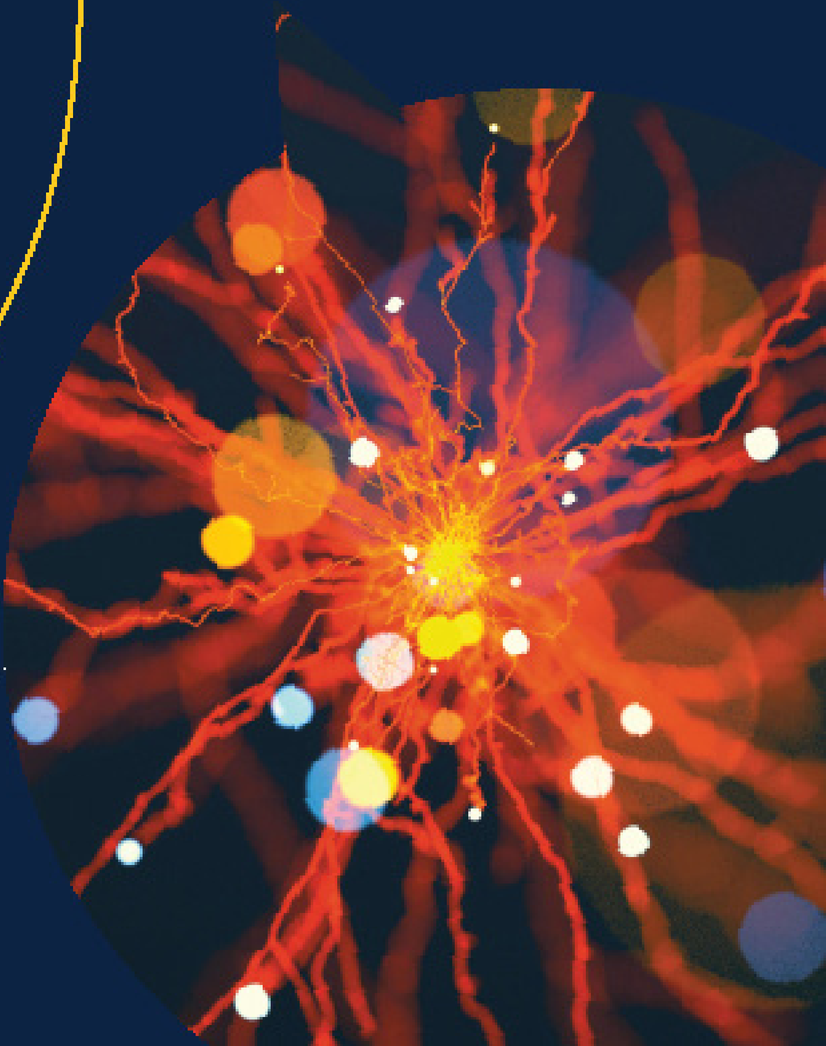
OXFORD AQA
INTERNATIONAL QUALIFICATIONS

International GCSE
Physics

(9203) Specification



For teaching from September 2016 onwards
For exams May/June 2018 onwards
For teaching and examination outside the United Kingdom

Contents

Key for symbol

Most of the subject content is common with and co-teachable with OxfordAQA International GCSE Combined Science (9204). Content that is only applicable to physics is indicated by P either next to the topic heading where it applies to the whole topic or immediately preceding each paragraph or bullet point as applicable.

Are you using the latest version of this specification?

- You will always find the most up-to-date version of this specification on our website at **oxfordaqa.com/9203**
- We will write to you if there are significant changes to the specification.

1 Introduction

1.1 Why choose OxfordAQA International GCSEs?

Our International qualifications enable schools that follow a British curriculum to benefit from the best education expertise in the United Kingdom (UK).

Our International GCSEs offer the same rigour and high quality as GCSEs in the UK and are relevant and appealing to students worldwide. They reflect a deep understanding of the needs of teachers and schools around the globe and are brought to you by Oxford University Press and AQA, the UK's leading awarding body.

Providing valid and reliable assessments, these qualifications are based on over 100 years of experience, academic research and international best practice. They have been independently validated as being to the same standard as the qualifications accredited by the UK examinations regulator, Ofqual. They reflect the latest changes to the British system, enabling students to progress to higher education with up-to-date qualifications.

You can find out about OxfordAQA at **oxfordaqa.com**

1.2 Why choose our International GCSE Physics?

In developing this specification we have consulted widely with teachers and science advisers to produce content and assessments that will both stimulate students' interest in and enthusiasm for physics and provide an excellent grounding for further study. This specification contains a broad range of topics that are designed to engage students whilst providing the knowledge and understanding required for progression to Level 3 qualifications.

Physics is an enquiry-based discipline involving practical and investigational skills as well as knowledge. The specification emphasises scientific knowledge, the application of science and the scientific process. Section 3 gives the fundamental ideas behind scientific enquiry that should be delivered through teaching of the content. The experimental and investigative skills that will be assessed in this specification are listed in Section 6.1. There are a number of required practicals identified in the specification, which students will need to cover as part of the content of the specification. These practicals will be assessed during the lifetime of the specification. These are summarised in Section 6.2.

The terminal assessment model is designed to ensure the maximum amount of time for teaching.

You can find out more about our International GCSE Physics qualifications at **oxfordaqa.com/science**

1.3 Recognition

OxfordAQA meet the needs of international students. They are an international alternative and comparable in standard to the Ofqual regulated qualifications offered in the UK. Our qualifications have been independently benchmarked by UK ENIC, the UK national agency for providing expert opinion on qualifications worldwide. They have confirmed they can be considered 'comparable to the overall GCE A-level and GCSE standard offered in the UK.'

To read their report and see the latest list of universities who have stated they accept these international qualifications, visit **oxfordaqa.com/recognition**

1.4 The Oxford International Programme learner attributes

In order to equip students with the skills they need for success both now and in the future, we have worked with Oxford University Press to create the Oxford International Programme. This combines the Oxford International Curriculum with OxfordAQA qualifications, creating an integrated offer for international schools, from Early Years to A-level.

At its core we have introduced the Oxford International Programme learner attributes – the skills and competencies that enable our students to thrive academically, socially and personally.

The learner attributes, alongside our focus on demonstrating higher order critical thinking skills, ensure that students are equipped to get the grades that will take them places, and build the skills they need to be successful when they get there.

Empowered & independent

Our students are independent, critical thinkers who are adaptable and look to develop strategies to be lifelong learners. They are confident leading on projects but also work well in a collaborative environment.

Inventive & curious

Our students are inventive, resourceful, and creative. They question the world around them with a sense of wonder, and aspire to shape a better future for themselves and their community.

Future-ready

Our students are more prepared to succeed in the world that lies ahead and have the knowledge, skills, and drive to achieve any objective they may set themselves. They are comfortable being challenged, acquiring new skills quickly, and seeking new adventures.

Ambitious & self-motivated

Our students are ambitious and want to strive for success in every aspect of their lives. They take the initiative, approaching every task with an eagerness to learn and take ownership of their own learning with the utmost integrity.

1.5 Support and resources to help you teach

We know that support and resources are vital for your teaching and that you have limited time to find or develop good quality materials. That's why we've worked with experienced teachers to provide resources that will help you confidently plan, teach and prepare for exams.

Teaching resources

You will have access to:

- sample schemes of work to help you plan your course with confidence
- training courses to help you deliver our qualifications
- student textbooks that have been checked and approved by us
- engaging worksheets and activities developed by teachers, for teachers
- command words with exemplars
- science vocabulary with definitions
- a handbook to support practical work.

Preparing for exams

You will have access to the support you need to prepare for our exams, including:

- specimen papers and mark schemes
- exemplar student answers with examiner commentaries
- a searchable bank of past AQA exam questions mapped to these new International qualifications.

Analyse your students' results with Data Insights

After the first examination series, you can use this tool to see which questions were the most challenging, how the results compare to previous years and where your students need to improve. Data Insights, our free online results analysis tool, will help you see where to focus your teaching.

Information about results, including maintaining standards over time, grade boundaries and our post-results services, will be available on our website in preparation for the first examination series.

Help and support

Visit our website for information, guidance, support and resources at **oxfordaqa.com/9203**

You can contact the subject team directly at **info@oxfordaqa.com** or call us on +44 (0)161 696 5995 (option 1 and then 1 again).

Please note: We aim to respond to all email enquiries within two working days.

Our UK office hours are Monday to Friday, 8am – 5pm.

2 Specification at a glance

The title of the qualification is:

- OxfordAQA International GCSE Physics.

This qualification is linear. Linear means that students will sit all their exams the end of the course.

Exams will be available May/June and in November.

The guided learning hours (GLH) for this qualification are 120. This figure is for guidance only and may vary according to local practice and the learner's prior experience of the subject.

2.1 Subject content

Forces and their effects

- Forces and their interactions
- Motion
- Resultant forces
- Momentum P
- Safety in public transport
- Forces and terminal velocity P
- Centre of mass P
- Moments and levers P

Energy

- Forces and energy
- Energy transfers, conservation and dissipation of energy
- Energy resources

Waves

- General properties of waves
- The electromagnetic spectrum
- Sound and ultrasound
- Reflection
- Refraction and total internal reflection P
- Lenses and the eye P

Particle model of matter

- Kinetic theory
- Energy transfers and particle motion

Electricity and magnetism

- Electrical circuits
- Magnetism and electromagnetism

Generating and distributing electricity and household use

- Generating electricity P
- Electricity transmission and distribution P
- Using electricity in the home
- The motor effect
- Transferring electrical energy

Nuclear physics

- Atomic structure
- Ionizing radiation from the nucleus
- Nuclear fission
- Nuclear fusion P

Space physics

- Life cycle of a star
- Solar system and orbital motion
- Red shift and the expanding universe P

2.2 Assessments

OxfordAQA International GCSE Physics is linear, with two question papers to be taken in the same examination series.

Paper 1	Paper 2
What's assessed Content from any part of the specification may be assessed.	What's assessed Content from any part of the specification may be assessed.
How it's assessed Written exam: 1 hour 30 minutes 90 marks	How it's assessed Written exam: 1 hour 30 minutes 90 marks
Questions Structured and open questions.	Questions Structured and open questions.

3 Subject content

Through the teaching of this physics syllabus, students will develop knowledge and understanding of the subject content of physics, the practices of science and how science as a discipline develops. Students will develop their ability to work as a scientist.

