaviour.

(i) calculate heat transferred in a change of state using the formula *thermal energy* = *mass* × *specific latent heat*.

(j) describe qualitatively the thermal expansion of solids, liquids and gases.

(k) describe the relative order of magnitude of the expansion of solids, liquids and gases.

(l) list and explain some of the everyday applications and consequences of thermal expansion.

(m) describe qualitatively the effect of a change of temperature on the volume of a gas at constant pressure.

12. Kinetic Model of Matter

Content

12.1 States of matter

12.2 Molecular model

12.3 Evaporation

Learning outcomes

Candidates should be able to:

(a) state the distinguishing properties of solids, liquids and gases.

(b) describe qualitatively the molecular structure of solids, liquids and gases, relating their properties to the forces and distances between molecules and to the motion of the molecules.

(c) describe the relationship between the motion of molecules and temperature.

(d) explain the pressure of a gas in terms of the motion of its molecules.

(e) describe evaporation in terms of the escape of more energetic molecules from the surface of a liquid.

(f) describe how temperature, surface area and draught over a surface influence evaporation.

(g) explain that evaporation causes cooling.

Section IV: Waves

13. General Wave Properties

Content

13.1 Describing wave motion

13.2 Wave terms

13.3 Wave behaviour

Learning outcomes

Candidates should be able to:

(a) describe what is meant by wave motion as illustrated by vibrations in ropes and springs and by experiments using a ripple tank.

(b) state what is meant by the term *wavefront*.

(c) define the terms *speed*, *frequency*, *wavelength* and *amplitude* and do calculations using *velocity* = *frequency* × *wavelength*.

(d) describe transverse and longitudinal waves in such a way as to illustrate the differences between them.

(e) describe the use of a ripple tank to show

(1) reflection at a plane surface,

(2) refraction due to a change of speed at constant frequency.

(f) describe simple experiments to show the reflection and refraction of sound waves.

14. Light

Content

14.1 Reflection of light

14.2 Refraction of light

14.3 Thin converging and diverging lenses

Learning outcomes

Candidates should be able to:

(a) define the terms used in reflection including *normal*, *angle of incidence* and *angle of reflection*.

(b) describe an experiment to illustrate the law of reflection.

(c) describe an experiment to find the position and characteristics of an optical image formed by a plane mirror.

(d) state that for reflection, the angle of incidence is equal to the angle of reflection and use this in constructions, measurements and calculations.

(e) define the terms used in refraction including *angle of incidence*, *angle of refraction* and *refractive index*.

(f) describe experiments to show refraction of light through glass blocks.

(g) do calculations using the equation sin i/sin r = constant.

(h) define the terms *critical angle* and *total internal reflection*.

(i) describe experiments to show total internal reflection.

(j) describe the use of optical fibres in telecommunications and state the advantages of their use.

(k) describe the action of thin lenses (both converging and diverging) on a beam of light.

(l) define the term *focal length*.

(m) *draw ray diagrams to illustrate the formation of real and virtual images of an object by a converging lens, and the formation of a virtual image by a diverging lens.

(n) define the term *linear magnification* and *draw scale diagrams to determine the focal length needed for particular values of magnification (converging lens only).

(o) describe the use of a single lens as a magnifying glass and in a camera, projector and photographic enlarger and draw ray diagrams to show how each forms an image.

(p) draw ray diagrams to show the formation of images in the normal eye, a short-sighted eye and a long-sighted eye.

(q) describe the correction of short-sight and long-sight.

15. Electromagnetic Spectrum

Content

15.1 Dispersion of light

15.2 Properties of electromagnetic waves

15.3 Applications of electromagnetic waves

Learning outcomes

Candidates should be able to:

(a) describe the dispersion of light as illustrated by the action on light of a glass prism.

(b) state the colours of the spectrum and explain how the colours are related to frequency/wavelength.

(c) state that all electromagnetic waves travel with the same high speed in air and state the magnitude of that speed.

(d) describe the main components of the electromagnetic spectrum.

