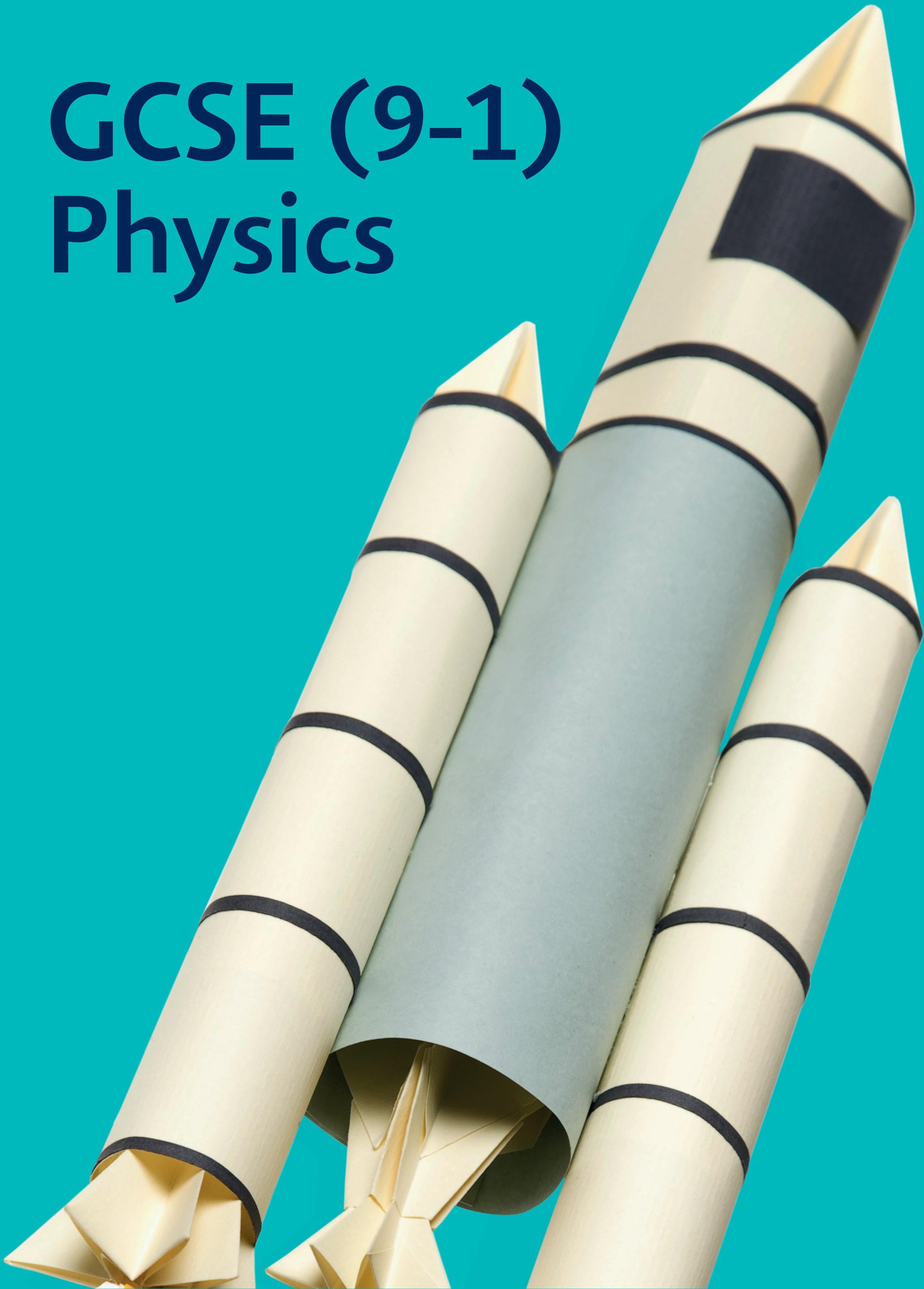
GCSE (9-1) Physics



Specification

Pearson Edexcel Level 1/Level 2 GCSE (9-1) in Physics (1PH0)

First teaching from September 2016

First certification from June 2018

Issue 1

ALWAYS LEARNING

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Contents

1 Introduction

Why choose Edexcel GCSE in Physics?

Supporting success in science

Science matters. That's why we've built the most inclusive GCSE (9–1) courses, so every student can enjoy science and succeed in their studies.

Every student is different. With the same science and equal number of exams across our tiered qualifications, you can structure the courses in the ways that mean you can best support and stretch your students together.

Our specifications are straightforward, and our selection of core practicals are designed to help bring science learning to life. And when it comes to our assessments, they're shaped to encourage all students to best show what they know and can do.

Supporting you in planning and implementing this qualification

Planning

- Our **Getting Started** guide gives you an overview of the new GCSE qualifications to help you to get to grips with the changes to content and assessment and to help you understand what these changes mean for you and your students.
- We will give you editable **schemes of work** that you can adapt to suit your department.
- **Our mapping documents** highlight key differences between the new and 2011 qualifications.

Teaching and learning

There will be lots of free teaching and learning support to help you deliver the new qualifications, including:

- a free series of teacher, student and technician **worksheets** will help cover each element of planning and delivering every core practical
- a free **practical** guide to help you prepare for the changes to practical assessment
- a free **maths** guide for scientists to help you embed mathematics in your science teaching.

Preparing for exams

We will also provide a range of resources to help you prepare your students for the assessments, including:

- additional assessment materials to support formative assessments and mock exams
- marked exemplars of student work with examiner commentaries.

ResultsPlus

ResutsPlus provides the most detailed analysis available of your students' exam performance. It can help you identify the topics and skills where further learning would benefit your students.

Get help and support

Our subject advisor service, led by Stephen Nugus and Julius Edwards will ensure you receive help and guidance from us and that you can share ideas and information with other teachers.

Learn more at qualifications.pearson.com

examWizard

examWizard is a free exam preparation tool containing a bank of Edexcel GCSE Science exam questions, mark schemes and examiners' reports. Existing questions will be reviewed and tagged to our new specifications so they can still be used, and question descriptions will be updated.

Qualification at a glance

Content and assessment overview

The Pearson Edexcel Level 1/Level 2 GCSE (9–1) in Physics consists of two externally-examined papers. These are available at foundation tier and higher tier.

Students must complete all assessments in the same tier.

Students must complete all assessment in May/June in any single year.

Paper 1 (*Paper code: 1PH0/1F and 1PH0/1H)
Written examination: 1 hour and 45 minutes ***50% of the qualification*** ***100 marks***
Content overview • Topic 1 – Key concepts of physics • Topic 2 – Motion and forces • Topic 3 – Conservation of energy • Topic 4 – Waves • Topic 5 – Light and the electromagnetic spectrum • Topic 6 – Radioactivity • Topic 7 – Astronomy
Assessment overview A mixture of different question styles, including multiple-choice questions, short answer questions, calculations and extended open-response questions.

Paper 2 (Paper code: 1PH0/2F and 1PH0/2H)
Written examination: 1 hour and 45 minutes ***50% of the qualification*** ***100 marks***
Content overview • Topic 1 – Key concepts of physics • Topic 8 – Energy - Forces doing work • Topic 9 – Forces and their effects • Topic 10 – Electricity and circuits • Topic 11 – Static electricity • Topic 12 – Magnetism and the motor effect • Topic 13 – Electromagnetic induction • Topic 14 – Particle model • Topic 15 – Forces and matter
Assessment overview A mixture of different question styles, including multiple-choice questions, short answer questions, calculations and extended open-response questions.

*See *Appendix 9: Codes* for a description of this code and all other codes relevant to this qualification.

2 Subject content

Qualification aims and objectives

GCSE study in the sciences provides the foundation for understanding the material world. Scientific understanding is changing our lives and is vital to the world's future prosperity. All students should learn essential aspects of the knowledge, methods, processes and uses of science. They should gain appreciation of how the complex and diverse phenomena of the natural world can be described in terms of a small number of key ideas that relate to the sciences and that are both inter-linked and of universal application. These key ideas include:

- the use of conceptual models and theories to make sense of the observed diversity of natural phenomena
- the assumption that every effect has one or more cause
- that change is driven by differences between different objects and systems when they interact
- that many such interactions occur over a distance without direct contact
- that science progresses through a cycle of hypothesis, practical experimentation, observation, theory development and review
- that quantitative analysis is a central element both of many theories and of scientific methods of inquiry.

These key ideas will be assessed through the content of this qualification in the examinations.

These key ideas are relevant in different ways and with different emphases in the three subjects. Examples of their relevance are given for each subject in the separate sections below for Biology, Chemistry and Physics.

The three GCSE Science qualifications enable students to:

- develop scientific knowledge and conceptual understanding through the specific disciplines of Biology, Chemistry and Physics
- develop understanding of the nature, processes and methods of science, through different types of scientific enquiries that help them to answer scientific questions about the world around them
- develop and learn to apply observational, practical, modelling, enquiry and problem-solving skills in the laboratory, in the field and in 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.

Students should study the sciences in ways that help them to develop curiosity about the natural world, that give them an insight into how science works and that enable them to appreciate its relevance to their everyday lives. The scope and nature of the study should be broad, coherent, practical and satisfying. It should encourage students to be inspired, motivated and challenged by the subject and its achievements.

The key ideas specific to the Physics content include:

- the use of models, as in the particle model of matter or the wave models of light and of sound
- the concept of cause and effect in explaining such links as those between force and acceleration, or between changes in atomic nuclei and radioactive emissions

- the phenomena of 'action at a distance' and the related concept of the field as the key to analysing electrical, magnetic and gravitational effects
- that differences, for example between pressures or temperatures or electrical potentials, are the drivers of change
- that proportionality, for example between weight and mass of an object or between force and extension in a spring, is an important aspect of many models in science
- that physical laws and models are expressed in mathematical form.

All of these key ideas will be assessed as part of this qualification, through the subject content.

Working scientifically

The GCSE in Physics requires students to develop the skills, knowledge and understanding of working scientifically. Working scientifically will be assessed through examination and the completion of the eight core practicals.

1 Development of scientific thinking

a Understand how scientific methods and theories develop over time.

b Use a variety of models, such as representational, spatial, descriptive, computational and mathematical, to solve problems, make predictions and to develop scientific explanations and an understanding of familiar and unfamiliar facts.

c Appreciate the power and limitations of science, and consider any ethical issues that may arise.

d Explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments.

e Evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequences.

f Recognise the importance of peer review of results and of communicating results to a range of audiences.

2 Experimental skills and strategies

a Use scientific theories and explanations to develop hypotheses.

b Plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena.

c Apply a knowledge of a range of techniques, instruments, apparatus and materials to select those appropriate to the experiment.

d Carry out experiments appropriately, having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.

e Recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative.

f Make and record observations and measurements using a range of apparatus and methods.

g Evaluate methods and suggest possible improvements and further investigations.

3 Analysis and evaluation

Apply the cycle of collecting, presenting and analysing data, including:

a presenting observations and other data using appropriate methods

b translating data from one form to another

c carrying out and representing mathematical and statistical analysis

d representing distributions of results and making estimations of uncertainty

e interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions

f presenting reasoned explanations, including relating data to hypotheses

g being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error

h communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions through paper-based and electronic reports and presentations using verbal, diagrammatic, graphical, numerical and symbolic forms.