Working as a scientist involves being able to observe, question, hypothesise and carry out various types of scientific enquiry to further scientific knowledge, and to be able to use models and arguments to support explanations and decision making. It also involves following established procedures to ensure that new scientific knowledge can be validated.

Working this way requires knowledge and understanding of the practices of science and how science as a discipline develops.

Knowledge of the subject content in isolation does **not** provide the knowledge, understanding and skills required for progression to higher qualifications or develop the knowledge, understanding and skills required for students to be future scientists or scientifically literate citizens.

There are three dimensions to working as a scientist:

- Subject content
- The practices of science
- How science as a discipline develops.

Subject content

The established facts, concepts, ideas and theories.

The assessed subject content is presented as a series of topic areas listing the statements students need to know, understand and apply. Expansion of the content and clarification of what may be examined is given in *italics*.

The practices of science

How observation and experimentation is carried out to obtain evidence. The assessment requirements are detailed in the specification appendices 6.1 and 6.2.

Students should develop an understanding of how the following elements relate to the subject content and practices of science.

Students should be able to:

- suggest, describe and explain experimental and investigative procedures
- justify the choice of experimental or investigative procedure and the use of apparatus
- identify possible hazards, the risks associated with these hazards, and methods of minimising the risks
- recognise and explain the need to manipulate and control variables, including the use of control groups where necessary
- assess whether sufficient measurements have been taken with appropriate precision, and appreciate when it is appropriate to calculate a mean
- recognise and identify the causes of anomalous results and suggest what should be done about them
- present, analyse and interpret data in tabular and graphical forms, identifying patterns and correlations (which may be causal or non-causal)
- recognise and identify the causes of random and systematic errors

- evaluate data, considering its validity, repeatability and reproducibility in supporting conclusions
- evaluate working methods, suggesting advantages and disadvantages of approaches used.

How science as a discipline develops

The defining features that characterise the nature of the subject and how new scientific knowledge is established.

The defining features of how science knowledge and understanding develops over time:

- Predictions are tested to support or refute a new scientific idea or explanation.
- Scientific claims are supported by evidence and scientific reasoning, and should be able to be confirmed by other scientists.
- Evidence and creative thinking is used to develop new scientific ideas and explanations.
- Different conclusions may be drawn from available evidence and can be influenced by personal background, experience or interests.
- New technologies and practical techniques can lead to new investigations and discoveries, and advance scientific knowledge and understanding.
- New evidence can lead to new lines of enquiry and changes in scientific ideas and explanations.
- Models are used to support scientific explanations with limits to what they can and cannot explain.
- Accepted scientific ideas and explanations can take a long time to be abandoned even if new evidence disagrees with predictions based upon them.
- Science often involves collaboration in interdisciplinary teams, often from several countries.

The scientific terms used in this specification are clearly defined by the ASE in *The Language of Measurement: Terminology used in school science investigations* (Association for Science Education, 2010).

Teachers should ensure that they and their students are familiar with these terms. Definitions of the terms will **not** be required in assessments, but students will be expected to use them correctly.

3.1 Forces and their effects

This topic explores the interactions (forces) between objects that can change their shape or the way they are moving. Mathematical relationships and models can describe and predict the resultant motion of an object. Applications illustrate how forces can be used to achieve certain outcomes and avoid others.

3.1.1 Forces and their interactions

a. Objects interact by non-contact (field) forces (including gravity, electrostatics, magnetism) and by contact forces (including friction, air resistance, tension and normal contact force).

b. Friction is a force between two surfaces, which impedes motion and may result in heating. Air resistance is a form of friction.

c. Pairs of objects interact to produce a force on each other, which can be represented as vectors.

d. Scalars are quantities that have magnitude only. Vectors are quantities that have direction as well as a magnitude. A vector quantity may be represented by an arrow. The length of the arrow represents the magnitude and the direction of the arrow represents the direction of the vector quantity.

   Students should be aware that distance, speed and time are examples of scalars and displacement, velocity, acceleration, force and momentum are examples of vectors.

e. Weight is the force acting on an object due to gravity. The weight of an object depends on the gravitational field strength at the point where the object is. The weight of an object can be calculated using the equation:

   Weight (N) = mass (kg) × gravitational field strength $(\mathrm{N/kg})$
   $W = m \times g$

   *Students will **not** be expected to know the value of g; it will be given in any examination items.*

f. When more than one force is applied to an object they may cause a change in the shape of the object, by stretching, bending or compressing. After elastic distortions an object returns to its original shape when the forces are removed. After inelastic distortions an object does not return to its original shape. P

g. A force applied to an elastic object such as a spring will result in the object stretching and storing elastic potential energy.

h. For an object behaving elastically, the extension is directly proportional to the force applied, provided that the limit of proportionality is not exceeded. The relationship between the force, F, and the extension, e, is:

   $F = k \times e$

   where k is a constant.

   Required practical:
   Investigate the relationship between force and extension for a spring.

3.1.2 Motion

a. If an object moves in a straight line, its distance from a certain point can be represented by a distance–time graph.

b. The speed of the object can be calculated from the gradient of a distance–time graph.

c. The velocity, v, of an object is its speed in a given direction and is given by the equation:

$$v = \frac{s}{t}$$

where s is the displacement and t is the time taken.

d. This equation can also be used to calculate the average speed of objects undergoing non-uniform motion.

3.1.3 Resultant forces

a. Whenever two objects interact, the forces they exert on each other are equal in magnitude and opposite in direction. This is Newton's Third Law.

b. A number of forces acting on an object may be replaced by a single force that has the same effect on the motion as all the original forces acting together. This single force is called the resultant force.

Students should be able to determine the resultant of opposite or parallel forces acting in a straight line and determine the resultant of two coplanar forces by scale drawing.

c. A non-zero resultant force acting on an object causes it to accelerate.

d. Acceleration is the rate of change of velocity. An object can accelerate by changing its direction even if it is going at a constant speed. Deceleration is a negative acceleration. The average acceleration, a, of an object is given by the equation:

$$a = \frac{\Delta v}{t}$$

where Δv is the change in velocity and t is the time taken for the object to accelerate.

e. The acceleration of an object can be calculated from the gradient of the velocity–time graph.

f. The distance travelled by an object can be calculated from the area under a velocity–time graph.

g. If the resultant force acting on an object is zero:

- a moving object will continue to move at the same velocity
- a stationary object will remain at rest.

This is Newton's First Law.

h. If the resultant force on an object is not zero, the object will accelerate in the direction of the resultant force. The relationship between the resultant force, F, acting on an object, its mass, m, and the acceleration caused, a, is:

$$F = m \times a$$

This is Newton's Second Law.

3.1.4 Momentum P

a. All moving objects have momentum. The relationship between momentum, p, mass, m, and velocity, v, is:

$$p = m \times v$$

b. In a closed system the total momentum before an interaction is equal to the total momentum after the interaction. This is called conservation of momentum.

Students may be required to complete calculations involving two objects. Examples of interactions are collisions and explosions.

c. The relationship between force, F, change in momentum, Δp, and time, t, is:

$$F = \frac{\Delta p}{t}$$

ie the force equals the rate of change of momentum.

Students should be able to use this relationship to explain qualitatively car safety features such as air bags, seat belts, side impact bars, crumple zones. Also, gymnasium crash mats, cushioned surfaces for playgrounds and cycle helmets.

3.1.5 Safety in public transport

a. When a vehicle travels at a steady speed in a straight line the resistive forces are balancing the driving force.

b. The greater the speed of a vehicle the greater the braking force needed to stop it in a certain distance. The greater the braking force the greater the deceleration of the vehicle. Large decelerations may lead to brakes overheating and/or loss of control.

Students should understand for a given braking force, the greater the speed, the greater the stopping distance.

c. The stopping distance of a vehicle is the sum of the distance the vehicle travels during the driver's reaction time (thinking distance) and the distance it travels under the braking force (braking distance). A driver's reaction time can be affected by tiredness, distractions, drugs and alcohol.

d. When the brakes of a vehicle are applied, work done by the friction force between the brakes and the wheel reduces the kinetic energy of the vehicle and the temperature of the brakes increases.

e. A vehicle's braking distance can be affected by adverse road and weather conditions and poor condition of the vehicle.

Students should understand that 'adverse road conditions' includes wet or icy conditions. Poor condition of the car is limited to the car's brakes or tyres.

3.1.6 Forces and terminal velocity P

a. An object moving through a fluid experiences friction. The faster the object moves, the greater the frictional forces (drag) acting on it.

b. An object falling through a fluid will initially accelerate due to the force of gravity and the drag forces increase as the velocity increases. Eventually the resultant force will be zero and the object will move at its terminal velocity.

c. Parachutes are designed to increase the drag force on a parachutist so that the terminal velocity is reduced.

Students should be able to draw and interpret velocity–time graphs for objects that reach terminal velocity, including a consideration of the forces acting on the object.

d. Streamlining reduces the drag force on an object so that its maximum velocity is increased.

Students should be able to describe how the streamlining of a shark (an adaptation) or a car (a design feature) reduces the drag force and the object.

3.1.7 Centre of mass P

a. The centre of mass of an object is the point at which the mass of the object may be thought to be concentrated.

Students will be expected to be able to describe how to find the centre of mass of a thin lamina with irregular shape.

b. If freely suspended, an object will come to rest with its centre of mass directly below the point of suspension.

c. The centre of mass of a symmetrical object is along the axis of symmetry. The position of the centre of mass affects the stability of objects.

3.1.8 Moments and levers P

a. The turning effect of a force is called the moment. The relationship between the moment, M, turning force, F, and perpendicular distance, d, from the point where the force is applied to the pivot is:

$$M = F \times d$$

b. If an object is not turning, the total clockwise moment must be exactly balanced by the total anticlockwise moment about any pivot.

Students should be able to calculate the size of a force, or its distance from a pivot, acting on an object that is balanced.

c. If the line of action of the weight of an object lies outside the base of the object there will be a resultant moment and the body will topple.

Examples should include vehicles and simple balancing toys.

d. Simple levers can be used as force multipliers.

3.2 Energy

This topic starts with the principles of energy transfer and then explores it in various contexts, such as heating. It considers the idea of energy as a useful accounting tool that allows us to do calculations to find out for example how long sources will last or whether some events can happen. Energy is never destroyed but may end up so dissipated that it is of little use.