(e) discuss the role of the following components in the stated applications:

(1) radiowaves – radio and television communications,

(2) microwaves – satellite television and telephone,

(3) infra-red – household electrical appliances, television controllers and intruder alarms,

(4) light – optical fibres in medical uses and telephone,

(5) ultra-violet – sunbeds, fluorescent tubes and sterilisation,

(6) X-rays – hospital use in medical imaging and killing cancerous cells, and engineering applications such as detecting cracks in metal,

(7) gamma rays – medical treatment in killing cancerous cells, and engineering applications such as detecting cracks in metal.

16. Sound

Content

16.1 Sound waves
16.2 Speed of sound
16.3 Ultrasound

Learning outcomes

Candidates should be able to:

(a) describe the production of sound by vibrating sources.
(b) describe the longitudinal nature of sound waves and describe compression and rarefaction.
(c) state the approximate range of audible frequencies.
(d) explain why a medium is required in order to transmit sound waves and describe an experiment to demonstrate this.
(e) describe a direct method for the determination of the speed of sound in air and make the necessary calculation.
(f) state the order of magnitude of the speeds of sound in air, liquids and solids.
(g) explain how the loudness and pitch of sound waves relate to amplitude and frequency.
(h) describe how the reflection of sound may produce an echo.
(i) describe the factors which influence the quality (timbre) of sound waves and how these factors may be demonstrated using a cathode-ray oscilloscope (c.r.o.).
(j) define *ultrasound*.
(k) describe the uses of ultrasound in cleaning, quality control and pre-natal scanning.

Section V: Electricity and Magnetism

17. Magnetism and Electromagnetism

Content

17.1 Laws of magnetism

17.2 Magnetic properties of matter

17.3 Electromagnetism

Learning outcomes

Candidates should be able to:

(a) state the properties of magnets.

(b) describe induced magnetism.

(c) state the differences between magnetic, non-magnetic and magnetised materials.

(d) describe electrical methods of magnetisation and demagnetisation.

(e) describe the plotting of magnetic field lines with a compass.

(f) state the differences between the properties of temporary magnets (e.g. iron) and permanent magnets (e.g. steel).

(g) describe uses of permanent magnets and electromagnets.

(h) explain the choice of material for, and use of, magnetic screening.

(i) describe the use of magnetic materials in audio/video tapes.

(j) describe the pattern of the magnetic field due to currents in straight wires and in solenoids and state the effect on the magnetic field of changing the magnitude and direction of the current.

(k) describe applications of the magnetic effect of a current in relays, circuit-breakers and loudspeakers.

18. Static Electricity

Content

18.1 Laws of electrostatics

18.2 Principles of electrostatics

18.3 Applications of electrostatics

Learning outcomes

Candidates should be able to:

(a) describe experiments to show electrostatic charging by friction.

(b) explain that charging of solids involves a movement of electrons.

(c) state that there are positive and negative charges and that charge is measured in coulombs.

(d) state that unlike charges attract and like charges repel.

(e) describe an electric field as a region in which an electric charge experiences a force.

(f) state the direction of lines of force and describe simple field patterns.

(g) describe the separation of charges by induction.

(h) discuss the differences between electrical conductors and insulators and state examples of each.

(i) state what is meant by *"earthing"* a charged object.

(j) describe examples where charging could be a problem, e.g. lightning.

(k) describe examples where charging is helpful, e.g. photocopier and electrostatic precipitator.

19. Current Electricity

Content

19.1 Current
19.2 Electromotive force
19.3 Potential difference
19.4 Resistance

Learning outcomes

Candidates should be able to:

(a) state that a current is a flow of charge and that current is measured in amperes.
(b) do calculations using the equation *charge* = *current* × *time*.
(c) describe the use of an ammeter with different ranges.
(d) explain that electromotive force (e.m.f.) is measured by the energy dissipated by a source in driving a unit charge around a complete circuit.
(e) state that e.m.f. is work done/charge.
(f) state that the volt is given by J / C.
(g) calculate the total e.m.f. where several sources are arranged in series and discuss how this is used in the design of batteries.
(h) discuss the advantage of making a battery from several equal voltage sources of e.m.f. arranged in parallel.
(i) state that the potential difference (p.d.) across a circuit component is measured in volts.
(j) state that the p.d. across a component in a circuit is given by the work done in the component/charge passed through the component.
(k) describe the use of a voltmeter with different ranges.
(l) state that *resistance* = *p.d./current* and use the equation *resistance* = *voltage/current* in calculations.
(m) describe an experiment to measure the resistance of a metallic conductor using a voltmeter and an ammeter and make the necessary calculations.
(n) discuss the temperature limitation on Ohm's Law.
(o) *use quantitatively the proportionality between resistance and the length and the cross-sectional area of a wire.
(p) calculate the net effect of a number of resistors in series and in parallel.
(q) describe the effect of temperature increase on the resistance of a resistor and a filament lamp and draw the respective sketch graphs of current/voltage.
(r) describe the operation of a light-dependent resistor.