4 Scientific vocabulary, quantities, units, symbols and nomenclature

a Use scientific vocabulary, terminology and definitions.

b Recognise the importance of scientific quantities and understand how they are determined.

c Use SI units (e.g. kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate.

d Use prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano).

e Interconvert units.

f Use an appropriate number of significant figures in calculation.

Practical work

The content includes eight mandatory core practicals, indicated as an entire specification point in italics.

Students must carry out all eight of the mandatory core practicals listed below.

Core practical:

2.19 *Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*

4.17 *Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*

5.9 *Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter*

5.19P *Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed*.

10.17 *Construct electrical circuits to:*

a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp

b test series and parallel circuits using resistors and filament lamps

14.3 *Investigate the densities of solid and liquids*

14.11 *Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice*

15.6 *Investigate the extension and work done when applying forces to a spring*

Students will need to use their knowledge and understanding of these practical techniques and procedures in the written assessments.

Centres must confirm that each student has completed the eight mandatory core practicals.

Students need to record the work that they have undertaken for the eight mandatory core practicals. The practical record must include the knowledge, skills and understanding they have derived from the practical activities. Centres must complete and submit a Practical Science Statement (see *Appendix 6*) to confirm that all students have completed the eight mandatory core practicals. This must be submitted to Pearson by 15th April in the year that the students will sit their examinations. Any failure by centres to provide this Practical Science Statement will be treated as malpractice and/or maladministration.

Scientific diagrams should be included, where appropriate, to show the set-up and to record the apparatus and procedures used in practical work.

It is important to realise that these core practicals are the minimum number of practicals that should be taken during the course. Suggested additional practicals are given beneath the content at the end of each topic. The eight mandatory core practicals cover all aspects of the apparatus and techniques listed in *Appendix 5: Apparatus and techniques*. This appendix also includes more detailed instructions for each core practical, which must be followed.

Safety is an overriding requirement for all practical work. Centres are responsible for ensuring appropriate safety procedures are followed whenever their students complete practical work.

These core practicals may be reviewed and amended if changes are required to the apparatus and techniques listed by the Department for Education. Pearson may also review and amend the core practicals if necessary. Centres will be told as soon as possible about any changes to core practicals.

Qualification content

The following notation is used in the tables that show the content for this qualification:

- text in **bold** indicates content that is for higher tier only
- entire specification points in italics indicates the core practicals.

Specification statement numbers with a P in them refer to content which is only in the GCSE in Physics and is not found in the GCSE in Combined Science (e.g. 3.18P).

Mathematics

Maths skills that can be assessed in relation to a specification point are referenced in the maths column, next to this specification point. Please see *Appendix 1: Mathematical skills* for full details of each maths skill.

After each topic of content in this specification, there are details relating to the 'Use of mathematics' which contains the Physics specific mathematic skills that are found in each topic of content in the document *Biology, Chemistry and Physics GCSE subject content*, published by the Department for Education (DfE) in June 2014. The reference in brackets after each statement refers to the mathematical skills from *Appendix 1*.

Equations

The required physics equations are listed in *Appendix 2: Equations in Physics*. The first list shows the equations which students are expected to recall for use in the exam papers. These equations may sometimes be given in the exam papers. The equations required for higher tier only are shown in bold text. These equations are also listed in the specification content.

Topics common to Paper 1 and Paper 2

Topic 1 – Key concepts of physics

Students should:		Maths skills
1.1	Recall and use the SI unit for physical quantities, as listed in *Appendix 3*	
1.2	Recall and use multiples and sub-multiples of units, including giga (G), mega (M), kilo (k), centi (c), milli (m), micro (μ) and nano (n)	3c
1.3	Be able to convert between different units, including hours to seconds	1c
1.4	Use significant figures and standard form where appropriate	1b

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).

Topics for Paper 1

Topic 2 – Motion and forces

Students should:		Maths skills
2.1	Explain that a scalar quantity has magnitude (size) but no specific direction	
2.2	Explain that a vector quantity has both magnitude (size) and a specific direction	5b
2.3	Explain the difference between vector and scalar quantities	5b
2.4	Recall vector and scalar quantities, including: a displacement/distance b velocity/speed c acceleration d force e weight/mass f momentum g energy	
2.5	Recall that velocity is speed in a stated direction	5b
2.6	Recall and use the equations: a (average) speed (metre per second, m/s) = distance (metre, m) ÷ time (s) b distance travelled (metre, m) = average speed (metre per second, m/s) × time (s)	1a, 1c, 1d 2a 3a, 3c, 3d
2.7	Analyse distance/time graphs including determination of speed from the gradient	2a 4a, 4b, 4d, 4e
2.8	Recall and use the equation: acceleration (metre per second squared, m/s^2) = change in velocity (metre per second, m/s) ÷ time taken (second, s) $a = \frac{(v - u)}{t}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
2.9	Use the equation: (final velocity)^2 ((metre/second)^2, (m/s)^2) – (initial velocity)^2 ((metre/second)^2, (m/s)^2) = 2 × acceleration (metre per second squared, m/s^2) × distance (metre, m) $v^2 - u^2 = 2 \times a \times x$	1a, 1c, 1d 2a 3a, 3c, 3d

Students should:		Maths skills
2.10	Analyse velocity/time graphs to: a compare acceleration from gradients qualitatively b calculate the acceleration from the gradient (for uniform acceleration only) c determine the distance travelled using the area between the graph line and the time axis (for uniform acceleration only)	1a, 1c, 1d 2a 4a, 4b, 4c, 4d, 4e, 4f 5c
2.11	Describe a range of laboratory methods for determining the speeds of objects such as the use of light gates	1a, 1d 2a, 2b, 2c, 2f, 2h 3a, 3c, 3d 4a, 4c
2.12	Recall some typical speeds encountered in everyday experience for wind and sound, and for walking, running, cycling and other transportation systems	
2.13	Recall that the acceleration, g, in free fall is 10 m/s^2 and be able to estimate the magnitudes of everyday accelerations	1d 2h
2.14	Recall Newton's first law and use it in the following situations: a where the resultant force on a body is zero, i.e. the body is moving at a constant velocity or is at rest b where the resultant force is not zero, i.e. the speed and/or direction of the body change(s)	1a, 1d 2a 3a, 3c, 3d
2.15	Recall and use Newton's second law as: force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s^2) $F = m \times a$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
2.16	Define weight, recall and use the equation: weight (newton, N) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg) $W = m \times g$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
2.17	Describe how weight is measured	
2.18	Describe the relationship between the weight of a body and the gravitational field strength	1c
2.19	*Core Practical: Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*	1a, 1c,1d 2a, 2b, 2f 3a, 3b, 3c, 3d 4a, 4b, 4c, 4d

Students should:		Maths skills
2.20	**Explain that an object moving in a circular orbit at constant speed has a changing velocity (qualitative only)**	5b
2.21	**Explain that for motion in a circle there must be a resultant force known as a centripetal force that acts towards the centre of the circle**	5b
2.22	**Explain that inertial mass is a measure of how difficult it is to change the velocity of an object (including from rest) and know that it is defined as the ratio of force over acceleration**	1c,
2.23	Recall and apply Newton's third law **both** to equilibrium situations **and to collision interactions and relate it to the conservation of momentum in collisions**	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
2.24	**Define momentum, recall and use the equation:** **momentum (kilogram metre per second, kg m/s) = mass (kilogram, kg) × velocity (metre per second, m/s)** $p = m \times v$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
2.25	**Describe examples of momentum in collisions**	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
2.26	**Use Newton's second law as:** **force (newton, N) = change in momentum (kilogram metre per second, kg m/s) ÷ time (second, s)** $F = \frac{(mv - mu)}{t}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
2.27	Explain methods of measuring human reaction times and recall typical results	2a, 2b, 2c, 2g
2.28	Recall that the stopping distance of a vehicle is made up of the sum of the thinking distance and the braking distance	1a
2.29	Explain that the stopping distance of a vehicle is affected by a range of factors including: a the mass of the vehicle b the speed of the vehicle c the driver's reaction time d the state of the vehicle's brakes e the state of the road f the amount of friction between the tyre and the road surface	1c, 1d 2b, 2c, 2h 3b, 3c

Students should:		Maths skills
2.30	Describe the factors affecting a driver’s reaction time including drugs and distractions	1d 2b, 2h 3c
2.31	Explain the dangers caused by large decelerations **and estimate the forces involved in typical situations on a public road**	1c, 1d, 2c, 2h, 3b, 3c
2.32P	Estimate how the distance required for a road vehicle to stop in an emergency varies over a range of typical speeds	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
2.33P	Carry out calculations on work done to show the dependence of braking distance for a vehicle on initial velocity squared (work done to bring a vehicle to rest equals its initial kinetic energy)	1c, 1d 2b, 2h 3b, 3c

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- Relate changes and differences in motion to appropriate distance-time, and velocity-time graphs, and interpret lines and slopes (4a, 4b, 4c, 4d).
- **Interpret enclosed areas in velocity-time graphs (4a, 4b, 4c, 4d, 4f).**
- Apply formulae relating distance, time and speed, for uniform motion, and for motion with uniform acceleration, and calculate average speed for non-uniform motion (1a, 1c, 3c).
- Estimate how the distances required for road vehicles to stop in an emergency, varies over a range of typical speeds (1c, 1d, 2c, 2h, 3b, 3c).
- Apply formulae relating force, mass and relevant physical constants, including gravitational field strength, to explore how changes in these are inter-related (1c, 3b, 3c).
- Apply formulae relating force, mass, velocity and acceleration to explain how the changes involved are inter-related (3b, 3c, 3d).
- Estimate, for everyday road transport, the speed, accelerations and forces involved in large accelerations (1d, 2b, 2h, 3c).

Suggested practicals

- Investigate the acceleration, g, in free fall and the magnitudes of everyday accelerations.
- Investigate conservation of momentum during collisions.
- Investigate inelastic collisions with the two objects remaining together after the collision and also ‘near’ elastic collisions.
- Investigate the relationship between mass and weight.
- Investigate how crumple zones can be used to reduce the forces in collisions.

Topic 3 – Conservation of energy

Students should:		Maths skills
3.1	Recall and use the equation to calculate the change in gravitational PE when an object is raised above the ground: change in gravitational potential energy (joule, J) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg) × change in vertical height (metre, m) $\Delta GPE = m \times g \times \Delta h$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
3.2	Recall and use the equation to calculate the amounts of energy associated with a moving object: kinetic energy (joule, J) = $\frac{1}{2}$ × mass (kilogram, kg) × (speed)^2 ((metre/second)^2, (m/s)^2) $KE = \frac{1}{2} \times m \times v^2$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
3.3	Draw and interpret diagrams to represent energy transfers	1c 2c
3.4	Explain what is meant by conservation of energy	
3.5	Analyse the changes involved in the way energy is stored when a system changes, including: a an object projected upwards or up a slope b a moving object hitting an obstacle c an object being accelerated by a constant force d a vehicle slowing down e bringing water to a boil in an electric kettle	
3.6	Explain that where there are energy transfers in a closed system there is no net change to the total energy in that system	
3.7	Explain that mechanical processes become wasteful when they cause a rise in temperature so dissipating energy in heating the surroundings	
3.8	Explain, using examples, how in all system changes energy is dissipated so that it is stored in less useful ways	
3.9	Explain ways of reducing unwanted energy transfer including through lubrication, thermal insulation	
3.10	Describe the effects of the thickness and thermal conductivity of the walls of a building on its rate of cooling qualitatively	
3.11	Recall and use the equation: $\text{efficiency} = \frac{(\text{useful energy transferred by the device})}{(\text{total energy supplied to the device})}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d

Students should:		Maths skills
3.12	**Explain how efficiency can be increased**	
3.13	Describe the main energy sources available for use on Earth (including fossil fuels, nuclear fuel, bio-fuel, wind, hydro-electricity, the tides and the Sun), and compare the ways in which both renewable and non-renewable sources are used	2c, 2g
3.14	Explain patterns and trends in the use of energy resources	2c, 2g

Uses of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- Calculate relevant values of stored energy and energy transfers; convert between newton-metres and joules (1c, 3c).
- Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system (1a, 1c, 3c).