3.2.1 Forces and energy

a. Work is done when a force causes an object to move through a distance. The relationship between work done, W, force, F, and distance, d, moved in the direction of the force is:

$$W = F \times d$$

b. Energy is transferred when work is done. Work done against frictional forces causes energy transfer by heating.

Students should be able to discuss the transfer of kinetic energy in particular situations, for example shuttle re-entry into the atmosphere or meteorites burning up in the atmosphere and braking systems on vehicles.

c. The amount of elastic potential energy stored in a stretched spring (assuming the limit of proportionality has not been exceeded) can be calculated using the equation:

$E_e = ½ \times k \times e^2$

d. An object gains gravitational potential energy when it is raised vertically because work is done against the gravitational force. The relationship between gravitational potential energy, E_p, mass, m, gravitational field strength, g, and height, h, is:

$E_p = m \times g \times h$

e. The kinetic energy of a moving object depends on its mass and its velocity. The relationship between kinetic energy, E_k, mass, m and velocity, v, is:

$E_k = ½ \times m \times v^2$

Students should understand that when the mass of an object is doubled, if it is travelling at the same speed it will have twice the kinetic energy. They should understand that an object travelling at twice the speed of another object with the same mass will have four times the kinetic energy and should be able to apply this idea in the context of road safety.

f. Power is the rate at which energy is transferred or the rate at which work is done. The relationship between power, P, work done, W, or energy transferred, E, and time, t, is:

$$P = \frac{E}{t}$$

and

$$P = \frac{W}{t}$$

3.2.2 Energy transfers, conservation and dissipation of energy

a. When a system changes, energy is transferred. A system is an object or group of objects.

Students should be able to identify when and where energy has been transferred using concepts such as kinetic energy, gravitational potential energy and elastic potential energy.

b. A simple pendulum is an example of oscillating motion and energy is transferred between kinetic energy and gravitational potential energy. P

c. Energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed.

d. When energy is transferred only part of it may be usefully transferred; the rest is dissipated so that it is stored in less useful ways. This energy is often described as being 'wasted'.

e. Friction and air resistance are forces that dissipate energy by heating the surroundings.

f. The efficiency of a device can be calculated using:

$$\text{efficiency} = \frac{\text{useful energy out}}{\text{total energy in}} \ (\times 100\%)$$

and

$$\text{efficiency} = \frac{\text{useful power out}}{\text{total power in}} \ (\times 100\%)$$

Students may be required to calculate efficiency as a decimal or as a percentage.

g. The energy flow in a system can be represented using Sankey diagrams.

Students should be able to draw and interpret Sankey diagrams to show how the overall energy in a system is redistributed when the system is changed but there is no net change to the total energy.

3.2.3 Energy resources

a. Fuels are a useful store of energy; different fuels are suitable for different situations and are selected according to a range of factors, such as ease of storage, energy content and safety.

b. When a fuel is used, some energy is transferred to the surroundings. Some fuels are more efficient than others.

c. There is a range of energy sources used on a national and global scale. Their use has implications for society in terms of factors including renewability and the environmental impacts of extraction, use and disposal.

d. A range of technologies have been developed to provide energy in a renewable way, such as wave power, solar power and geothermal power.

Students should be aware of these and other examples and be able to identify advantages and drawbacks with their use.

3.3 Waves

Waves, both transverse and longitudinal, carry energy from a source and can be detected by a receiver. This topic explores the use of the wave model to explore the behaviour of waves and its application to contexts such as information communication, sight and medicine.

3.3.1 General properties of waves

a. A wave is a disturbance caused by an oscillating source that transfers energy and information in the direction of wave travel, without transferring matter.

b. In a transverse wave the oscillations are perpendicular to the direction of energy transfer.

c. In a longitudinal wave the oscillations are parallel to the direction of energy transfer. Longitudinal waves have areas of compression and rarefaction.

d. Electromagnetic waves and water waves are transverse, sound waves are longitudinal and mechanical waves may be either transverse or longitudinal.

e. Waves can be reflected, transmitted or absorbed (or a combination of these) at the boundary between two different materials.

f. Waves can undergo refraction due to a change in velocity and diffraction through a narrow gap or at an edge.

Students should appreciate that for appreciable diffraction to take place the wavelength of the wave has to be comparable to the size of the obstacle or gap. Students may be required to apply these ideas to the reduction of diffraction in optical *instruments, ultrasound waves in medicine and radio wave reception.*

g. Wave motion can be described in terms of their frequency, wavelength, period, amplitude and wavefront.

Students should be able to explain the meaning of these terms.

h. The relationship between wave speed, v, frequency, f, and wavelength, λ, is:

$v = f \times \lambda$

3.3.2 The electromagnetic spectrum

a. Electromagnetic waves are transverse waves that transfer energy from the source of the waves to an absorber.

b. Electromagnetic waves form a continuous spectrum and all types of electromagnetic wave travel at the same speed through a vacuum (space).

Students should know the order of electromagnetic waves within the spectrum, grouped in terms of energy, frequency and wavelength. They should appreciate that the wavelengths of the electromagnetic spectrum range from 10^{-15} m to 10^{4} m and beyond.

c. Visible light is the part of the electromagnetic spectrum that is detected by our eyes; we see different wavelengths as different colours.

d. All objects emit and absorb infrared radiation. [Objects emit infrared radiation because of the motion of their particles. The amount and frequency of emitted radiation depends on the temperature and surface of the object P]. The hotter an object is the more infrared radiation it radiates in a given time.

- Dark, matt surfaces are good absorbers and good emitters of infrared radiation.
- Light, shiny surfaces are poor absorbers and poor emitters of infrared radiation.
- Light, shiny surfaces are good reflectors of infrared radiation.

e. As an object heats up it radiates more and more infrared and radiation at higher frequencies. P

f. Black-body radiation is the range of electromagnetic radiation emitted by an object at a particular temperature. P

g. Radio waves, microwaves, infrared and visible light can be used for communication.

h. Electromagnetic waves have many practical applications. For example:

- radio waves – television and radio systems (including Bluetooth)
- microwaves – mobile phones and satellite television systems
- infrared – TV remote controls, night vision devices, heating
- visible light – photography, fibre optic communications
- ultraviolet – security marking
- X-rays – medical imaging
- gamma rays – sterilising surgical instruments and killing harmful bacteria in food.

i. Excessive exposure of the human body to electromagnetic waves can be hazardous. Low energy waves have a heating effect and higher energy waves have enough energy to cause ionisation (remove an electron from an atom or molecule). For example:

- microwaves – heating of body tissue

- infrared – skin burns
- ultraviolet – skin cancer and blindness
- X-rays – high doses kill cells
- gamma rays – genetic mutations.

Students should be able to describe simple protection measures against risks.

j. X-rays are part of the electromagnetic spectrum. They have a very short wavelength, high energy and cause ionisation.

k. Properties of X-rays include:

- they affect a photographic film in the same way as light
- they are absorbed strongly by metal and bone
- they are transmitted by healthy tissue.

l. X-rays can be used to diagnose some medical conditions, for example in computed tomography (CT) scanning, bone fractures and dental problems. X-rays are also used to treat some conditions, for example in killing cancer cells.

m. The use of high energy ionising radiation can be dangerous, and precautions need to be taken to monitor and minimise the levels of radiation that people who work with it are exposed to.

3.3.3 Sound and ultrasound

a. Sound waves are longitudinal waves and cause vibrations in a medium, which are detected as sound. The range of human hearing is about 20 Hz to 20 000 Hz.

No *details of the structure of the ear are required.*

b. The pitch of a sound is determined by the frequency of vibrations of the source. Its loudness is related to the size of the amplitude of the disturbance.

c. Sound waves can be reflected (echoes) and diffracted.

d. Ultrasound is acoustic (sound) energy, in the form of waves with a frequency above the human hearing range. P

e. Electronic systems can be used to produce ultrasound waves, which have a frequency higher than the upper limit of hearing for humans. P

f. Ultrasound waves are partially reflected when they meet a boundary between two different media. The time taken for the reflections to reach a detector can be used to determine how far away such a boundary is. P

g. The distance, s, between interfaces in various media can be calculated using: P

$$s = v \times t$$

where v is wave speed and t is time taken.

Students may be required to use and interpret data from diagrams of oscilloscope traces.

h. Ultrasound waves can be used in medicine. Examples include prenatal scanning and the removal of kidney stones. P

3.3.4 Reflection

a. When waves are reflected the angle of incidence is equal to the angle of reflection.

b. The normal is a construction line perpendicular to the reflecting surface at the point of incidence.

c. The image produced in a plane mirror is virtual, upright and laterally inverted.

Students will be expected to be able to construct ray diagrams to represent the changing path of reflected rays.

3.3.5 Refraction and total internal reflection P

a. The velocity of waves is affected by the medium they are travelling through. The speed changes. Unless the wave enters at 90° to the surface (along the normal) the direction also changes. This is called refraction.

b. Light waves are refracted at an interface:

- when light enters a denser medium it is refracted towards the normal
- when light enters a less dense medium it is refracted away from the normal.

Students should have the opportunity to use wave front diagrams to explain refraction in terms of the change in speed that happens when a wave travels from one medium to another.

c. Refraction by a prism can lead to dispersion of light waves and the formation of a spectrum.

d. Refractive index can be defined in terms of wave speed.

The refractive index of a medium is defined as:

$$\frac{\text{speed of light in vacuum (air)}}{\text{speed of light in the medium}}$$

e. The relationship between refractive index, n, angle of incidence, i, and angle of refraction, r, is:

$$n = \frac{\sin i}{\sin r}$$

Required practical:
Investigate the refraction of light by different substances.

f. The relationship between refractive index, n, and critical angle, c, is:

$$n = \frac{1}{\sin c}$$

Recall of the values of critical angles is not required.

g. Total internal reflection is a special case of refraction, which occurs if the angle of incidence within the denser medium is greater than the critical angle.

h. Visible light and infra red can be transmitted through optical fibres by total internal reflection.

Students should be able to describe the application and benefits of optical fibres in medicine and communication technology.

3.3.6 Lenses and the eye P

a. A lens forms an image by refracting light.

b. In a convex (converging) lens, parallel rays of light are brought to a focus at the principal focus.

