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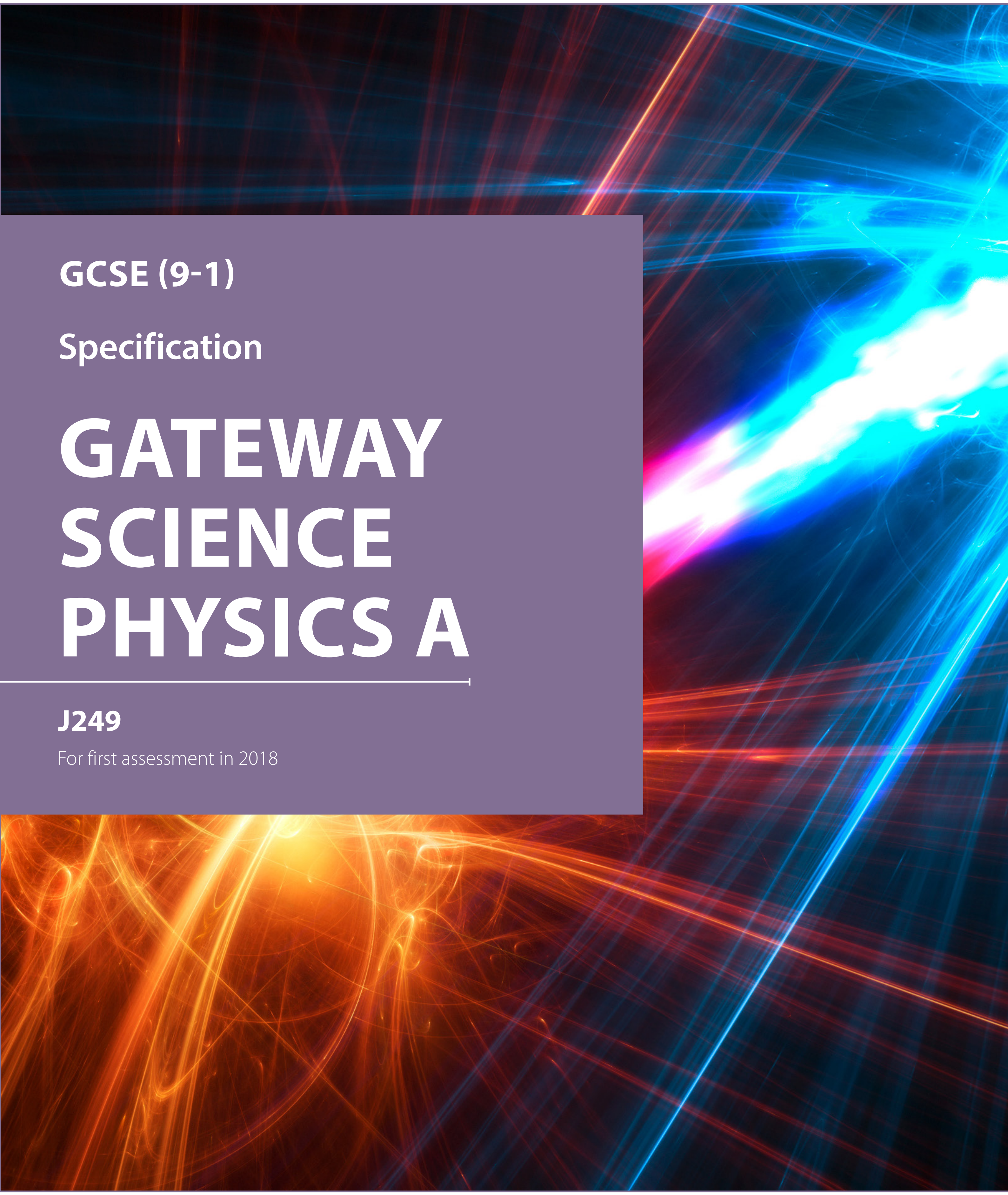

GCSE (9-1)

Specification

GATEWAY SCIENCE PHYSICS A

J249

For first assessment in 2018

Version 4.2 (February 2024)

ocr.org.uk/gcsegatewayphysics

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Contents

Support and Guidance

Introducing a new specification brings challenges for implementation and teaching, but it also opens up new opportunities. Our aim is to help you at every stage.
We are working hard with teachers and other experts to bring you a package of practical support, resources and training.

Subject Advisors

OCR Subject Advisors provide information and support to centres including specification and non-exam assessment advice, updates on resource developments and a range of training opportunities.

Our Subject Advisors work with subject communities through a range of networks to ensure the sharing of ideas and expertise supporting teachers and students alike. They work with developers to help produce our specifications and the resources needed to support these qualifications during their development.

You can contact our Science Subject Advisors for specialist advice, guidance and support:

Phone: 01223 553998
email: ScienceGCSE@ocr.org.uk
twitter: https://twitter.com/OCR_Science

Teaching and learning resources

Our resources are designed to provide you with a range of teaching activities and suggestions that enable you to select the best activity, approach or context to support your teaching style and your particular students. The resources are a body of knowledge that will grow throughout the lifetime of the specification, they include:

- Delivery Guides
- Transition Guides
- Topic Exploration Packs
- Lesson Elements.

We also work with a number of leading publishers who publish textbooks and resources for our specifications. For more information on our publishing partners
and their resources visit: https://ocr.org.uk/qualifications/resource-finder/publishing-partners/

Professional development

Our improved Professional Development Programme fulfils a range of needs through course selection, preparation for teaching, delivery and assessment. Whether you want to come to face-to-face events, look at our new digital training or search for training materials, you can find what you're looking for all in one place at the CPD Hub: cpdhub.ocr.org.uk

An introduction to new specifications

We run training events throughout the academic year that are designed to help prepare you for first teaching and support every stage of your delivery of the new qualifications.

To receive the latest information about the training we offer on GCSE and A Level, please register for email updates at: ocr.org.uk/i-want-to/email-updates

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Along with subject-specific resources and tools, you'll also have access to a selection of generic resources that focus on skills development, professional guidance for teachers and results data analysis.

ExamBuilder
Enabling you to build, mark and assess tests from OCR exam questions and produce a complete mock GCSE or A Level exam.
Find out more at **ocr.org.uk/exambuilder**

Subject Advisors Support
Our Subject Advisors provide you with access to specifications, high-quality teaching resources and assessment materials.

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Assess students' progress under formal examination conditions with question papers downloaded from a secure location, well-presented, easy-to-interpret mark schemes and commentary on marking and sample answers.

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These guides cover topics that could be relevant to a range of qualifications, for example communication, legislation and research.

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Our free online results analysis service helps you review the performance of individual students or your whole cohort. For more details, please refer to **ocr.org.uk/activeresults**

1 Why choose an OCR GCSE (9–1) in Physics A (Gateway Science)?

1a. Why choose an OCR qualification?

Choose OCR and you've got the reassurance that you're working with one of the UK's leading exam boards. Our new OCR GCSE (9–1) in Physics A (Gateway Science) course has been developed in consultation with teachers, employers and Higher Education (HE) to provide learners with a qualification that's relevant to them and meets their needs.

We're part of the Cambridge Assessment Group, Europe's largest assessment agency and a department of the University of Cambridge. Cambridge Assessment plays a leading role in developing and delivering assessments throughout the world, operating in over 150 countries.

We work with a range of education providers, including schools, colleges, workplaces and other institutions in both the public and private sectors. Over 13,000 centres choose our A Levels, GCSEs and vocational qualifications including Cambridge Nationals and Cambridge Technicals.

Our Specifications

We believe in developing specifications that help you bring the subject to life and inspire your learners to achieve more.

We've created teacher-friendly specifications based on extensive research and engagement with the teaching community. They're designed to be straightforward and accessible so that you can tailor the delivery of the course to suit your needs. We aim to encourage learners to become responsible for their own learning, confident in discussing ideas, innovative and engaged.

We provide a range of support services designed to help you at every stage, from preparation through to the delivery of our specifications. This includes:

- A wide range of high-quality creative resources including:
  - Delivery Guides
  - Transition Guides
  - Topic Exploration Packs
  - Lesson Elements
  - . . . and much more.
- Access to Subject Advisors to support you through the transition and throughout the lifetime of the specification.
- CPD/Training for teachers to introduce the qualifications and prepare you for first teaching.
- Active Results – our free results analysis service to help you review the performance of individual learners or whole schools.
- ExamBuilder – our free online past papers service that enables you to build your own test papers from past OCR exam questions.

All GCSE (9–1) qualifications offered by OCR are accredited by Ofqual, the Regulator for qualifications offered in England. The accreditation number for OCR's GCSE (9–1) in Physics A (Gateway Science) is QN601/8651/3.

1b. Why choose an OCR GCSE (9–1) in Physics A (Gateway Science)?

We appreciate that one size doesn't fit all so we offer two suites of qualifications in each science:

Physics A (Gateway Science) – Provides a flexible approach to teaching. The specification is divided into topics, each covering different key concepts of physics. Teaching of practical skills is integrated with the theoretical topics and they are assessed through the written papers.

Physics B (Twenty First Century Science) – Learners study physics using a narrative-based approach. Ideas are introduced within relevant and interesting settings which help learners to anchor their conceptual knowledge of the range of topics required at GCSE level. Practical skills are embedded within the specification and learners are expected to carry out practical work in preparation for a written examination that will specifically test these skills.

All of our specifications have been developed with subject and teaching experts. We have worked in close consultation with teachers and other stakeholders with the aim of including up-to-date relevant content within a framework that is interesting to teach and easy to administer within all centres.

Our new GCSE (9–1) in Physics A (Gateway Science) qualification builds on our existing popular course. We've based the redevelopment of our GCSE sciences on an understanding of what works well in centres large and small. We've undertaken a significant amount of consultation through our science forums (which include representatives from: learned societies, HE, teaching and industry) and through focus groups with teachers.

The content is clear and logically laid out for both existing centres and those new to OCR, with assessment models that are straightforward to administer. We have worked closely with teachers to provide high quality support materials to guide you through the new qualifications.

Aims and learning outcomes

GCSE study in the sciences provides the foundation for understanding the material world. Scientific understanding is changing our lives and is vital to world's future prosperity, and all learners should be taught essential aspects of the knowledge, methods, process and uses of science. They should be helped to appreciate how the complex and diverse phenomena of the natural world can be described in terms of a small number of key ideas relating to the sciences which are both inter-linked, and are 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 and over time 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

OCR's GCSE (9–1) in Physics A (Gateway Science) will encourage learners to:

- develop scientific knowledge and conceptual understanding of 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, both 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.

1c. What are the key features of this specification?

Our GCSE (9–1) in Physics A (Gateway Science) specification is designed with a concept-led approach and provides a flexible way of teaching. The specification:

- is laid out clearly in a series of teaching topics with guidance included where required to provide further advice on delivery
- is co-teachable with the GCSE (9–1) in Combined Science A (Gateway Science)
- embeds practical requirements within the teaching topics
- identifies opportunities for carrying out practical activities that enhance learners' understanding of physics theory and practical skills
- highlights opportunities for the introduction of key mathematical requirements (see Appendix 5g and the To include column for each topic) into your teaching
- identifies, within the Working scientifically column, how the skills, knowledge and understanding of Working Scientifically (WS) can be incorporated within teaching.

1d. How do I find out more information?

Whether new to our specifications, or continuing on from our legacy offerings, you can find more information on our webpages at www.ocr.org.uk

Visit our subject pages to find out more about the assessment package and resources available to support your teaching. The science team also release a termly newsletter *Science Spotlight* (despatched to centres and available from our subject pages).

If you are not already a registered OCR centre then you can find out more information on the benefits of becoming one at: www.ocr.org.uk

If you are not yet an approved centre and would like to become one go to: www.ocr.org.uk/approvals

Want to find out more?

You can contact the Science Subject Advisors:

E-mail:
ScienceGCSE@ocr.org.uk

Telephone:
01223 553998

Visit our Online Support Centre at support.ocr.org.uk

Check what CPD events are available:
www.cpdhub.ocr.org.uk

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2 The specification overview

2a. OCR's GCSE (9–1) in Physics A (Gateway Science) (J249)

Learners are entered for either Foundation Tier (Paper 1 and Paper 2) **or** Higher Tier (Paper 3 and Paper 4) to be awarded the OCR GCSE (5–1) in Physics A (Gateway Science).

2

Content Overview	Assessment Overview	
Foundation Tier, grades 5 to 1		
Content is split into eight teaching topics P1-P8 and a practical activity skills topic P9: • Topic P1: Matter • Topic P2: Forces • Topic P3: Electricity • Topic P4: Magnetism and magnetic fields • Topic P5: Waves in matter • Topic P6: Radioactivity • Topic P7: Energy • Topic P8: Global challenges • Topic P9 Practical skills Paper 1 assesses content from Topics P1-P4 and P9 Paper 2 assesses content from Topics P5-P8, with assumed knowledge of Topics P1-P4 and P9	Paper 1 J249/01 90 marks 1 hour 45 minutes Written paper	**50%** of total GCSE
	Paper 2 J249/02 90 marks 1 hour 45 minutes Written paper	**50%** of total GCSE
Higher Tier, grades 9 to 4		
Content is split into eight teaching topics P1-P8 and a practical activity skills topic P9: • Topic P1: Matter • Topic P2: Forces • Topic P3: Electricity • Topic P4: Magnetism and magnetic fields • Topic P5: Waves in matter • Topic P6: Radioactivity • Topic P7: Energy • Topic P8: Global challenges • Topic P9: Practical skills Paper 3 assesses content from Topics P1-P4 and P9 Paper 4 assesses content from Topics P5-P8, with assumed knowledge of Topics P1-P4 and P9	Paper 3 J249/03 90 marks 1 hour 45 minutes Written paper	**50%** of total GCSE
	Paper 4 J249/04 90 marks 1 hour 45 minutes Written paper	**50%** of total GCSE

J249/02 and J249/04 include synoptic assessment.