Suggested practicals

- Investigate conservation of energy.

Topic 4 – Waves

Students should:		Maths skills
4.1	Recall that waves transfer energy and information without transferring matter	
4.2	Describe evidence that with water and sound waves it is the wave and not the water or air itself that travels	
4.3	Define and use the terms frequency and wavelength as applied to waves	
4.4	Use the terms amplitude, period, wave velocity and wavefront as applied to waves	
4.5	Describe the difference between longitudinal and transverse waves by referring to sound, electromagnetic, seismic and water waves	
4.6	Recall and use both the equations below for all waves: wave speed (metre/second, m/s) = frequency (hertz, Hz) × wavelength (metre, m) $v = f \times \lambda$ wave speed (metre/second, m/s) = distance (metre, m) ÷ time (second, s) $v = \frac{x}{t}$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
4.7	Describe how to measure the velocity of sound in air and ripples on water surfaces	2g
4.8P	**Calculate depth or distance from time and wave velocity**	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
4.9P	Describe the effects of a reflection b refraction c transmission d absorption of waves at material interfaces	5b
4.10	Explain how waves will be refracted at a boundary in terms of the change of direction **and speed**	1c 3c 5b
4.11	**Recall that different substances may absorb, transmit, refract or reflect waves in ways that vary with wavelength**	

Students should:		Maths skills
4.12P	**Describe the processes which convert wave disturbances between sound waves and vibrations in solids, and** **a explain why such processes only work over a limited frequency range** **b use this to explain the way the human ear works**	
4.13P	**Recall that sound with frequencies greater than 20 000 hertz, Hz, is known as ultrasound**	
4.14P	**Recall that sound with frequencies less than 20 hertz, Hz, is known as infrasound**	
4.15P	**Explain uses of ultrasound and infrasound, including** **a sonar** **b foetal scanning** **c exploration of the Earth's core**	1a, 1b, 1c, 2a 3a, 3b, 3c, 3d 5b
4.16P	Describe how changes, if any, in velocity, frequency and wavelength, in the transmission of sound waves from one medium to another are inter-related	1a, 1c, 1d 2a 3a, 3c, 3d
4.17	*Core Practical: Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*	2g

Use of mathematics

- Apply formulae relating velocity, frequency and wavelength (1c, 3c).
- Show how changes, if any, in velocity, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related (1c, 3c).

Suggested practicals

- Investigate models to show refraction, such as toy cars travelling into a region of sand.
- Investigate refraction in rectangular glass blocks.

Topic 5 – Light and the electromagnetic spectrum

Students should:		Maths skills
5.1P	Explain, with the aid of ray diagrams, reflection, refraction and total internal reflection (TIR), including the law of reflection and critical angle	5a, 5b
5.2P	Explain the difference between specular and diffuse reflection	5b
5.3P	Explain how colour of light is related to a differential absorption at surfaces b transmission of light through filters	
5.4P	Relate the power of a lens to its focal length and shape	5b
5.5P	Use ray diagrams to show the similarities and differences in the refraction of light by converging and diverging lenses	5b
5.6P	Explain the effects of different types of lens in producing real and virtual images	5b
5.7	Recall that all electromagnetic waves are transverse, that they travel at the same speed in a vacuum	
5.8	Explain, with examples, that all electromagnetic waves transfer energy from source to observer	
5.9	*Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter*	
5.10	Recall the main groupings of the continuous electromagnetic spectrum including (in order) radio waves, microwaves, infrared, visible (including the colours of the visible spectrum), ultraviolet, x-rays and gamma rays	
5.11	Describe the electromagnetic spectrum as continuous from radio waves to gamma rays and that the radiations within it can be grouped in order of decreasing wavelength and increasing frequency	1a, 1c 3c
5.12	Recall that our eyes can only detect a limited range of frequencies of electromagnetic radiation	
5.13	**Recall that different substances may absorb, transmit, refract or reflect electromagnetic waves in ways that vary with wavelength**	
5.14	Explain the effects of differences in the velocities of electromagnetic waves in different substances	1a, 1c 3c
5.15P	Explain that all bodies emit radiation, that the intensity and wavelength distribution of any emission depends on their temperature	5c
5.16P	**Explain that for a body to be at a constant temperature it needs to radiate the same average power that it absorbs**	

Students should:		Maths skills
5.17P	**Explain what happens to a body if the average power it radiates is less or more than the average power that it absorbs**	
5.18P	**Explain how the temperature of the Earth is affected by factors controlling the balance between incoming radiation and radiation emitted**	
5.19P	*Core Practical: Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed*	1a, 1c, 1d 2a, 2c, 2f 3a, 3c, 3d 4a, 4c
5.20	Recall that the potential danger associated with an electromagnetic wave increases with increasing frequency	
5.21	Describe the harmful effects on people of excessive exposure to electromagnetic radiation, including: a microwaves: internal heating of body cells b infrared: skin burns c ultraviolet: damage to surface cells and eyes, leading to skin cancer and eye conditions d x-rays and gamma rays: mutation or damage to cells in the body	
5.22	Describe some uses of electromagnetic radiation a radio waves: including broadcasting, communications and satellite transmissions b microwaves: including cooking, communications and satellite transmissions c infrared: including cooking, thermal imaging, short range communications, optical fibres, television remote controls and security systems d visible light: including vision, photography and illumination e ultraviolet: including security marking, fluorescent lamps, detecting forged bank notes and disinfecting water f x-rays: including observing the internal structure of objects, airport security scanners and medical x-rays g gamma rays: including sterilising food and medical equipment, and the detection of cancer and its treatment	
5.23	**Recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits**	
5.24	Recall that changes in atoms and nuclei can a generate radiations over a wide frequency range b be caused by absorption of a range of radiations	

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- Apply the relationships between frequency and wavelength across the electromagnetic spectrum (1a, 1c, 3c).
- Construct two-dimensional ray diagrams to illustrate reflection and refraction (qualitative – equations not needed) (5a, 5b).

Suggested practicals

- Investigate total internal reflection using a semi-circular block (glass or plastic).
- Construct devices using two converging lenses of differing focal lengths.
- Construct a simple spectrometer, from a CD or DVD, and use it to analyse common light sources.
- Investigate the areas beyond the visible spectrum, such as the work of Herschel and Ritter in discovering IR and UV respectively.

Topic 6 – Radioactivity

Students should:		Maths skills
6.1	Describe an atom as a positively charged nucleus, consisting of protons and neutrons, surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atom and with almost all of the mass in the nucleus	5b
6.2	Recall the typical size (order of magnitude) of atoms and small molecules	
6.3	Describe the structure of nuclei of isotopes using the terms atomic (proton) number and mass (nucleon) number and using symbols in the format using symbols in the format $^{13}_{6}C$	1a 3a
6.4	Recall that the nucleus of each element has a characteristic positive charge, but that isotopes of an element differ in mass by having different numbers of neutrons	2g 5b
6.5	Recall the relative masses and relative electric charges of protons, neutrons, electrons and positrons	
6.6	Recall that in an atom the number of protons equals the number of electrons and is therefore neutral	
6.7	Recall that in each atom its electrons orbit the nucleus at different set distances from the nucleus	5b
6.8	Explain that electrons change orbit when there is absorption or emission of electromagnetic radiation	5b
6.9	Explain how atoms may form positive ions by losing outer electrons	5b
6.10	Recall that alpha, β– (beta minus), β+ (positron), gamma rays and neutron radiation are emitted from unstable nuclei in a random process	
6.11	Recall that alpha, β– (beta minus), β+ (positron) and gamma rays are ionising radiations	
6.12	Explain what is meant by background radiation	
6.13	Describe the origins of background radiation from Earth and space	
6.14	Describe methods for measuring and detecting radioactivity limited to photographic film and a Geiger–Müller tube	
6.15	Recall that an alpha particle is equivalent to a helium nucleus, a beta particle is an electron emitted from the nucleus and a gamma ray is electromagnetic radiation	
6.16	Compare alpha, beta and gamma radiations in terms of their abilities to penetrate and ionise	

Students should:		Maths skills
6.17	Describe how and why the atomic model has changed over time including reference to the plum pudding model and Rutherford alpha particle scattering leading to the Bohr model	5b
6.18	Describe the process of β– decay (a neutron becomes a proton plus an electron)	1b, 1c, 3c
6.19	Describe the process of β+ decay (a proton becomes a neutron plus a positron)	1b, 1c, 3c
6.20	Explain the effects on the atomic (proton) number and mass (nucleon) number of radioactive decays (α, β, γ and neutron emission)	1b, 1c, 3c
6.21	Recall that nuclei that have undergone radioactive decay often undergo nuclear rearrangement with a loss of energy as gamma radiation	
6.22	Use given data to balance nuclear equations in terms of mass and charge	1b, 1c, 3c
6.23	Describe how the activity of a radioactive source decreases over a period of time	2g 4c
6.24	Recall that the unit of activity of a radioactive isotope is the Becquerel, Bq	
6.25	Explain that the half-life of a radioactive isotope is the time taken for half the undecayed nuclei to decay or the activity of a source to decay by half	1c, 1d 2a
6.26	Explain that it cannot be predicted when a particular nucleus will decay but half-life enables the activity of a very large number of nuclei to be predicted during the decay process	1c, 3d
6.27	Use the concept of half-life to carry out simple calculations on the decay of a radioactive isotope, including graphical representations	1a, 1b, 1c, 1d 2a, 2g 3a, 3b, 3c, 3d
6.28P	Describe uses of radioactivity, including: a household fire (smoke) alarms b irradiating food c sterilisation of equipment d tracing and gauging thicknesses e diagnosis and treatment of cancer	
6.29	Describe the dangers of ionising radiation in terms of tissue damage and possible mutations and relate this to the precautions needed	
6.30P	Explain how the dangers of ionising radiation depend on half-life and relate this to the precautions needed	

Students should:		Maths skills
6.31	Explain the precautions taken to ensure the safety of people exposed to radiation, including limiting the dose for patients and the risks to medical personnel	
6.32	Describe the differences between contamination and irradiation effects and compare the hazards associated with these two	
6.33P	Compare and contrast the treatment of tumours using radiation applied internally or externally	5b
6.34P	Explain some of the uses of radioactive substances in diagnosis of medical conditions, including PET scanners and tracers	
6.35P	Explain why isotopes used in PET scanners have to be produced nearby	
6.36P	Evaluate the advantages and disadvantages of nuclear power for generating electricity, including the lack of carbon dioxide emissions, risks, public perception, waste disposal and safety issues	
6.37P	Recall that nuclear reactions, including fission, fusion and radioactive decay, can be a source of energy	
6.38P	Explain how the fission of U-235 produces two daughter nuclei and the emission of two or more neutrons, accompanied by a release of energy	1b, 1c, 3c
6.39P	Explain the principle of a controlled nuclear chain reaction	
6.40P	Explain how the chain reaction is controlled in a nuclear reactor, including the action of moderators and control rods	5b
6.41P	Describe how thermal (heat) energy from the chain reaction is used in the generation of electricity in a nuclear power station	
6.42P	Recall that the products of nuclear fission are radioactive	
6.43P	Describe nuclear fusion as the creation of larger nuclei resulting in a loss of mass from smaller nuclei, accompanied by a release of energy, and recognise fusion as the energy source for stars	1b, 1c, 3c
6.44P	Explain the difference between nuclear fusion and nuclear fission	
6.45P	Explain why nuclear fusion does not happen at low temperatures and pressures, due to electrostatic repulsion of protons	
6.46P	Relate the conditions for fusion to the difficulty of making a practical and economic form of power station	

Uses of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- Balance equations representing alpha-, beta- or gamma-radiations in terms of the masses and charges of the atoms involved (1b, 1c, 3c).
- **Calculate the net decline, expressed as a ratio, in a radioactive emission after a given number of half-lives (1c, 3d).**

Suggested practicals

- Investigate models which simulate radioactive decay.

