Cambridge Secondary 2

Cambridge IGCSE

Syllabus

Cambridge IGCSE™ Physics 0625

For examination in June and November 2019.
Also available for examination in March 2019 for India only.

Version 3

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

CAMBRIDGE
International Examinations

Why choose Cambridge?

Cambridge International Examinations prepares school students for life, helping them develop an informed curiosity and a lasting passion for learning. We are part of Cambridge Assessment, a department of the University of Cambridge.

Our international qualifications are recognised by the world's best universities and employers, giving students a wide range of options in their education and career. As a not-for-profit organisation, we devote our resources to delivering high-quality educational programmes that can unlock students' potential.

Our programmes and qualifications set the global standard for international education. They are created by subject experts, rooted in academic rigour and reflect the latest educational research. They provide a strong platform for learners to progress from one stage to the next, and are well supported by teaching and learning resources.

Our mission is to provide educational benefit through provision of international programmes and qualifications for school education and to be the world leader in this field. Together with schools, we develop Cambridge students who are confident, responsible, reflective, innovative and engaged – equipped for success in the modern world.

Every year, nearly a million Cambridge students from 10 000 schools in 160 countries prepare for their future with an international education from Cambridge.

'We think the Cambridge curriculum is superb preparation for university.'
Christoph Guttentag, Dean of Undergraduate Admissions, Duke University, USA

Quality management

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

Contents

Changes to this syllabus

The latest syllabus is version 3, published January 2019. There are no significant changes which affect teaching.

Any textbooks endorsed to support the syllabus for examination from 2016 are still suitable for use with this syllabus.

1 Why choose this syllabus?

Key benefits

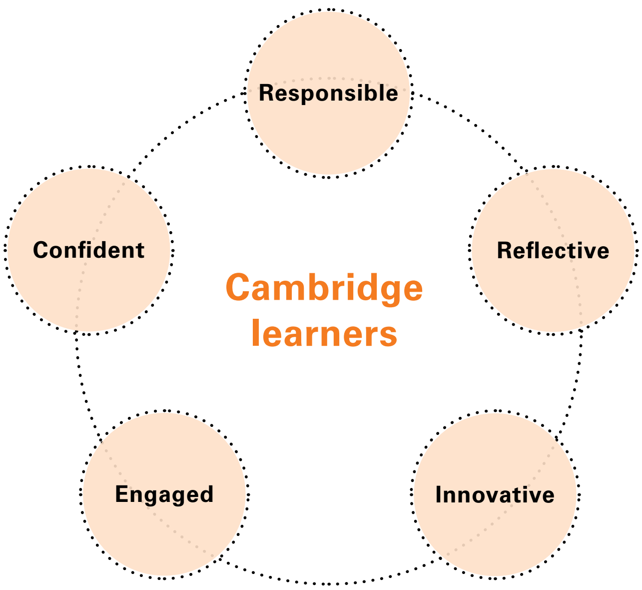
Cambridge IGCSE™ syllabuses are created especially for international students. For over 25 years, we have worked with schools and teachers worldwide to develop syllabuses that are suitable for different countries, different types of schools and for learners with a wide range of abilities.

Cambridge IGCSE Physics enables learners to:

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

Our programmes balance a thorough knowledge and understanding of a subject and help to develop the skills learners need for their next steps in education or employment.

Our approach encourages learners to be:



'The strength of Cambridge IGCSE qualifications is internationally recognised and has provided an international pathway for our students to continue their studies around the world.'

Gary Tan, Head of Schools and CEO, Raffles International Group of Schools, Indonesia

Recognition and progression

The combination of knowledge and skills in Cambridge IGCSE Physics gives learners a solid foundation for further study. Candidates who achieve grades A* to C are well prepared to follow a wide range of courses including Cambridge International AS & A Level Physics.

Cambridge IGCSEs are accepted and valued by leading universities and employers around the world as evidence of academic achievement. Many universities require a combination of Cambridge International AS & A Levels and Cambridge IGCSEs to meet their entry requirements.

Learn more at **www.cie.org.uk/recognition**

Supporting teachers

We provide a wide range of practical resources, detailed guidance and innovative training and professional development so that you can give your learners the best possible preparation for Cambridge IGCSE.

Support for Cambridge IGCSE

Teaching resources

- Syllabus
- Scheme of work
- Learner guide
- Endorsed textbooks and digital resources
- Teacher support **teachers.cie.org.uk**
- Discussion forum
- Resource List

Exam preparation resources

- Question papers
- Mark schemes
- Example candidate responses to understand what examiners are looking for at key grades
  - Examiner reports to improve future teaching

Training

- Face-to-face workshops around the world
- Online self-study training
- Online tutor-led training
- Professional development qualifications

Community

Community forum **teachers.cie.org.uk**

LinkedIn **linkd.in/cambridgeteacher**

Twitter **@cie_education**

Facebook **facebook.com/cie.org.uk**

'Cambridge IGCSE is one of the most sought-after and recognised qualifications in the world. It is very popular in Egypt because it provides the perfect preparation for success at advanced level programmes.'

Mrs Omnia Kassabgy, Managing Director of British School in Egypt BSE

2 Syllabus overview

Aims

The syllabus aims summarise the context in which you should view the subject content and describe the purposes of a course based on this syllabus. They are not listed in order of priority.

You can deliver some of the aims using suitable local, international or historical examples and applications, or through collaborative experimental work.

The aims are:

- to provide an enjoyable and worthwhile educational experience for all learners, whether or not they go on to study science beyond this level
- to enable learners to acquire sufficient knowledge and understanding to:
  - become confident citizens in a technological world and develop an informed interest in scientific matters
  - be suitably prepared for studies beyond Cambridge IGCSE
- to allow learners to recognise that science is evidence based and understand the usefulness, and the limitations, of scientific method
- to develop skills that:
  - are relevant to the study and practice of physics
  - are useful in everyday life
  - encourage a systematic approach to problem solving
  - encourage efficient and safe practice
  - encourage effective communication through the language of science
- to develop attitudes relevant to physics such as:
  - concern for accuracy and precision
  - objectivity
  - integrity
  - enquiry
  - initiative
  - inventiveness
- to enable learners to appreciate that:
  - science is subject to social, economic, technological, ethical and cultural influences and limitations
  - the applications of science may be both beneficial and detrimental to the individual, the community and the environment.