20. D.C. Circuits

Content

20.1 Current and potential difference in circuits

20.2 Series and parallel circuits

Learning outcomes

Candidates should be able to:

(a) *draw circuit diagrams with power sources (cell, battery or a.c. mains), switches (closed and open), resistors (fixed and variable), light-dependent resistors, thermistors, lamps, ammeters, voltmeters, magnetising coils, bells, fuses, relays, light-emitting diodes and rectifying diodes.

(b) state that the current at every point in a series circuit is the same, and use this in calculations.

(c) state that the sum of the potential differences in a series circuit is equal to the potential difference across the whole circuit and use this in calculations.

(d) state that the current from the source is the sum of the currents in the separate branches of a parallel circuit.

(e) do calculations on the whole circuit, recalling and using formulae including $R = V/I$ and those for potential differences in series, resistors in series and resistors in parallel.

21. Practical Electricity

Content

21.1 Uses of electricity

21.2 Dangers of electricity

21.3 Safe use of electricity in the home

Learning outcomes

Candidates should be able to:

(a) describe the use of electricity in heating, lighting and motors.

(b) do calculations using the equations *power* = *voltage* × *current*, and *energy* = *voltage* × *current* × *time*.

(c) calculate the cost of using electrical appliances where the energy unit is the kW h.

(d) state the hazards of damaged insulation, overheating of cables and damp conditions.

(e) explain the use of fuses and circuit breakers, and fuse ratings and circuit breaker settings.

(f) explain the need for earthing metal cases and for double insulation.

(g) state the meaning of the terms *live*, *neutral* and *earth*.

(h) describe how to wire a mains plug safely. Candidates will not be expected to show knowledge of the colours of the wires used in a mains supply.

(i) explain why switches, fuses and circuit breakers are wired into the live conductor.

22. Electromagnetism

Content

22.1 Force on a current-carrying conductor

22.2 The d.c. motor

Learning outcomes

Candidates should be able to:

(a) describe experiments to show the force on a current-carrying conductor, and on a beam of charged particles, in a magnetic field, including the effect of reversing (1) the current, (2) the direction of the field.

(b) state the relative directions of force, field and current.

(c) describe the field patterns between currents in parallel conductors and relate these to the forces which exist between the conductors (excluding the Earth's field).

(d) explain how a current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by increasing (1) the number of turns on the coil, (2) the current.

(e) discuss how this turning effect is used in the action of an electric motor.

(f) describe the action of a split-ring commutator in a two-pole, single-coil motor and the effect of winding the coil onto a soft iron cylinder.

23. Electromagnetic Induction

Content

23.1 Principles of electromagnetic induction

23.2 The a.c. generator

23.3 The transformer

Learning outcomes

Candidates should be able to:

(a) describe an experiment which shows that a changing magnetic field can induce an e.m.f. in a circuit.

(b) state the factors affecting the magnitude of the induced e.m.f.

(c) state that the direction of a current produced by an induced e.m.f. opposes the change producing it (Lenz's Law) and describe how this law may be demonstrated.

(d) describe a simple form of a.c. generator (rotating coil or rotating magnet) and the use of slip rings where needed.

(e) *sketch a graph of voltage output against time for a simple a.c. generator.

(f) describe the structure and principle of operation of a simple iron-cored transformer.

(g) state the advantages of high voltage transmission.

(h) discuss the environmental and cost implications of underground power transmission compared to overhead lines.