2b. Content of GCSE (9–1) in Physics A (Gateway Science) (J249)

The GCSE (9–1) in Physics A (Gateway Science) specification content is specified in Section 2c. It is divided into eight teaching topics P1-P8 and a practical activity skills topic P9.

Learning at GCSE (9–1) in Physics A (Gateway Science) is described in the tables that follow:

Overview of the content layout

Topic P1: Topic title

P1.1 sub-topic

Summary
A short overview of the sub-topic that will be assessed in the examination

Underlying knowledge and understanding
Underlying knowledge and understanding learners should be familiar with linked to the sub-topic

Common misconceptions
Common misconceptions students often have associated with this topic

Tiering
A brief summary of the tiering of the sub-topic

Reference	Mathematical learning outcomes	Mathematical skills (See Appendix 5g)
OCRs mathematics reference code	This column defines the areas of mathematics that will need to be taught specifically within the context of this sub-topic. Questions in the examination will assess these learning outcomes within the context of the topic.	Mathematical skill code as indicated in Appendix 5g

Topic content			**Opportunities to cover:** (see Section 2c) Items that are contained within these columns are intended as a starting point for lesson planning.		**Practical suggestions** (See topic P9)
Learning outcomes		**To include**	**Maths** (See Appendix 5g)	**Working scientifically** (See Appendix 5f)	
Spec. reference number ☑	Column specifies the subject content that will be assessed in the examinations. This symbol indicates content that is found only in the physics separate science qualification	This column is included to provide further/specific advice on delivery of the learning outcome.	Mathematical skills will be assessed throughout the examination. This column highlights the mathematical skills that could be taught alongside the topic content.	Working scientifically will be assessed throughout the examination. This column highlights the working scientifically skills that could be taught alongside the topic content.	The compulsory practical skills covered by the Practical Activity Groups or PAGs are indicated in the table in Topic P9. Activities in this column can be used to supplement the PAGs using topic appropriate experiments

2

Physics key ideas

Physics is the science of the fundamental concepts of field, force, radiation and particle structures, which are inter-linked to form unified models of the behaviour of the material universe. From such models, a wide range of ideas, from the broadest issue of the development of the universe over time to the numerous and detailed ways in which new technologies may be invented, have emerged. These have enriched both our basic understanding of, and our many adaptations to, our material environment.

Students should be helped to understand how, through the ideas of physics, the complex and diverse phenomena of the natural world can be described in terms of a small number of key ideas which are of universal application and which can be illustrated in the separate topics set out below. These ideas 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.

Summary of content for GCSE (9–1) in Physics A (Gateway Science)

Topic P1: Matter	Topic P2: Forces	Topic P3: Electricity
P1.1 The particle model P1.2 Changes of state P1.3 Pressure	P2.1 Motion P2.2 Newton's laws P2.3 Forces in action	P3.1 Static and charge P3.2 Simple circuits
Topic P4: Magnetism and magnetic fields	**Topic P5: Waves in matter**	**Topic P6: Radioactivity**
P4.1 Magnets and magnetic fields P4.2 Uses of magnetism	P5.1 Wave behaviour P5.2 The electromagnetic spectrum P5.3 Wave interaction	P6.1 Radioactive emissions P6.2 Uses and hazards
Topic P7: Energy	**Topic P8: Global challenges**	
P7.1 Work done P7.2 Power and efficiency	P8.1 Physics on the move P8.2 Powering Earth P8.3 Beyond Earth	

Topic P9 is a practical-based topic which provides learners with the necessary skills to undertake the 15% practical content in the examinations.

2c. Content of topics P1 to P9

Topic P1: Matter

P1.1 The particle model

Summary

Knowledge and understanding of the particle nature of matter is fundamental to physics. Learners need to have an appreciation of matter in its different forms, they must also be aware of subatomic particles, their relative charges, masses and positions inside the atom. The structure and nature of atoms are essential to the further understanding of physics. The knowledge of subatomic particles is needed to explain many phenomena, for example the transfer of charges, as well as radioactivity. (Much of this content overlaps with that in the GCSE (9–1) in Chemistry A (Gateway Science content.)

Underlying knowledge and understanding

Learners should be aware of the atomic model, and that atoms are examples of particles. They should also know the difference between atoms, molecules and compounds. Learners should understand how density can be affected by the state materials are in.

Common misconceptions

Learners commonly confuse the different types of particles (subatomic particles, atoms and molecules) which can be addressed through the teaching of this topic. They commonly misunderstand the conversions between different units used in the measurement of volume.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
PM1.1i	recall and apply: $\text{density}\,(\text{kg/m}^3) = \dfrac{\text{mass}\,(\text{kg})}{\text{volume}\,(\text{m}^3)}$	M1a, M1b, M1c, M3b, M3c, M5c

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P1.1a	describe how and why the atomic model has changed over time	the Thomson, Rutherford (alongside Geiger and Marsden) and Bohr models	M5b	WS1.1a, WS1.1c, WS1.1g	Timeline showing the development of atomic theory. Discussion of the different roles played in developing the atomic model and how different scientists worked together.
P1.1b	describe the atom as a positively charged nucleus 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		M5b	WS1.1b	Model making (including 3D) of atomic structures.
P1.1c	recall the typical size (order of magnitude) of atoms and small molecules	knowledge that it is typically 1×10^{-10}m	M1b	WS1.1d	
P1.1d	define density			WS1.2b, WS1.2c, WS1.3c, WS1.3d, WS1.4a, WS1.4b, WS1.4e, WS1.4f, WS2a, WS2b, WS2c, WS2d	Measurement of length, volume and mass and using them to calculate density. (PAG P1) Investigation of Archimedes' Principle using eureka cans. (PAG P1)
P1.1e	explain the differences in density between the different states of matter in terms of the arrangements of the atoms and molecules		M5b	WS1.1b	
P1.1f	apply the relationship between density, mass and volume to changes where mass is conserved		M1a, M1b, M1c, M3c		

P1.2 Changes of state

Summary

A clear understanding of the foundations of the physical world forms a solid basis for further study of physics. Understanding of the relationship between the states of matter helps to explain different types of everyday physical changes that we see around us.

Underlying knowledge and understanding

Learners should be familiar with the structure of matter and the similarities and differences between solids, liquids and gases. They should have an idea of the particle model and be able to use it to model changes in particle behaviour during changes of state. Learners should be aware of the effect of temperature in the motion and spacing of particles and an understanding that energy can be stored internally by materials.

Common misconceptions

Learners commonly carry misconceptions about matter: assuming atoms are always synonymous with particles. Learners also struggle to explain what is between the particles, instinctively ‘filling’ the gaps with ‘air’ or ‘vapour’. They often struggle to visualise the 3D arrangement of particles in all states of matter. Learners can find it challenging to understand how kinetic theory applies to heating materials and how to use the term temperature correctly, regularly confusing the terms temperature and heat.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
PM1.2i	apply: change in thermal energy (J) = mass (kg) × specific heat capacity (J/kg °C) × change in temperature (°C)	M1a, M3b, M3c, M3d
PM1.2ii	apply: thermal energy for a change in state (J) = mass (kg) × specific latent heat (J/kg)	M1a, M3b, M3c, M3d

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P1.2a	describe how mass is conserved when substances melt, freeze, evaporate, condense or sublimate			WS1.3a, WS1.3e, WS1.4a, WS2a, WS2c	Use of a data logger to record change in state and mass at different temperatures. (PAG P5) Demonstration of distillation to show that mass is conserved during evaporation and condensation. (PAG P5)

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P1.2b	describe that physical changes differ from chemical changes because the material recovers its original properties if the change is reversed				
P1.2c	describe how heating a system will change the energy stored within the system and raise its temperature or produce changes of state			WS1.3a, WS1.3e, WS1.4a, WS2a, WS2b, WS2c	Observation of the crystallisation of salol in water under a microscope. Use of thermometer with a range of -10–110 °C, to record the temperature changes of ice as it is heated. (PAG P1)
P1.2d	define the term specific heat capacity and distinguish between it and the term specific latent heat	specific latent heat of fusion and specific latent heat of vaporisation		WS1.2e, WS1.3b, WS1.3c, WS1.3h, WS1.4a, WS1.4f, WS2a, WS2b	Investigation of the specific heat capacity of different metals or water using electrical heaters and a joulemeter. (PAG P5)
P1.2e	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		M1a, M3c, M3d		
P1.2f	apply the relationship between specific latent heat and mass to calculate the energy change involved in a change of state		M1a, M3c, M3d	WS1.2e, WS1.3b, WS1.3c, WS1.3h, WS1.4a, WS1.4f, WS2a, WS2b	Measurement of the specific latent heat of vaporisation of water. (PAG P5) Measurement of the specific latent heat of stearic acid. (PAG P5)

P1.3 Pressure

Summary
This section develops the understanding of pressure in gases and liquids. Pressure in gases builds on the particle model, and in liquids the increase in pressure with depth is explained as the weight of a column of liquid acting on a unit area.

Underlying knowledge and understanding
Learners should be aware of the change in pressure in the atmosphere and in liquids with height (qualitative relationship only). They should have an understanding of floating and sinking and the effect of upthrust. Learners should know that pressure is measured by a ratio of force over area which is acting at a normal to the surface.

Common misconceptions
Learners commonly have misconceptions about floating and sinking, based on the premise that light or small objects float and heavy or large objects sink. They often misunderstand the role of pressure difference and suction e.g. the collapsing can experiment and the forcing of air into the lungs during inhalation.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
PM1.3i ☑	apply: for a given mass of gas at a constant temperature pressure (Pa) × volume (m^3) = constant	M1a, M3b, M3c, M3d
PM1.3ii ☑	**apply:** **pressure due to a column of liquid (Pa) = height of column (m) × density of liquid (kg/m^3) × gravitational field strength (N/kg)**	**M1a, M1c, M3b, M3c, M3d**

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P1.3a	explain how the motion of the molecules in a gas is related both to its temperature and its pressure	application to closed systems only	M1c, M4a, M5b	WS1.1b, WS1.2a, WS1.2e, WS1.3e, WS1.4a, WS2a	Demonstration of the difference in pressure in an inflated balloon that has been heated and frozen. (PAG P1) Building manometers and using them to show pressure changes in heated/cooled volumes of gas. (PAG P1)

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P1.3b	explain the relationship between the temperature of a gas and its pressure at constant volume (qualitative only)		M1c, M5b	WS1.1b, WS1.2a, WS1.2e, WS1.3e, WS1.4a, WS2a	Demonstration of the exploding can experiment. Building of Alka-Seltzer rockets with film canisters.
P1.3c ☑	recall that gases can be compressed or expanded by pressure changes and that the pressure produces a net force at right angles to any surface		M4a, M5b	WS1.1b, WS1.2a, WS1.2e, WS1.3e, WS1.4a, WS2a	Compressing syringes containing sand, water and air. (PAG P1) Demonstration of the collapsing can experiment. Demonstration of the Cartesian diver experiment.
P1.3d ☑	explain how increasing the volume in which a gas is contained, at constant temperature can lead to a decrease in pressure	behaviour regarding particle velocity and collisions	M1c, M4a, M5b	WS1.1b, WS1.2a, WS1.2e, WS1.3e, WS1.4a	Demonstration of the behaviour of marshmallows in a vacuum.
P1.3e ☑	**explain how doing work on a gas can increase its temperature**	**examples such as a bicycle pump**		WS1.1b, WS1.2a	Demonstration of heat production in a bicycle inner tube as it is pumped up.
P1.3f ☑	describe a simple model of the Earth's atmosphere and of atmospheric pressure	an assumption of uniform density; knowledge of layers is not expected	M5b		
P1.3g ☑	explain why atmospheric pressure varies with height above the surface of the planet				

Learning outcomes	To include	Maths	Working scientifically	Practical suggestions
P1.3h ☑ describe the factors which influence floating and sinking				
P1.3i ☑ explain why pressure in a liquid varies with depth and density and how this leads to an upwards force on a partially submerged object			WS1.1b, WS1.2a, WS1.3a, WS2a	Discussion of buoyancy of a ping pong ball in water.
P1.3j ☑ calculate the differences in pressure at different depths in a liquid	**knowledge that *g* is the strength of the gravitational field and has a value of 10 N/kg near the Earth's surface**	M1c, M3c	WS1.1b, WS1.2a	Demonstration of differences in water pressure using a pressure can with holes.

Topic P2: Forces

P2.1 Motion

Summary

Having looked at the nature of matter which makes up objects, we move on to consider the effects of forces. The interaction between objects leads to actions which can be seen by the observer, these actions are caused by forces between the objects in question. Some of the interactions involve contact between the objects, others involve no contact. We will also consider the importance of the direction in which forces act to allow understanding of the importance of vector quantities when trying to predict the action.