Topic 7 – Astronomy

Students should:		Maths skills
7.1P	Explain how and why both the weight of any body and the value of g differ between the surface of the Earth and the surface of other bodies in space, including the Moon	
7.2P	Recall that our Solar System consists of the Sun (our star), eight planets and their natural satellites (such as our Moon); dwarf planets; asteroids and comets	5b
7.3P	Recall the names and order, in terms of distance from the Sun, of the eight planets	
7.4P	Describe how ideas about the structure of the Solar System have changed over time	5b
7.5P	Describe the orbits of moons, planets, comets and artificial satellites	5b
7.6P	Explain for circular orbits how the force of gravity can lead to changing velocity of a planet but unchanged speed	5b
7.7P	Explain how, for a stable orbit, the radius must change if orbital speed changes (qualitative only)	
7.8P	Compare the Steady State and Big Bang theories	5b
7.9P	Describe evidence supporting the Big Bang theory, limited to red-shift and the cosmic microwave background (CMB) radiation	
7.10P	Recall that as there is more evidence supporting the Big Bang theory than the Steady State theory, it is the currently accepted model for the origin of the Universe	
7.11P	Describe that if a wave source is moving relative to an observer there will be a change in the observed frequency and wavelength	5b
7.12P	Describe the red-shift in light received from galaxies at different distances away from the Earth	2g 5b
7.13P	Explain why the red-shift of galaxies provides evidence for the Universe expanding	5b
7.14P	Explain how both the Big Bang and Steady State theories of the origin of the Universe both account for red-shift of galaxies	
7.15P	Explain how the discovery of the CMB radiation led to the Big Bang theory becoming the currently accepted model	

Students should:		Maths skills
7.16P	Describe the evolution of stars of similar mass to the Sun through the following stages: a nebula b star (main sequence) c red giant d white dwarf	2g
7.17P	Explain how the balance between thermal expansion and gravity affects the life cycle of stars	
7.18P	Describe the evolution of stars with a mass larger than the Sun	2g
7.19P	Describe how methods of observing the Universe have changed over time including why some telescopes are located outside the Earth's atmosphere	

Topics for Paper 2

Topic 8 – Energy – forces doing work

Students should:		Maths skills
8.1	Describe the changes involved in the way energy is stored when systems change	
8.2	Draw and interpret diagrams to represent energy transfers	1c, 2c
8.3	Explain that where there are energy transfers in a closed system there is no net change to the total energy in that system	
8.4	Identify the different ways that the energy of a system can be changed a through work done by forces b in electrical equipment c in heating	
8.5	Describe how to measure the work done by a force and understand that energy transferred (joule, J) is equal to work done (joule, J)	
8.6	Recall and use the equation: work done (joule, J) = force (newton, N) × distance moved in the direction of the force (metre, m) $E = F \times d$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d 4f
8.7	Describe and calculate the changes in energy involved when a system is changed by work done by forces	
8.8	Recall and use the equation to calculate the change in gravitational PE when an object is raised above the ground: change in gravitational potential energy (joule, J) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg) × change in vertical height (metre, m) $\Delta GPE = m \times g \times \Delta h$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
8.9	Recall and use the equation to calculate the amounts of energy associated with a moving object: kinetic energy (joule, J) = $\frac{1}{2}$ × mass (kilogram, kg) × (speed)^2 ((metre/second)^2, (m/s)^2) $KE = \frac{1}{2} \times m \times v^2$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
8.10	Explain, using examples, how in all system changes energy is dissipated so that it is stored in less useful ways	

Students should:		Maths skills
8.11	Explain that mechanical processes become wasteful when they cause a rise in temperature so dissipating energy in heating the surroundings	
8.12	Define power as the rate at which energy is transferred and use examples to explain this definition	1c
8.13	Recall and use the equation: power (watt, W) = work done (joule, J) ÷ time taken (second, s) $P = \frac{E}{t}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
8.14	Recall that one watt is equal to one joule per second, J/s	1c
8.15	Recall and use the equation: $\text{efficiency} = \frac{(\text{useful energy transferred by the device})}{(\text{total energy supplied to the device})}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d

Use of mathematics

- Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system (1a, 1c, 3c).
- Calculate relevant values of stored energy and energy transfers; convert between newton-metres and joules (1c, 3c).
- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).

Suggested practicals

- Investigate power by moving up the stairs, step-ups onto a low platform or lifting objects of different weights.

Topic 9 – Forces and their effects

Students should:		Maths skills
9.1	Describe, with examples, how objects can interact a at a distance without contact, linking these to the gravitational, electrostatic and magnetic fields involved b by contact, including normal contact force and friction c producing pairs of forces which can be represented as vectors	
9.2	Explain the difference between vector and scalar quantities using examples	
9.3	**Use vector diagrams to illustrate resolution of forces, a net force, and equilibrium situations (scale drawings only)**	4a, 5a, 5b
9.4	**Draw and use free body force diagrams**	4a, 5a, 5b
9.5	**Explain examples of the forces acting on an isolated solid object or a system where several forces lead to a resultant force on an object and the special case of balanced forces when the resultant force is zero**	5a
9.6P	Describe situations where forces can cause rotation	
9.7P	Recall and use the equation: moment of a force (newton metre, N m) = force (newton, N) × distance normal to the direction of the force (metre, m)	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
9.8P	Recall and use the principle of moments in situations where rotational forces are in equilibrium: the sum of clockwise moments = the sum of anti-clockwise moments for rotational forces in equilibrium	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
9.9P	Explain how levers and gears transmit the rotational effects of forces	5b
9.10	Explain ways of reducing unwanted energy transfer through lubrication	

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- **Use vector diagrams to illustrate resolution of forces, a net force, and equilibrium situations (scale drawings only) (4a, 5a, 5b).**

Suggested practicals

- Investigate levers and gears.

Topic 10 – Electricity and circuits

Students should:		Maths skills
10.1	Describe the structure of the atom, limited to the position, mass and charge of protons, neutrons and electrons	5b
10.2	Draw and use electric circuit diagrams representing them with the conventions of positive and negative terminals, and the symbols that represent cells, including batteries, switches, voltmeters, ammeters, resistors, variable resistors, lamps, motors, diodes, thermistors, LDRs and LEDs	5b
10.3	Describe the differences between series and parallel circuits	
10.4	Recall that a voltmeter is connected in parallel with a component to measure the potential difference (voltage), in volt, across it	
10.5	Explain that potential difference (voltage) is the energy transferred per unit charge passed and hence that the volt is a joule per coulomb	1a, 1c 3c
10.6	Recall and use the equation: energy transferred (joule, J) = charge moved (coulomb, C) × potential difference (volt, V) $E = Q \times V$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
10.7	Recall that an ammeter is connected in series with a component to measure the current, in amp, in the component	
10.8	Explain that an electric current as the rate of flow of charge and the current in metals is a flow of electrons	
10.9	Recall and use the equation: charge (coulomb, C) = current (ampere, A) × time (second, s) $Q = I \times t$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
10.10	Describe that when a closed circuit includes a source of potential difference there will be a current in the circuit	
10.11	Recall that current is conserved at a junction in a circuit	
10.12	Explain how changing the resistance in a circuit changes the current and how this can be achieved using a variable resistor	
10.13	Recall and use the equation: potential difference (volt, V) = current (ampere, A) × resistance (ohm, Ω) $V = I \times R$	1a, 1d 2a 3a, 3c, 3d
10.14	Explain why, if two resistors are in series, the net resistance is increased, whereas with two in parallel the net resistance is decreased	

Students should:		Maths skills
10.15	Calculate the currents, potential differences and resistances in series circuits	1a, 1d 2a 3a, 3c, 3d
10.16	Explain the design and construction of series circuits for testing and measuring	
10.17	*Core Practical: Construct electrical circuits to:* *a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp* *b test series and parallel circuits using resistors and filament lamps*	1a, 1c, 1d 2a, 2b, 2f 3a, 3b, 3c, 3d 4a, 4b, 4c, 4d, 4e
10.18	Explain how current varies with potential difference for the following devices and how this relates to resistance a filament lamps b diodes c fixed resistors	2g 4a, 4b, 4c, 4d, 4e
10.19	Describe how the resistance of a light-dependent resistor (LDR) varies with light intensity	4c, 4d
10.20	Describe how the resistance of a thermistor varies with change of temperature (negative temperature coefficient thermistors only)	4c, 4d
10.21	Explain how the design and use of circuits can be used to explore the variation of resistance in the following devices a filament lamps b diodes c thermistors d LDRs	5b
10.22	Recall that, when there is an electric current in a resistor, there is an energy transfer which heats the resistor	
10.23	Explain that electrical energy is dissipated as thermal energy in the surroundings when an electrical current does work against electrical resistance	
10.24	Explain the energy transfer (in 10.22 above) as the result of collisions between electrons and the ions in the lattice	
10.25	Explain ways of reducing unwanted energy transfer through low resistance wires	
10.26	Describe the advantages and disadvantages of the heating effect of an electric current	

Students should:		Maths skills
10.27	Use the equation: energy transferred (joule, J) = current (ampere, A) × potential difference (volt, V) × time (second, s) $E = I \times V \times t$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
10.28	Describe power as the energy transferred per second and recall that it is measured in watt	1c
10.29	Recall and use the equation: power (watt, W) = energy transferred (joule, J) ÷ time taken (second, s) $P = \frac{E}{t}$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
10.30	Explain how the power transfer in any circuit device is related to the potential difference across it and the current in it	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
10.31	Recall and use the equations: electrical power (watt, W) = current (ampere, A) × potential difference (volt, V) $P = I \times V$ electrical power (watt, W) = current squared (ampere^2, A^2) × resistance (ohm, Ω) $P = I^2 \times R$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
10.32	Describe how, in different domestic devices, energy is transferred from batteries and the a.c. mains to the energy of motors and heating devices	
10.33	Explain the difference between direct and alternating voltage	4c
10.34	Describe direct current (d.c.) as movement of charge in one direction only and recall that cells and batteries supply direct current (d.c.)	
10.35	Describe that in alternating current (a.c.) the movement of charge changes direction	
10.36	Recall that in the UK the domestic supply is a.c., at a frequency of 50 Hz and a voltage of about 230 V	
10.37	Explain the difference in function between the live and the neutral mains input wires	
10.38	Explain the function of an earth wire and of fuses or circuit breakers in ensuring safety	
10.39	Explain why switches and fuses should be connected in the live wire of a domestic circuit	

Students should:		Maths skills
10.40	Recall the potential differences between the live, neutral and earth mains wires	
10.41	Explain the dangers of providing any connection between the live wire and earth	
10.42	Describe, with examples, the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use	1c 2c

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- Apply the equations relating p.d., current, quantity of charge, resistance, power, energy, and time, and solve problems for circuits which include resistors in series, using the concept of equivalent resistance (1c, 3b, 3c, 3d).
- Use graphs to explore whether circuit elements are linear or non-linear and relate the curves produced to their function and properties (4c, 4d).
- Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system (1a, 1c, 3c).