Content

Candidates study the following topics:

1 General physics
2 Thermal physics
3 Properties of waves, including light and sound
4 Electricity and magnetism
5 Atomic physics

Teacher support for Cambridge IGCSE Physics

We provide a wide range of support resources to give your learners the best possible preparation for Cambridge programmes and qualifications. Support for Cambridge IGCSE Physics includes a Teacher Guide, Learner Guide and a Scheme of Work. These and other resources are available online through Teacher Support at **https://teachers.cie.org.uk**

Assessment

All candidates take three papers.

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

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

Core candidates take:	Extended candidates take:
Paper 1 45 minutes Multiple Choice 30% 40 marks 40 four-choice multiple-choice questions Questions will be based on the Core subject content Externally assessed	**Paper 2** 45 minutes Multiple Choice 30% 40 marks 40 four-choice multiple-choice questions Questions will be based on the Extended subject content (Core and Supplement) Externally assessed
and Core candidates take:	**and Extended candidates take:**
Paper 3 1 hour 15 minutes Theory 50% 80 marks Short-answer and structured questions Questions will be based on the Core subject content Externally assessed	**Paper 4** 1 hour 15 minutes Theory 50% 80 marks Short-answer and structured questions Questions will be based on the Extended subject content (Core and Supplement) Externally assessed
All candidates take either:	**or:**
Paper 5 1 hour 15 minutes Practical Test 20% 40 marks Questions will be based on the experimental skills in Section 4 Externally assessed	**Paper 6** 1 hour Alternative to Practical 20% 40 marks Questions will be based on the experimental skills in Section 4 Externally assessed

3 Subject content

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

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

1 General physics

1.1 Length and time

Core

- Use and describe the use of rules and measuring cylinders to find a length or a volume
- Use and describe the use of clocks and devices, both analogue and digital, for measuring an interval of time
- Obtain an average value for a small distance and for a short interval of time by measuring multiples (including the period of a pendulum)

Supplement

- Understand that a micrometer screw gauge is used to measure very small distances

1.2 Motion

Core

- Define speed and calculate average speed from $\frac{\text{total distance}}{\text{total time}}$
- Plot and interpret a speed-time graph or a distance-time graph
- Recognise from the shape of a speed-time graph when a body is
  - at rest
  - moving with constant speed
  - moving with changing speed
- Calculate the area under a speed-time graph to work out the distance travelled for motion with constant acceleration
- Demonstrate understanding that acceleration and deceleration are related to changing speed including qualitative analysis of the gradient of a speed-time graph
- State that the acceleration of free fall for a body near to the Earth is constant

Supplement

- Distinguish between speed and velocity
- Define and calculate acceleration using $\frac{\text{change of velocity}}{\text{time taken}}$
- Calculate speed from the gradient of a distance-time graph
- Calculate acceleration from the gradient of a speed-time graph
- Recognise linear motion for which the acceleration is constant
- Recognise motion for which the acceleration is not constant
- Understand deceleration as a negative acceleration
- Describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity)

1.3 Mass and weight

Core

- Show familiarity with the idea of the mass of a body
- State that weight is a gravitational force
- Distinguish between mass and weight
- Recall and use the equation $W = mg$
- Demonstrate understanding that weights (and hence masses) may be compared using a balance

Supplement

- Demonstrate an understanding that mass is a property that 'resists' change in motion
- Describe, and use the concept of, weight as the effect of a gravitational field on a mass

1.4 Density

Core

- Recall and use the equation $\rho = \frac{m}{V}$
- Describe an experiment to determine the density of a liquid and of a regularly shaped solid and make the necessary calculation
- Describe the determination of the density of an irregularly shaped solid by the method of displacement
- Predict whether an object will float based on density data

1.5 Forces

1.5.1 Effects of forces

Core

- Recognise that a force may produce a change in size and shape of a body
- Plot and interpret extension-load graphs and describe the associated experimental procedure
- Describe the ways in which a force may change the motion of a body
- Find the resultant of two or more forces acting along the same line
- Recognise that if there is no resultant force on a body it either remains at rest or continues at constant speed in a straight line
- Understand friction as the force between two surfaces which impedes motion and results in heating
- Recognise air resistance as a form of friction

Supplement

- State Hooke's Law and recall and use the expression $F = kx$, where k is the spring constant
- Recognise the significance of the 'limit of proportionality' for an extension-load graph
- Recall and use the relationship between force, mass and acceleration (including the direction), $F = ma$
- Describe qualitatively motion in a circular path due to a perpendicular force ($F = mv^2/r$ is not required)

1.5.2 Turning effect

Core

- Describe the moment of a force as a measure of its turning effect and give everyday examples
- Understand that increasing force or distance from the pivot increases the moment of a force
- Calculate moment using the product force × perpendicular distance from the pivot
- Apply the principle of moments to the balancing of a beam about a pivot

Supplement

- Apply the principle of moments to different situations

1.5.3 Conditions for equilibrium

Core

- Recognise that, when there is no resultant force and no resultant turning effect, a system is in equilibrium

Supplement

- Perform and describe an experiment (involving vertical forces) to show that there is no net moment on a body in equilibrium

1.5.4 Centre of mass

Core

- Perform and describe an experiment to determine the position of the centre of mass of a plane lamina
- Describe qualitatively the effect of the position of the centre of mass on the stability of simple objects

1.5.5 Scalars and vectors

Supplement

- Understand that vectors have a magnitude and direction
- Demonstrate an understanding of the difference between scalars and vectors and give common examples
- Determine graphically the resultant of two vectors