Underlying knowledge and understanding

From their work in Key Stage 3 Science, learners will have a basic knowledge of the mathematical relationship between speed, distance and time. They should also be able to represent this information in a distance-time graph and have an understanding of relative motion of objects.

Common misconceptions

Learners can find the concept of action at a distance challenging. They have a tendency to believe that a velocity must have a positive value and have difficulty in associating a reverse in direction with a change in sign. It is therefore important to make sure learners are knowledgeable about the vector–scalar distinction.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
PM2.1i	recall and apply: distance travelled (m) = speed (m/s) × time (s)	M1a, M2b, M3a, M3b, M3c, M3d, M4a, M4b, M4c, M4d, M4e
PM2.1ii	recall and apply: $\text{acceleration (m/s}^2\text{)} = \dfrac{\text{change in velocity (m/s)}}{\text{time (s)}}$	M1a, M3a, M3b, M3c, M3d
PM2.1iii	apply: $(\text{final velocity (m/s)})^2 - (\text{initial velocity (m/s)})^2 = 2 \times \text{acceleration (m/s}^2\text{)} \times \text{distance (m)}$	M1a, M3a, M3b, M3c, M3d
PM2.1iv	recall and apply: $\text{kinetic energy (J)} = \frac{1}{2} \times \text{mass (kg)} \times (\text{speed (m/s)})^2$	M1a, M3a, M3b, M3c, M3d

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P2.1a	describe how to measure distance and time in a range of scenarios				
P2.1b	describe how to measure distance and time and use these to calculate speed	from graphs	M4a, M4b, M4c, M4d, M4f	WS1.2b, WS1.2e, WS1.3a, WS1.3b, WS1.3c, WS1.3g, WS1.3h, WS1.3i, WS2a, WS2b, WS2c, WS2d	Calculations of the speeds of learners when they walk and run a measured distance. Investigation of trolleys on ramps at an angle and whether this affects speed. (PAG P3)
P2.1c	make calculations using ratios and proportional reasoning to convert units and to compute rates	conversion from non-SI to SI units	M1c, M3c		
P2.1d	explain the vector–scalar distinction as it applies to displacement and distance, velocity and speed				
P2.1e	relate changes and differences in motion to appropriate distance-time, and velocity-time graphs; interpret lines and slopes		M4a, M4b, M4c, M4d	WS1.3a	Learners to draw displacement-time and velocity-time graphs of their journey to school. (PAG P3)
P2.1f	**interpret enclosed area in velocity-time graphs**		M4a, M4b, M4c, M4d, M4f		

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P2.1g	calculate average speed for non-uniform motion		M1a, M1c, M2b, M3c		
P2.1h	apply formulae relating distance, time and speed, for uniform motion, and for motion with uniform acceleration		M1a, M1c, M2b, M3c	WS1.2b, WS1.2e, WS1.3a, WS1.3b, WS1.3c, WS1.3g, WS1.3h, WS1.3i, WS2a, WS2b, WS2c, WS2d	Investigation of acceleration. (PAG P3)

P2.2 Newton's laws

Summary

Newton's laws of motion essentially define the means by which motion changes and the relationship between these changes in motion with force and mass.

Underlying knowledge and understanding

Learners should have an understanding of contact and non-contact forces influencing the motion of an object. They should be aware of the newton and that this is the unit of force. The three laws themselves will be new to the learners. Learners are expected to be able to use force arrows and have an understanding of balanced and unbalanced forces.

Common misconceptions

Learners commonly have misconceptions about objects needing a net force for them to continue to move steadily and can struggle to understand that stationary objects also have forces acting on them. Difficulties faced by learners when trying to differentiate between scalar and vector quantities is the idea of objects with a changing direction not having a constant vector value, for example, objects moving in a circle. This issue also arises with the concept of momentum and changes in momentum of colliding objects.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
PM2.2i	recall and apply: force (N) = mass (kg) × acceleration (m/s^2)	M1a, M2a, M3a, M3b, M3c, M3d
PM2.2ii	**recall and apply: momentum (kg m/s) = mass (kg)** × **velocity (m/s)**	**M1a, M2a, M3a, M3b, M3c, M3d**
PM2.2iii	recall and apply: work done (J) = force (N) × distance (m) (along the line of action of the force)	M1a, M2a, M3a, M3b, M3c, M3d
PM2.2iv	recall and apply: $\text{power (W)} = \dfrac{\text{work done (J)}}{\text{time (s)}}$	M1a, M2a, M3a, M3b, M3c, M3d

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P2.2a	recall examples of ways in which objects interact	electrostatics, gravity, magnetism and by contact (including normal contact force and friction)			
P2.2b	describe how such examples involve interactions between pairs of objects which produce a force on each object				
P2.2c	represent forces as vectors	drawing free body force diagrams to demonstrate understanding of forces acting as vectors	M5b	WS1.2a, WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3c, WS1.3e, WS1.3h, WS2a, WS2b, WS2d	Measurement of the velocity of ball bearings in glycerol at different temperatures or of differing sizes. (PAG P3)
P2.2d	apply Newton's first law to explain the motion of an object moving with uniform velocity and also an object where the speed and/or direction change	looking at forces on one body and resultant forces and their effects (qualitative only)		WS1.3e, WS2a	Demonstration of the behaviour of colliding gliders on a linear air track. (PAG P3) Use of balloon gliders to consider the effect of a force on a body.
P2.2e	**use vector diagrams to illustrate resolution of forces, a net force (resultant force), and equilibrium situations**	**scale drawings limited to parallel and perpendicular vectors only**	M4a, M5a, M5b		

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P2.2f	**describe examples of the forces acting on an isolated solid object or system**	**examples of objects that reach terminal velocity for example skydivers and applying similar ideas to vehicles**		WS1.2a, WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3c, WS1.3e, WS1.3h, WS2a, WS2b, WS2d	Learners to design and build a parachute for a mass, and measure its terminal velocity as it is dropped. (PAG P3)
P2.2g	**describe, using free body diagrams, examples where two or more forces lead to a resultant force on an object**				
P2.2h	**describe, using free body diagrams, examples of the special case where forces balance to produce a resultant force of zero (qualitative only)**				
P2.2i	apply Newton's second law in calculations relating forces, masses and accelerations		M1a, M2a, M3b, M3c, M3d	WS1.2a, WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3c, WS1.3e, WS1.3h, WS2a, WS2b, WS2c, WS2d	Use of light gates, weights and trolleys to investigate the link between force and acceleration. (PAG P2)

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P2.2j	**explain that inertia is a measure of how difficult it is to change the velocity of an object and that the inertial mass is defined as the ratio of force over acceleration**				
P2.2k	**define momentum and describe examples of momentum in collisions**	**an idea of the law of conservation of momentum in collisions**		WS1.2a, WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3c, WS1.3e, WS1.3h, WS2a, WS2b, WS2c, WS2d	Use of light gates, weights and trolleys to measure momentum of colliding trollies. (PAG P3) Use of a water rocket to demonstrate that the explosion propels the water down with the same momentum as the rocket shoots up.
P2.2l ☑	apply formulae relating force, mass, velocity and acceleration to explain how the changes involved are inter-related		M3b, M3c, M3d		
P2.2m	use the relationship between work done, force, and distance moved along the line of action of the force and describe the energy transfer involved		M1a, M2a, M3a, M3b, M3c, M3d	WS1.4a, WS2a, WS2b	Measurement of work done by learners lifting weights or walking up stairs. (PAG P5)
P2.2n	calculate relevant values of stored energy and energy transfers; convert between newton-metres and joules		M1c, M3c	WS1.4e, WS1.4f	
P2.2o	explain, with reference to examples, the definition of power as the rate at which energy is transferred				
P2.2p	recall and apply Newton's third law	application to situations of equilibrium and non-equilibrium			
P2.2q	**explain why an object moving in a circle with a constant speed has a changing velocity (qualitative only)**			WS1.3e	Demonstration of spinning a rubber bung on a string.

P2.3 Forces in action

Summary

Forces acting on an object can result in a change of shape or motion. Having looked at the nature of matter, we can now introduce the idea of fields and forces causing changes. This develops the idea that force interactions between objects can take place even if they are not in contact. Learners should be familiar with forces associated with deforming objects, with stretching and compressing (springs).

Underlying knowledge and understanding

Learners should have an understanding of forces acting to deform objects and to restrict motion. They should already be familiar with Hooke's Law and the idea that, when work is done by a force, it results in an energy transfer and leads to energy being stored by an object. Learners are expected to know that there is a force due to gravity and that gravitational field strength differs on other planets and stars.

Common misconceptions

Learners commonly have difficulty understanding that the weight of an object is not the same as its mass from the everyday use of the term 'weighing'. The concept of force multipliers can also be challenging even though the basic concepts are ones covered at Key Stage 3.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
PM2.3i	recall and apply: force exerted by a spring (N) = spring constant (N/m) × extension (m)	M1a, M2a, M3a, M3b, M3c, M3d
PM2.3ii	apply: energy transferred in stretching (J) = $\frac{1}{2}$ × spring constant (N/m) × (extension (m))^2	M1a, M2a, M3a, M3b, M3c, M3d
PM2.3iii	recall and apply: gravitational force (N) = mass (kg) × gravitational field strength (N/kg)	M1a, M2a, M3a, M3b, M3c, M3d
PM2.3iv	recall and apply: gravitational potential energy (J) = mass (kg) × gravitational field strength (N/kg) × height (m)	M1a, M2a, M3a, M3b, M3c, M3d
PM2.3v ☑	recall and apply: pressure (Pa) = $\frac{\text{force normal to a surface (N)}}{\text{area of that surface (m}^2\text{)}}$	M1a, M2a, M3a, M3b, M3c, M3d
PM2.3vi ☑	recall and apply: moment of a force (N m) = force (N) × distance (m) (normal to direction of the force)	M1a, M2a, M3a, M3b, M3c, M3d

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P2.3a	explain that to stretch, bend or compress an object, more than one force has to be applied	applications to real life situations		WS1.1b, WS1.1e, WS1.2a, WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3c, WS1.3e, WS1.3f, WS1.3g, WS2a, WS2b, WS2c	Use of a liquorice bungee or spring to explore extension and stretching. (PAG P2)
P2.3b	describe the difference between elastic and plastic deformation (distortions) caused by stretching forces			WS1.1b, WS1.1e, WS1.2a, WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3c, WS1.3e, WS1.3f, WS1.3g, WS2a, WS2b, WS2c	Comparisons of behaviour of springs and elastic bands when loading and unloading with weights. (PAG P2)

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P2.3c	describe the relationship between force and extension for a spring and other simple systems	graphical representation of the extension of a spring	M1a, M2a, M4a, M4b, M4c	WS1.1b, WS1.1e, WS1.2a, WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3c, WS1.3e, WS1.3f, WS1.3g, WS1.4f, WS2a, WS2b, WS2c	Investigation of forces on springs – Hooke’s law. (PAG P2)
P2.3d	describe the difference between linear and non-linear relationships between force and extension		M1a, M2a, M4a, M4b, M4c	WS1.1b, WS1.1e, WS1.2a, WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3c, WS1.3e, WS1.3f, WS1.3g, WS2a, WS2b, WS2c	Investigation of the elastic limit of springs and other materials. (PAG P2)
P2.3e	calculate a spring constant in linear cases		M1a, M2a, M3a, M3b, M3c, M3d		

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P2.3f	calculate the work done in stretching		M1a, M2a, M3a, M3b, M3c, M3d, M4a, M4b, M4c, M4f	WS1.1b, WS1.2a, WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3c, WS1.3e, WS1.3f, WS1.3g, WS1.4f, WS2c	Use of data from stretching an elastic band with weights to plot a graph to calculate the work done. (PAG P2)
P2.3g	describe that all matter has a gravitational field that causes attraction, and the field strength is much greater for massive objects				
P2.3h	define weight, describe how it is measured and describe the relationship between the weight of an object and the gravitational field strength, *g*	knowledge that the gravitational field strength is known as *g* and has a value of 10 N/kg at the Earth's surface		WS1.1b	Calculations of weight on different planets.
P2.3i	recall the acceleration in free fall				
P2.3j ☑	apply formulae relating force, mass and relevant physical constants, including gravitational field strength, *g*, to explore how changes in these are inter-related		M1c, M3b, M3c		
P2.3k ☑	describe examples in which forces cause rotation	location of pivot points and whether a resultant turning force will be in a clockwise or anticlockwise direction			

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P2.3l ☑	define and calculate the moment of a force	application of the principle of moments for objects which are balanced	M1a, M1c, M2a, M3a, M3b, M3c, M3d	WS1.2a, WS1.2b, WS1.3e, WS2a, WS2b, WS2c	Investigation of moments using a meter ruler, pivot and balancing masses. (PAG P2)
P2.3m ☑	explain how levers and gears transmit the rotational effects of forces	an understanding of ratios and how this enables gears and levers to work as force multipliers	M1c		
P2.3n ☑	recall that the pressure in fluids (gases and liquids) causes a net force at right angles to any surface			WS1.1b, WS1.2a, WS1.4a	Demonstration of balloons being pushed onto a single drawing pin versus many drawing pins.
P2.3o ☑	use the relationship between the force, the pressure and the area in contact	an understanding of how simple hydraulic systems work	M1a, M2a, M3a, M3b, M3c, M3d		

Topic P3: Electricity

P3.1 Static and charge

Summary

Having established the nature of matter, consideration is now given to the interactions between matter and electrostatic fields. These interactions are derived from the structure of matter which was considered in Topic P1. The generation of charge is considered. Charge is a fundamental property of matter. There are two types of charge which are given the names 'positive' and 'negative'.