Students should be aware of the nature of the image produced by a converging lens for an object placed at different distances from the lens, including the use of the converging lens as a magnifying glass.

c. In a concave (diverging) lens, parallel rays of light diverge as if coming from the principal focus.

Students should be aware of the nature of the image produced by a diverging lens for an object placed at different distances from the lens.

d. The distance from the lens to the principal focus is called the focal length.

e. The nature of an image is defined by its size relative to the object, whether it is upright or inverted relative to the object and whether it is real or virtual.

f. Ray diagrams are used to show the formation of images by convex and concave lenses.

Students may be asked to draw and interpret ray diagrams drawn on graph paper.

g. The magnification produced by a lens may be calculated using the equation:

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

h. Our eyes only detect visible light, a limited range of electromagnetic waves. The eye contains the following structures:

- retina
- variable focus lens
- cornea
- pupil/iris
- ciliary muscle
- suspensory ligaments.

Students should know the function of each of these parts and understand how the action of the ciliary muscle causes changes in the shape of the lens that allow light to be focused arriving from varying distances. They should understand that light entering the eye is refracted by the cornea as well as by the lens.

i. Usually the near point of the human eye is approximately 25 cm from the eye and the far point is at infinity. The eye can focus on objects between the near point and the far point. The distance between these points is called the range of vision.

j. Lenses can be used to correct defects of vision:

- long sight, caused by the eyeball being too short, or the eye lens being unable to focus a sharp image on the retina
- short sight, caused by the eyeball being too long, or the eye lens being unable to focus a sharp image on the retina.

Students should understand the use of convex and concave lenses to rectify these defects and assist the eye to produce a focused image on the retina.

k. Lasers are concentrated sources of light and can be used for cutting, cauterising and burning. Lasers can be used in eye surgery, to correct visual defects.

*Knowledge of how lasers work is **not** required.*

l. Comparisons can be made between the structure of the eye and the camera. In the eye the image is brought to focus on the retina by changing the shape of the lens, in a camera the image is brought to focus on the film or CCD sensor by varying the distance between the film and the lens.

Students should be aware that the film (or CCD sensor) in a camera is the equivalent of the retina in the eye.

3.4 Particle model of matter

All material in the Universe is made of very small particles. The properties of all materials, living and non-living can be understood in terms of the motion, separation and interactions of these constituent particles.

3.4.1 Kinetic theory

a. Kinetic theory can be used to explain the different states of matter and their properties. The particles in solids, liquids and gases have different amounts of energy.

Students should be able to recognise, use and compare simple diagrams to represent key features of solids, liquids and gases.

b. The specific heat capacity of a substance is the amount of energy required to change the temperature of one kilogram of the substance by one degree Celsius. The relationship between energy, E, mass, m, specific heat capacity, c, and temperature change, $\Delta\theta$, is:

$$E = m \times c \times \Delta\theta$$

c. The specific latent heat of vaporisation of a substance is the amount of energy required to change the state of one kilogram of the substance from a liquid to a vapour with no change in temperature. The relationship between energy, E, mass, m, and specific latent heat of vaporization, L_V , is:

$$E = m \times L_V$$

d. The specific latent heat of fusion of a substance is the amount of energy required to change the state of one kilogram of the substance from a solid to a liquid with no change in temperature. The relationship between energy, E, mass, m, and specific latent heat of fusion, L_F , is:

$$E = m \times L_F$$

e. The melting point of a solid and the boiling point of a liquid are affected by impurities.

Required practical:
Investigate cooling curves for stearic acid. P

Throughout Section 3.4, students should be able to explain the shape of the temperature–time graph for a substance that is either cooled or heated through changes in state.

3.4.2 Energy transfers and particle motion

a. Energy may be transferred by conduction and convection.

Students should be able to explain, in terms of particles, how these energy transfers take place. They should understand in simple terms how the arrangement and movement of particles determine whether a material is a conductor or an insulator and understand the role of free electrons in conduction through a metal. They should be able to use the idea of particles moving apart to make a fluid less dense, to explain and apply the concept of convection.

b. Energy may be transferred by evaporation and condensation.

Students should be able to explain evaporation, and the cooling effect this causes, using kinetic theory. Students should be able to discuss the factors that affect the rate of evaporation.

c. The rate at which an object transfers energy by heating depends on:

- its surface area and volume
- the material from which the object is made
- the nature of the surface with which the object is in contact.

Students should be able to explain the design of devices in terms of energy transfer, for example cooling fins, and should be able to explain animal adaptations in terms of energy transfer, for example relative ear size of animals in cold and warm climates.

d. The bigger the temperature difference between an object and its surroundings, the faster the rate at which energy is transferred by heating.

e. Most substances expand when heated.

Students should understand that the expansion of substances on heating may be a hazard (for example, the expansion of roofs and bridges) or useful (for example, the bi-metallic strip thermostat).

3.5 Electricity and magnetism

Electricity is convenient because it is easily transmitted over distances and can be easily transferred in a range of different ways. By controlling the flow of current and understanding the factors that affect this flow it can be used to make a range of applications work. Electricity is also a good context for considering how energy is transferred. Magnetism provides a connection with forces through the study of fields and the way it can produce and be produced by electricity.

3.5.1 Electrical circuits

a. Electrical charges can move easily through some substances; for example metals have many charges (electrons) that are free to move.

b. There may be an imbalance of charge in an object or area; this is known as static electricity. The charge has no conducting route to travel along. If such a route is provided, the result is a discharge. P

Students should be aware of some common instances of static electricity, such as lightning, and how they can be explained using the concepts of charge and discharge. P

c. Electric current is the rate of flow of electric charge. Charge flow, Q, current, I, and time, t, are linked by the equation:

$$I = \frac{Q}{t}$$

d. The voltage of a source is the energy supplied by a source in driving charges round a complete circuit and is measured in volts.

e. Potential difference across a component measures the energy transfer by charges and is measured in volts.

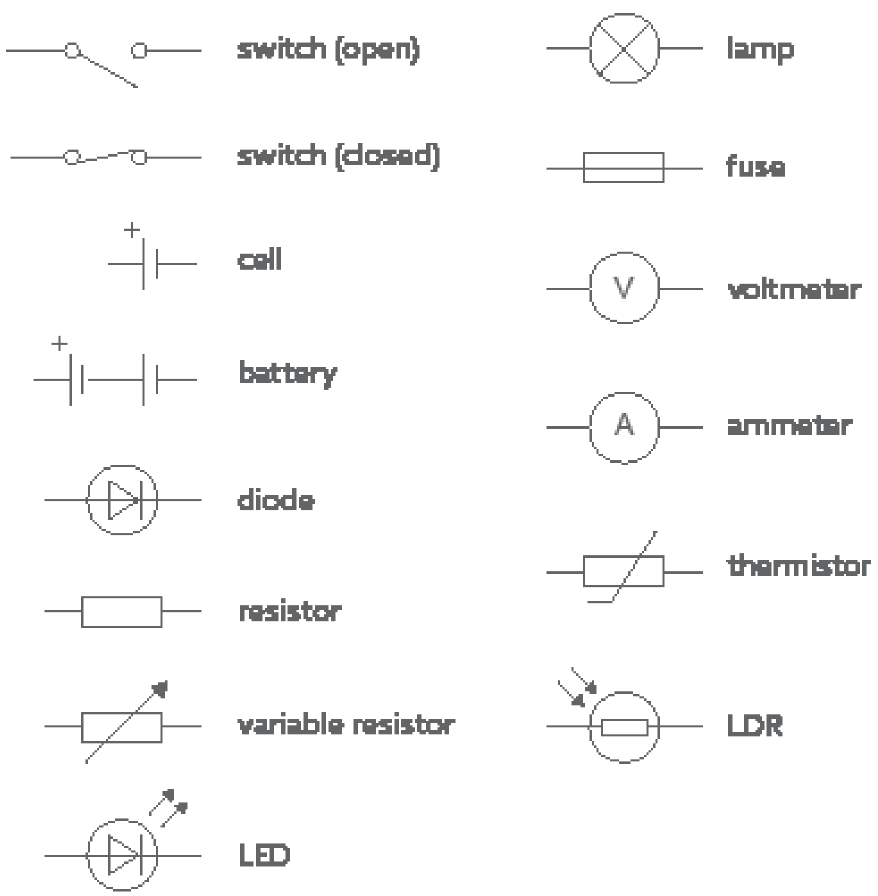
f. The relationship between potential difference, V, energy transferred, E, and charge, Q, is:

$$V = \frac{E}{Q}$$

Teachers can use either of the terms potential difference or voltage. Questions will be set using the term potential difference. Students will gain credit for the correct use of either term.

g. Circuit diagrams use standard symbols.

Students will be required to interpret and draw circuit diagrams. Students should know the following standard symbols:



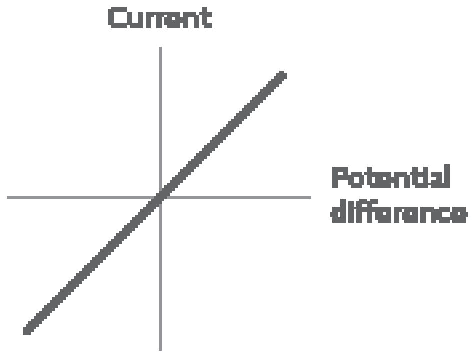
Students should understand the use of thermistors in circuits, for example thermostats.

Students should understand the use of light-dependent resistors (LDRs) in circuits, for example switching lights on when it gets dark.

h. Components resist the flow of charge through them. The greater the resistance the smaller the current for a given potential difference across the component. The resistance of a component can be found by measuring the current through and potential difference across, the component. The relationship between potential difference, V, current, I, and resistance, R, is:

$V = I \times R$

i. The current through a resistor (at a constant temperature) is directly proportional to the potential difference across the resistor. This means that the resistance remains constant as the current changes.



j. The resistance of components such as lamps, diodes, thermistors and LDRs is not constant; it changes with the current through the component.