1.6 Momentum

Supplement

- Understand the concepts of momentum and impulse
- Recall and use the equation momentum = mass × velocity, $p = mv$
- Recall and use the equation for impulse $Ft = mv - mu$
- Apply the principle of the conservation of momentum to solve simple problems in one dimension

1.7 Energy, work and power

1.7.1 Energy

Core

- Identify changes in kinetic, gravitational potential, chemical, elastic (strain), nuclear and internal energy that have occurred as a result of an event or process
- Recognise that energy is transferred during events and processes, including examples of transfer by forces (mechanical working), by electrical currents (electrical working), by heating and by waves
- Apply the principle of conservation of energy to simple examples

Supplement

- Recall and use the expressions kinetic energy = $\frac{1}{2}mv^2$ and change in gravitational potential energy = $mg\Delta h$
- Apply the principle of conservation of energy to examples involving multiple stages
- Explain that in any event or process the energy tends to become more spread out among the objects and surroundings (dissipated)

1.7.2 Energy resources

Core

- Describe how electricity or other useful forms of energy may be obtained from:
  - chemical energy stored in fuel
  - water, including the energy stored in waves, in tides, and in water behind hydroelectric dams
  - geothermal resources
  - nuclear fission
  - heat and light from the Sun (solar cells and panels)
  - wind
- Give advantages and disadvantages of each method in terms of renewability, cost, reliability, scale and environmental impact
- Show a qualitative understanding of efficiency

Supplement

- Understand that the Sun is the source of energy for all our energy resources except geothermal, nuclear and tidal
- Show an understanding that energy is released by nuclear fusion in the Sun
- Recall and use the equations:

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{power input}} \times 100\%$$

1.7.3 Work

Core

- Demonstrate understanding that work done = energy transferred
- Relate (without calculation) work done to the magnitude of a force and the distance moved in the direction of the force

Supplement

- Recall and use $W = Fd = \Delta E$

1.7.4 Power

Core

- Relate (without calculation) power to work done and time taken, using appropriate examples

Supplement

- Recall and use the equation $P = \Delta E / t$ in simple systems

1.8 Pressure

Core

- Recall and use the equation $p = F/A$
- Relate pressure to force and area, using appropriate examples
- Describe the simple mercury barometer and its use in measuring atmospheric pressure
- Relate (without calculation) the pressure beneath a liquid surface to depth and to density, using appropriate examples
- Use and describe the use of a manometer

Supplement

- Recall and use the equation $p = h\rho g$

2 Thermal physics

2.1 Simple kinetic molecular model of matter

2.1.1 States of matter

Core

- State the distinguishing properties of solids, liquids and gases

2.1.2 Molecular model

Core

- Describe qualitatively the molecular structure of solids, liquids and gases in terms of the arrangement, separation and motion of the molecules
- Interpret the temperature of a gas in terms of the motion of its molecules
- Describe qualitatively the pressure of a gas in terms of the motion of its molecules
- Show an understanding of the random motion of particles in a suspension as evidence for the kinetic molecular model of matter
- Describe this motion (sometimes known as Brownian motion) in terms of random molecular bombardment

Supplement

- Relate the properties of solids, liquids and gases to the forces and distances between molecules and to the motion of the molecules
- Explain pressure in terms of the change of momentum of the particles striking the walls creating a force
- Show an appreciation that massive particles may be moved by light, fast-moving molecules

2.1.3 Evaporation

Core

- Describe evaporation in terms of the escape of more-energetic molecules from the surface of a liquid
- Relate evaporation to the consequent cooling of the liquid

Supplement

- Demonstrate an understanding of how temperature, surface area and draught over a surface influence evaporation
- Explain the cooling of a body in contact with an evaporating liquid

2.1.4 Pressure changes

Core

- Describe qualitatively, in terms of molecules, the effect on the pressure of a gas of:
  - a change of temperature at constant volume
  - a change of volume at constant temperature

Supplement

- Recall and use the equation pV = constant for a fixed mass of gas at constant temperature

2.2 Thermal properties and temperature

2.2.1 Thermal expansion of solids, liquids and gases

Core

- Describe qualitatively the thermal expansion of solids, liquids, and gases at constant pressure
- Identify and explain some of the everyday applications and consequences of thermal expansion

Supplement

- Explain, in terms of the motion and arrangement of molecules, the relative order of the magnitude of the expansion of solids, liquids and gases

2.2.2 Measurement of temperature

Core

- Appreciate how a physical property that varies with temperature may be used for the measurement of temperature, and state examples of such properties
- Recognise the need for and identify fixed points
- Describe and explain the structure and action of liquid-in-glass thermometers

Supplement

- Demonstrate understanding of sensitivity, range and linearity
- Describe the structure of a thermocouple and show understanding of its use as a thermometer for measuring high temperatures and those that vary rapidly
- Describe and explain how the structure of a liquid-in-glass thermometer relates to its sensitivity, range and linearity

2.2.3 Thermal capacity (heat capacity)

Core

- Relate a rise in the temperature of a body to an increase in its internal energy
- Show an understanding of what is meant by the thermal capacity of a body

Supplement

- Give a simple molecular account of an increase in internal energy
- Recall and use the equation thermal capacity = mc
- Define specific heat capacity
- Describe an experiment to measure the specific heat capacity of a substance
- Recall and use the equation change in energy = $mc\Delta T$

2.2.4 Melting and boiling

Core

- Describe melting and boiling in terms of energy input without a change in temperature
- State the meaning of melting point and boiling point
- Describe condensation and solidification in terms of molecules

Supplement

- Distinguish between boiling and evaporation
- Use the terms latent heat of vaporisation and latent heat of fusion and give a molecular interpretation of latent heat
- Define specific latent heat
- Describe an experiment to measure specific latent heats for steam and for ice
- Recall and use the equation energy = ml

2.3 Thermal processes

2.3.1 Conduction

Core

- Describe experiments to demonstrate the properties of good and bad thermal conductors