Underlying knowledge and understanding

Learners should be aware of electron transfer leading to objects becoming statically charged and the forces between them. They should also be aware of the existence of an electric field.

Common misconceptions

Learners commonly have difficulty classifying materials as insulators or conductors. They find it difficult to remember that positive charge does not move to make a material positive, rather it is the movement of electrons.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
PM3.1i	recall and apply: charge flow (C) = current (A) × time (s)	M1a, M2a, M3a, M3b, M3c, M3d

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P3.1a	describe that charge is a property of all matter and that there are positive and negative charges	the understanding that in most bodies there are an equal number of positive and negative charges resulting in the body having zero net charge		WS1.1b, WS1.1e, WS1.2a, WS1.3e, WS2a	Use of charged rods to repel or attract one another. Use of a charged rod to deflect water or pick up paper. Discussion of why charged balloons are attracted to walls.
P3.1b	describe the production of static electricity, and sparking, by rubbing surfaces, and evidence that charged objects exert forces of attraction or repulsion on one another when not in contact	the understanding that static charge only builds up on insulators		WS1.1b, WS1.1e, WS1.2a, WS1.3e	Use of a Van de Graaff generator.
P3.1c	explain how transfer of electrons between objects can explain the phenomena of static electricity			WS1.1b, WS1.3e, WS1.3f, WS2a	Use of the gold leaf electroscope and a charged rod to observe and discuss behaviour.
P3.1d ☑	explain the concept of an electric field and how it helps to explain the phenomena of static electricity	how electric fields relate to the forces of attraction and repulsion	M5b	WS1.3e	Demonstration of semolina on castor oil to show electric fields.
P3.1e	recall that current is a rate of flow of charge (electrons) and the conditions needed for charge to flow	conditions for charge to flow: source of potential difference and a closed circuit			
P3.1f	recall that current has the same value at any point in a single closed loop				
P3.1g	recall and use the relationship between quantity of charge, current and time		M1a, M2a, M3a, M3b, M3c, M3d		

P3.2 Simple circuits

Summary

Electrical currents depend on the movement of charge and the interaction of electrostatic fields. Electrical current, potential difference and resistance are all discussed in this section. The relationship between them is considered and learners will investigate this using circuits.

Underlying knowledge and understanding

Learners should have been introduced to the measurement of conventional current and potential difference in circuits. They will have an understanding of how to assemble series and parallel circuits and of how they differ with respect to conventional current and potential difference. Learners are expected to have an awareness of the relationship between potential difference, current and resistance and the units in which they are measured.

Common misconceptions

Learners find the concept of potential difference very difficult to grasp. They find it difficult to understand the behaviour of charge in circuits and through components and how this relates to energy or work done within a circuit.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
PM3.2i	recall and apply: potential difference (V) = current (A) × resistance (Ω)	M1a, M2a, M3a, M3b, M3c, M3d
PM3.2ii	recall and apply: energy transferred (J) = charge (C) × potential difference (V)	M1a, M2a, M3a, M3b, M3c, M3d
PM3.2iii	recall and apply: power (W) = potential difference (V) × current (A)	M1a, M2a, M3a, M3b, M3c, M3d
	recall and apply: power (W) = (current (A))^2 × resistance (Ω)	
PM3.2iv	recall and apply: energy transferred (J, kW h) = power (W, kW) × time (s, h)	M1a, M2a, M3a, M3b, M3c, M3d

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P3.2a	describe the differences between series and parallel circuits	positioning of measuring instruments in circuits and descriptions of the behaviour of energy, current and potential difference		WS1.1b, WS1.2a, WS1.2b, WS1.2c, WS1.3a, WS1.3b, WS1.3e, WS1.3f, WS1.3h, WS1.4a, WS2a, WS2b, WS2c, WS2d	Building of circuits to measure potential difference and current in both series and parallel circuits. (PAG P7)
P3.2b	represent d.c. circuits with the conventions of positive and negative terminals, and the symbols that represent common circuit elements	cells, power supply, diodes, LDRs, NTC thermistors, filament lamps, ammeter, voltmeter, fixed and variable resistors and switch		WS1.1b, WS1.2a, WS1.2b, WS1.2c, WS1.3a, WS1.3b, WS1.3e, WS1.3f, WS1.3h, WS1.4a, WS2a, WS2b, WS2c, WS2d	Building circuits from diagrams. (PAG P7)

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P3.2c	recall that current, *I*, depends on both resistance, *R*, and potential difference, *V*, and the units in which these are measured	the definition of potential difference		WS1.1b, WS1.2a, WS1.2b, WS1.2c, WS1.3a, WS1.3b, WS1.3c, WS1.3e, WS1.3f, WS1.3h, WS1.4a, WS2a, WS2b, WS2c, WS2d	Recording of p.d. across and current through different components and calculate resistances. (PAG P6)
P3.2d	recall and apply the relationship between *I*, *R* and *V*, and that for some resistors the value of R remains constant but that in others it can change as the current changes		M1a, M2a, M3a, M3b, M3c, M3d	WS1.1b, WS1.2a, WS1.2b, WS1.2c, WS1.3a, WS1.3b, WS1.3c, WS1.3e, WS1.3f, WS1.3h, WS1.4a, WS2a, WS2b, WS2c, WS2d	Investigation of resistance in a wire. (PAG P6) Investigation of the effect of length on resistance in a wire. (PAG P7)
P3.2e	explain that for some resistors the value of *R* remains constant but that in others it can change as the current changes				
P3.2f	explain the design and use of circuits to explore such effects	components such as wire of varying resistance, filament lamps, diodes, NTC thermistors and LDRs			Building circuits and measurement of current and potential difference.

Learning outcomes		To include	Maths	Working scientifically	Practical suggestion
P3.2g	use graphs to explore whether circuit elements are linear or non-linear		M4c, M4d	WS1.1b, WS1.2a, WS1.2b, WS1.2c, WS1.3a, WS1.3b, WS1.3c, WS1.3e, WS1.3f, WS1.3h, WS1.4a, WS2a, WS2b, WS2c, WS2d	Investigation of I-V characteristics of circuit elements. (PAG P6)
P3.2h	use graphs and relate the curves produced to the function and properties of circuit elements	components such as wire of varying resistance, filament lamps, diodes, NTC thermistors and LDRs	M4c, M4d	WS1.1b, WS1.2a, WS1.2b, WS1.2c, WS1.3a, WS1.3b, WS1.3c, WS1.3e, WS1.3f, WS1.3h, WS1.4a, WS2a, WS2b, WS2c, WS2d	Use of wires, filament lamps, diodes, in simple circuits. Alter p.d. and keep current same using variable resistor. Record and plot results. (PAG P6)

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P3.2i	explain why, if two resistors are in series the net resistance is increased, whereas with two in parallel the net resistance is decreased (qualitative explanation only)		M1c	WS1.1b, WS1.2a, WS1.2b, WS1.2c, WS1.3a, WS1.3b, WS1.3e, WS1.3f, WS1.3h, WS1.4a, WS2a, WS2b, WS2c, WS2d	Investigation of the brightness of bulbs in series and parallel. (PAG P7)
P3.2j	calculate the currents, potential differences and resistances in d.c. series and parallel circuits	components such as wire of varying resistance, filament lamps, diodes, NTC thermistors and LDRs	M1a, M2a, M3a, M3b, M3c, M3d	WS1.1b, WS1.2a, WS1.2b, WS1.2c, WS1.3a, WS1.3b, WS1.3c, WS1.3e, WS1.3f, WS1.3h, WS1.4a, WS2a, WS2b, WS2c, WS2d	Investigation of resistance of a thermistor in a beaker of water being heated. (PAG P6) Investigation of resistance of an LDR with exposure to different light intensities. (PAG P6) Investigation of how the power of a photocell depends on its surface area and its distance from the light source. (PAG P6)
P3.2k	explain the design and use of d.c. circuits for measurement and testing purposes				
P3.2l	explain how the power transfer in any circuit device is related to the potential difference across it and the current, and to the energy changes over a given time				
P3.2m	apply the equations relating potential difference, 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		M1c, M3b, M3c, M3d		

Topic P4: Magnetism and magnetic fields

P4.1 Magnets and magnetic fields

Summary
Having an understanding of how charge can be generated and its effects, we can now consider the link between movement of charge and magnetism. To begin, learners will investigate magnets and magnetic fields around magnets and current-carrying wires.

Underlying knowledge and understanding
Learners should have been introduced to magnets and the idea of attractive and repulsive forces. They should have an idea of the shape of the fields around bar magnets. Learners are expected to have an awareness of the magnetic effect of a current and electromagnets.

Common misconceptions
Common misconceptions that learners have include the idea that larger magnets will always be stronger magnets. They also have difficulty understanding the concept of field line density being an indicator of field strength. Learners often do not know that the geographic and magnetic poles are not located in the same place.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P4.1a	describe the attraction and repulsion between unlike and like poles for permanent magnets	diagrams of magnetic field patterns around bar magnets to show attraction and repulsion		WS1.1b, WS1.2a, WS1.2b, WS2a, WS2b	Use of suspended magnets to show attraction and repulsion.
P4.1b	describe the difference between permanent and induced magnets				
P4.1c	describe the characteristics of the magnetic field of a magnet, showing how strength and direction change from one point to another	diagrams to show how the strength of the field varies around them and ways of investigating this	M5b	WS1.1b, WS1.2a, WS1.2b, WS2a, WS2b, WS2c	Plotting of magnetic fields around different shaped magnets.
P4.1d	explain how the behaviour of a magnetic (dipping) compass is related to evidence that the core of the Earth must be magnetic				

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P4.1e	describe how to show that a current can create a magnetic effect and describe the directions of the magnetic field around a conducting wire			WS1.1b, WS1.2a, WS1.2b, WS2a, WS2b, WS2c	Investigation of the magnetic field around a current-carrying wire using plotting compasses.
P4.1f	recall that the strength of the field depends on the current and the distance from the conductor		M1c		
P4.1g	explain how solenoid arrangements can enhance the magnetic effect		M1c	WS1.1b, WS1.2a, WS1.2b, WS2a, WS2b, WS2c, WS2d	Investigation of the magnetic field around a current-carrying solenoid using plotting compasses. Investigation of the factors that can affect the magnetic effect e.g. number of turns, and length.

P4.2 Uses of magnetism

Summary

Forces show the existence of fields and how they interact with one another but here the force itself is discussed in more depth and then quantified. These forces also lead to the use of magnetic fields to induce electrical currents and the applications of this electromagnetic induction in motors, dynamos and transformers.

Underlying knowledge and understanding

This topic will predominantly be new content for learners with some understanding of D.C. motors. Learners will have looked at fields in the previous subtopic and now this knowledge will be built on to give learners the understanding of the application.

Common misconceptions

Learners find understanding the manner in which electric and magnetic fields interact to produce a force challenging. Learners commonly have difficulty with the right angles and three-dimensional requirements of Fleming's left-hand rule. Their ability to visualise this will impact how they deal with this concept. Learners find the action of a commutator difficult to apply in the D.C. motor. The application of changing direction of field in the transformer is found challenging by many learners and hence often leads to a superficial grasp of the working of the transformer.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
PM4.2i	**apply: force on a conductor (at right angles to a magnetic field) carrying a current:** **force (N) = magnetic flux density (T) × current (A) × length (m)**	**M1a, M1b, M1d, M2a, M3a, M3b, M3c, M3d**
PM4.2ii ☑	**apply:** $\frac{\text{potential difference across primary coil (V)}}{\text{potential difference across secondary coil (V)}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$	**M1a, M1b, M1c, M1d, M2a, M3a, M3b, M3c, M3d**

Topic content			Opportunities to cover:		
Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P4.2a	**describe how a magnet and a current-carrying conductor exert a force on one another**			WS1.1b, WS1.1e, WS1.2a, WS1.3e	Demonstration of the jumping wire experiment.
P4.2b	**show that Fleming's left-hand rule represents the relative orientations of the force, the current and the magnetic field**				
P4.2c	**apply the equation that links the force on a conductor to the magnetic flux density, the current and the length of conductor to calculate the forces involved**		M1a, M1b, M1d, M2a, M3a, M3b, M3c, M3d		
P4.2d	**explain how the force exerted from a magnet and a current-carrying conductor is used to cause rotation in electric motors**	**an understanding of how electric motors work but knowledge of the structure of a motor is not expected**		WS1.1e, WS1.3e, WS2a	Construction of simple motors.
P4.2e ☑	**recall that a change in the magnetic field around a conductor can give rise to an induced potential difference across its ends, which could drive a current, generating a magnetic field that would oppose the original change**			WS1.1e, WS1.3e, WS2a	Examination of wind up radios or torches to investigate how dynamos work. Demonstration of induction using a strong magnet and a wire using a zero point galvanometer.
P4.2f ☑	**explain how this effect is used in an alternator to generate a.c., and in a dynamo to generate d.c.**			WS1.1a, WS1.1e, WS1.4a	Research the structure of dynamos and compare with DC motors.