24. Introductory Electronics

Content

24.1 Thermionic emission

24.2 Simple treatment of cathode-ray oscilloscope

24.3 Action and use of circuit components

Learning outcomes

Candidates should be able to:

(a) state that electrons are emitted by a hot metal filament.

(b) explain that to cause a continuous flow of emitted electrons requires (1) high positive potential and (2) very low gas pressure.

(c) describe the deflection of an electron beam by electric fields and magnetic fields.

(d) state that the flow of electrons (electron current) is from negative to positive and is in the opposite direction to conventional current.

(e) describe in outline the basic structure and action of a cathode-ray oscilloscope (c.r.o.) (detailed circuits are not required).

(f) describe the use of a cathode-ray oscilloscope to display waveforms and to measure p.d.s and short intervals of time (detailed circuits are not required).

(g) explain how the values of resistors are chosen according to a colour code and why widely different values are needed in different types of circuit.

(h) discuss the need to choose components with suitable power ratings.

(i) describe the action of thermistors and light-dependent resistors and explain their use as input sensors (thermistors will be assumed to be of the negative temperature coefficient type).

(j) describe the action of a variable potential divider (potentiometer).

(k) describe the action of a capacitor as a charge store and explain its use in time-delay circuits.

(l) describe and explain the action of reed relays in switching circuits.

(m) describe and explain circuits operating as light-sensitive switches and temperature-operated alarms (using a reed relay or other circuits).

25. Electronic Systems

Note: There is no compulsory question set on Section 25 of the syllabus. Questions set on topics within Section 25 are always set as an alternative within a question.

Content

25.1 Switching and logic circuits

25.2 Bistable and astable circuits

Learning outcomes

Candidates should be able to:

(a) describe the action of a bipolar npn transistor as an electrically operated switch and explain its use in switching circuits.

(b) state in words and in truth table form, the action of the following logic gates, AND, OR, NAND, NOR and NOT (inverter).

(c) state the symbols for the logic gates listed above (American ANSI Y 32.14 symbols will be used).

(d) describe the use of a bistable circuit.

(e) discuss the fact that bistable circuits exhibit the property of memory.

(f) describe the use of an astable circuit (pulse generator).

(g) describe how the frequency of an astable circuit is related to the values of the resistive and capacitative components.

Section VI: Atomic Physics

26. Radioactivity

Content

26.1 Detection of radioactivity

26.2 Characteristics of the three types of emission

26.3 Nuclear reactions

26.4 Half-life

26.5 Uses of radioactive isotopes including safety precautions

Learning outcomes

Candidates should be able to:

(a) describe the detection of alpha-particles, beta-particles and gamma-rays by appropriate methods.

(b) state and explain the random emission of radioactivity in direction and time.

(c) state, for radioactive emissions, their nature, relative ionising effects and relative penetrating powers.

(d) describe the deflection of radioactive emissions in electric fields and magnetic fields.

(e) explain what is meant by *radioactive decay*.

(f) explain the processes of fusion and fission.

(g) describe, with the aid of a block diagram, one type of fission reactor for use in a power station.

(h) discuss theories of star formation and their energy production by fusion.

(i) explain what is meant by the term *half-life*.

(j) make calculations based on half-life which might involve information in tables or shown by decay curves.

(k) describe how radioactive materials are handled, used and stored in a safe way.

(l) discuss the way in which the type of radiation emitted and the half-life determine the use for the material.

(m) discuss the origins and effect of background radiation.

(n) discuss the dating of objects by the use of ^{14}C.

27. The Nuclear Atom

Content

27.1 Atomic model

27.2 Nucleus

Learning outcomes

Candidates should be able to:

(a) describe the structure of the atom in terms of nucleus and electrons.

(b) describe how the Geiger-Marsden alpha-particle scattering experiment provides evidence for the nuclear atom.

(c) describe the composition of the nucleus in terms of protons and neutrons.

(d) define the terms *proton number* (atomic number), Z and *nucleon number* (mass number), A.

(e) explain the term *nuclide* and use the nuclide notation $^{A}_{Z}X$ to construct equations where radioactive decay leads to changes in the composition of the nucleus.

(f) define the term *isotope*.