Supplement

- Give a simple molecular account of conduction in solids including lattice vibration and transfer by electrons

2.3.2 Convection

Core

- Recognise convection as an important method of thermal transfer in fluids
- Relate convection in fluids to density changes and describe experiments to illustrate convection

2.3.3 Radiation

Core

- Identify infra-red radiation as part of the electromagnetic spectrum
- Recognise that thermal energy transfer by radiation does not require a medium
- Describe the effect of surface colour (black or white) and texture (dull or shiny) on the emission, absorption and reflection of radiation

Supplement

- Describe experiments to show the properties of good and bad emitters and good and bad absorbers of infra-red radiation
- Show understanding that the amount of radiation emitted also depends on the surface temperature and surface area of a body

2.3.4 Consequences of energy transfer

Core

- Identify and explain some of the everyday applications and consequences of conduction, convection and radiation

3 Properties of waves, including light and sound

3.1 General wave properties

Core

- Demonstrate understanding that waves transfer energy without transferring matter
- Describe what is meant by wave motion as illustrated by vibration in ropes and springs and by experiments using water waves
- Use the term wavefront
- Give the meaning of speed, frequency, wavelength and amplitude
- Distinguish between transverse and longitudinal waves and give suitable examples
- Describe how waves can undergo:
  - reflection at a plane surface
  - refraction due to a change of speed
  - diffraction through a narrow gap
- Describe the use of water waves to demonstrate reflection, refraction and diffraction

Supplement

- Recall and use the equation $v = f\lambda$
- Describe how wavelength and gap size affects diffraction through a gap
- Describe how wavelength affects diffraction at an edge

3.2 Light

3.2.1 Reflection of light

Core

- Describe the formation of an optical image by a plane mirror, and give its characteristics
- Recall and use the law
  angle of incidence = angle of reflection

Supplement

- Recall that the image in a plane mirror is virtual
- Perform simple constructions, measurements and calculations for reflection by plane mirrors

3.2.2 Refraction of light

Core

- Describe an experimental demonstration of the refraction of light
- Use the terminology for the angle of incidence *i* and angle of refraction *r* and describe the passage of light through parallel-sided transparent material
- Give the meaning of critical angle
- Describe internal and total internal reflection

Supplement

- Recall and use the definition of refractive index *n* in terms of speed
- Recall and use the equation $\frac{\sin i}{\sin r} = n$
- Recall and use $n = \frac{1}{\sin c}$
- Describe and explain the action of optical fibres particularly, in medicine and communications technology

3.2.3 Thin converging lens

Core

- Describe the action of a thin converging lens on a beam of light
- Use the terms principal focus and focal length
- Draw ray diagrams for the formation of a real image by a single lens
- Describe the nature of an image using the terms enlarged/same size/diminished and upright/inverted

Supplement

- Draw and use ray diagrams for the formation of a virtual image by a single lens
- Use and describe the use of a single lens as a magnifying glass
- Show understanding of the terms real image and virtual image

3.2.4 Dispersion of light

Core

- Give a qualitative account of the dispersion of light as shown by the action on light of a glass prism including the seven colours of the spectrum in their correct order

Supplement

- Recall that light of a single frequency is described as monochromatic

3.3 Electromagnetic spectrum

Core

- Describe the main features of the electromagnetic spectrum in order of wavelength
- State that all electromagnetic waves travel with the same high speed in a vacuum
- Describe typical properties and uses of radiations in all the different regions of the electromagnetic spectrum including:
  - radio and television communications (radio waves)
  - satellite television and telephones (microwaves)
  - electrical appliances, remote controllers for televisions and intruder alarms (infra-red)
  - medicine and security (X-rays)
- Demonstrate an awareness of safety issues regarding the use of microwaves and X-rays

Supplement

- State that the speed of electromagnetic waves in a vacuum is 3.0×10^8 m/s and is approximately the same in air

3.4 Sound

Core

- Describe the production of sound by vibrating sources
- Describe the longitudinal nature of sound waves
- State that the approximate range of audible frequencies for a healthy human ear is 20 Hz to 20 000 Hz
- Show an understanding of the term ultrasound
- Show an understanding that a medium is needed to transmit sound waves
- Describe an experiment to determine the speed of sound in air
- Relate the loudness and pitch of sound waves to amplitude and frequency
- Describe how the reflection of sound may produce an echo

Supplement

- Describe compression and rarefaction
- State typical values of the speed of sound in gases, liquids and solids

4 Electricity and magnetism

4.1 Simple phenomena of magnetism

Core

- Describe the forces between magnets, and between magnets and magnetic materials
- Give an account of induced magnetism
- Distinguish between magnetic and non-magnetic materials
- Describe methods of magnetisation, to include stroking with a magnet, use of direct current (d.c.) in a coil and hammering in a magnetic field
- Draw the pattern of magnetic field lines around a bar magnet
- Describe an experiment to identify the pattern of magnetic field lines, including the direction
- Distinguish between the magnetic properties of soft iron and steel
- Distinguish between the design and use of permanent magnets and electromagnets

Supplement

- Explain that magnetic forces are due to interactions between magnetic fields
- Describe methods of demagnetisation, to include hammering, heating and use of alternating current (a.c.) in a coil

4.2 Electrical quantities

4.2.1 Electric charge

Core

- State that there are positive and negative charges
- State that unlike charges attract and that like charges repel
- Describe simple experiments to show the production and detection of electrostatic charges
- State that charging a body involves the addition or removal of electrons
- Distinguish between electrical conductors and insulators and give typical examples

Supplement

- State that charge is measured in coulombs
- State that the direction of an electric field at a point is the direction of the force on a positive charge at that point
- Describe an electric field as a region in which an electric charge experiences a force
- Describe simple field patterns, including the field around a point charge, the field around a charged conducting sphere and the field between two parallel plates (not including end effects)
- Give an account of charging by induction
- Recall and use a simple electron model to distinguish between conductors and insulators