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P4.2g ☑	**explain how the effect of an alternating current in one circuit, in inducing a current in another, is used in transformers**				
P4.2h ☑	**explain how the ratio of the potential differences across the two coils in a transformer depends on the ratio of the numbers of turns in each**		M1c	WS1.1e, WS1.2a, WS1.2b, WS1.3a, WS1.3b, WS1.3e, WS1.3h, WS2a, WS2b	Building of a step-up and step-down transformer to investigate their effects.
P4.2i ☑	**apply the equations linking the potential differences and numbers of turns in the two coils of a transformer**		M1c, M3b, M3c		
P4.2j ☑	**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**	**an understanding of how dynamic microphones work using electromagnetic induction**		WS1.1e, WS1.2a, WS1.3e, WS1.3h, WS2a, WS2b	Examination of the construction of a loudspeaker. Building of a loud speaker.

Topic P5: Waves in matter

P5.1 Wave behaviour

Summary

Waves are means of transferring energy and the two main types of wave are introduced in this section: mechanical and electromagnetic. This section considers both what these types of waves are and how they are used. The main terms used to describe waves are defined and exemplified in this topic.

Underlying knowledge and understanding

Learners should have prior knowledge of transverse and longitudinal waves through sound and light. Learners should be aware of how waves behave and how the speed of a wave may change as it passes through different media. They may already have knowledge of how sound is heard and the hearing ranges of different species.

Common misconceptions

Although they will often have heard of the terms ultrasound and sonar, learners find it challenging to explain how images and traces are formed and to apply their understanding to calculations. Learners often misinterpret distance and displacement–time graphical presentations of waves.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
PM5.1i	recall and apply: wave speed (m/s) = frequency (Hz) × wavelength (m)	M1a, M1b, M1c, M2a, M3a, M3b, M3c, M3d

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P5.1a	describe wave motion in terms of amplitude, wavelength, frequency and period			WS1.1b, WS1.3b, WS1.3e	Observing sound waves on an oscilloscope.
P5.1b	define wavelength and frequency				
P5.1c	describe and apply the relationship between wavelength, frequency and wave velocity		M1a, M1b, M1c, M2a, M3a, M3b, M3c, M3d	WS1.1b, WS1.3a, WS1.3b, WS1.3c, WS1.3d, WS1.3e, WS1.3g, WS1.3h, WS1.3d, WS2a, WS2b	Investigation of reflection in a ripple tank (PAG P4)
P5.1d	apply formulae relating velocity, frequency and wavelength		M1c, M3c		
P5.1e	describe differences between transverse and longitudinal waves	direction of travel and direction of vibration	M5b	WS1.1b, WS1.3e	Use of a slinky to model waves.
P5.1f ☑	show how changes, in velocity, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related		M1c, M3c		

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P5.1g ☑	describe the effects of reflection, transmission, and absorption of waves at material interface	examples such as ultrasound and sonar		WS1.2a, WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3e, WS1.3f, WS1.3h, WS2a, WS2b, WS2c	Refraction of light through a glass block. (PAG P8) Investigation of reflection with a plane mirror. (PAG P8) Demonstration of refraction of white light through a prism.
P5.1h ☑	**describe, with examples, processes which convert wave disturbances between sound waves and vibrations in solids**	**knowledge of a simple structure of the parts of the ear is expected**		WS1.1b, WS1.1f, WS1.3b, WS1.3e	Use of a signal generator and loudspeaker. Demonstration of sound waves using a Rubens' tube or an oscilloscope.
P5.1i ☑	**explain why such processes only work over a limited frequency range, and the relevance of this to human hearing**	**why hearing (audition) changes due to ageing**			
P5.1j	describe how ripples on water surfaces are used to model transverse waves whilst sound waves in air are longitudinal waves, and how the speed of each may be measured			WS1.1b, WS1.3a, WS1.3b, WS1.3c, WS1.3d, WS1.3e, WS1.3g, WS1.3h, WS1.3d, WS2a, WS2b	Investigation of refraction in a ripple tank. (PAG P8)
P5.1k	describe evidence for the cases of ripples on water surfaces and for sound waves in air that it is the wave that travels and not the water or the air				

P5.2 The electromagnetic spectrum

Summary

Having looked at mechanical waves, waves in the electromagnetic spectrum are now considered. This section includes the application of electromagnetic waves with a specific focus on the behaviour of light. Alongside this, it explores the application of other types of electromagnetic radiation for use in medical imaging.

Underlying knowledge and understanding

Learners may be familiar with uses of some types of radiation but an understanding of all parts of the electromagnetic spectrum is not expected and should be taught as new content.

Common misconceptions

Learners can have misconceptions such as gamma rays, X-rays, ultraviolet light, visible light, infrared light, microwaves and radio waves being independent entities and not being able to view it as a spectrum. They struggle to link the features that waves have in common, alongside the differences and how these relate to their different properties.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P5.2a	recall that electromagnetic waves are transverse and are transmitted through space where all have the same velocity				
P5.2b	explain that electromagnetic waves transfer energy from source to absorber	examples from a range of electromagnetic waves			
P5.2c	apply the relationships between frequency and wavelength across the electromagnetic spectrum		M1a, M1c, M3c	WS1.1b, WS1.3b, WS1.3e	Investigation of electromagnetic waves on chocolate or processed cheese in a microwave to measure wavelength. (PAG P4)
P5.2d	describe the main groupings of the electromagnetic spectrum and that these groupings range from long to short wavelengths and from low to high frequencies	radio, microwave, infrared, visible (red to violet), ultraviolet, X-rays and gamma rays		WS1.1c, WS1.1d, WS1.1e, WS1.1f, WS1.1h, WS1.1i	Research and design a poster to show the properties, uses and dangers of the different electromagnetic wave groups.
P5.2e	describe that our eyes can only detect a limited range of the electromagnetic spectrum				

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P5.2f	recall that light is an electromagnetic wave				
P5.2g	give examples of some practical uses of electromagnetic waves in the radio, microwave, infrared, visible, ultraviolet, X-ray and gamma ray regions			WS1.1b, WS1.1d, WS1.1e, WS1.1f, WS1.1h, WS1.1i, WS1.3e, WS1.3f	Demonstration of how microwaves can be used to light a bulb in a beaker of water and of how this shows that microwaves heat water in foods. Use a microwave emitter and absorber to demonstrate behaviour of waves. (PAG P8) Use of a phone camera to look at the infrared emitter on a remote control. (PAG P8)
P5.2h	describe how ultraviolet waves, X-rays and gamma rays can have hazardous effects, notably on human bodily tissues			WS1.1a, WS1.1c, WS1.1d, WS1.1e, WS1.1f, WS1.1h, WS1.1i	Show images of X-rays to discuss how the images are formed; their advantages and disadvantages. Investigation of the balance of risks for staff and patients during radiotherapy.
P5.2i ☑	**explain, in qualitative terms, how the differences in velocity, absorption and reflection between different types of waves in solids and liquids can be used both for detection and for exploration of structures which are hidden from direct observation, notably in our bodies**	**the use of infrared, X-rays, gamma rays and ultrasound as an alternative in medical imaging**			
P5.2j	**recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits**				

P5.3 Wave interactions

Summary

Having studied the electromagnetic spectrum learners now go on to look at the interactions of waves with materials, this will include absorption, refraction and reflection. Learners will also be expected to draw ray diagrams to illustrate the refraction of rays through lenses.

Underlying knowledge and understanding

Learners will already be familiar with the properties and behaviour of light. They are expected to have an understanding of behaviour such as reflection, refraction, absorption and scattering. Learners should know that colours are produced by light at different frequencies.

Common misconceptions

A common misconception is that when light passes through a coloured filter, the filter will add colour to the light. In addition, learners are often confused about which colours are primary colours.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P5.3a	**recall that different substances may absorb, transmit, refract, or reflect electromagnetic waves in ways that vary with wavelength**				
P5.3b	**explain how some effects are related to differences in the velocity of electromagnetic waves in different substances**				
P5.3c ☑	use ray diagrams to illustrate reflection, refraction and the similarities and differences between convex and concave lenses (qualitative only)	how the behaviour of convex and concave lenses determine how they may be used, for example, to correct vision	M5a, M5b	WS1.1b, WS1.2c, WS1.3a, WS1.3e, WS2a, WS2b, WS2c	Use of concave and convex lenses to investigate how they alter the path of light in different ways. (PAG P4) Investigation using convex lenses to see how the image of a light bulb varies with the distance of the bulb from the lens. (PAG P4)

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P5.3d ☑	construct two-dimensional ray diagrams to illustrate reflection and refraction (qualitative only – equations not needed)		M5a, M5b		
P5.3e ☑	explain how colour is related to differential absorption, transmission and reflection	specular reflection and scattering		WS1.1b, WS1.2c, WS1.3a, WS1.3e, WS2a, WS2b, WS2c	Use of coloured filters and light sources to investigate how filters work. (PAG P4)

Topic P6: Radioactivity

P6.1 Radioactive emissions

Summary
Having considered the general characteristics of waves and particles, we now move on to look at radioactive decay which combines these two ideas. The idea of isotopes is introduced, leading into looking at the different types of emissions from atoms.

Underlying knowledge and understanding
Learners should have prior understanding of the atomic model, chemical symbols and formulae. An understanding of radioactivity is not expected and should be taught as new content.

Common misconceptions
Learners tend to struggle with the concept that radioactivity is a random and unpredictable process. The idea of half-life is another area that can lead to confusion. Learners often find it difficult to understand that objects being irradiated does not lead to them becoming radioactive.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Topic content			Opportunities to cover:		
Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P6.1a	recall that atomic nuclei are composed of both protons and neutrons, that the nucleus of each element has a characteristic positive charge		M5b		
P6.1b	recall that atoms of the same elements can differ in nuclear mass by having different numbers of neutrons				
P6.1c	use the conventional representation for nuclei to relate the differences between isotopes	identities, charges and masses			

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P6.1d	recall that some nuclei are unstable and may emit alpha particles, beta particles, or neutrons, and electromagnetic radiation as gamma rays			WS1.1a, WS1.1b, WS1.2a, WS1.2d, WS1.3b, WS1.3f	Use of a Geiger-Müller tube and radioactive sources to investigate activity.
P6.1e	relate the emission of alpha particles, beta particles, gamma radiation and neutrons to possible changes in the mass or the charge of the nucleus, or both				
P6.1f	use names and symbols of common nuclei and particles to write balanced equations that represent radioactive decay				
P6.1g	balance equations representing the emission of alpha, beta or gamma radiation in terms of the masses, and charges of the atoms involved		M1b, M1c, M3c		
P6.1h	recall that in each atom its electrons are arranged at different distances from the nucleus, that such arrangements may change with absorption or emission of electromagnetic radiation and that atoms can become ions by loss of outer electrons	knowledge that inner electrons can be 'excited' when they absorb energy from radiation and rise to a higher energy level. When this energy is lost by the electron it is emitted as radiation. When outer electrons are lost this is called ionisation			
P6.1i	recall that changes in atoms and nuclei can also generate and absorb radiations over a wide frequency range	an understanding that these types of radiation may be from any part of the electromagnetic spectrum which includes gamma rays		WS1.1b, WS1.3e	Demonstration of fluorescence with a black light lamp and tonic water.

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P6.1j	explain the concept of half-life and how this is related to the random nature of radioactive decay		M1c, M3d, M4a, M4c	WS1.1b, WS1.3a, WS1.3b, WS1.3c, WS1.3e, WS1.3f, WS1.3h, WS2a	Using dice to model random decay and half-life. Research how half-life can be used in radioactive dating.
P6.1k	**calculate the net decline, expressed as a ratio, during radioactive emission after a given (integral) number of half-lives**	**half-life graphs**	M1c, M3d		
P6.1l	recall the differences in the penetration properties of alpha particles, beta particles and gamma rays			WS1.1b, WS1.2a, WS1.2b, WS1.2c, WS1.3a, WS1.3f, WS1.3g, WS1.3h	Use of Geiger-Müller tube, sources and aluminium plates of varying thicknesses to investigate change in count rate.

P6.2 Uses and hazards

Summary
We now address the hazards and applications of radioactive decay. The processes of fission and fusion as a source of energy are also considered.

Underlying knowledge and understanding
Learners may have prior understanding of the term radioactivity from the previous sub topic and may be familiar with some uses, but will not have covered this content prior to this topic.

Common misconceptions
Learners tend to think that radioactivity will always cause physical mutations when humans or animals come into contact with it. They tend to only think of the negative impacts of radiation and not the positive uses.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P6.2a	recall the differences between contamination and irradiation effects and compare the hazards associated with these two			WS1.1a, WS1.1b, WS1.2a, WS1.2d, WS1.3b, WS1.3f	Use of spark chamber to demonstrate a different type of activity counter.
P6.2b ☑	explain why the hazards associated with radioactive material differ according to the half-life involved			WS1.1a, WS1.1c, WS1.1d, WS1.1e, WS1.1f, WS1.1h, WS1.1i	Illustrate an everyday use of radioactive sources in smoke detectors and discuss why they might be suitable.