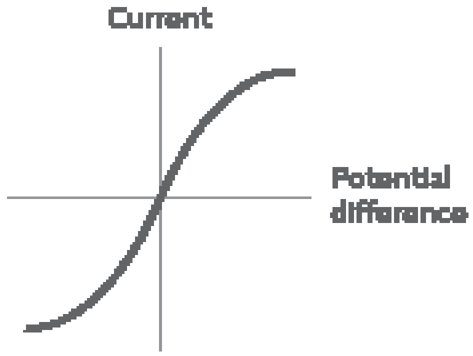
k. The resistance of a thermistor decreases as the temperature increases. P

Students should be able to describe the applications of thermistors in circuits eg a thermostat.

l. The resistance of an LDR decreases as light intensity increases. P

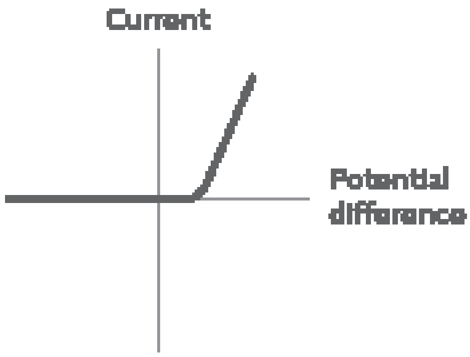
Students should be able to describe the applications of LDRs in circuits eg switching lights on when it gets dark.

m. The resistance of a filament lamp increases as the temperature of the filament increases.



Students should be able to explain change in resistance in terms of ions and electrons.

n. The 'forward' resistance is low in a diode and the 'reverse' resistance is very high. The current through a diode flows in one direction only. P



Required practical:
Investigate the V–I characteristics of a filament lamp, a diode and a resistor at constant temperature. P

o. An LED emits light when a current flows through it in the forward direction.

Students should be aware that the use of LEDs for lighting is increasing, as they use a much smaller current than other forms of lighting.

p. The combined voltage of several sources in series is their sum.

q. There are two ways of joining electrical components: in series and in parallel. Some circuits include both series and parallel parts.

r. For components connected in series:

- the combined resistance is the sum of the resistance of each component
- the current is the same in each component
- the total potential difference of the power supply is shared between the components.

s. For components connected in parallel:

- the combined resistance is less than that of either component
- the current from the supply splits in the branches
- the potential difference across each component is the same.

t. When an electrical charge flows through a resistor, the resistor gets hot because of collisions between moving charges and stationary atoms in the wire.

Students should understand that a lot of energy is wasted in filament bulbs by heating. Less energy is wasted in power saving lamps such as Compact Fluorescent Lamps (CFLs). They should understand that there is a choice when buying new appliances in how efficiently they transfer energy.

3.5.2 Magnetism and electromagnetism

a. Magnetic forces are strongest at the poles of a magnet. When two magnets are brought close together they exert a force on each other. Two like poles repel each other and two unlike poles attract. Attraction and repulsion between two magnetic poles are examples of non-contact forces.

Students should be able to predict the interaction between magnets given their physical arrangement.

b. The space around a magnet where a force acts on another magnet or on a magnetic material (iron, steel, cobalt, nickel) is called a magnetic field. The strength and direction of a magnetic field change from one point to another.

Students should be able to recognise magnetic field patterns using one or two bar magnets. In a uniform magnetic field the lines of the magnetic field are parallel.

c. An induced magnet is a material that becomes a magnet when it is placed in a magnetic field. Induced magnetism always causes a force of attraction. When removed from the magnetic field an induced magnet loses most/all of its magnetism quickly.

Students should be able to explain how a magnet attracts a magnetic object by inducing a magnetic field around it.

d. The earth has a magnetic field that is most concentrated at the magnetic north and south poles.

Students should be able to explain how a plotting compass can be used to detect the earth's magnetic field and to assist in navigation.

e. A magnetic field is produced when an electric current flows through a wire. The magnetic field lines are concentric circles in a plane, perpendicular to the wire:

- the field is stronger closer to the wire
- increasing the current makes the magnetic field stronger
- reversing the current reverses the direction of the magnetic field lines.

f. Shaping a wire to form a solenoid increases the strength of the magnetic field created by a current through the wire. The magnetic field inside a solenoid is strong and uniform.

g. The magnetic field around a solenoid has a similar shape to that of a bar magnet. Adding an iron core increases the magnetic field strength. An electromagnet consists of a solenoid with an iron core.

Students should be familiar with some typical uses of electromagnets.

Required practical:
Investigate the factors that determine the strength of an electromagnet.

3.6 Generating and distributing electricity and household use

Electricity and magnetism are linked; this has important technological consequences. In this topic magnetism and electricity are studied in the context of their uses in using current to cause motion and vice versa and in changing the voltages of an ac supply. In so doing the big ideas of field forces and energy transfer are also used.

3.6.1 Generating electricity P

a. A potential difference *(pd)* is induced across the ends of a conductor when:

- the conductor moves relative to a magnetic field
- the conductor is in a changing magnetic field.

This is called the generator effect.

Students should be able to suggest the factors that affect the size of the induced pd.

b. A potential difference is induced across the ends of a coil of wire when:

- a permanent magnet is moved into or out of the coil
- the coil is moved relative to the magnet.

c. If the conductor is part of a complete circuit, a current flows in the wire. The magnetic field produced by the induced current opposes the field of the permanent magnet.

d. If the direction of motion, or the polarity of the magnet, is reversed, the polarity of the induced potential difference and direction of flow of any induced current are reversed.

e. The size of the induced potential difference increases when:

- the speed of the movement increases
- the strength of the magnetic field increases
- the number of turns on the coil increases
- the area of the coil increases.

Students should be able to explain how an alternator generates ac and a dynamo generates dc, including graphs of potential difference generated in the coil against time. However, detailed knowledge of slip rings and split rings are not required.

f. Power stations use turbines to turn wire coils between magnets to generate electricity.

3.6.2 Electricity transmission and distribution P

a. Electricity is distributed from power stations to consumers along transmission cables with transformers at both ends.

Students should be able to identify and label the essential parts of an electric power transmission and distribution system.

b. For a given power rating, a high distribution voltage reduces the current flowing, therefore reducing energy losses due to heating and making the system more efficient.

c. A basic transformer consists of a primary coil and a secondary coil wound on a soft iron core. An alternating current in the primary coil of a transformer produces a changing magnetic field in the iron core and hence in the secondary coil. This induces a changing potential difference across the ends of the secondary coil and an alternating current flows.

*Students should be able to describe the basic structure and operation of a transformer. Knowledge of laminations and eddy currents in the core are **not** required.*

d. Step-up and step-down transformers are used to increase the voltage before the distribution lines and reduce it at the end to produce a safer voltage for local consumers.

- In a step-up transformer the potential difference across the secondary coil is greater than the potential difference across the primary coil.
- In a step-down transformer the potential difference across the secondary coil is less than the potential difference across the primary coil.

e. The potential differences across the primary and secondary coils of a transformer, V_p and V_s, are related to the number of turns on the coils, n_p and n_s, by:

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

f. For a 100% efficient transformer, the electrical power output would equal the electrical power input.

$$V_p \times I_p = V_s \times I_s$$

Where V_p and I_p are power input (primary coil) and V_s and I_s are power output (secondary coil).

Students should be aware that the turns ratio is selected to produce the required output from the input.

g. Switch mode transformers are transformers that:

- operate at a high frequency, often between 50 kHz and 200 kHz
- are much lighter and smaller than traditional transformers that work from a 50 Hz mains supply, making them useful for applications such as mobile phone chargers
- use very little power when they are switched on but no load is applied.

3.6.3 Using electricity in the home

a. Cells and batteries supply current that always passes in the same direction. This is called direct current (dc).

b. An alternating current (ac) is one that is repeatedly changing direction.

Students should be able to determine the period, and hence the frequency, of a supply from diagrams. They should be able to compare and calculate potential differences of dc supplies and the peak potential differences of ac supplies from diagrams.

c. Mains electricity is an ac supply, which has a set frequency and voltage.

Knowledge of root mean square (rms) measurements and values are not required.

d. There are a number of safety features that can be incorporated in electrical systems and appliances. One of these is earthing: if the metal body of an appliance becomes live through a fault, the current is harmlessly conducted away.

e. If an electrical fault causes too great a current to flow, a fuse or a circuit breaker in the live wire disconnects the circuit. The current will cause the fuse wire to overheat and melt or the circuit breaker to switch off ('trip'). A circuit breaker operates much faster than a fuse and can be reset.

f. Appliances with metal cases are usually earthed. If a fault develops a large current flows from the live wire to earth. This melts the fuse and disconnects the live wire.

Students should be aware that some appliances are double insulated and therefore have no earth wire connection.

3.6.4 The motor effect

a. A current carrying conductor has a magnetic field around the wire. When a current carrying conductor is placed in a magnetic field so that it cuts lines of magnetic force, the magnet and conductor exert a force on each other. This is called the motor effect. The conductor will not experience a force if it is parallel to the magnetic field.

b. The size of the force can be increased by:

- increasing the strength of the magnetic field
- increasing the size of the current
- increasing the length of the conductor in the magnetic field.

c. The direction of the force is reversed if either the direction of the current or the direction of the magnetic field is reversed.

Students should be able to identify the direction of the force using Flemings left-hand rule.

d. A coil of wire carrying a current in a magnetic field tends to rotate. This is the basis of an electric motor.

3.6.5 Transferring electrical energy

a. Electrical appliances are designed to transfer energy.

Students should be able to give examples of such devices and identify the energy transfers.

b. The rate at which energy is transferred by an appliance is called the power. The relationship between power, P, energy transferred, E, and time, t, is:

$$P = \frac{E}{t}$$

c. The power transfer, P, in any device is related to the current, I, flowing through it and potential difference, V, across it:

$$P = I \times V$$

Students should be able to calculate the current through an appliance from its power and the potential difference of the supply and from this determine the size of fuse needed.

d. The relationship between energy transferred, E, potential difference, V, and charge, Q, is:

$$E = V \times Q$$

e. The amount of energy an appliance transfers depends on how long the appliance is switched on for and its power rating. It is often more convenient to measure energy transfers in domestic appliances in kWh instead of J due to the small size of the latter.

f. The relationship between energy transferred, E, from the mains, power, P, and time, t, is:

$$E(\mathrm{kW\,h}) = P(\mathrm{kW}) \times t(\mathrm{h})$$

*Students will **not** be required to convert between kilowatt-hours and joules.*

Students should be able to calculate the cost of mains electricity given the cost per kilowatt-hour and interpret and use electricity meter readings to calculate total cost over a period of time.