4.2.2 Current

Core

- State that current is related to the flow of charge
- Use and describe the use of an ammeter, both analogue and digital
- State that current in metals is due to a flow of electrons

Supplement

- Show understanding that a current is a rate of flow of charge and recall and use the equation $I = Q/t$
- Distinguish between the direction of flow of electrons and conventional current

4.2.3 Electromotive force

Core

- State that the electromotive force (e.m.f.) of an electrical source of energy is measured in volts

Supplement

- Show understanding that e.m.f. is defined in terms of energy supplied by a source in driving charge round a complete circuit

4.2.4 Potential difference

Core

- State that the potential difference (p.d.) across a circuit component is measured in volts
- Use and describe the use of a voltmeter, both analogue and digital

Supplement

- Recall that 1 V is equivalent to 1 J/C

4.2.5 Resistance

Core

- State that resistance = p.d./current and understand qualitatively how changes in p.d. or resistance affect current
- Recall and use the equation $R = V/I$
- Describe an experiment to determine resistance using a voltmeter and an ammeter
- Relate (without calculation) the resistance of a wire to its length and to its diameter

Supplement

- Sketch and explain the current-voltage characteristic of an ohmic resistor and a filament lamp
- Recall and use quantitatively the proportionality between resistance and length, and the inverse proportionality between resistance and cross-sectional area of a wire

4.2.6 Electrical working

Core

- Understand that electric circuits transfer energy from the battery or power source to the circuit components then into the surroundings

Supplement

- Recall and use the equations $P = IV$ and $E = IVt$

4.3 Electric circuits

4.3.1 Circuit diagrams

Core

- Draw and interpret circuit diagrams containing sources, switches, resistors (fixed and variable), heaters, thermistors, light-dependent resistors, lamps, ammeters, voltmeters, galvanometers, magnetising coils, transformers, bells, fuses and relays

Supplement

- Draw and interpret circuit diagrams containing diodes

4.3.2 Series and parallel circuits

Core

- Understand that the current at every point in a series circuit is the same
- Give the combined resistance of two or more resistors in series
- State that, for a parallel circuit, the current from the source is larger than the current in each branch
- State that the combined resistance of two resistors in parallel is less than that of either resistor by itself
- State the advantages of connecting lamps in parallel in a lighting circuit

Supplement

- Calculate the combined e.m.f. of several sources in series
- Recall and use the fact that the sum of the p.d.s across the components in a series circuit is equal to the total p.d. across the supply
- Recall and use the fact that the current from the source is the sum of the currents in the separate branches of a parallel circuit
- Calculate the effective resistance of two resistors in parallel

4.3.3 Action and use of circuit components

Core

- Describe the action of a variable potential divider (potentiometer)
- Describe the action of thermistors and light-dependent resistors and show understanding of their use as input transducers
- Describe the action of a relay and show understanding of its use in switching circuits

Supplement

- Describe the action of a diode and show understanding of its use as a rectifier
- Recognise and show understanding of circuits operating as light-sensitive switches and temperature-operated alarms (to include the use of a relay)

4.4 Digital electronics

Supplement

- Explain and use the terms analogue and digital in terms of continuous variation and high/low states
- Describe the action of NOT, AND, OR, NAND and NOR gates
- Recall and use the symbols for logic gates
- Design and understand simple digital circuits combining several logic gates
- Use truth tables to describe the action of individual gates and simple combinations of gates

4.5 Dangers of electricity

Core

- State the hazards of:
  - damaged insulation
  - overheating of cables
  - damp conditions
- State that a fuse protects a circuit
- Explain the use of fuses and circuit breakers and choose appropriate fuse ratings and circuit-breaker settings
- Explain the benefits of earthing metal cases

4.6 Electromagnetic effects

4.6.1 Electromagnetic induction

Core

- Show understanding that a conductor moving across a magnetic field or a changing magnetic field linking with a conductor can induce an e.m.f. in the conductor
- Describe an experiment to demonstrate electromagnetic induction
- State the factors affecting the magnitude of an induced e.m.f.

Supplement

- Show understanding that the direction of an induced e.m.f. opposes the change causing it
- State and use the relative directions of force, field and induced current

4.6.2 a.c. generator

Core

- Distinguish between d.c. and a.c.

Supplement

- Describe and explain a rotating-coil generator and the use of slip rings
- Sketch a graph of voltage output against time for a simple a.c. generator
- Relate the position of the generator coil to the peaks and zeros of the voltage output

4.6.3 Transformer

Core

- Describe the construction of a basic transformer with a soft-iron core, as used for voltage transformations
- Recall and use the equation $(V_p / V_s) = (N_p / N_s)$
- Understand the terms step-up and step-down
- Describe the use of the transformer in high-voltage transmission of electricity
- Give the advantages of high-voltage transmission

Supplement

- Describe the principle of operation of a transformer
- Recall and use the equation $I_p V_p = I_s V_s$ (for 100% efficiency)
- Explain why power losses in cables are lower when the voltage is high

4.6.4 The magnetic effect of a current

Core

- Describe the pattern of the magnetic field (including direction) due to currents in straight wires and in solenoids
- Describe applications of the magnetic effect of current, including the action of a relay

Supplement

- State the qualitative variation of the strength of the magnetic field over salient parts of the pattern
- State that the direction of a magnetic field line at a point is the direction of the force on the N pole of a magnet at that point
- Describe the effect on the magnetic field of changing the magnitude and direction of the current

4.6.5 Force on a current-carrying conductor

Core

- Describe an experiment to show that a force acts on a current-carrying conductor in a magnetic field, including the effect of reversing:
  - the current
  - the direction of the field

Supplement

- State and use the relative directions of force, field and current
- Describe an experiment to show the corresponding force on beams of charged particles

4.6.6 d.c. motor

Core

- State that a current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by:
  - increasing the number of turns on the coil
  - increasing the current
  - increasing the strength of the magnetic field