Suggested practicals

- Investigate the power consumption of low-voltage electrical items.

Topic 11 – Static electricity

Students should:		Maths skills
11.1P	Explain how an insulator can be charged by friction, through the transfer of electrons	
11.2P	Explain how the material gaining electrons becomes negatively charged and the material losing electrons is left with an equal positive charge	
11.3P	Recall that like charges repel and unlike charges attract	
11.4P	Explain common electrostatic phenomena in terms of movement of electrons, including a shocks from everyday objects b lightning c attraction by induction such as a charged balloon attracted to a wall and a charged comb picking up small pieces of paper	
11.5P	Explain how earthing removes excess charge by movement of electrons	
11.6P	Explain some of the uses of electrostatic charges in everyday situations, including insecticide sprayers	
11.7P	Describe some of the dangers of sparking in everyday situations, including fuelling cars, and explain the use of earthing to prevent dangerous build-up of charge	
11.8P	Define an electric field as the region where an electric charge experiences a force	
11.9P	Describe the shape and direction of the electric field around a point charge and between parallel plates and relate the strength of the field to the concentration of lines	5b
11.10P	Explain how the concept of an electric field helps to explain the phenomena of static electricity	

Suggested practicals

- Investigate the forces of attraction and repulsion between charged objects.

Topic 12 – Magnetism and the motor effect

Students should:		Maths skills
12.1	Recall that unlike magnetic poles attract and like magnetic poles repel	
12.2	Describe the uses of permanent and temporary magnetic materials including cobalt, steel, iron and nickel	
12.3	Explain the difference between permanent and induced magnets	
12.4	Describe the shape and direction of the magnetic field around bar magnets and for a uniform field, and relate the strength of the field to the concentration of lines	5b
12.5	Describe the use of plotting compasses to show the shape and direction of the field of a magnet and the Earth's magnetic field	5b
12.6	Explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic	5b
12.7	Describe how to show that a current can create a magnetic effect around a long straight conductor, describing the shape of the magnetic field produced and relating the direction of the magnetic field to the direction of the current	5b
12.8	Recall that the strength of the field depends on the size of the current and the distance from the long straight conductor	
12.9	Explain how inside a solenoid (an example of an electromagnet) the fields from individual coils a add together to form a very strong almost uniform field along the centre of the solenoid b cancel to give a weaker field outside the solenoid	5b
12.10	**Recall that a current carrying conductor placed near a magnet experiences a force and that an equal and opposite force acts on the magnet**	5b
12.11	**Explain that magnetic forces are due to interactions between magnetic fields**	
12.12	**Recall and use Fleming's left-hand rule to represent the relative directions of the force, the current and the magnetic field for cases where they are mutually perpendicular**	5b

Students should:		Maths skills
12.13	**Use the equation:** **force on a conductor at right angles to a magnetic field carrying a current (newton, N) = magnetic flux density (tesla, T or newton per ampere metre, N/A m) × current (ampere, A) × length (metre, m)** $\boldsymbol{F = B \times I \times l}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
12.14P	**Explain how the force on a conductor in a magnetic field is used to cause rotation in electric motors**	5b

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).

Suggested practicals

- Construct an electric motor.

Topic 13 – Electromagnetic induction

Students should:		Maths skills
13.1P	**Explain how to produce an electric current by the relative movement of a magnet and a conductor** **a on a small scale in the laboratory** **b in the large-scale generation of electrical energy**	
13.2	**Recall the factors that affect the size and direction of an induced potential difference, and describe how the magnetic field produced opposes the original change**	5b
13.3P	**Explain how electromagnetic induction is used in alternators to generate current which alternates in direction (a.c.) and in dynamos to generate direct current (d.c.)**	5b
13.4P	**Explain the action of the microphone in converting the pressure variations in sound waves into variations in current in electrical circuits, and the reverse effect as used in loudspeakers and headphones**	5b
13.5	**Explain how an alternating current in one circuit can induce a current in another circuit in a transformer**	
13.6	**Recall that a transformer can change the size of an alternating voltage**	
13.7P	**Use the turns ratio equation for transformers to calculate either the missing voltage or the missing number of turns:** $\frac{\text{potential difference across primary coil}}{\text{potential difference across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$ $\frac{V_p}{V_s} = \frac{N_p}{N_s}$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d 5b
13.8	Explain why, in the national grid, electrical energy is transferred at high voltages from power stations, and then transferred at lower voltages in each locality for domestic uses as it improves the efficiency by reducing heat loss in transmission lines	
13.9	Explain where and why step-up and step-down transformers are used in the transmission of electricity in the national grid	

Students should:		Maths skills
13.10	Use the power equation (for transformers with100% efficiency): potential difference across primary coil (volt, V) × current in primary coil (ampere, A) = potential difference across secondary coil (volt, V) × current in secondary coil (ampere, A) $V_P \times I_P = V_S \times I_S$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
13.11P	**Explain the advantages of power transmission in high-voltage cables, using the equations in 10.29, 10.31, 13.7P and 13.10**	1a, 1c, 1d 2a 3a, 3b, 3c, 3d 5b

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- **Apply the equations linking the p.d.s and numbers of turns in the two coils of a transformer, to the currents and the power transfer involved, and relate these to the advantages of power transmission at high voltages (1c, 3b, 3c).**
- Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system (1a, 1c, 3c).

Suggested practicals

- Investigate factors affecting the generation of electric current by induction.

Topic 14 – Particle model

Students should:		Maths skills
14.1	Use a simple kinetic theory model to explain the different states of matter (solids, liquids and gases) in terms of the movement and arrangement of particles	
14.2	Recall and use the equation: density (kilogram per cubic metre, kg/m^3) = mass (kilogram, kg) ÷ volume (cubic metre, m^3) $\rho = \frac{m}{V}$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d 5c
14.3	*Core Practical: Investigate the densities of solid and liquids*	1a, 1b, 1c, 1d 2a, 2c, 2f 3a, 3b, 3c, 3d 4a, 4c 5c
14.4	Explain the differences in density between the different states of matter in terms of the arrangements of the atoms or molecules	5b
14.5	Describe that when substances melt, freeze, evaporate, boil, condense or sublimate mass is conserved and that these physical changes differ from some chemical changes because the material recovers its original properties if the change is reversed	
14.6	Explain how heating a system will change the energy stored within the system and raise its temperature or produce changes of state	
14.7	Define the terms specific heat capacity and specific latent heat and explain the differences between them	
14.8	Use the equation: change in thermal energy (joule, J) = mass (kilogram, kg) × specific heat capacity (joule per kilogram degree Celsius, J/kg °C) × change in temperature (degree Celsius, °C) $\Delta Q = m \times c \times \Delta\theta$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
14.9	Use the equation: thermal energy for a change of state (joule , J) = mass (kilogram, kg) × specific latent heat (joule per kilogram, J/kg) $Q = m \times L$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
14.10	Explain ways of reducing unwanted energy transfer through thermal insulation	

Students should:		Maths skills
14.11	*Core Practical: Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice*	1a, 1b, 1c, 1d 2a, 2b, 2f 3a, 3b, 3c, 3d 4a, 4c, 4e
14.12	Explain the pressure of a gas in terms of the motion of its particles	5b
14.13	Explain the effect of changing the temperature of a gas on the velocity of its particles and hence on the pressure produced by a fixed mass of gas at constant volume (qualitative only)	5b
14.14	Describe the term absolute zero, −273 °C, in terms of the lack of movement of particles	
14.15	Convert between the kelvin and Celsius scales	1a 2a
14.16P	Explain that gases can be compressed or expanded by pressure changes	
14.17P	Explain that the pressure of a gas produces a net force at right angles to any surface	
14.18P	Explain the effect of changing the volume of a gas on the rate at which its particles collide with the walls of its container and hence on the pressure produced by a fixed mass of gas at constant temperature	5b
14.19P	Use the equation: $P_1 \times V_1 = P_2 \times V_2$ to calculate pressure or volume for gases of fixed mass at constant temperature	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
14.20P	**Explain why doing work on a gas can increase its temperature, including a bicycle pump**	

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system (1a, 1c, 3c).
- Calculate relevant values of stored energy and energy transfers; convert between newton-metres and joules (1c, 3c).
- Apply the relationship between density, mass and volume to changes where mass is conserved (1a, 1b, 1c, 3c).
- Apply the relationship between change in internal energy of a material and its mass, specific heat capacity and temperature change to calculate the energy change involved; apply the relationship between specific latent heat and mass to calculate the energy change involved in a change of state (1a, 3c, 3d).

Suggested practicals

- Investigate the temperature and volume relationship for a gas.
- Investigate the volume and pressure relationship for a gas.
- Investigate latent heat of vaporisation.

Topic 15 – Forces and matter

Students should:		Maths skills
15.1	Explain, using springs and other elastic objects, that stretching, bending or compressing an object requires more than one force	
15.2	Describe the difference between elastic and inelastic distortion	
15.3	Recall and use the equation for linear elastic distortion including calculating the spring constant: force exerted on a spring (newton, N) = spring constant (newton per metre, N/m) × extension (metre, m) $F = k \times x$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d
15.4	Use the equation to calculate the work done in stretching a spring: energy transferred in stretching (joules, J) = 0.5 × spring constant (newton per metre, N/m) × (extension (metre, m))^2 $E = \frac{1}{2} \times k \times x^2$	1a, 1c, 1d 2a 3a, 3b, 3c, 3d 4c, 4e, 4f
15.5	Describe the difference between linear and non-linear relationships between force and extension	4c, 4e
15.6	*Core Practical: Investigate the extension and work done when applying forces to a spring*	1a, 1c, 1d 2a, 2b, 2c, 2f 3a, 3b, 3c, 3d 4a, 4b, 4c, 4d
15.7P	Explain why atmospheric pressure varies with height above the Earth's surface with reference to a simple model of the Earth's atmosphere	
15.8P	Describe the pressure in a fluid as being due to the fluid and atmospheric pressure	
15.9P	Recall that the pressure in fluids causes a force normal to any surface	
15.10P	Explain how pressure is related to force and area, using appropriate examples	1c
15.11P	Recall and use the equation: pressure (pascal, Pa) = force normal to surface (newton, N) ÷ area of surface (square metre, m^2) $P = \frac{F}{A}$	1a, 1b, 1c, 1d 2a 3a, 3c, 3d 5b, 5c
15.12P	Describe how pressure in fluids increases with depth and density	1c

Students should:		Maths skills
15.13P	**Explain why the pressure in liquids varies with density and depth**	1c
15.14P	**Use the equation to calculate the magnitude of the pressure in liquids and calculate the differences in pressure at different depths in a liquid:** **pressure due to a column of liquid (pascal, Pa) = height of column (metre, m) × density of liquid (kilogram per cubic metre, kg/m^3) × gravitational field strength (newton per kilogram, N/kg)** $P = h \times \rho \times g$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
15.15P	**Explain why an object in a fluid is subject to an upwards force (upthrust) and relate this to examples including objects that are fully immersed in a fluid (liquid or gas) or partially immersed in a liquid**	5b
15.16P	**Recall that the upthrust is equal to the weight of fluid displaced**	
15.17P	**Explain how the factors (upthrust, weight, density of fluid) influence whether an object will float or sink**	5b

Use of mathematics

- Make calculations using ratios and proportional reasoning to convert units and to compute rates (1c, 3c).
- **Calculate the differences in pressure at different depths in a liquid (1c, 3c).**
- Calculate relevant values of stored energy and energy transfers; convert between newton-metres and joules (1c, 3c).
- Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system (1a, 1c, 3c).