3.7 Nuclear physics

The particle model is developed further in this topic. When the nucleus of an unstable atom breaks apart or the nuclei of atoms fuse together, this topic explores what might happen. Energy far greater than any reaction between atoms is released. This provides ways of actually or potentially generating power and explains processes at the centre of stars.

3.7.1 Atomic structure

a. Atoms are very small, having a radius of about 10^{-10} metres. The simple model of an atom is a small central positively charged nucleus composed of protons and neutrons, surrounded by electrons. The radius of the nucleus is much smaller than that of the atom with almost all of the mass in the nucleus.

b. The scattering of alpha particles by thin metal foil provides evidence of the distribution of mass in the atom.

c. The relative masses and electric charges of protons, neutrons and electrons are as follows:

	Relative mass	Relative charge
proton	1	1
neutron	1	0
electron	Very small	–1

d. In an atom the number of electrons is equal to the number of protons in the nucleus. The atom has no overall electrical charge.

e. In each atom its electrons are arranged at various distances from the nucleus. Atoms may lose or gain outer electrons to form charged particles called ions.

f. The atoms of a particular element always have the same number of protons, but have a different number of neutrons for each isotope. The total number of protons in an atom is called its proton number or atomic number. The total number of protons and neutrons in an atom is called its mass number. Atoms can be represented as shown:

{Mass number} 23
{Atomic number} 11 $^{23}_{11}Na$

3.7.2 Ionizing radiation from the nucleus

a. Some atomic nuclei are unstable. The nucleus emits particles or radiation and the nucleus changes to that of a different element and becomes more stable. This is a random process called radioactive decay.

b. Energy is emitted by changes in the nucleus.

c. Unstable nuclei emit alpha particles, beta particles, or neutrons, and electromagnetic radiation as gamma waves. Neither chemical nor physical processes affect this behaviour. These substances are said to be radioactive and although the general process follows a pattern this radioactive decay is a random process. It is impossible to predict when a particular atom might decay.

d. Background radiation is around us all of the time. It comes from a range of sources, such as radioactive substances in the environment, from space or from devices such as X-ray machines in hospitals.

e. An alpha particle consists of two neutrons and two protons (ie a Helium nucleus). A beta particle is a high speed electron ejected from the nucleus as a neutron turns into a proton. Gamma radiation is electromagnetic radiation from the nucleus.

f. Nuclear equations are used to represent radioactive decay.

Students will be required to balance equations for single alpha and beta decay, limited to the completion of atomic number *and mass number. The identification of daughter elements from such decays is not required.*

g. Properties of the alpha, beta and gamma radiations are limited to their relative ionising power, their penetration through materials and their range in air.

h. Radioactive decay is random, but with a large enough number of nuclei it is possible to predict how many will decay in a certain amount of time. The half-life of a radioactive isotope is: P

- the average time it takes for the number of nuclei of the isotope in a sample to halve
- the time it takes for the count rate from a sample containing the isotope to fall to half its initial level.

i. Radioactive contamination is the unwanted presence of radioactive atoms on other materials. The hazard from contamination is due to the decay of the contaminating atoms. The type of radiation emitted affects the level of hazard. Irradiation is the process of exposing an object to ionizing radiation. The irradiated object does not become radioactive. Suitable precautions must be taken to protect against the hazards of the radioactive source used in irradiation. P

Students should be able to compare the hazards associated with contamination and irradiation.

j. Radioactive isotopes have a very wide range of half-life values. The most unstable nuclei have the shortest half-lives; decay is rapid with a lot of radiation emitted in a short time. The least unstable nuclei have the longest half-lives; hey emit little radiation each second but emit radiation for a long time. There are uses and dangers associated with each type of nuclear radiation. P

Students should be able to evaluate the possible hazards associated with the use of different types of ionizing radiation and the effect of half-life.

3.7.3 Nuclear fission

a. Nuclear fission is the splitting of a large and unstable nucleus and the release of energy.

b. There are two fissionable substances in common use in nuclear reactors: uranium-235 and plutonium-239. P

Students should be aware that the majority of nuclear reactors use uranium-235.

c. For fission to occur a uranium-235 or plutonium-239 nucleus must first absorb a neutron to make the nucleus unstable. The nucleus undergoing fission splits into two smaller nuclei, releasing two or three neutrons and energy. The amount of energy released during nuclear fission is much greater than that released in a chemical reaction involving a similar mass of material.

d. A chain reaction occurs when neutrons from the fission go on to cause further fission. In a nuclear reactor control rods absorb fission neutrons to ensure that on average only one neutron per fission goes on to produce further fission and energy transfer.

Students should be able to sketch or complete a labelled diagram to illustrate how a chain reaction may occur.

e. Nuclear reactions produce waste which may be dangerous due to its radioactive nature and may remain so for a long time, depending upon its half life and products. The disposal of such waste needs to be managed with care and is a factor that may influence the use of nuclear power for the generation of electricity.

3.7.4 Nuclear fusion P

a. Nuclear fusion is the joining of two light nuclei to form a heavier nucleus.

b. In this process some of the mass of the smaller nuclei is converted into energy.

c. The force of repulsion between the two positive nuclei must be overcome for them to get close and fuse and this happens at very high temperatures and pressures.

d. Nuclear fusion is the process by which energy is released in stars.

3.8 Space physics

Space physics uses ideas about forces and motion, energy transfer, atomic structure and fields to develop explanations about the start and end of the universe and about how the Earth receives energy from the Sun. Space was one of the first challenges that civilisation tried to explain in its attempts to account for day, season, year and the appearance of the night sky and remains one of the most challenging due to its scale and complexity.

3.8.1 Life cycle of a star

a. Stars form when enough dust and gas (mainly hydrogen and helium) from space are pulled together by gravitational attraction. Smaller masses may form and be attracted by a larger mass to become planets, or even stars.

b. During the 'main sequence' period of its life cycle, energy is released by the fusion of hydrogen nuclei to make helium nuclei in the core and a star is stable because the forces within it are balanced.

*The term 'radiation pressure' will **not** be required.*

c. The core (centre) of a star is where the temperature and density are greatest and where most nuclear fusion takes place.

d. The more massive a star, the hotter its core and the heavier the nuclei it can create by fusion.

e. Stars change over time; they have a life cycle. This life cycle is determined by the mass of the star.

f. A main sequence star uses nuclear reactions to produce light and heat. When it runs out of hydrogen, what happens next in its life cycle depends upon its mass.

g. A larger star will swell to become a red supergiant, in which helium nuclei fuse to form carbon, followed by further fusion that produces heavier nuclei such as nitrogen and oxygen. It expands, cools and turns red. The outer layers then blast away as a supernova is formed. The core collapses and depending upon mass, it forms either a neutron star or a black hole.

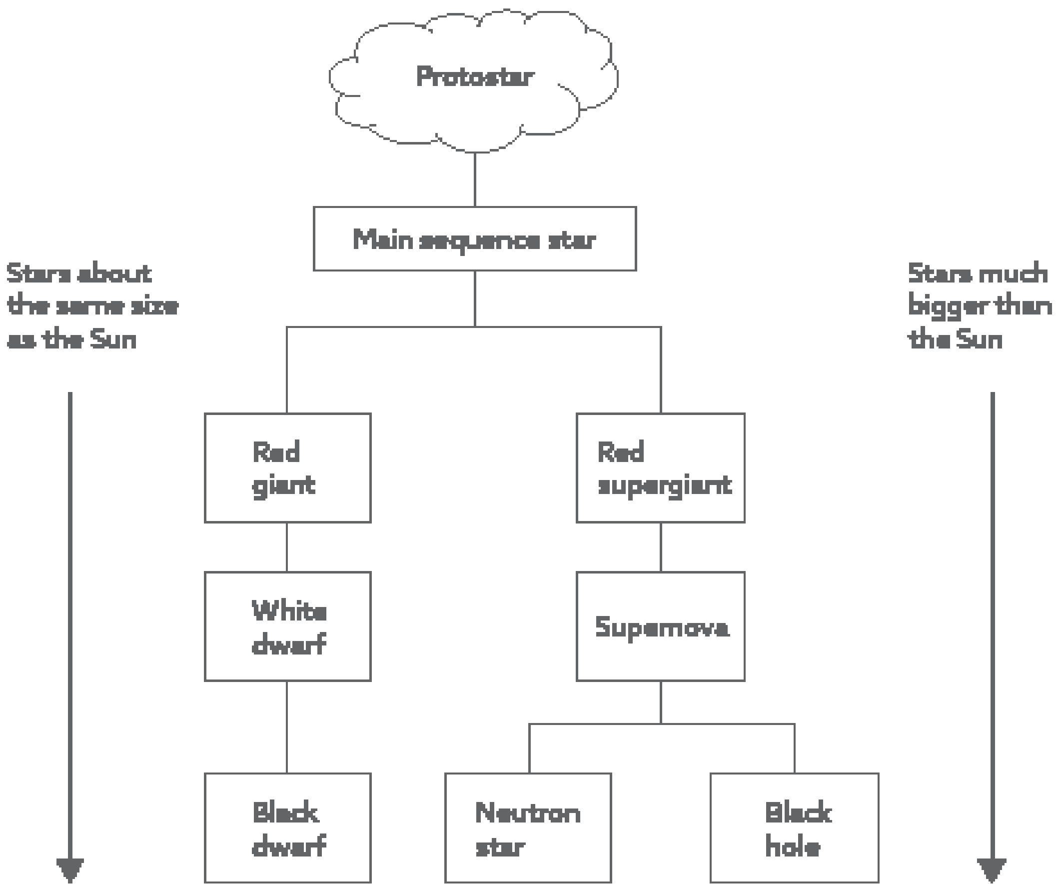
h. A smaller star, similar to our Sun, follows a different sequence, expanding to become a red giant. It then sheds out layers of gas, exposing the core as a white dwarf and finally cools to become a black dwarf.

Students should be familiar with charts that show the life cycles of stars.

i. Fusion processes in stars are the source of energy and produce all of the naturally occurring elements. These elements may be distributed throughout the universe by the explosion of a massive star (supernova) at the end of its life.

Students should be able to explain how stars are able to maintain their energy output for millions of years, why the early universe contained only hydrogen but now contains a large variety of different elements and that elements heavier than iron are formed in a supernova.

j.