(g) explain, using nuclide notation, how one element may have a number of isotopes.

5. 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. Two alternative means of assessment are provided: a formal practical written test and a written alternative-to-practical paper. Both papers assess the skills outlined in Assessment Objective AO3.

5.1 Paper 3: Practical Test

Introduction

This paper is designed to assess a candidate's competence in those practical skills which can realistically be assessed within the context of a formal test of limited duration. The best preparation for this paper is for candidates to pursue a comprehensive course in practical physics throughout the time during which they are being taught the theoretical content. It is not expected that all the experiments and exercises will follow the style of the Practical Test, but candidates should regularly be made aware of the points examiners will be looking for when marking this paper.

The questions in the Practical Test cover most of the objectives outlined above. In particular, candidates should be prepared to make measurements or determinations of physical quantities such as mass, length, area, volume, time, current and potential difference. Candidates should be aware of the need to take simple precautions for safety and/or accuracy. The questions are not necessarily restricted to topics in the curriculum content. The test does not involve the use of textbooks, nor will candidates need access to their own records of laboratory work carried out during the course. Candidates are required to follow instructions given in the question paper. Candidates may use an electronic calculator, which complies with the current version of the Regulations: alternatively, mathematical tables may be used. Examiners assume that an electronic calculator will be used when they are setting the papers and judging the length of time required for each question. Candidates answer on the question paper.

Apparatus requirements

Instructions are sent to Centres several months in advance of the date of the Practical Test. Every effort is made to minimise the cost to Centres by designing experiments around basic apparatus which should be available in most school physics laboratories. For guidance, a list of the items used in recent papers is included at the end of this section. It is not intended to be exhaustive, but should be taken as a guide to the requirements.

Candidates should have:

- 20 minutes with the apparatus for each of the three questions in Section A
- 60 minutes with the apparatus for the question in Section B.

Candidates may be instructed as to the order in which they are to attempt the questions. To reduce the number of sets of apparatus required, a 'circus' arrangement may be used for Section A, and some candidates may be told to do Section B first.

Please provide a seating plan of each stage of the examination, as indicated on the instructions.

It is essential that candidates are warned of these arrangements in advance. Supervisors should check every set of apparatus before the examination, and spare sets of apparatus must be available to allow for breakage and malfunction. If any significant deviations from the specified apparatus are necessary, the Product Manager at Cambridge must be consulted well in advance of the date on which the paper is set, by fax or e-mail. For some Centres, communication must be through the appropriate Ministry of Education. Specimen results must be provided in the envelope which is sent to the examiner containing the scripts.

Apparatus

- adhesive tape (e.g. Sellotape)
- ammeter FSD 1 A, or 1.5 A*
- beaker 100 cm^3, 250 cm^3, 1 litre
- Blu-tack
- boiling tube, 150 mm × 25 mm
- card
- cells, 1.5 V
- connecting leads
- crocodile clips
- d.c. power supply – variable to 12 V
- filament lamp, 12 V, 24 W
- G-clamp
- half-metre rule
- lens, converging f = 15 cm
- low voltage (2.5 V) filament lamps in holders
- masses, 50 g, 100 g
- measuring cylinder 100 cm^3, 250 cm^3
- metre rule
- microscope slides
- mirror, plane, 50 mm × 10 mm
- modelling clay (e.g. Plasticine)
- newton meter, max. reading 1.0 N
- nichrome wire 28 swg (0.38 mm diameter), 30 swg (0.32 mm diameter)
- pendulum bob
- pin board
- pivot (to fit a hole in metre rule)
- plastic or polystyrene cup, 200 cm^3
- protractor
- resistors, various
- retort stand, boss and clamp
- springs
- stopwatch reading to 0.1 s or better
- switch
- thermometer –10 °C–110 °C (by 1 °C)
- thread
- tracing paper
- voltmeter FSD 1 V, 5 V*
- wooden board

*Digital multimeters may be suitable as a flexible, low-cost alternative to both ammeters and voltmeters.

General marking points

Setting up apparatus

Candidates are expected to be able to follow written instructions for the assembly and use of apparatus, for example, an electrical circuit or ray-tracing equipment. They may be expected to make a sensible choice of measuring instrument.