Suggested practicals

- Investigate the upthrust on objects in different liquids.
- Investigate the stretching of rubber bands.

3 Assessment information

Paper 1 (Paper code: 1PH0/1F, 1PH0/1H) • First assessment: May/June 2018. • The assessment is 1 hour and 45 minutes. • The assessment is out of 100 marks. • The assessment consists of ten questions. • Students must answer all questions. • The paper will include multiple-choice, short answer questions, calculations and extended open response questions. • Calculators may be used in the examination. • Available at foundation tier and higher tier. • Students must complete all assessments for this qualification in the same tier. • The foundation tier paper will target grades 1–5. • The higher tier paper will target grades 4–9. • 27 marks of the paper will be overlap questions that appear in both the foundation and higher tier papers.
Content assessed • Topic 1 – Key concepts of physics • Topic 2 – Motion and forces • Topic 3 – Conservation of energy • Topic 4 – Waves • Topic 5 – Light and the electromagnetic spectrum • Topic 6 – Radioactivity • Topic 7 – Astronomy

Paper 2 (Paper code: 1PH0/2F, 1PH0/2H)

- First assessment: May/June 2018.
- The assessment is 1 hour and 45 minutes.
- The assessment is out of 100 marks.
- The assessment consists of ten questions.
- Students must answer all questions.
- The paper will include multiple-choice, short answer questions, calculations and extended open response questions.
- Calculators may be used in the examination.
- Available at foundation tier and higher tier.
- Students must complete all assessments for this qualification in the same tier.
- The foundation tier paper will target grades 1–5.
- The higher tier paper will target grades 4–9.
- 27 marks of the paper will be overlap questions that appear in both the foundation and higher tier papers.

Content assessed

- Topic 1 – Key concepts of physics
- Topic 8 – Energy - Forces doing work
- Topic 9 – Forces and their effects
- Topic 10 – Electricity and circuits
- Topic 11 – Static electricity
- Topic 12 – Magnetism and the motor effect
- Topic 13 – Electromagnetic induction
- Topic 14 – Particle model
- Topic 15 – Forces and matter

Assessment Objectives

Students must:		% in GCSE
AO1	Demonstrate knowledge and understanding of: • scientific ideas • scientific techniques and procedures.	40
AO2	Apply knowledge and understanding of: • scientific ideas • scientific enquiry, techniques and procedures.	40
AO3	Analyse information and ideas to: • interpret and evaluate • make judgements and draw conclusions • develop and improve experimental procedures.	20
	Total	**100%**

Breakdown of Assessment Objectives

Paper	Assessment Objectives			Total for all Assessment Objectives
	AO1 %	AO2 %	AO3 %	
Paper 1 (F/H)	20	20	10	50%
Paper 2 (F/H)	20	20	10	50%
Total for GCSE	**40% ±3**	**40% ±3**	**20% ±3**	**100%**

Synoptic assessment

Synoptic assessment requires students to work across different parts of a qualification and to show their accumulated knowledge and understanding of a topic or subject area.

Synoptic assessment enables students to show their ability to combine their skills, knowledge and understanding with breadth and depth of the subject.

Questions that naturally draw together different aspects of physics will assess synopticity.

Sample assessment materials

Sample papers and mark schemes can be found in the *Pearson Edexcel Level 1/Level 2 GCSE (9–1) in Physics Sample Assessment Materials* (SAMs) document.

4 Administration and general information

Entries

Details of how to enter students for the examinations for this qualification can be found in our *UK Information Manual*. A copy is made available to all examinations officers and is available on our website: qualifications.pearson.com

Forbidden combinations and discount code

Centres should be aware that students who enter for more than one GCSE, or other Level 2 qualifications with the same discount code, will have only the grade for their 'first entry' counted for the purpose of the School and College Performance Tables (please see *Appendix 9: Codes*). For further information about what constitutes 'first entry' and full details of how this policy is applied, please refer to the DfE website: www.education.gov.uk

Students should be advised that, if they take two GCSEs with the same discount code, schools and colleges to which they wish to progress are very likely to take the view that they have achieved only one of the two GCSEs. The same view may be taken if students take two GCSE or other Level 2 qualifications that have different discount codes but which have significant overlap of content. Students or their advisers who have any doubts about their subject combinations should check with the institution to which they wish to progress before embarking on their programmes.

Access arrangements, reasonable adjustments, special consideration and malpractice

Equality and fairness are central to our work. Our equality policy requires all students to have equal opportunity to access our qualifications and assessments, and our qualifications to be awarded in a way that is fair to every student.

We are committed to making sure that:

- students with a protected characteristic (as defined by the Equality Act 2010) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to students who do not share that characteristic
- all students achieve the recognition they deserve for undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

Language of assessment

Assessment of this qualification will be available in English. All student work must be in English.

Access arrangements

Access arrangements are agreed before an assessment. They allow students with special educational needs, disabilities or temporary injuries to:

- access the assessment
- show what they know and can do without changing the demands of the assessment.

The intention behind an access arrangement is to meet the particular needs of an individual student with a disability, without affecting the integrity of the assessment. Access arrangements are the principal way in which awarding bodies comply with the duty under the Equality Act 2010 to make 'reasonable adjustments'.

Access arrangements should always be processed at the start of the course. Students will then know what is available and have the access arrangement(s) in place for assessment.

Reasonable adjustments

The Equality Act 2010 requires an awarding organisation to make reasonable adjustments where a person with a disability would be at a substantial disadvantage in undertaking an assessment. The awarding organisation is required to take reasonable steps to overcome that disadvantage.

A reasonable adjustment for a particular person may be unique to that individual and therefore might not be in the list of available access arrangements.

Whether an adjustment will be considered reasonable will depend on a number of factors, which will include:

- the needs of the student with the disability
- the effectiveness of the adjustment
- the cost of the adjustment; and
- the likely impact of the adjustment on the student with the disability and other students.

An adjustment will not be approved if it involves unreasonable costs to the awarding organisation, timeframes or affects the security or integrity of the assessment. This is because the adjustment is not 'reasonable'.

Special consideration

Special consideration is a post-examination adjustment to a student's mark or grade to reflect temporary injury, illness or other indisposition at the time of the examination/ assessment, which has had, or is reasonably likely to have had, a material effect on a candidate's ability to take an assessment or demonstrate their level of attainment in an assessment.

Private candidates

Private candidates can complete this qualification only if they carry-out the mandatory core practicals with the centre in which they are sitting the exams, as long as the centre is willing to accept the candidate. These candidates need to fulfil the same requirements as all other candidates.

Further information

Please see our website for further information about how to apply for access arrangements and special consideration.

For further information about access arrangements, reasonable adjustments and special consideration, please refer to the JCQ website: www.jcq.org.uk.

Malpractice

Candidate malpractice

Candidate malpractice refers to any act by a candidate that compromises or seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

Candidate malpractice in examinations **must** be reported to Pearson using a *JCQ M1 Form* (available at www.jcq.org.uk/exams-office/malpractice). The form can be emailed to pqsmalpractice@pearson.com or posted to Investigations Team, Pearson, 190 High Holborn, London, WC1V 7BH. Please provide as much information and supporting documentation as possible. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice constitutes staff or centre malpractice.

Staff/centre malpractice

Staff and centre malpractice includes both deliberate malpractice and maladministration of our qualifications. As with candidate malpractice, staff and centre malpractice is any act that compromises or seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

All cases of suspected staff malpractice and maladministration **must** be reported immediately, before any investigation is undertaken by the centre, to Pearson on a *JCQ M2(a) Form* (available at www.jcq.org.uk/exams-office/malpractice). The form, supporting documentation and as much information as possible can be emailed to pqsmalpractice@pearson.com or posted to Investigations Team, Pearson, 190 High Holborn, London, WC1V 7BH. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice itself constitutes malpractice.

More-detailed guidance on malpractice can be found in the latest version of the document *JCQ General and Vocational Qualifications Suspected Malpractice in Examinations and Assessments,* available at www.jcq.org.uk/exams-office/malpractice.

Awarding and reporting

This qualification will be graded, awarded and certificated to comply with the requirements of Ofqual's General Conditions of Recognition.

This GCSE qualification will be graded and certificated on a nine-grade scale from 9 to 1 using the total subject mark where 9 is the highest grade. Individual papers are not graded. For foundation tier, grades 1–5 are available and for higher tier, grades 4–9 are available, however if the mark achieved is a smaller number of marks below the 4/3 grade boundary, then a grade 3 may be awarded.

Students whose level of achievement is below the minimum judged by Pearson to be of sufficient standard to be recorded on a certificate will receive an unclassified U result.

The first certification opportunity for this qualification will be 2018.

Student recruitment and progression

Pearson follows the JCQ policy concerning recruitment to our qualifications in that:

- they must be available to anyone who is capable of reaching the required standard
- they must be free from barriers that restrict access and progression
- equal opportunities exist for all students.

Prior learning and other requirements

This qualification is based on the subject content, published by the DfE. The DfE designed the subject content to reflect or build on Key Stage 3. Consequently, students taking this qualification will benefit from previously studying Physics at Key Stage 3.

Progression

Students can progress from this qualification to:

- GCEs, for example in Physics
- Level 3 vocational qualifications in science, for example BTEC Level 3 in Applied Science
- employment, for example in a science-based industry where an Apprenticeship may be available.

The content and skills for these qualifications are set by the DfE to be suitable to allow these progression routes.

Appendices

Appendix 1: Mathematical skills

This appendix is taken from the document *Biology, Chemistry and Physics GCSE subject content* published by the Department for Education (DfE) in June 2014.

The mathematical skills and use of mathematics statements listed will be assessed through the content of this qualification in the examinations. The minimum level of mathematics in the foundation tier examination papers will be equivalent to Key Stage 3 mathematics. The minimum level of mathematics in the higher tier examination papers will be equivalent to foundation tier GCSE in Mathematics.

Mathematical skills

Details of the mathematical skills in other science subjects are given for reference.