Supplement

- Relate this turning effect to the action of an electric motor including the action of a split-ring commutator

5 Atomic physics

5.1 The nuclear atom

5.1.1 Atomic model

Core

- Describe the structure of an atom in terms of a positive nucleus and negative electrons

Supplement

- Describe how the scattering of α-particles by thin metal foils provides evidence for the nuclear atom

5.1.2 Nucleus

Core

- Describe the composition of the nucleus in terms of protons and neutrons
- State the charges of protons and neutrons
- Use the term proton number *Z*
- Use the term nucleon number *A*
- Use the term nuclide and use the nuclide notation ${}^{A}_{Z}X$
- Use and explain the term isotope

Supplement

- State the meaning of nuclear fission and nuclear fusion
- Balance equations involving nuclide notation

5.2 Radioactivity

5.2.1 Detection of radioactivity

Core

- Demonstrate understanding of background radiation
- Describe the detection of α-particles, β-particles and γ-rays (β^+ are not included: β-particles will be taken to refer to β^-)

5.2.2 Characteristics of the three kinds of emission

Core

- Discuss the random nature of radioactive emission
- Identify α, β and γ-emissions by recalling
  - their nature
  - their relative ionising effects
  - their relative penetrating abilities (β^+ are not included, β-particles will be taken to refer to β^-)

Supplement

- Describe their deflection in electric fields and in magnetic fields
- Interpret their relative ionising effects
- Give and explain examples of practical applications of α, β and γ-emissions

5.2.3 Radioative decay

Core

- State the meaning of radioactive decay
- State that during α- or β-decay the nucleus changes to that of a different element

Supplement

- Use equations involving nuclide notation to represent changes in the composition of the nucleus when particles are emitted

5.2.4 Half-life

Core

- Use the term half-life in simple calculations, which might involve information in tables or decay curves

Supplement

- Calculate half-life from data or decay curves from which background radiation has not been subtracted

5.2.5 Safety precautions

Core

- Recall the effects of ionising radiations on living things
- Describe how radioactive materials are handled, used and stored in a safe way

4 Details of the assessment

For information on the Assessment objectives (AOs), see section 5.

All candidates take three papers.

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

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

Core Assessment

Core candidates take the following papers that have questions based on the Core subject content only:

Paper 1 – Multiple Choice (Core)

45 minutes, 40 marks

Forty compulsory multiple-choice items of the four-choice type. This paper tests assessment objectives AO1 and AO2.

Paper 3 – Theory (Core)

1 hour 15 minutes, 80 marks

Short-answer and structured questions testing assessment objectives AO1 and AO2.

Extended Assessment

Extended candidates take the following papers that have questions based on the Core and Supplement subject content:

Paper 2 – Multiple Choice (Extended)

45 minutes, 40 marks

Forty compulsory multiple-choice items of the four-choice type. This paper tests assessment objectives AO1 and AO2.

Paper 4 – Theory (Extended)

1 hour 15 minutes, 80 marks

Short-answer and structured questions testing assessment objectives AO1 and AO2.

Practical Assessment

All candidates take one practical component from a choice of two:

Paper 5 – Practical Test

1 hour 15 minutes, 40 marks

This paper tests assessment objective AO3 in a practical context.

or

Paper 6 – Alternative to Practical Test

1 hour, 40 marks

This paper tests assessment objective AO3 in a written paper.

Whichever practical paper is chosen please be aware that:

- they test the same assessment objective, AO3
- they require the same experimental skills to be learned and developed
- the same sequence of practical activities is appropriate.

Candidates must not use textbooks or any of their course notes in the practical component.

Questions in the practical papers are structured to assess performance across the full grade range. The information candidates need to answer the questions is in the question paper itself or the experimental context and skills listed below. The questions do not assess specific syllabus content.

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

Candidates may be asked questions on the following experimental contexts:

- measurement of physical quantities such as length or volume or force
- cooling and heating
- springs and balances
- timing motion or oscillations
- electric circuits
- optics equipment such as mirrors, prisms and lenses
- procedures using simple apparatus, in situations where the method may not be familiar to the candidate.

Candidates may be required to do the following:

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

- explain the manipulation of the apparatus to obtain observations or measurements, for example:
  - when determining a derived quantity, such as the extension per unit load for a spring
  - when testing/identifying the relationship between two variables, such as between the p.d. across a wire and its length
  - when comparing physical quantities, such as two masses using a balancing method
- make estimates or describe outcomes which demonstrate their familiarity with an experiment, procedure or technique
- take readings from an appropriate measuring device or from an image of the device (for example thermometer, rule, protractor, measuring cylinder, ammeter, stopwatch), including:
  - reading analogue and digital scales with accuracy and appropriate precision
  - interpolating between scale divisions when appropriate
  - correcting for zero errors, where appropriate
- plan to take a sufficient number and range of measurements, repeating where appropriate to obtain an average value
- describe or explain precautions taken in carrying out a procedure to ensure safety or the accuracy of observations and data, including the control of variables
- identify key variables and describe how, or explain why, certain variables should be controlled
- record observations systematically, for example in a table, using appropriate units and to a consistent and appropriate degree of precision
- process data, using a calculator where necessary
- present and analyse data graphically, including the use of best-fit lines where appropriate, interpolation and extrapolation, and the determination of a gradient, intercept or intersection
- draw an appropriate conclusion, justifying it by reference to the data and using an appropriate explanation
- comment critically on a procedure or point of practical detail and suggest an appropriate improvement
- evaluate the quality of data, identifying and dealing appropriately with any anomalous results
- identify possible causes of uncertainty, in data or in a conclusion
- plan an experiment or investigation including making reasoned predictions of expected results and suggesting suitable apparatus and techniques.

Teaching experimental skills

We expect you to look for suitable opportunities to embed practical techniques and investigative work throughout the course.