Taking readings

During the course of their preparation for this paper, candidates should be taught to observe the following points of good practice, which often feature in the mark scheme.

- A measuring instrument should be used to its full precision.
- Thermometers are often marked with intervals of 1 °C. It is appropriate to record a reading which coincides exactly with a mark as, for example, 22.0 °C, rather than as a bald 22 °C.
- Interpolation between scale divisions should be to one half of a division or better. For example, consider a thermometer with scale divisions of 1 °C. A reading of 22.3 °C might best be recorded as 22.5 °C, since '0.3' is nearer '0.5' than '0'. That is, where a reading lies between two scale marks, an attempt should be made to interpolate between those two marks, rather than simply rounding to the nearest mark.
- The length of an object measured on a rule with a centimetre and millimetre scale should be recorded as 12.0 cm rather than a bald 12 cm, if the ends of the object coincide exactly with the 0 and 12 cm marks.
- A measurement or calculated quantity must be accompanied by a correct unit, where appropriate.
- Candidates should be able to make allowance for zero errors.

Recording readings

- A table of results should include, in the heading of each column, the name or symbol of the measured or calculated quantity, together with the appropriate unit. Solidus notation is expected.
- Each reading should be repeated, if possible, and recorded. (This is particularly true in Section B.)
- The number of significant figures given for calculated quantities should be the same as the least number of significant figures in the raw data used.
- A ratio should be calculated as a decimal number, of two or three significant figures.

Drawing graphs

- A graph should be drawn with a sharp pencil.
- The axes should be labelled with quantity and unit.
- The scales for the axes should allow the majority of the graph paper to be used in both directions, and be based on sensible ratios, e.g. 2 cm on the graph paper representing 1, 2 or 5 units of the variable (or 10, 20 or 50, etc.).
- Each data point should be plotted to an accuracy of better than one half of one of the smallest squares on the grid.
- Points should be indicated by a small cross or a fine dot with a circle drawn around it. Large 'dots' are penalised.
- Where a straight line is required to be drawn through the data points, Examiners expect to see an equal number of points either side of the line over its entire length. That is, points should not be seen to lie all above the line at one end, and all below the line at the other end.

- The gradient of a straight line should be taken using a triangle whose hypotenuse extends over at least half the length of the candidate's line. Data values should be read from the line to an accuracy better than one half of one of the smallest squares on the grid. The same accuracy should be used in reading off an intercept. Calculation of the gradient should be to two or three significant figures.
- Candidates should be able to determine the intercept of the graph line.
- Candidates should be able to take readings from the graph by extrapolation or interpolation.

Conclusion

- Candidates should be able to indicate how they carried out a specific instruction and to describe the precautions taken in carrying out a procedure.
- They should be able to explain the choice of a particular piece of apparatus.
- They should also be able to comment on a procedure and suggest an improvement.

5.2 Paper 4: Alternative to Practical

This paper is designed for those Centres for whom the preparation and execution of the Practical Test is impracticable.

The Alternative to Practical Paper consists of four or five questions relating to practical physics: candidates answer on the question paper.

The best preparation for this paper is a thorough course in experimental physics. Candidates are unlikely to demonstrate their full potential on this paper unless they have become fully familiar with the techniques and apparatus involved by doing experiments for themselves. Questions may involve the description of particular techniques, the drawing of diagrams, or the analysis of data. The examiners expect the same degree of detail as for Paper 3 and candidates should be taught to adopt practices which satisfy the same general marking points. In addition, candidates should be able to draw, complete and label diagrams of apparatus and to take readings from diagrams of apparatus given in the question paper. Where facilities permit, demonstration experiments by the teacher can be very useful in the teaching of particular techniques, and can be the source of useful data for candidates to analyse.

6. Appendix

6.1 Summary of key quantities, symbols and units

Candidates should be able to state 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 (*).