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P6.2c ☑	describe the different uses of nuclear radiations for exploration of internal organs, and for control or destruction of unwanted tissue			WS1.1a, WS1.1c, WS1.1d, WS1.1e, WS1.1f, WS1.1h, WS1.1i	Research the medical uses of radioactive tracers and radiotherapy.
P6.2d ☑	recall that some nuclei are unstable and may split, and relate such effects to radiation which might emerge, to transfer of energy to other particles and to the possibility of chain reactions	knowledge of the term nuclear fission for fission to occur the unstable nucleus must usually first absorb a neutron			
P6.2e ☑	describe the process of nuclear fusion	knowledge that mass may be converted into the energy of radiation			

Topic P7: Energy

P7.1 Work done

Summary
We now move on to consider how energy can be stored and transferred. This topic acts to consolidate the ideas of energy that have been covered in previous topics as it is a fundamental concept that underpins many of the ways in which matter interacts.

Underlying knowledge and understanding
Learners may have prior knowledge of energy listed as nine types, as this is the teaching approach often taken at Key Stage 2 and Key Stage 3 to increase accessibility to an abstract concept. Learners may find it difficult to move away from this idea but need to be able to approach systems in terms of energy transfers and stores. They will have an understanding that energy can be transferred in processes such as changing motion, burning fuels and in electrical circuits. Learners should also be aware of the idea of conservation of energy and that it has a quantity that can be calculated.

Common misconceptions
Learners may have misconceptions around energy being a fuel-like substance that matter has to 'use up', that resting objects do not have any energy and that all energy is transferred efficiently. There is also often confusion between forces and energy.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P7.1a	describe for situations where there are energy transfers in a system, that there is no net change to the total energy of a closed system (qualitative only)	the law of conservation of energy			
P7.1b	describe all the changes involved in the way energy is stored when a system changes for common situations	an object projected upwards or up a slope, a moving object hitting an obstacle, an object being accelerated by a constant force, a vehicle slowing down, bringing water to a boil in an electric kettle		WS1.2a, WS1.2b, WS1.3c, WS1.3f, WS1.4a, WS1.4e, WS2a, WS2b, WS2c	Exploring energy stores and transfers in different objects in a circus based activity. Objects could include a wind up toy, a weight on a spring, a weight being lifted or dropped, water being heated, electrical appliances.

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P7.1c	describe the changes in energy involved when a system is changed by heating (in terms of temperature change and specific heat capacity), by work done by forces, and by work done when a current flows				
P7.1d	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	work done by forces, current flow, through heating and the use of kW h to measure energy use in electrical appliances in the home	M1a, M1c, M3c	WS1.3a, WS1.3b, WS1.3c, WS1.3e, WS2a, WS2b	Use of a joulemeter to measure the energy used by different electrical appliances. (PAG P5)
P7.1e	calculate the amounts of energy associated with a moving body, a stretched spring and an object raised above ground level		M1a, M1b, M1c, M2a, M3a, M3b, M3c, M3d	WS1.1b, WS1.2a, WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3b, WS1.3c, WS1.3e, WS2a, WS2b	Use of light gates and trolleys to investigate kinetic energy. (PAG P5) Use of a joulemeter and electrical motor to lift a weight to investigate potential energy. (PAG P5) Investigation of energy changes and efficiency of bouncy balls. (PAG P5)

P7.2 Power and efficiency

Summary

This considers the idea of conservation and dissipation of energy in systems and how this leads to the efficiency. Ways of reducing unwanted energy transfers and thereby increasing efficiency will be explored.

Underlying knowledge and understanding

Learners should be aware of the transfer of energy into useful and waste energies. They will have an understanding of power and how domestic appliances can be compared. Learners will have knowledge of insulators and how energy transfer is influenced by temperature. They should have an awareness of ways to reduce heat loss in the home.

Common misconceptions

Learners have the common misconception that energy can be "used up" or that energy is truly lost in many energy transformations. They also tend to have the belief that energy can be completely changed from one form to another with no energy dissipated.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
PM7.2i	recall and apply: $\text{efficiency} = \dfrac{\text{useful output energy transfer (J)}}{\text{input energy transfer (J)}}$	M1a, M1b, M1d, M2a, M3a, M3b, M3c, M3d

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P7.2a	describe, with examples, the process by which energy is dissipated, so that it is stored in less useful ways				
P7.2b	describe how, in different domestic devices, energy is transferred from batteries or the a.c. from the mains	how energy may be wasted in the transfer to and within motors and heating devices			

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P7.2c	describe, with examples, the relationship between the power ratings for domestic electrical appliances and how this is linked to the changes in stored energy when they are in use			WS1.3a, WS1.3b, WS1.3c, WS1.3e, WS2a, WS2b	Use of a joulemeters to investigate the power output of different electrical appliances. (PAG P5)
P7.2d	calculate energy efficiency for any energy transfer		M1a, M1b, M1d, M2a, M3a, M3b, M3c, M3d		
P7.2e	**describe ways to increase efficiency**				
P7.2f	explain ways of reducing unwanted energy transfer	lubrication and thermal insulation		WS1.1b, WS1.1e, WS1.1f, WS1.1g, WS1.1i, WS1.3b	Research, design and building of energy efficient model houses. Examination of thermograms of houses.
P7.2g	describe how the rate of cooling of a building is affected by the thickness and thermal conductivity of its walls (qualitative only)			WS1.2a, WS1.2b, WS1.2c, WS1.3a, WS1.3c, WS1.3d, WS1.3e, WS1.3g, WS1.3h, WS1.3i, WS2a, WS2b, WS2c, WS2d	Investigation of rate of cooling with insulated and non-insulated copper cans. (PAG P5)

Topic P8: Global challenges

This topic seeks to integrate learners' knowledge and understanding of physical systems and processes, with the aim of applying it to global challenges. Applications of physics can be used to help humans improve their own lives and strive to create a sustainable world for future generations, and these challenges are considered in this topic. It therefore provides opportunities to draw together the concepts covered in earlier topics, allowing synoptic treatment of the subject of physics.

P8.1 Physics on the move

Summary
Learners will use their knowledge of forces and motion to develop their ideas about how objects are affected by external factors. They will develop a better understanding of these external factors to be able to understand how the design of objects such as cars may be modified to operate more safely.

Underlying knowledge and understanding
Learners should be familiar with how forces affect motion of objects. They will also need to have a good understanding of momentum from P2.2. Learners may already have some knowledge of how vehicles are adapted to increase safety.

Common misconceptions
Learners tend to confuse the factors that affect thinking distance and braking distance, thinking that alcohol, drugs and tiredness will affect braking distance rather than thinking distance. It needs to be made clear the distinction between these two terms and that the combination of these gives us the stopping distance.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P8.1a	recall typical speeds encountered in everyday experience for wind and sound, and for walking, running, cycling and other transportation systems		M1d		
P8.1b	estimate the magnitudes of everyday accelerations		M1d		
P8.1c	make calculations using ratios and proportional reasoning to convert units and to compute rates	conversion from non-SI to SI units	M1c, M3c		

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P8.1d	explain methods of measuring human reaction times and recall typical results		M1a, M2a, M2b	WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3b, WS1.3c, WS1.3e, WS1.3g, WS1.3h, WS2a, WS2b, WS2c, WS2d	Investigation of reaction time using ruler drop experiments. (PAG P3)
P8.1e	explain the factors which affect the distance required for road transport vehicles to come to rest in emergencies and the implications for safety	factors that affect thinking and braking distance and overall stopping distance			
P8.1f ☑	estimate how the distances required for road vehicles to stop in an emergency, varies over a range of typical speeds		M1c, M1d, M2c, M2h, M3b, M3c	WS1.1e, WS1.1h	Research stopping distances using the Highway Code.
P8.1g	explain the dangers caused by large decelerations			WS1.1e, WS1.1f, WS1.1h, WS1.2a, WS1.2b, WS1.2c, WS1.2e, WS2a, WS2b	Research and building of casing on trolleys for eggs to investigate crumple zones and safety features in cars.
P8.1h ☑	**estimate the forces involved in typical situations on a public road**				
P8.1i ☑	estimate, for everyday road transport, the speed, accelerations and forces involved in large accelerations		M1d, M2b, M2h, M3c		

P8.2 Powering Earth

Summary

We are reliant on electricity for everyday life and this topic explores the production of electricity. Consideration will be given to the use of non-renewable and renewable sources and the problems that are faced in the efficient transportation of electricity to homes and businesses. Safe use of electricity in the home is also covered in this topic. It may be an opportunity to revisit power and efficiency.

Underlying knowledge and understanding

Learners should already be familiar with renewable and non-renewable energy sources. Learners are expected to have a basic understanding of how power stations work and the cost of electricity in the home. They may have some idea of electrical safety features in the home.

Common misconceptions

Learners often confuse the idea of energy with terms including the word power such as solar power. There are often difficulties in understanding that higher voltages are applied across power lines and not along them. Another common misconception is that batteries and wall sockets have current inside them ready to escape.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
PM8.2i	apply: potential difference across primary coil (V) × current in primary coil (A) = potential difference across secondary coil (V) × current in secondary coil (A)	M1a, M1b, M1c, M1d, M2a, M3a, M3b, M3c, M3d

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P8.2a	describe the main energy sources available for use on Earth, compare the ways in which they are used and distinguish between renewable and non-renewable sources	fossil fuels, nuclear fuel, biofuel, wind, hydroelectricity, tides and the Sun		WS1.1c, WS1.1d, WS1.1e, WS1.1f, WS1.1g, WS1.1h, WS1.1i, WS1.3e	Research of different energy sources. Demonstration of a steam engine and discussion of the transfer of energy taking place.

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P8.2b	explain patterns and trends in the use of energy resources	the changing use of different resources over time		WS1.1a, WS1.1b, WS1.1c, WS1.1d, WS1.1e, WS1.1f, WS1.1g, WS1.1h, WS1.1i	Research and present information to convince people to invest in energy saving measures. Research how the use of electricity has changed in the last 150 years.
P8.2c	recall that, in the national grid, electrical power is transferred at high voltages from power stations, and then transferred at lower voltages in each locality for domestic use				
P8.2d	recall that step-up and step-down transformers are used to change the potential difference as power is transferred from power stations			WS1.1b, WS1.1e, WS1.1f, WS1.3e	Use of a model power line to demonstrate the energy losses at lower voltage and higher current.
P8.2e	explain how the national grid is an efficient way to transfer energy				
P8.2f ☑	**link the potential differences and numbers of turns of a transformer to the power transfer involved; relate this to the advantages of power transmission at high voltages**		M1c, M3b, M3c		
P8.2g	recall that the domestic supply in the UK is a.c. at 50 Hz and about 230 volts				
P8.2h	explain the difference between direct and alternating voltage			WS1.3b, WS1.3e	Use of a data logger to compare a.c. and d.c. output traces. (PAG P7)

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P8.2i	recall the differences in function between the live, neutral and earth mains wires, and the potential differences between these wires			WS2a	Wiring of a plug.
P8.2j	explain that a live wire may be dangerous even when a switch in a mains circuit is open, and explain the dangers of providing any connection between the live wire and earth	the protection offered by insulation of devices			

P8.3 Beyond Earth

Summary

In this astrophysics topic learners will look in more detail at how we can investigate the characteristics of planets. To begin with learners will investigate bodies that are close to our own planet and consider factors that affect natural and artificial satellites. The topic then moves onto considering bodies within the universe, and will apply their knowledge of fusion processes to understand the life cycle of a star and waves to consider black body radiation. The Big Bang theory will be studied and the evidence that supports it as a scientific theory.

Underlying knowledge and understanding

Learners should already be familiar with the bodies within our own solar system and the behaviour of satellites. They may have a basic understanding of the Big Bang theory and that distances to other celestial bodies are large.