		Biology	Chemistry	Physics
1	**Arithmetic and numerical computation**			
a	Recognise and use expressions in decimal form	✓	✓	✓
b	Recognise and use expressions in standard form	✓	✓	✓
c	Use ratios, fractions and percentages	✓	✓	✓
d	Make estimates of the results of simple calculations	✓	✓	✓
2	**Handling data**			
a	Use an appropriate number of significant figures	✓	✓	✓
b	Find arithmetic means	✓	✓	✓
c	Construct and interpret frequency tables and diagrams, bar charts and histograms	✓	✓	✓
d	Understand the principles of sampling as applied to scientific data	✓		
e	Understand simple probability	✓		
f	Understand the terms mean, mode and median	✓		✓
g	Use a scatter diagram to identify a correlation between two variables	✓		✓
h	Make order of magnitude calculations	✓	✓	✓
3	**Algebra**			
a	Understand and use the symbols: $=$, $<$, $<<$, $>>$, $>$, $\propto$, $\sim$	✓	✓	✓
b	Change the subject of an equation		✓	✓
c	Substitute numerical values into algebraic equations using appropriate units for physical quantities		✓	✓
d	Solve simple algebraic equations	✓		✓

		Biology	Chemistry	Physics
4	**Graphs**			
a	Translate information between graphical and numeric form	✓	✓	✓
b	Understand that $y = mx + c$ represents a linear relationship	✓	✓	✓
c	Plot two variables from experimental or other data	✓	✓	✓
d	Determine the slope and intercept of a linear graph	✓	✓	✓
e	Draw and use the slope of a tangent to a curve as a measure of rate of change		✓	✓
f	Understand the physical significance of area between a curve and the x-axis and measure it by counting squares as appropriate			✓
5	**Geometry and trigonometry**			
a	Use angular measures in degrees			✓
b	Visualise and represent 2D and 3D forms, including two dimensional representations of 3D objects		✓	✓
c	Calculate areas of triangles and rectangles, surface areas and volumes of cubes.	✓	✓	✓

Appendix 2: Equations in Physics

This appendix is taken from the document *Biology, Chemistry and Physics GCSE subject content* published by the Department for Education (DfE) in June 2014.

This identifies which equations students are required to recall and apply (list a) and which they are required to select from a list and apply (list b). List b also includes three additional equations to the DfE equations.

a Students should be able to recall and apply all the following equations

Students may be asked to recall, recall and apply, or only apply these equations in the exam papers. If students are required to only apply an equation from this section the equation will be given in the question.

Equations required for higher tier only are shown in bold text. Higher tier only equations will not be required in the foundation tier papers.

Specification reference	Equation
2.6b	distance travelled = average speed × time
2.8	acceleration = change in velocity ÷ time taken $a = \frac{(v - u)}{t}$
2.15	force = mass × acceleration $F = m \times a$
2.16	weight = mass × gravitational field strength $W = m \times g$
2.24	**momentum = mass × velocity** $\boldsymbol{p = m \times v}$
3.1 and 8.8	change in gravitational potential energy = mass × gravitational field strength × change in vertical height $\Delta GPE = m \times g \times \Delta h$
3.2 and 8.9	kinetic energy = $\frac{1}{2}$ × mass × (speed)^2 $KE = \frac{1}{2} \times m \times v^2$
3.11 and 8.15	efficiency = $\frac{\text{(useful energy transferred by the device)}}{\text{(total energy supplied to the device)}}$
4.6	wave speed = frequency × wavelength $v = f \times \lambda$
	wave speed = distance ÷ time $v = \frac{x}{t}$

Specification reference	Equation
8.6	work done = force × distance moved in the direction of the force $E = F \times d$
8.13	power = work done ÷ time taken $P = \frac{E}{t}$
9.7P	moment of a force = force × distance normal to the direction of the force
10.6	energy transferred = charge moved × potential difference $E = Q \times V$
10.9	charge = current × time $Q = I \times t$
10.13	potential difference = current × resistance $V = I \times R$
10.29	power = energy transferred ÷ time taken $P = \frac{E}{t}$
10.31	electrical power = current × potential difference $P = I \times V$
	electrical power = current squared × resistance $P = I^2 \times R$
14.2	density = mass ÷ volume $\rho = \frac{m}{V}$
15.3	force exerted on a spring = spring constant × extension $F = k \times x$
15.11P	pressure = force normal to surface ÷ area of surface $P = \frac{F}{A}$

b Students should be able to select and apply the following equations

Students may be asked to select and apply these equations in the exam papers. These equations will be given in a formulae sheet at the end of the exam papers.

Equations required for higher tier only are shown in bold text. Higher tier only equations will not be given in the formulae sheet for the foundation tier papers.

Specification reference	Equation
2.9	(final velocity)^2 – (initial velocity)^2 = 2 × acceleration × distance $v^2 - u^2 = 2 \times a \times x$
2.26	**force = change in momentum ÷ time** $\boldsymbol{F = \frac{(mv - mu)}{t}}$
10.27	energy transferred = current × potential difference × time $E = I \times V \times t$
12.13	**force on a conductor at right angles to a magnetic field carrying a current = magnetic flux density × current × length** $\boldsymbol{F = B \times I \times l}$
13.7P	$\boldsymbol{\frac{\text{potential difference across primary coil}}{\text{potential difference across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}}$ $\boldsymbol{\frac{V_p}{V_s} = \frac{N_p}{N_s}}$
13.10	For transformers with 100% efficiency, potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil $V_P \times I_P = V_S \times I_S$
14.8	change in thermal energy = mass × specific heat capacity × change in temperature $\Delta Q = m \times c \times \Delta\theta$
14.9	thermal energy for a change of state = mass × specific latent heat $Q = m \times L$
14.19P	$P_1 \times V_1 = P_2 \times V_2$ to calculate pressure or volume for gases of fixed mass at constant temperature
15.4	energy transferred in stretching = 0.5 × spring constant × (extension)^2 $E = \frac{1}{2} \times k \times x^2$

Specification reference	Equation
15.14P	**pressure due to a column of liquid = height of column × density of liquid × gravitational field strength** $P = h \times \rho \times g$

Appendix 3: SI Units in Physics

This appendix is taken from the document *Biology, Chemistry and Physics GCSE subject content* published by the Department for Education (DfE) in June 2014.

The International System of Units (Système International d'Unités), which is abbreviated SI, is a coherent system of base units. The six which are relevant for the GCSE in Physics are listed below. Also listed are eight of the derived units (which have special names) selected from the SI list of derived units in the same source.

Base units

These units and their associated quantities are dimensionally independent.

metre

Unit symbol: **m**

kilogram

Unit symbol: **kg**

second

Unit symbol: **s**

ampere

Unit symbol: **A**

kelvin

Unit symbol: **K**

mole

Unit symbol: **mol**

Some derived units with special names

name	unit	abbreviation
Frequency	hertz	Hz
Force	newton	N
Energy	joule	J
Power	watt	W
Pressure	pascal	Pa
Electric charge	coulomb	C
Electric potential difference	volt	V
Electric resistance	ohm	Ω
Magnetic flux density	tesla	T

Appendix 4: Taxonomy

The following table lists the command words used in the external assessments.

Command word	Definition
Add/Label	Requires the addition or labelling to a stimulus material given in the question, for example labelling a diagram or adding units to a table.
Assess	Give careful consideration to all the factors or events that apply and identify which are the most important or relevant. Make a judgement on the importance of something, and come to a conclusion where needed.
Calculate	Obtain a numerical answer, showing relevant working. If the answer has a unit, this must be included. This can include using an equation to calculate a numerical answer.
Comment on	Requires the synthesis of a number of variables from data/information to form a judgement.
Compare	Looking for the similarities **or** differences of two (or more) things. Should not require the drawing of a conclusion. Answer must relate to both (or all) things mentioned in the question.
Compare and contrast	Looking for the similarities **and** differences of two (or more) things. Should not require the drawing of a conclusion. Answer must relate to both (or all) things mentioned in the question. The answer must include at least one similarity and one difference.
Complete	Requires the completion of a table/diagram.
Deduce	Draw/reach conclusion(s) from the information provided.
Describe	To give an account of something. Statements in the response need to be developed as they are often linked but do not need to include a justification or reason.
Determine	The answer must have an element which is quantitative from the stimulus provided, or must show how the answer can be reached quantitatively. To gain maximum marks there must be a quantitative element to the answer.
Devise	Plan or invent a procedure from existing principles/ideas.
Discuss	Identify the issue/situation/problem/argument that is being assessed within the question. Explore all aspects of an issue/situation/problem/argument. Investigate the issue/situation etc. by reasoning or argument.
Draw	Produce a diagram either using a ruler or using freehand.
Estimate	Find an approximate value, number, or quantity from a diagram/given data or through a calculation.

Command word	Definition
Evaluate	Review information (e.g. data, methods) then bring it together to form a conclusion, drawing on evidence including strengths, weaknesses, alternative actions, relevant data or information. Come to a supported judgement of a subject's qualities and relation to its context.
Explain	An explanation requires a justification/exemplification of a point. The answer must contain some element of reasoning/justification, this can include mathematical explanations.
Give/State/Name	All of these command words are really synonyms. They generally all require recall of one or more pieces of information.
Give a reason/reasons	When a statement has been made and the requirement is only to give the reasons why.
Identify	Usually requires some key information to be selected from a given stimulus/resource.
Justify	Give evidence to support (either the statement given in the question or an earlier answer).
Measure	To determine the dimensions or angle from a diagram using an instrument such as a ruler or protractor.
Plot	Produce a graph by marking points accurately on a grid from data that is provided and then drawing a line of best fit through these points. A suitable scale and appropriately labelled axes must be included if these are not provided in the question.
Predict	Give an expected result.
Show that	Verify the statement given in the question.
Sketch	Produce a freehand drawing. For a graph this would need a line and labelled axis with important features indicated, the axis are not scaled.
State and explain	Make a point and link ideas to justify that point. An explanation requires a justification/exemplification of a point. The answer must contain some element of reasoning/justification, this can include mathematical explanations.
State what is meant by	When the meaning of a term is expected but there are different ways of how these can be described.
Write	When the questions ask for an equation.

Verbs preceding a command word	
Suggest a …	Suggest an explanation or suggest a description.

Appendix 5: Apparatus and techniques

The apparatus and techniques listed in the table below are taken from the document *Biology, Chemistry and Physics GCSE subject content* published by the Department for Education (DfE) in June 2014.

Use and coverage of the apparatus and techniques listed are mandatory. The eight mandatory core practicals cover all aspects of the listed apparatus and techniques and are referenced in the table.

Safety is an overriding requirement for all practical work. Centres are responsible for ensuring that whenever their students complete practical work appropriate safety procedures are followed.

Scientific diagrams should be included, where appropriate, to show the set-up and to record the apparatus and procedures used in practical work.

	Apparatus and techniques	Core practical (specification reference)	
1	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, volume and temperature. Use of such measurements to determine densities of solid and liquid objects.	2.19	*Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*
		4.17	*Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*
		14.3	*Investigate the densities of solid and liquids*
		14.11	*Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice*
2	Use of appropriate apparatus to measure and observe the effects of forces including the extension of springs	2.19	*Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*
		15.6	*Investigate the extension and work done when applying forces to a spring*
3	Use of appropriate apparatus and techniques for measuring motion, including determination of speed and rate of change of speed (acceleration/deceleration)	2.19	*Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*

Apparatus and techniques		Core practical (specification reference)
4	Making observations of waves in fluids and solids to identify the suitability of apparatus to measure speed/frequency/wavelength. Making observations of the effects of the interaction of electromagnetic waves with matter.	4.17 *Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid* 5.9 *Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter* 5.19P *Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed*
5	Safe use of appropriate apparatus in a range of contexts to measure energy changes/transfers and associated values such as work done	14.11 *Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice* 15.6 *Investigate the extension and work done when applying forces to a spring*
6	Use of appropriate apparatus to measure current, potential difference (voltage) and resistance, and to explore the characteristics of a variety of circuit elements	10.17 *Construct electrical circuits to:* *a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp* *b test series and parallel circuits using resistors and filament lamps*
7	Use of circuit diagrams to construct and check series and parallel circuits including a variety of common circuit elements	10.17 *Construct electrical circuits to*: *a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp* *b test series and parallel circuits using resistors and filament lamps*
8	Making observations of waves in fluids and solids to identify the suitability of apparatus to measure the effects of the interaction of waves with matter.	4.17 *Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*

These core practicals may be reviewed and amended if changes are required to the apparatus and techniques listed by the Department for Education. Pearson may also review and amend the core practicals if necessary. Centres will be told about any changes as soon as possible.