Quantity	Symbol	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, mg
time	*t*	h, min, s, ms
density*	ρ	g/cm^3, kg/m^3
speed*	*u*, *v*	km/h, m/s, cm/s
acceleration	*a*	m/s^2
acceleration of free fall	*g*	
force*	*F*, *P* …	N
moment of force*		N m
work done	*W*, *E*	J*, kW h*
energy	*E*	J
power*	*P*	W*
pressure*	*p*, *P*	Pa*, N/m^2
atmospheric pressure		use of millibar
temperature	θ, *t*, *T*	°C
heat capacity	*C*	J/°C
specific heat capacity*	*c*	J/(kg °C), J/(g °C)
latent heat	*L*	J
specific latent heat*	*l*	J/kg, J/g
frequency*	*f*	Hz
wavelength*	λ	m, cm

Quantity	**Symbol**	**Unit**
focal length	*f*	m, cm
angle of incidence	*i*	degree (°)
angles of reflection, refraction	*r*	degree (°)
critical angle	*c*	degree (°)
potential difference*/voltage	*V*	V*, mV
current*	*I*	A, mA
charge		C, A s
e.m.f.*	*E*	V
resistance	*R*	Ω

6.2 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 not exhaustive. 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, such as the defining equation with symbols identified, being required.
2. *Explain*/*What is meant by* ... 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 be obtained 'by inspection'.
4. *List* requires a number of points with no elaboration. Where a given number of points is specified, this should not be exceeded.
5. *Describe* requires candidates to state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. In the former instance, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena. The amount of description intended should be interpreted in the light of the indicated mark value.
6. *Discuss* requires candidates to give a critical account of the points involved in the topic.
7. *Deduce* implies that candidates are 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.
8. *Suggest* is used in two main contexts. It may either imply that there is no unique answer or that candidates are expected to apply their general knowledge to a 'novel' situation, one that formally may not be 'in the syllabus'.
9. *Calculate* is used when a numerical answer is required. In general, working should be shown.
10. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument, e.g. length, using a rule, or angle, using a protractor.
11. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula, e.g. the Young modulus, relative molecular mass.
12. *Show* is used when an algebraic deduction has to be made to prove a given equation. It is important that the terms being used by candidates are stated explicitly.
13. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned. Candidates should make such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.
14. *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct. However, 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, asymptote or discontinuity at a particular value. On a sketch graph it is essential that candidates clearly indicate what is being plotted on each axis.

    Sketch, when applied to diagrams, implies that a simple, freehand drawing is acceptable: nevertheless, care should be taken over proportions and the clear exposition of important detail.

7. Additional information

7.1 Guided learning hours

Cambridge O Level syllabuses are designed on 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 of the subject.

7.2 Recommended prior learning

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 O Level 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 O Level 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 O Level results are shown by one of the grades A*, A, B, C, D or E indicating the standard achieved, Grade A* being the highest and Grade E the lowest. 'Ungraded' indicates that the candidate's performance fell short of the standard required for Grade E. 'Ungraded' will be reported on the statement of results but not on the certificate.

Percentage uniform marks are also provided on each candidate's statement of results to supplement their grade for a syllabus. They are determined in this way:

- A candidate who obtains…
  … the minimum mark necessary for a Grade A* obtains a percentage uniform mark of 90%.
  … the minimum mark necessary for a Grade A obtains a percentage uniform mark of 80%.
  … the minimum mark necessary for a Grade B obtains a percentage uniform mark of 70%.

… the minimum mark necessary for a Grade C obtains a percentage uniform mark of 60%.
… the minimum mark necessary for a Grade D obtains a percentage uniform mark of 50%.
… the minimum mark necessary for a Grade E obtains a percentage uniform mark of 40%.
… no marks receives a percentage uniform mark of 0%.

Candidates whose mark is none of the above receive a percentage mark in between those stated according to the position of their mark in relation to the grade 'thresholds' (i.e. the minimum mark for obtaining a grade). For example, a candidate whose mark is halfway between the minimum for a Grade C and the minimum for a Grade D (and whose grade is therefore D) receives a percentage uniform mark of 55%.

The percentage uniform mark is stated at syllabus level only. It is not the same as the 'raw' mark obtained by the candidate, since it depends on the position of the grade thresholds (which may vary from one series to another and from one subject to another) and it has been turned into a percentage.

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 syllabuses, 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/olevel**. 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 categorised 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 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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