Common misconceptions

A common misconception among learners is that the Sun is not a star but a separate entity; it needs to be instilled in learners that the sun is a star. In addition, learners have difficulty grasping how far away celestial objects are.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
P8.3a ☑	explain the red-shift of light as seen from galaxies which are receding (qualitative only). The change with distance of each galaxy's speed is evidence of an expanding universe	understanding of changes in frequency and wavelength		WS1.1b	Use of a Doppler ball to model red-shift. Use of a balloon to illustrate why galaxies are moving away from us and that expansion is from the centre of the universe.
P8.3b ☑	explain how red shift and other evidence can be linked to the Big-Bang model	CMBR			

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P8.3c ☑	recall that our Sun was formed from dust and gas drawn together by gravity and explain how this caused fusion reactions, leading to equilibrium between gravitational collapse and expansion due to the energy released during fusion	lifecycle of a star		WS1.1a, WS1.1b, WS1.1c	Research and produce a poster illustrating the life cycle of a star.
P8.3d ☑	explain that all bodies emit radiation, and that the intensity and wavelength distribution of any emission depends on their temperatures	an understanding that hot objects can emit a continuous range of electromagnetic radiation at different energy values and therefore frequencies and wavelengths		WS1.1a, WS1.1b, WS1.1c, WS1.1d, WS1.1f, WS1.1g, WS1.1i, WS1.3e	Comparison of temperature changes inside sealed transparent containers with different gases inside. Research evidence of global warming from the last 200 years.
P8.3e ☑	recall the main features of our solar system, including the similarities and distinctions between the planets, their moons, and artificial satellites	the 8 planets and knowledge of minor planets, geostationary and polar orbits for artificial satellites and how these may be similar to or differ from natural satellites		WS1.1a, WS1.1b, WS1.1c, WS1.1g, WS1.1i	Building a model of the solar system to demonstrate scale. Research the evidence for the presence of the Moon as a result of a collision between the Earth and another planet. Research the uses of geostationary and polar satellites.
P8.3f ☑	**explain for circular orbits, how the force of gravity can lead to changing velocity of a planet but unchanged speed (qualitative only)**				
P8.3g ☑	**explain how, for a stable orbit, the radius must change if this speed changes (qualitative only)**				

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
P8.3h ☑	**explain how the temperature of a body is related to the balance between incoming radiation absorbed and radiation emitted; illustrate this balance using everyday examples and the example of the factors which determine the temperature of the Earth**	**an understanding that Earth's atmosphere affects the electromagnetic radiation from the Sun that passes through it**			
P8.3i ☑	**explain, in qualitative terms, how the differences in velocity, absorption and reflection between different types of waves in solids and liquids can be used both for detection and for exploration of structures which are hidden from direct observation, notably in the Earth's core and in deep water**	**P and S waves, use of sonar**	M5b	WS1.1a, WS1.1b, WS1.1c, WS1.1f, WS1.1h, WS1.3b	Examination of seismographic traces of recent earthquakes. Research the design of buildings that are in countries that experience earthquakes regularly and how the design is linked to P and S wave characteristics.

Topic P9: Practical skills

Compliance with the requirements for practical work

It is compulsory that learners complete at least *eight* practical activities. OCR has split the requirements from the Department for Education '*Biology, chemistry and physics GCSE subject content, July 2015*' – Appendix 4 into eight Practical Activity Groups or PAGs.

The Practical Activity Groups allow centres flexibility in their choice of activity. Upon completion of at least eight practical activities, each learner must have had the opportunity to use all of the apparatus and techniques described in the following tables of this topic.

The tables illustrate the apparatus and techniques required for each PAG and an example practical that may be used to contribute to the PAG. It should be noted that some apparatus and techniques can be used in more than one PAG. It is therefore important that teachers take care to ensure that learners do have the opportunity to use all of the required apparatus and techniques during the course with the activities chosen by the centre.

Within the specification there are a number of practicals that are described in the 'Practical suggestions' column. These can count towards each PAG. We are expecting that centres will provide learners with opportunities to carry out a wide range of practical activities during the course. These can be the ones described in the specification or can be practicals that are devised by the centre. Activities can range from whole investigations to simple starters and plenaries.

It should be noted that the practicals described in the specification need to be covered in preparation for the 15% of questions in the written examinations that will assess practical skills. Learners also need to be prepared to answer questions using their knowledge and understanding of practical techniques and procedures in written papers.

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

Use and production of appropriate scientific diagrams to set up and record apparatus and procedures used in practical work is common to all science subjects and should be included wherever appropriate.

Revision of the requirements for practical work

OCR will review the practical activities detailed in Topic P9 of this specification following any revision by the Secretary of State of the apparatus or techniques published specified in respect of the GCSE Physics A (Gateway Science) qualification.

OCR will revise the practical activities if appropriate.

If any revision to the practical activities is made, OCR will produce an amended specification which will be published on the OCR website. OCR will then use the following methods to communicate the amendment to Centres: Notice to Centres sent to all Examinations Officers, e-alerts to Centres that have registered to teach the qualification and social media.

The following list includes opportunities for choice and use of appropriate laboratory apparatus for a variety of experimental problem-solving and/or enquiry based activities.

Practical Activity Group (PAG)	Apparatus and techniques that the practical must use or cover	Example of a suitable physics activity (a range of practicals are included in the specification and centres can devise their own activity) *
P1 Materials	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, volume and temperature.[1]	Determine the densities of a variety of objects both solid and liquid
	Use of such measurements to determine densities of solid and liquid objects.[1]	
P2 Forces	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, volume and temperature.[1]	Investigate the effect of forces on springs
	Use of appropriate apparatus to measure and observe the effects of forces including the extension of springs.[2]	
P3 Motion	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, volume and temperature.[1]	Investigate acceleration of a trolley down a ramp
	Use of appropriate apparatus and techniques for measuring motion, including determination of speed and rate of change of speed (acceleration/deceleration).[3]	
P4 Measuring waves	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, volume and temperature.[1]	Use of a ripple tank to measure the speed, frequency and wavelength of a wave
	Making observations of waves in fluids and solids to identify the suitability of apparatus to measure speed/frequency/wavelength.[4]	
P5 Energy	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, volume and temperature.[1]	Determine the specific heat capacity of a metal
	Safe use of appropriate apparatus in a range of contexts to measure energy changes/transfers and associated values such as work done.[5]	
P6 Circuit components	Use of appropriate apparatus to measure current, potential difference (voltage) and resistance, and to explore the characteristics of a variety of circuit elements. [6]	Investigate the I-V characteristics of circuit elements

Practical Activity Group (PAG)	Apparatus and techniques that the practical must use or cover	Example of a suitable physics activity (a range of practicals are included in the specification and centres can devise their own activity) *
P7 Series and parallel circuits	Use of circuit diagrams to construct and check series and parallel circuits including a variety of common circuit elements. [7]	Investigate the brightness of bulbs in series and parallel
P8 Interactions of waves	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. [8]	Investigate the reflection of light off a plane mirror and the refraction of light through prisms
	Making observations of the effects of the interaction of electromagnetic waves with matter. [4]	

*** Centres are free to substitute alternative practical activities that also cover the apparatus and techniques from DfE: *Biology, chemistry and physics GCSE subject content, July 2015* Appendix 4.**
[1–8] These apparatus and techniques may be covered in any of the groups indicated. Number corresponds to that used in from DfE: *Biology, chemistry and physics GCSE subject content, July 2015* Appendix 4.

2

Choice of activity

Centres can include additional apparatus and techniques within an activity beyond those listed as the minimum in the above tables. Learners *must* complete a *minimum of eight* practicals covering all the apparatus and techniques listed.

The apparatus and techniques can be covered:

(i) by using OCR suggested activities (provided as resources)
(ii) through activities devised by the Centre.

Centres can receive guidance on the suitability of their own practical activities through our free coursework consultancy service (e-mail: ScienceGCSE@ocr.org.uk).

Where Centres devise their own practical activities to cover the apparatus and techniques listed above, the practical must cover all the requirements and be of a level of demand appropriate for GCSE 9–1. Each set of apparatus and techniques described in the middle column can be covered by more than one Centre devised practical activity e.g. "measurement of rates of reaction by a variety of methods including production of gas, uptake of water and colour change of indicator" could be split into two or more activities (rather than one).

NEA Centre Declaration Form: Practical Science Statement

Centres must provide a written **practical science statement** confirming that reasonable opportunities have been provided to all learners being submitted for entry within that year's set of assessments to undertake at least **eight** practical activities.

The practical science statement is contained within the NEA Centre Declaration Form which can be found on the OCR website at www.ocr.org.uk/formsfinder. By signing the form, the centre is confirming that they have taken reasonable steps to secure that each learner:

a) has completed the practical activities set by OCR as detailed in Topic P9
b) has made a contemporaneous record of:
   (i) the work which the learner has undertaken during those practical activities, and
   (ii) the knowledge, skills and understanding which that learner has derived from those practical activities.

Centres should retain records confirming points (a) to (b) above as they may be requested as part of the JCQ inspection process. Centres must provide practical science opportunities for their learners. This does not go so far as to oblige centres to ensure that all of their learners take part in all of the practical science opportunities. There is always a risk that an individual learner may miss the arranged practical science work, for example because of illness. It could be costly for the centre to run additional practical science opportunities for the learner.

However, the opportunities to take part in the specified range of practical work must be given to all learners. Learners who do not take up the full range of opportunities may be disadvantaged as there will be questions on practical science in the GCSE Physics A (Gateway Science) assessment. Please see the JCQ publication *Instructions for conducting non-examination assessments* for further information.

Any failure by a centre to provide a practical science statement to OCR in a timely manner (by means of an NEA Centre Declaration Form) will be treated as malpractice and/or maladministration [under General Condition A8 (*Malpractice and maladministration*)].

2d. Prior knowledge, learning and progression

- Learners in England who are beginning a GCSE (9–1) course are likely to have followed a Key Stage 3 programme of study.
- There are no prior qualifications required in order for learners to enter for a GCSE (9–1) in Physics A (Gateway Science).
- GCSEs (9–1) are qualifications that enable learners to progress to further qualifications either Vocational or General.

There are a number of Science specifications at OCR. Find out more at www.ocr.org.uk

3 Assessment of GCSE (9–1) in Physics A (Gateway Science)

3a. Forms of assessment

The GCSE (9–1) in Physics A (Gateway Science) is a linear qualification with 100% external assessment.

OCR's GCSE (9–1) in Physics A (Gateway Science) consists of four examined papers that are externally assessed. Two are at Foundation Tier and two are at Higher Tier. Learners are entered for only the Foundation Tier or the Higher Tier. Each paper carries an equal weighting of 50% for that tier of the GCSE (9–1) qualification. Each paper has a duration of 1 hour and 45 minutes.

Physics Paper 1 and Paper 3

These papers, one at Foundation Tier and one at Higher Tier, are each worth 90 marks, are split into two sections and assess content from Topics P1 to P4 and P9.

Section A contains multiple choice questions. This section of the paper is worth 15 marks.

Section B includes short answer question styles (practical, maths, structured questions) and an extended six-mark Level of Response question. This section of the paper is worth 75 marks.

Physics Paper 2 and Paper 4

These papers, one at Foundation Tier and one at Higher Tier, are each worth 90 marks, are split into two sections and assess content from Topics P5 to P8, with assumed knowledge of Topics P1 to P4 and P9.

Section A contains multiple choice questions. This section of the paper is worth 15 marks.

Section B includes short answer question styles (practical, maths, synoptic questions, structured questions) and an extended six-mark Level of Response question. This section of the paper is worth 75 marks, some of which will be synoptic.

3b. Assessment objectives (AO)

There are three Assessment Objectives in OCR GCSE (9–1) in Physics A (Gateway Science).

These are detailed in the table below:

Assessment Objectives		Weighting (%)	
		Higher	Foundation
AO1	**Demonstrate knowledge and understanding of:** • scientific ideas • scientific techniques and procedures.	40	40
AO2	**Apply knowledge and understanding of:** • scientific ideas • scientific enquiry, techniques and procedures.	40	40
AO3	**Analyse information and ideas to:** • interpret and evaluate • make judgements and draw conclusions • develop and improve experimental procedures.	20	20

The Assessment Objectives are further broken down to Assessment Objective elements as shown in the table below.

Assessment Objective elements	
AO1	**Demonstrate knowledge and understanding of scientific ideas and scientific techniques and procedures.**
AO1.1	Demonstrate knowledge and understanding of scientific ideas.
AO1.2	Demonstrate knowledge and understanding of scientific techniques and procedures.
AO2	**Apply knowledge and understanding of scientific ideas and scientific enquiry, techniques and procedures.**
AO2.1	Apply knowledge and understanding of scientific ideas.
AO2.2	Apply knowledge and understanding of scientific enquiry, techniques and procedures.
AO3	**Analyse information and ideas to interpret and evaluate, make judgements and draw conclusions and develop and improve experimental procedures.**
AO3.1	Analyse information and ideas to interpret and evaluate.
AO3.1a	Analyse information and ideas to interpret.
AO3.1b	Analyse information and ideas to evaluate.
AO3.2	Analyse information and ideas to make judgements and draw conclusions.
AO3.2a	Analyse information and ideas to make judgements.

Assessment Objective elements	
AO3.2b	Analyse information and ideas to draw conclusions.
AO3.3	Analyse information and ideas to develop and improve experimental procedures.
AO3.3a	Analyse information and ideas to develop experimental procedures.
AO3.3b	Analyse information and ideas to improve experimental procedures.

3c. Command words

The key list of common command words used in our exams is listed below. The definitions are intended to provide guidance to teachers and students as to what a student will be expected to do when these words are used in examinations.

The exact response expected to a command word will be dependent on the context. At all times, we advise students to read the full question carefully to be sure of what they are being asked to do.

Command word	Definition
analyse	Separate information into components and identify their characteristics. Discuss the pros and cons of a topic or argument and make reasoned comment.
calculate	Generate a numerical answer, with workings shown.
choose	Select from a list or a number of alternatives.
classify	Assign to a category or group.
compare and contrast	Identify similarities and differences.
complete	Add words, numbers, labels or plots to complete a sentence, table, diagram or graph.
conclude	Make a decision after reasoning something out.
construct	Write out or draw the requested item, e.g. '…Construct a dot and cross diagram for sodium chloride…' or '…Construct a balanced equation for a specific reaction…'
convert	Change a defined item to another defined item, e.g. '…Convert your calculated answer in g to an answer in moles…'
deduce	Use your knowledge and/or supplied data to work something out, e.g. '…Deduce the empirical formula of compound **X** (using supplied data)…'
define	Use your knowledge to state the meaning of a given term, e.g. '…Define the term specific heat capacity…' or '…Define the term momentum…'
describe	Set out the facts or characteristics. The description of a process should address what happens, and when and/or where it happens. (Compare with 'Explain') For example, when asked to <u>describe</u> the change in rate of reaction seen on a graph, the expected response might be to describe whether the rate of reaction remains constant, or decreases or increases over time.
design	Plan and present ideas to show a layout / function / workings / object / system / process.