You must follow the instructions in the table below for each core practical.

Core practical		Description
2.19	*Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*	Different masses must be used to investigate the effect of varying masses on the acceleration of a trolley down a ramp. Appropriate methods must be used to measure the force and time taken for the trolley to travel down the ramp, and data analysis must include calculating the acceleration.
4.17	*Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*	This investigation involves looking at the characteristics of waves and using the equation: $v = f \times \lambda$ It is expected that students will have looked at waves in a liquid using a ripple tank, and waves in a solid using a metal rod and a method of measuring the frequency. Suitability of apparatus to take these measurements must also be considered.
5.9	*Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter*	A light source with grating must be used to produce a beam of light, which must then be used to investigate the effect of refraction using a glass block. An appreciation of the interaction of the light ray with the glass block and the effect of changing medium on the light ray (moving towards and away from the normal) must be included.
5.19P	*Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed*	A minimum of four different beakers or test tubes must be covered in different materials (different colours, or shiny/dull surfaces). The same volume of hot water must then be poured into each container, and covered with a lid. Using a thermometer the temperature can be monitored and recorded at fixed times using a stopwatch.
10.17	*Construct electrical circuits to:* *a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp* *b test series and parallel circuits using resistors and filament lamps*	This investigation involves constructing a circuit to investigate potential difference, current and resistance for a resistor and a filament lamp. The behaviour of parallel and series circuits must also be included, and this must be done using filament lamps. A series circuit should be set up initially with a resistor, ammeter and voltmeter. The current must be recorded at different voltages. This must then be repeated using a filament lamp instead of a resistor. To investigate series and parallel circuits, a parallel circuit must be set up with ammeters, voltmeters, and filament lamps. Readings from this circuit must then be compared with series circuits used initially. Analysis must include use of the equation: $V = I \times R$

Core practical		Description
14.3	*Investigate the densities of solid and liquids*	The density of a solid object must be determined by measuring the mass and volume of the object, and then using the equation: $\rho = \frac{m}{v}$ The volume must be determined by putting the object into water, and measuring the volume of water that has been displaced. The density of a liquid can be calculated by weighing the liquid using a balance, and determining the volume. The equation: $\rho = \frac{m}{v}$ must then be used to calculate the density.
14.11	*Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice*	The temperature of crushed ice must be recorded using a thermometer. This must then be melted using a Bunsen burner and beaker of water as a water bath. The temperature must be monitored as the ice melts. To determine specific heat capacity of water, the temperature of water using a thermometer must be monitored while heating it using a heat supply connected to a joulemeter. This must then be used to calculate the specific heat capacity.
15.6	*Investigate the extension and work done when applying forces to a spring*	The stretching of a spring must be investigated by measuring the length of a spring with no weights, followed by adding varying masses and measuring the new length. This must include calculating the work done and an appreciation of the forces involved.

Appendix 6: Practical Science Statement

Pearson Edexcel Level 1/Level 2 GCSE (9–1) in Physics	1PH0
Centre name:	Centre number:
All candidates must carry out the eight mandatory core practicals throughout the course of this qualification.	
Details of practical work	
Core practical:	
2.19	*Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*
4.17	*Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*
5.9	*Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter*
5.19P	*Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed*
10.17	*Construct electrical circuits to:* *a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp* *b test series and parallel circuits using resistors and filament lamps*
14.3	*Investigate the densities of solid and liquids*
14.11	*Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice*
15.6	*Investigate the extension and work done when applying forces to a spring*

Head teacher declaration

I declare that the practical science work recorded above has been carried out in accordance with Pearson Edexcel Level 1/Level 2 GCSE in Physics (9–1) practical science work requirements.

Each candidate has made a contemporaneous record of:

i the work that they have undertaken during these practical activities, and

ii the knowledge, skills and understanding they have derived from those practical activities.

Head teacher name:			
Head teacher signature:		**Date:**	

Appendix 7: The context for the development of this qualification

All our qualifications are designed to meet our World Class Qualification Principles[1] and our ambition to put the student at the heart of everything we do.

We have developed and designed this qualification by:

- reviewing other curricula and qualifications to ensure that it is comparable with those taken in high-performing jurisdictions overseas
- consulting with key stakeholders on content and assessment, including learned bodies, subject associations, higher education academics and teachers to ensure this qualification is suitable for a UK context
- reviewing the legacy qualification and building on its positive attributes.

This qualification has also been developed to meet criteria stipulated by Ofqual in their documents *GCSE (9 to 1) Qualification Level Conditions and Requirements* and *GCSE Subject Level Conditions and Requirements for Single Science (Biology, Chemistry and Physics)*, published in April 2014.

[1] Pearson's World Class Qualification Principles ensure that our qualifications are:

- **demanding**, through internationally benchmarked standards, encouraging deep learning and measuring higher-order skills
- **rigorous**, through setting and maintaining standards over time, developing reliable and valid assessment tasks and processes, and generating confidence in end users of the knowledge, skills and competencies of certified students
- **inclusive**, through conceptualising learning as continuous, recognising that students develop at different rates and have different learning needs, and focusing on progression
- **empowering**, through promoting the development of transferable skills, see *Appendix 8*.

From Pearson's Expert Panel for World Class Qualifications

" The reform of the qualifications system in England is a profoundly important change to the education system. Teachers need to know that the new qualifications will assist them in helping their learners make progress in their lives.

When these changes were first proposed we were approached by Pearson to join an 'Expert Panel' that would advise them on the development of the new qualifications.

We were chosen, either because of our expertise in the UK education system, or because of our experience in reforming qualifications in other systems around the world as diverse as Singapore, Hong Kong, Australia and a number of countries across Europe.

We have guided Pearson through what we judge to be a rigorous qualification development process that has included:

- Extensive international comparability of subject content against the highest-performing jurisdictions in the world
- Benchmarking assessments against UK and overseas providers to ensure that they are at the right level of demand
- Establishing External Subject Advisory Groups, drawing on independent subject-specific expertise to challenge and validate our qualifications
- Subjecting the final qualifications to scrutiny against the DfE content and Ofqual accreditation criteria in advance of submission.

Importantly, we have worked to ensure that the content and learning is future oriented. The design has been guided by what is called an 'Efficacy Framework', meaning learner outcomes have been at the heart of this development throughout.

We understand that ultimately it is excellent teaching that is the key factor to a learner's success in education. As a result of our work as a panel we are confident that we have supported the development of qualifications that are outstanding for their coherence, thoroughness and attention to detail and can be regarded as representing world-class best practice. "

Sir Michael Barber (Chair)

Chief Education Advisor, Pearson plc

Bahram Bekhradnia

President, Higher Education Policy Institute

Dame Sally Coates

Principal, Burlington Danes Academy

Professor Robin Coningham

Pro-Vice Chancellor, University of Durham

Dr Peter Hill

Former Chief Executive ACARA

Professor Sing Kong Lee

Director, National Institute of Education, Singapore

Professor Jonathan Osborne

Stanford University

Professor Dr Ursula Renold

Federal Institute of Technology, Switzerland

Professor Bob Schwartz

Harvard Graduate School of Education

Appendix 8: Transferable skills

The need for transferable skills

In recent years, higher education institutions and employers have consistently flagged the need for students to develop a range of transferable skills to enable them to respond with confidence to the demands of undergraduate study and the world of work.

The Organisation for Economic Co-operation and Development (OECD) defines skills, or competencies, as 'the bundle of knowledge, attributes and capacities that can be learned and that enable individuals to successfully and consistently perform an activity or task and can be built upon and extended through learning.' [1]

To support the design of our qualifications, the Pearson Research Team selected and evaluated seven global 21st-century skills frameworks. Following on from this process, we identified the National Research Council's (NRC) framework as the most evidence-based and robust skills framework. We adapted the framework slightly to include the Program for International Student Assessment (PISA) ICT Literacy and Collaborative Problem Solving (CPS) Skills.

The adapted National Research Council's framework of skills involves: [2]

Cognitive skills

- **Non-routine problem solving** – expert thinking, metacognition, creativity.
- **Systems thinking** – decision making and reasoning.
- **Critical thinking** – definitions of critical thinking are broad and usually involve general cognitive skills such as analysing, synthesising and reasoning skills.
- **ICT literacy** – access, manage, integrate, evaluate, construct and communicate. [3]

Interpersonal skills

- **Communication** – active listening, oral communication, written communication, assertive communication and non-verbal communication.
- **Relationship-building skills** – teamwork, trust, intercultural sensitivity, service orientation, self-presentation, social influence, conflict resolution and negotiation.
- **Collaborative problem solving** – establishing and maintaining shared understanding, taking appropriate action, establishing and maintaining team organisation.

Intrapersonal skills

- **Adaptability** – ability and willingness to cope with the uncertain, handling work stress, adapting to different personalities, communication styles and cultures, and physical adaptability to various indoor and outdoor work environments.
- **Self-management and self-development** – ability to work remotely in virtual teams, work autonomously, be self-motivating and self-monitoring, willing and able to acquire new information and skills related to work.

Transferable skills enable young people to face the demands of further and higher education, as well as the demands of the workplace, and are important in the teaching and learning of this qualification. We will provide teaching and learning materials, developed with stakeholders, to support our qualifications.

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[1] OECD (2012), Better Skills, Better Jobs, Better Lives (2012): http://skills.oecd.org/documents/OECDSkillsStrategyFINALENG.pdf

[2] Koenig, J. A. (2011) *Assessing 21st Century Skills: Summary of a Workshop*, National Research Council

[3] PISA (2011) The PISA Framework for Assessment of ICT Literacy, PISA

Appendix 9: Codes

Type of code	Use of code	Code
Discount codes	Every qualification is assigned to a discount code indicating the subject area to which it belongs. This code may change. See our website (qualifications.pearson.com) for details of any changes.	RC1
National Qualifications Framework (NQF) codes	Each qualification title is allocated an Ofqual National Qualifications Framework (NQF) code. The NQF code is known as a Qualification Number (QN). This is the code that features in the DfE Section 96 and on the LARA as being eligible for 16–18 and 19+ funding, and is to be used for all qualification funding purposes. The QN will appear on students' final certification documentation.	The QN for this qualification is: 601/8609/4
Subject codes	The subject code is used by centres to enter students for a qualification. Centres will need to use the entry codes only when claiming students' qualifications.	GCSE – 1PH0
Paper codes	These codes are provided for reference purposes. Students do not need to be entered for individual components.	Paper 1: 1PH0/1F, 1PH0/1H Paper 2: 1PH0/2F, 1PH0/2H

Edexcel, BTEC and LCCI qualifications

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