The best way to prepare candidates for these papers is to integrate practical work fully into the course so that it becomes a normal part of your teaching. Practical work helps candidates to:

- develop a deeper understanding of the syllabus topics
- learn to appreciate the way in which scientific theories are developed and tested
- develop experimental skills and positive scientific attitudes such as objectivity, integrity, cooperation, enquiry and inventiveness.

Apparatus list

This list contains the items you will need for teaching the experimental skills needed for both practical papers, as well as the Paper 5 exam. It is not exhaustive and does not include equipment commonly regarded as standard in a physics laboratory. The *Confidential Instruction*s we send you before the Paper 5 exam will give the detailed requirements for the exam.

- an ammeter FSD 1 A or 1.5 A
- voltmeter FSD 1 V, 5 V
- cells and holders to enable several cells to be joined
- connecting leads and crocodile clips
- d.c. power supply, variable to 12 V
- low voltage filament lamps in holders
- various resistors and resistance wire
- switch
- metre rule
- good supply of masses and holder
- springs
- stopwatch
- newton meter
- plastic or polystyrene cup
- Plasticine or modelling clay
- thermometer, –10 °C to +110 °C at 1 °C graduations
- wooden board
- converging lens with f = 15 cm
- glass or Perspex block, rectangular and semicircular
- optics pins
- ray box
- measuring cylinder, 25 cm^3, 100 cm^3.

5 Assessment objectives

The assessment objectives (AOs) are:

AO1 Knowledge with understanding

AO2 Handling information and problem solving

AO3 Experimental skills and investigations

AO1 Knowledge with understanding

Candidates should be able to demonstrate knowledge and understanding of:

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

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

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

AO2 Handling information and problem solving

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

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

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

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

AO3 Experimental skills and investigations

Candidates should be able to:

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

Weighting for assessment objectives

The approximate weightings allocated to each of the assessment objectives (AOs) are summarised below.

Assessment objectives as a percentage of the qualification

Assessment objective	Weighting in IGCSE %
AO1 Knowledge with understanding	50
AO2 Handling information and problem solving	30
AO3 Experimental skills and investigations	20

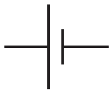
Assessment objectives as a percentage of each component

Assessment objective	Weighting in components %		
	Papers 1 and 2	Papers 3 and 4	Papers 5 and 6
AO1 Knowledge with understanding	63	63	0
AO2 Handling information and problem solving	37	37	0
AO3 Experimental skills and investigations	0	0	100

6 Appendix

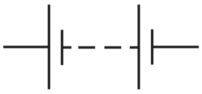
Electrical symbols

cell



battery of cells

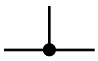
or



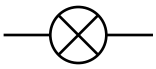
power supply

a.c. power supply

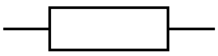
junction of conductors



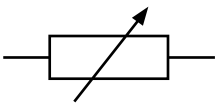
lamp



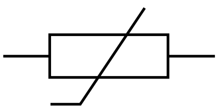
fixed resistor



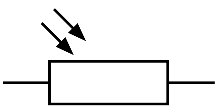
variable resistor



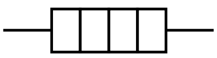
thermistor



light dependent resistor

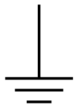


heater

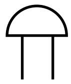


switch

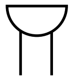
earth or ground



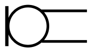
electric bell



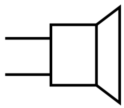
buzzer



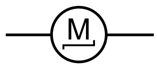
microphone



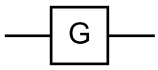
loudspeaker



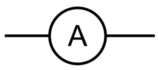
motor



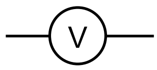
generator



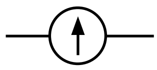
ammeter



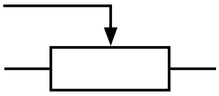
voltmeter



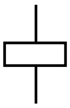
galvanometer



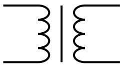
potential divider



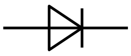
relay coil



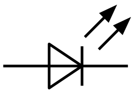
transformer



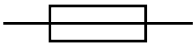
diode



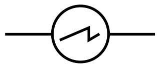
light-emitting diode



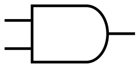
fuse



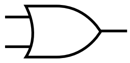
oscilloscope



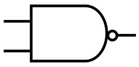
AND gate



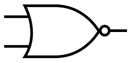
OR gate



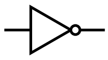
NAND gate



NOR gate



NOT gate



Symbols and units for physical quantities

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

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

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

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

Safety in the laboratory

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

Associations

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

Publications

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

UK Regulations

Control of Substances Hazardous to Health Regulations (COSHH) 2002 and subsequent amendment in 2004
http://www.legislation.gov.uk/uksi/2002/2677/contents/made
http://www.legislation.gov.uk/uksi/2004/3386/contents/made

A brief guide may be found at
http://www.hse.gov.uk/pubns/indg136.pdf

Glossary of terms used in science papers

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Mathematical requirements

Calculators may be used in all parts of the examination.

Candidates should be able to:

- add, subtract, multiply and divide
- use averages, decimals, fractions, percentages, ratios and reciprocals
- use standard notation, including both positive and negative indices
- understand significant figures and use them appropriately
- recognise and use direct and inverse proportion
- use positive, whole number indices in algebraic expressions
- draw charts and graphs from given data
- interpret charts and graphs
- determine the gradient and intercept of a graph
- select suitable scales and axes for graphs
- make approximate evaluations of numerical expressions
- recall and use equations for the areas of a rectangle, triangle and circle and the volumes of a rectangular block and a cylinder
- use mathematical instruments (ruler, compasses, protractor and set square)
- understand the meaning of angle, curve, circle, radius, diameter, circumference, square, parallelogram, rectangle and diagonal
- solve equations of the form $x = y + z$ and $x = yz$ for any one term when the other two are known
- recognise and use clockwise and anticlockwise directions
- recognise and use points of the compass (N, S, E, W)
- use sines and inverse sines (Extended candidates only).