3.8.2 Solar system and orbital motion

a. The Earth is one of eight planets orbiting the Sun (a medium sized star), which together with other smaller objects (asteroids, dwarf planets, comets) and moons orbiting several planets, make up the solar system.

Students should be able to describe the principal differences between planets, moons, the Sun, comets and asteroids in terms of relative size and motion.

b. Our universe is made up of:

- thousands of millions of galaxies that are each made up of thousands of millions of stars
- our Sun is one of thousands of millions of stars in our galaxy called the Milky Way.

c. Planets orbit the Sun and a moon is a natural satellite of a planet. Artificial satellites orbit the Earth and can be in geostationary or low polar orbits.

d. Gravity provides the centripetal force that keeps planets and satellites (both natural and artificial) in orbit.

e. The force of gravity acts towards the centre of the orbit. This unbalanced force causes acceleration towards the centre of the orbit, changing the direction of motion of the body (its velocity) but not its speed.

The equation for calculating centripetal force is not required.

f. The centripetal force due to gravity decreases as the separation of orbiting masses increases, resulting in lower orbital speeds.

g. At a particular separation of the masses, the centripetal force results in a particular orbital speed. To stay in a stable orbit at a particular distance, the planet or satellite moves at a particular speed. A change in orbital speed results in a change in orbital radius.

Students should be able to explain the motion of moons and artificial satellites and be able to apply this to the design of satellite placing where the speed will determine the radius of the satellite's final position.

3.8.3 Red shift and the expanding universe P

a. If a wave source is moving relative to an observer there will be a change in the observed wavelength and frequency. This is known as the Doppler effect.

Students should understand that:

- *the wave source could be, for example, light, sound or microwaves*
- *when the source moves away from the observer, the observed wavelength increases and the frequency decreases*
- *when the source moves towards the observer, the observed wavelength decreases and the frequency increases.*

b. There is an observed increase in the wavelength of light from most distant galaxies. The further away the galaxies, the faster they are moving and the bigger the observed increase in wavelength. This effect is called red shift. The observed red shift suggests that space itself is expanding and supports the Big Bang model (that the universe began from a very small initial point).

Students should be able to explain how red shift provides evidence for the Big Bang.

c. Cosmic microwave background radiation (CMBR) is a form of electromagnetic radiation filling the universe. It comes from radiation that was present shortly after the beginning of the universe.

d. Scientists believe that the universe began with a 'big bang', 14 thousand million years ago. The Big Bang theory is currently the only theory that can explain the existence of CMBR.

4 Scheme of assessment

Find mark schemes, and specimen papers for new courses, on our website at **oxfordaqa.com/9203**

This specification is designed to be taken over two years.

This is a linear qualification. In order to achieve the award, students must complete all assessments at the end of the course and in the same series.

Our International GCSE exams and certification for this specification are available for the first time in May/June 2018 and then every May/June and November for the life of the specification.

All materials are available in English only.

Our International GCSE exams in Physics include questions that allow students to demonstrate their ability to:

- recall the knowledge and understanding developed through the substantive content of the course
- apply their knowledge and understanding gained in discussing, evaluating and suggesting implications of data and evidence in both familiar and unfamiliar situations
- understand the scientific process while working scientifically and the skills developed while carrying out practical investigations.

4.1 Aims and learning outcomes

Our International GCSE in Physics should encourage students to be inspired, motivated and challenged by following a broad, coherent, practical, satisfying and worthwhile course of study. It should encourage students to develop their curiosity about the living world, enable students to engage with physics in their everyday lives in order to make informed choices about further study in physics and related disciplines.

Our International GCSE in Physics should enable students to:

- develop their knowledge and understanding of physics
- develop and apply their knowledge and understanding of the scientific process
- develop their understanding of the relationships between hypotheses, evidence, theories and explanations
- develop and apply their observational, practical, modelling, enquiry and problem-solving skills, and their understanding in laboratory, field and other learning environments
- develop their ability to evaluate claims based on science through critical analysis of the methodology, evidence and conclusions both qualitatively and quantitatively
- develop their skills in reporting and presenting information clearly and logically in different formats
- develop their skills in communication, mathematics and the use of technology in scientific contexts.

4.2 Assessment Objectives

The exams will measure how students have achieved the following assessment objectives.

- AO1: Knowledge and understanding of scientific principles.
- AO2: Application of knowledge and understanding of scientific principles and concepts in both familiar and novel contexts.
- AO3: Ability to describe, analyse, interpret and evaluate scientific information presented in different forms.
- AO4: Ability to select, describe and evaluate scientific procedures.

4.2.1 Assessment Objective weightings

Assessment Objectives (AOs)	Component weightings approx		Overall weighting (approx %)
	Paper 1	Paper 2	
AO1	20	10	30
AO2	20	20	40
AO3	7	13	20
AO4	3	7	10
Overall weighting of components (%)	50	50	100

4.3 Assessment weightings

The assessments are equally weighted.

Component	Maximum mark
Paper 1	90
Paper 2	90
Total mark:	180

5 General administration

We are committed to delivering assessments of the highest quality and have developed practices and procedures that support this aim. To ensure that all students have a fair experience, we have worked with other awarding bodies in England to develop best practice for maintaining the integrity of exams. This is published through the Joint Council for Qualifications (JCQ). We will maintain the same high standard through their use for OxfordAQA.

More information on all aspects of administration is available at **oxfordaqa.com/exams-administration**

For any immediate enquiries please contact **info@oxfordaqa.com**

Please note: We aim to respond to all email enquiries within two working days.

Our UK office hours are Monday to Friday, 8am – 5pm local time.

5.1 Entries and codes

You only need to make one entry for each qualification – this will cover all the question papers and certification.

Qualification title	OxfordAQA entry code
OxfordAQA International GCSE Physics	9203

Please check the current version of the Entry Codes book and the latest information about making entries on **oxfordaqa.com/exams-administration**

Exams will be available May/June and in November.

5.2 Overlaps with other qualifications

This specification overlaps with the AQA UK GCSE Physics (8463). This specification overlaps with the OxfordAQA International GCSE Combined Science (9204). Entry for this specification and OxfordAQA International GCSE Combined Science (9204) is **not** permitted in the same series.

5.3 Awarding grades and reporting results

In line with UK GCSEs, this qualification will be graded on a nine-point scale: 1 to 9 – where 9 is the best grade. Students who fail to reach the minimum standard for grade 1 will be recorded as U (unclassified) and will not receive a qualification certificate.

To find out more about the new grading system, visit our website at **oxfordaqa.com**

5.4 Resits

Candidates can re-take the whole qualification as many times as they wish. This is a traditional linear specification, individual components cannot be re-sat.

You only need to make one entry for each qualification – this will cover all the question papers and certification.

5.5 Previous learning and prerequisites

There are no previous learning requirements. Any requirements for entry to a course based on this specification are at the discretion of schools.

5.6 Access to assessment: equality and inclusion

Our general qualifications are designed to prepare students for a wide range of occupations and further study whilst assessing a wide range of competences.

The subject criteria have been assessed to ensure they test specific competences. The skills or knowledge required do not disadvantage particular groups of students.

Exam access arrangements are available for students with disabilities and special educational needs.

We comply with the *UK Equality Act 2010* to make reasonable adjustments to remove or lessen any disadvantage that affects a disabled student. Information about access arrangements will be issued to schools when they become OxfordAQA centres.

5.7 Working with OxfordAQA for the first time

You will need to apply to become an OxfordAQA centre to offer our specifications to your students. Find out how at **oxfordaqa.com/centreapprovals**

5.8 Private Candidates

Centres may accept private candidates for examined units/components only with the prior agreement of OxfordAQA. If you are an approved OxfordAQA centre and wish to accept private candidates, please contact OxfordAQA at: **info@oxfordaqa.com**

As some of the marks in the GCSE papers will relate to practical work, students undertaking this specification must carry out the required practical activities in section 6.2 of the specification.

Centres accepting private candidates must ensure they have carried out this minimum requirement. Private candidates may also enter for examined only units via the British Council; please contact your local British Council office for details.

6 Appendices

6.1 Experimental and investigative skills

During this course, students should be encouraged to develop their understanding of the scientific process and the skills associated with scientific enquiry. In Paper 2, students will be assessed on aspects of the skills listed below, and may be required to read and interpret information from scales given in diagrams and charts, present data in appropriate formats, design investigations and evaluate information that is presented to them.

Scientific process and skill	
Designing a practical procedure	Design a practical procedure to answer a question, solve a problem or test a hypothesis. Comment on/evaluate plans for practical procedures. Select suitable apparatus for carrying out experiments accurately and safely.
Control	Appreciate that, unless certain variables are controlled, experimental results may not be valid. Recognise the need to choose appropriate sample sizes, and study control groups where necessary.
Risk assessment	Identify possible hazards in practical situations, the risks associated with these hazards, and methods of minimising the risks.
Collecting data	Make and record observations and measurements with appropriate precision and record data collected in an appropriate format (such as a table, chart or graph).
Analysing data	Recognise and identify the cause of anomalous results and suggest what should be done about them. Appreciate when it is appropriate to calculate a mean, calculate a mean from a set of at least three results and recognise when it is appropriate to ignore anomalous results in calculating a mean. Recognise and identify the causes of random errors and systematic errors. Recognise patterns in data, form hypotheses and deduce relationships. Use and interpret tabular and graphical representations of data.
Making conclusions	Draw conclusions that are consistent with the evidence obtained and support them with scientific explanations.
Evaluation	Evaluate data, considering its repeatability, reproducibility and validity in presenting and justifying conclusions. Evaluate methods of data collection and appreciate that the evidence obtained may not allow a conclusion to be made with confidence. Suggest ways of improving an investigation or practical procedure to obtain extra evidence to allow a conclusion to be made.

6.2 Required practicals

The table below summaries the five required practicals:

Specification	Suggested required practicals
1. Forces and their effects 3.1.1 Forces and their interactions	Investigate the relationship between force and extension for a spring.
2. Waves 3.3.5 Refraction and total internal reflection	Investigate the refraction of light by different substances.
3. Particle model of matter 3.4.1 Kinetic theory P	Investigate cooling curves for stearic acid.
4. Electricity and magnetism 3.5.1 Electrical circuits P	Investigate the V-I characteristics of a filament lamp, a diode and a resistor at constant temperature.
5. Electricity and magnetism 3.5.2 Magnetism and electromagnetism	Investigate the factors that determine the strength of an electromagnet.