Presentation of data

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

(a) Tables

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

(b) Graphs

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

(c) Bar charts

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

(d) Numerical results

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

ICT opportunities

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

Opportunities for ICT include:

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

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

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

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

Decimal markers

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

Numbers

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

7 What else you need to know

This section is an overview of other information you need to know about this syllabus. It will help to share the administrative information with your exams officer so they know when you will need their support. Find more information about our administrative processes at **www.cie.org.uk/examsofficers**

Before you start

Previous study

We recommend that learners starting this course should have studied a physics curriculum such as the Cambridge Secondary 1 programme or equivalent national educational framework. Learners in England will normally have followed the Key Stage 3 programme of study within the National Curriculum for England.

Guided learning hours

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

Total qualification time

This syllabus has been designed on the assumption that the total qualification time per subject will include both guided learning and independent learning activities. The estimated number of guided learning hours for this syllabus is 130 hours over the duration of the course. The total qualification time for this syllabus has been estimated to be approximately 200 hours. These values are guidance only. The number of hours required to gain the qualification may vary according to local curricular practice and the learners' prior experience of the subject.

Availability and timetables

You can enter candidates in the June and November exam series. If your school is in India, you can enter your candidates in the March exam series. You can view the timetable for your administrative zone at **www.cie.org.uk/timetables**

Private candidates can enter for this syllabus.

Combining with other syllabuses

Candidates can take this syllabus alongside other Cambridge syllabuses in a single exam series. The only exceptions are:

- Cambridge IGCSE (9–1) Physics (0972)*
- Cambridge IGCSE Physical Science (0652)
- Cambridge IGCSE Combined Science (0653)
- Cambridge IGCSE Co-ordinated Sciences (Double Award) (0654)
- Cambridge IGCSE (9–1) Co-ordinated Sciences (Double Award) (0973)**
- Cambridge O Level Combined Science (5129)
- syllabuses with the same title at the same level.

Cambridge IGCSE, Cambridge IGCSE (9–1) (Level 1/Level 2 Certificates) and Cambridge O Level syllabuses are at the same level.

Group awards: Cambridge ICE

Cambridge ICE (International Certificate of Education) is a group award for Cambridge IGCSE. It allows schools to offer a broad and balanced curriculum by recognising the achievements of learners who pass examinations in a range of different subjects.

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

Making entries

Exams officers are responsible for submitting entries to Cambridge. We encourage them to work closely with you to make sure they enter the right number of candidates for the right combination of syllabus components. Entry option codes and instructions for submitting entries are in the *Cambridge Guide to Making Entries*. Your exams officer has a copy of this guide.

Option codes for entries

To keep our exams secure we allocate all Cambridge schools to one of six administrative zones. Each zone has a specific timetable. The majority of option codes have two digits:

- the first digit is the component number given in the syllabus
- the second digit is the location code, specific to an administrative zone.

Support for exams officers

We know how important exams officers are to the successful running of exams. We provide them with the support they need to make your entries on time. Your exams officer will find this support, and guidance for all other phases of the Cambridge Exams Cycle, at **www.cie.org.uk/examsofficers**

Retakes

Candidates can retake the whole qualification as many times as they want to. This is a linear qualification so candidates cannot re-sit individual components.

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* Available from June 2018
** Available from June 2019

Equality and inclusion

We have taken great care to avoid bias of any kind in the preparation of this syllabus and related assessment materials. In compliance with the UK Equality Act (2010) we have designed this qualification to avoid any direct and indirect discrimination.

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

Candidates who cannot access the assessment of any component may be able to receive an award based on the parts of the assessment they have completed.

Information on access arrangements is in the *Cambridge Handbook* at
www.cie.org.uk/examsofficers

Language

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

After the exam

Grading and reporting

Grades A*, A, B, C, D, E, F or G indicate the standard a candidate achieved at Cambridge IGCSE.

A* is the highest and G is the lowest. 'Ungraded' means that the candidate's performance did not meet the standard required for grade G. 'Ungraded' is reported on the statement of results but not on the certificate. In specific circumstances your candidates may see one of the following letters on their statement of results:

- Q (result pending)
- X (no result)
- Y (to be issued)

These letters do not appear on the certificate.

Regulation

Cambridge International Level 1/Level 2 Certificates are regulated in England, Wales and Northern Ireland. This syllabus is included in the *Register of Regulated Qualifications* as a Cambridge International Level 1/ Level 2 Certificate.

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

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

Grade descriptions

Grade descriptions are provided to give an indication of the standards of achievement candidates awarded particular grades are likely to show. Weakness in one aspect of the examination may be balanced by a better performance in some other aspect.

A **Grade A** Cambridge IGCSE Physics candidate will be able to:

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

A **Grade C** Cambridge IGCSE Physics candidate will be able to:

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

A **Grade F** Cambridge IGCSE Physics candidate will be able to:

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

Changes to this syllabus for 2019

The syllabus has been updated. The latest syllabus is version 3, published January 2019.

This document has been refreshed and rebranded. The subject content and the specimens remain the same.

Minor changes to the wording of some sections have been made to improve clarity.

You are strongly advised to read the whole syllabus before planning your teaching programme.

Changes to syllabus content	**Changes to version 3 of the syllabus, published January 2019** We have clarified the information about the grades available for Core and Extended tier assessment. • The information has been clarified in section 2 *Syllabus overview*. • Information has been added to section 4 *Details of the assessment* for additional clarity. **Changes to version 2 of the syllabus, published August 2017** Combining with other syllabuses • From 2019 candidates cannot take Cambridge IGCSE (9–1) Co-ordinated Sciences (Double Award) (0973) with this syllabus.

Any textbooks endorsed to support the syllabus for examination from 2016 are still suitable for use with this syllabus.

‘While studying Cambridge IGCSE and Cambridge International A Levels, students broaden their horizons through a global perspective and develop a lasting passion for learning.’

Zhai Xiaoning, Deputy Principal, The High School Affiliated to Renmin University of China

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