Opportunities to develop experimental and investigative skills during the teaching and learning of the required practicals are indicated in the table below.

Scientific process and skill	Investigating the relationship between force and extension for a spring	Investigating refraction of light by glass blocks	Investigating cooling curve for stearic acid	Investigating the V-I characteristics of a filament lamp, a diode and a resistor at constant temperature	Investigating the factors that determine the strength of an electromagnet
Designing a practical procedure	✓	x	x	✓	✓
Control	✓	✓	x	✓	✓
Risk assessment	✓	✓	✓	✓	✓
Collecting data	✓	✓	✓	✓	✓
Analysing data	✓	✓	✓	✓	✓
Making conclusions	✓	✓	✓	✓	✓
Evaluation	✓	✓	✓	✓	✓

6.3 Mathematical requirements

Mathematical requirements

This specification provides learners with the opportunity to develop their skills in communication, mathematics and the use of technology in scientific contexts. In order to deliver the mathematical element of this outcome, assessment materials for this specification contain opportunities for students to demonstrate scientific knowledge using appropriate mathematical skills.

The areas of mathematics that arise naturally from the science content are listed below. This is not a checklist for each question paper, but assessments reflect these mathematical requirements, covering the full range of mathematical skills over a reasonable period of time.

Students are permitted to use calculators in all assessments.

Students are expected to use units appropriately. However, not all questions reward the appropriate use of units.

All Students should be able to:

1. Understand number size and scale and the quantitative relationship between units.
2. Understand when and how to use estimation.
3. Carry out calculations involving +, –, x, ÷, either singly or in combination, decimals, fractions, percentages and positive whole number powers.
4. Provide answers to calculations to an appropriate number of significant figures.
5. Understand and use the symbols =, <, >, ~
6. Understand and use direct proportion and simple ratios.
7. Calculate arithmetic means.
8. Understand and use common measures and simple compound measures such as speed.
9. Plot and draw graphs (line graphs, bar charts, pie charts, scatter graphs, histograms) selecting appropriate scales for the axes.
10. Substitute numerical values into simple formulae and equations using appropriate units.
11. Translate information between graphical and numeric form.
12. Extract and interpret information from charts, graphs and tables.
13. Understand the idea of probability.
14. Calculate area, perimeters and volumes of simple shapes.
15. Use angular measures in degrees.
16. Interpret order and calculate with numbers written in standard form.
17. Carry out calculations involving negative powers (only –1 for rate).
18. Change the subject of an equation.
19. Understand and use inverse proportion.
20. Understand and use percentiles and deciles.

Units, symbols and nomenclature

Units, symbols and nomenclature used in examination papers will normally conform to the recommendations contained in the following:

- *The Language of Measurement: Terminology used in school science investigations*. Association for Science Education (ASE), 2010. ISBN 978 0 86357 424 5.
- *Signs, Symbols and Systematics – the ASE companion to 16–19 Science*. Association for Science Education (ASE), 2000. ISBN 978 0 86357 312 5.
- *Signs, Symbols and Systematics – the ASE companion to 5–16 Science*. Association for Science Education (ASE), 1995. ISBN 0 86357 232 4.

6.4 Physics equation sheet

$v = \frac{s}{t}$	v s t	velocity displacement time
$a = \frac{\Delta v}{t}$	a Δv t	acceleration change in velocity time taken
$F = m \times a$	F m a	force mass acceleration
$p = m \times v$	p m v	momentum mass velocity
$F = \frac{\Delta p}{t}$	F Δp t	force change in momentum time
$W = m \times g$	W m g	weight mass gravitational field strength
$F = k \times e$	F k e	force spring constant extension
$W = F \times d$	W F d	work done force distance moved in the direction of the force
$P = \frac{W}{t}$	P W t	power work done time
$P = \frac{E}{t}$	P E t	power energy transferred time
$E_p = m \times g \times h$	E_p m g h	change in gravitational potential energy mass gravitational field strength (acceleration of free fall) height
$E_k = \frac{1}{2} \times m \times v^2$	E_k m v	kinetic energy mass velocity
$E_e = \frac{1}{2} \times k \times e^2$	E_e k e	elastic potential energy spring constant extension
$M = F \times d$	M F d	moment of the force force perpendicular distance from the line of action of the force to the pivot

$v = f \times \lambda$	v f λ	speed frequency wavelength
$n = \frac{\sin i}{\sin r}$	n i r	refractive index angle of incidence angle of refraction
$n = \frac{1}{\sin c}$	n c	refractive index critical angle
$\text{magnification} = \frac{\text{image height}}{\text{object height}}$		
$E = m \times c \times \Delta\theta$	E m c $\Delta\theta$	energy mass specific heat capacity temperature change
$E = m \times L_V$	E m L_V	energy mass specific latent heat of vaporisation
$E = m \times L_F$	E m L_F	energy mass specific latent heat of fusion
$\text{efficiency} = \frac{\text{useful energy out}}{\text{total energy in}} (\times 100\%)$		
$\text{efficiency} = \frac{\text{useful power out}}{\text{total power in}} (\times 100\%)$		
$I = \frac{Q}{t}$	I Q t	current charge flow time
$V = \frac{E}{Q}$	V E Q	potential difference energy transferred charge
$V = I \times R$	V I R	potential difference current resistance
$P = I \times V$	P I V	power current potential difference
$E(\text{kW h}) = P(\text{kW}) \times t(\text{h})$	E P t	energy transferred power time

$\frac{V_p}{V_s} = \frac{n_p}{n_s}$	V_p potential difference across the primary coil V_s potential difference across the secondary coil n_p number of turns on the primary coil n_s number of turns on the secondary coil
$V_p \times I_p = V_s \times I_s$	V_p potential difference across the primary coil I_p current in the primary coil V_s potential difference across the secondary coil I_s current in the secondary coil

6.5 Glossary of subject specific terminology

The following subject specific vocabulary provides definitions of key terms used in our International GCSE science specifications.

Wherever possible we have used the definitions derived from a booklet created in a joint project of the Association for Science Education and the Nuffield Foundation:

The Language of Measurement: Terminology used in school science investigations. Association for Science Education (ASE), 2010. ISBN 978 0 86357 424 5.

This list is **draft** and subject to change.

Accuracy

A measurement result is considered accurate if it is judged to be close to the true value.

Calibration

Marking a scale on a measuring instrument.

This involves establishing the relationship between indications of a measuring instrument and standard or reference quantity values, which must be applied.

For example, placing a thermometer in melting ice to see whether it reads zero, in order to check if it has been calibrated correctly.

Data

Information, either qualitative or quantitative, that has been collected.

Errors

See also uncertainty.

Measurement error: the difference between a measured value and the true value.

Anomalies: these are values in a set of results which are judged not to be part of the variation caused by random uncertainty.

Random error: these cause readings to be spread about the true value, due to results varying in an unpredictable way from one measurement to the next. Random errors are present when any measurement is made, and cannot be corrected. The effect of random errors can be reduced by making more measurements and calculating a new mean.

Systematic error: these cause readings to differ from the true value by a consistent amount each time a measurement is made. Sources of systematic error can include the environment, methods of observation or instruments used. Systematic errors cannot be dealt with by simple repeats. If a systematic error is suspected, the data collection should be repeated using a different technique or a different set of equipment, and the results compared.

Zero error: any indication that a measuring system gives a false reading when the true value of a measured quantity is zero, eg the needle on an ammeter failing to return to zero when no current flows. A zero error may result in a systematic uncertainty.

Evidence

Data which has been shown to be valid.

Fair test

A fair test is one in which only the independent variable has been allowed to affect the dependent variable.

Hypothesis

A proposal intended to explain certain facts or observations.

Interval

The quantity between readings, eg a set of 11 readings equally spaced over a distance of 1 metre would give an interval of 10 centimetres.

Precision

Precise measurements are ones in which there is very little spread about the mean value.

Precision depends only on the extent of random errors – it gives no indication of how close results are to the true value.

Prediction

A prediction is a statement suggesting what will happen in the future, based on observation, experience or a hypothesis.

Range

The maximum and minimum values of the independent or dependent variables; important in ensuring that any pattern is detected.

For example a range of distances may be quoted as either: 'From 10 cm to 50 cm' or 'From 50 cm to 10 cm'.

Repeatable

A measurement is repeatable if the original experimenter repeats the investigation using same method and equipment and obtains the same results.

Reproducible

A measurement is reproducible if the investigation is repeated by another person, or by using different equipment or techniques, and the same results are obtained.

Resolution

This is the smallest change in the quantity being measured (input) of a measuring instrument that gives a perceptible change in the reading.

Sketch graph

A line graph, not necessarily on a grid, that shows the general shape of the relationship between two variables. It will not have any points plotted and although the axes should be labelled they may not be scaled.

True value

This is the value that would be obtained in an ideal measurement.

Uncertainty

The interval within which the true value can be expected to lie, with a given level of confidence or probability, eg 'the temperature is 20 °C ± 2 °C, at a level of confidence of 95%'.

Validity

Suitability of the investigative procedure to answer the question being asked. For example, an investigation to find out if the rate of a chemical reaction depended upon the concentration of one of the reactants would not be a valid procedure if the temperature of the reactants was not controlled.

Valid conclusion

A conclusion supported by valid data, obtained from an appropriate experimental design and based on sound reasoning.

Variables

These are physical, chemical or biological quantities or characteristics.

Categoric: categoric variables have values that are labels eg names of plants or types of material.

Continuous: continuous variables can have values (called a quantity) that can be given a magnitude either by counting (as in the case of the number of shrimp) or by measurement (eg light intensity, flow rate etc).

Control: a control variable is one which may, in addition to the independent variable, affect the outcome of the investigation and therefore has to be kept constant or at least monitored.

Dependent: the dependent variable is the variable of which the value is measured for each and every change in the independent variable.

Independent: the independent variable is the variable for which values are changed or selected by the investigator.

Terms no longer used

The term 'discrete variable' will no longer be used as this has been subsumed by the definition of 'continuous variable'.

The terms 'reliable' and 'reliability' will no longer be used. Instead, the terms 'repeatable' or 'repeatability' and 'reproducible' or 'reproducibility' will be used.

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