Command word	Definition
determine	Obtain a solution by following a set of procedures. Obtain a numerical value by carrying out a series of calculations. Also see 'Find' which is more commonly used for Foundation tier.
discuss	Give an account that addresses a range of ideas and arguments.
draw	Produce a diagram with sufficient detail and labels to illustrate the answer. (Compare with 'Sketch')
estimate	Assign an approximate value.
evaluate	Make a qualitative judgement taking into account different factors and using available knowledge / experience / evidence.
explain	Set out reasons and/or mechanisms to address why and/or how something happens. (Compare with 'Describe') For example, when asked to explain the change in rate of reaction seen on a graph, the expected response would suggest scientific reasons for any change seen, for example in terms of molecular collisions or enzymatic action.
find	Obtain a solution by following a set of procedures. Obtain a numerical value by carrying out a series of calculations. Also see 'Determine'. Find is more commonly used for Foundation tier.
give	A short answer is required without explanation (unless separately requested).
how	In what way?
identify	Recognise, list, name or otherwise characterise.
illustrate	Make clear by using examples or providing diagrams.
justify	Present a reasoned case for actions or decisions made.
label	Add names or other identifying words or symbols to a diagram.
measure	Establish a value using a suitable measuring instrument or technique.
name	Provide appropriate word(s) or term(s).
outline	Provide a description setting out the main characteristics / points.
plan	Consider, set out and communicate what is to be done.
plot	Translate data into a suitable graph or chart, with labelled axes.
predict	Make a judgement of an event or action that will or would happen in the future, as a result of knowledge, experience or evidence.
recall	Use your knowledge of the specification to remember a relevant key fact which needs to be used in the question.
select	Carefully choose as being the most suitable for a task or purpose.
show	Write down details, steps or calculations to prove a fact or answer.
sketch	Produce a simple, freehand drawing to illustrate the general point being conveyed. Detail is not required. (Compare with 'Draw') In the context of a graph, the general shape of the curve would be sufficient without plotting precise points. (Compare with 'Plot')

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Command word	Definition
state or define	Express in precise terms the nature, state or meaning.
suggest	Give possible alternatives, produce an idea, put forward (for example) an idea or a plan for consideration.
use / using	The answer must be based on information given in the question.
what	A request for information, clarified by the context or question in which it is contained.
which	Identify an object, word or explanation.
why	For what reason?
write	Present the required information, e.g. '...Write balanced equations that represent the radioactive decay of...'

AO weightings in OCR GCSE (9–1) in Physics A (Gateway Science)

The relationship between the Assessment Objectives and the components are shown in the following table:

Component (Foundation Tier)	% of overall GCSE (9–1) in Physics A (Gateway Science) (J249)			
	AO1	AO2	AO3	Total
Paper 1 (Foundation Tier) J249/01	20	20	10	50
Paper 2 (Foundation Tier) J249/02	20	20	10	50
Total	40	40	20	100
Component (Higher Tier)	**AO1**	**AO2**	**AO3**	**Total**
Paper 3 (Higher Tier) J249/03	20	20	10	50
Paper 4 (Higher Tier) J249/04	20	20	10	50
Total	40	40	20	100

3d. Tiers

This scheme of assessment consists of two tiers: Foundation Tier and Higher Tier. Foundation Tier assesses grades 5 to 1 and Higher Tier assesses grades 9 to 4. An allowed grade 3 may be awarded on the Higher Tier option for learners who are a small number of marks below the grade 3/4 boundary. Learners must be entered for either the Foundation Tier or the Higher Tier.

3e. Total qualification time

Total qualification time (TQT) is the total amount of time, in hours, expected to be spent by a learner to achieve a qualification. It includes both guided learning hours and hours spent in preparation, study, and assessment. The total qualification time for GCSE Physics A is 140 hours. The total guided learning time is 120-140 hours.

3f. Qualification availability outside of England

This qualification is available in England. For Wales and Northern Ireland please check the Qualifications in Wales Portal (QIW) or the Northern Ireland Department of Education Performance Measures / Northern Ireland Entitlement Framework Qualifications Accreditation Number (NIEFQAN) list to see current availability.

3g. Language

This qualification is available in English only. All assessment materials are available in English only and all candidate work must be in English.

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3h. Assessment availability

There will be one examination series available each year in May/June to **all** learners.

All examined papers must be taken in the same examination series at the end of the course.

This specification will be certificated from the June 2018 examination series onwards.

3i. Retaking the qualification

Learners can retake the qualification as many times as they wish.

They retake all the papers within the relevant tier to be awarded the qualification.

3j. Assessment of extended response

Extended response questions which are marked using a level of response mark scheme are included in all externally assessed papers. These are indicated in papers and mark schemes by an asterisk (*).

Extended response questions provide learners with the opportunity to demonstrate their ability to construct and develop a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.

3k. Synoptic assessment

Synoptic assessment tests the learners' understanding of the connections between different elements of the subject.

Synoptic assessment involves the explicit drawing together of knowledge, understanding and skills learned in different parts of the GCSE (9–1) course. The emphasis of synoptic assessment is to encourage the development of the understanding of the subject as a discipline. Paper 2 and Paper 4 contain an element of synoptic assessment.

Synoptic assessment requires learners to make and use connections within and between different areas of physics, for example by:

- applying knowledge and understanding of more than one area to a particular situation or context
- using knowledge and understanding or principles and concepts in planning experimental and investigative work and in the analysis and evaluation of data
- bringing together scientific knowledge and understanding from different areas of the subject and applying them.

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3l. Calculating qualification results

A learner's overall qualification grade for OCR GCSE (9–1) in Physics A (Gateway Science) will be calculated by adding together their marks from the two papers taken to give their total weighted mark. This mark will then be compared to the qualification level grade boundaries for the entry option taken by the learner and for the relevant exam series to determine the learner's overall qualification grade.

4 Admin: what you need to know

The information in this section is designed to give an overview of the processes involved in administering this qualification so that you can speak to your exams officer. All of the following processes require you to submit something to OCR by a specific deadline.

More information about the processes and deadlines involved at each stage of the assessment cycle can be found in the Administration area of the OCR website.

OCR's *Admin overview* is available on the OCR website at http://www.ocr.org.uk/administration.

4a. Pre-assessment

Estimated entries

Estimated entries are your best projection of the number of learners who will be entered for a qualification in a particular series. Estimated entries should be submitted to OCR by the specified deadline. They are free and do not commit your centre in any way.

Final entries

Final entries provide OCR with detailed data for each learner, showing each assessment to be taken. It is essential that you use the correct entry code, considering the relevant entry rules.

Final entries must be submitted to OCR by the published deadlines or late entry fees will apply.

All learners taking a GCSE (9–1) in Physics A (Gateway Science) must be entered for one of the following entry options:

Entry option		Components		
Entry code	**Title**	**Code**	**Title**	**Assessment type**
J249 F	Physics A (Gateway Science) (Foundation Tier)	01	Paper 1 (Foundation Tier)	External assessment
		02	Paper 2 (Foundation Tier)	External assessment
J249 H	Physics A (Gateway Science) (Higher Tier)	03	Paper 3 (Higher Tier)	External assessment
		04	Paper 4 (Higher Tier)	External assessment

Each learner must be entered for either the Foundation Tier **or** the Higher Tier only. They cannot be entered for a combination of tiers.

Collecting evidence of student performance to ensure resilience in the qualifications system

Regulators have published guidance on collecting evidence of student performance as part of long-term contingency arrangements to improve the resilience of the qualifications system. You should review and consider this guidance when delivering this qualification to students at your centre.

For more detailed information on collecting evidence of student performance please visit our website at: https://www.ocr.org.uk/administration/general-qualifications/assessment/

4b. Special consideration

Special consideration is a post-assessment adjustment to marks or grades to reflect temporary injury, illness or other indisposition at the time the assessment was taken.

Detailed information about eligibility for special consideration can be found in the JCQ publication *A guide to the special consideration process*.

4c. External assessment arrangements

Regulations governing examination arrangements are contained in the JCQ *Instructions for conducting examinations*.

Learners are permitted to use a scientific or graphical calculator for components 01, 02, 03 and 04. Calculators are subject to the rules in the document *Instructions for Conducting Examinations* published annually by JCQ (www.jcq.org.uk).

Head of Centre Annual Declaration

The Head of Centre is required to provide a declaration to the JCQ as part of the annual NCN update, conducted in the autumn term, to confirm that the centre is meeting all the requirements detailed in the specification, including that they have provided all candidates with the opportunity to undertake the prescribed practical activities.

Any failure by a centre to provide the Head of Centre Annual Declaration will result in your centre status being suspended and could lead to the withdrawal of our approval for you to operate as a centre.

Private candidates

Private candidates may enter for OCR assessments.

A private candidate is someone who pursues a course of study independently but takes an examination or assessment at an approved examination centre. A private candidate may be a part-time student, someone taking a distance learning course, or someone being tutored privately. They must be based in the UK.

The GCSE Physics A (Gateway Science) qualification requires learners to complete eight practical activities. These practical activities are an essential part of the course and will allow learners to develop skills for further study or employment as well as imparting important knowledge that is part of the specification.

There is no direct assessment of the practical skills part of the course. However, learners will need to have completed the activities to prepare fully for the written examinations as there will be questions that assess practical skills.

Private candidates need to contact OCR approved centres to establish whether they are prepared to host them as a private candidate. The centre may charge for this facility and OCR recommends that the arrangement is made early in the course.

Further guidance for private candidates may be found on the OCR website: http://www.ocr.org.uk.

4d. Results and certificates

Grade scale

GCSE (9–1) qualifications are graded on the scale: 9–1, where 9 is the highest. Learners who fail to reach the minimum standard of 1 will be Unclassified (U).

Only subjects in which grades 9 to 1 are attained will be recorded on certificates.

Results

Results are released to centres and learners for information and to allow any queries to be resolved before certificates are issued.

Centres will have access to the following results information for each learner:

- the grade for the qualification
- the raw mark for each component
- the total weighted mark for the qualification.

The following supporting information will be available:

- raw mark grade boundaries for each component
- weighted mark grade boundaries for each entry option.

Until certificates are issued, results are deemed to be provisional and may be subject to amendment.

A learner's final result(s) will be recorded on an OCR certificate. The qualification title will be shown on the certificate as 'OCR Level 1/Level 2 GCSE (9–1) in Physics A (Gateway Science)'.

4e. Post-results services

A number of post-results services are available:

- **Review of results** – If you are not happy with the outcome of a learner's results, centres may request a review of marking.
- **Missing and incomplete results** – This service should be used if an individual subject result for a learner is missing, or the learner has been omitted entirely from the results supplied
- **Access to scripts** – Centres can request access to marked scripts.

4f. Malpractice

Any breach of the regulations for the conduct of examinations and non-exam assessment may constitute malpractice (which includes maladministration) and must be reported to OCR as soon as it is detected. Detailed information on malpractice can be found in the JCQ publication *Suspected Malpractice in Examinations and Assessments: Policies and Procedures*.

5 Appendices

5a. Grade descriptors

Grade descriptors for GCSE (9–1) single science (biology, chemistry and physics) and combined science:

1. Grades 8 and 8–8

1.1 To achieve Grades 8 and 8–8 candidates will be able to:

- demonstrate relevant and comprehensive knowledge and understanding and apply these correctly to both familiar and unfamiliar contexts using accurate scientific terminology
- use a range of mathematical skills to perform complex scientific calculations
- critically analyse qualitative and quantitative data to draw logical, well-evidenced conclusions
- critically evaluate and refine methodologies, and judge the validity of scientific conclusions.

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2. Grades 5 and 5–5

2.1 To achieve Grades 5 and 5–5 candidates will be able to:

- demonstrate mostly accurate and appropriate knowledge and understanding and apply these mostly correctly to familiar and unfamiliar contexts, using mostly accurate scientific terminology
- use appropriate mathematical skills to perform multi-step calculations
- analyse qualitative and quantitative data to draw plausible conclusions supported by some evidence
- evaluate methodologies to suggest improvements to experimental methods, and comment on scientific conclusions.

3. Grades 2 and 2–2

3.1 To achieve Grades 2 and 2–2 candidates will be able to:

- demonstrate some relevant scientific knowledge and understanding using limited scientific terminology
- perform basic calculations
- draw simple conclusions from qualitative or quantitative data
- make basic comments relating to experimental method.

5b. Overlap with other qualifications

There is a small degree of overlap between the content of this specification and those for GCSE (9–1) in Combined Science A (Gateway Science), GCSE (9–1) in Biology A (Gateway Science) and GCSE (9–1) in Chemistry A (Gateway Science) courses. The links between the specifications may allow for some co-teaching, particularly in the area of working scientifically.

5c. Accessibility

Reasonable adjustments and access arrangements allow learners with special educational needs, disabilities or temporary injuries to access the assessment and show what they know and can do, without changing the demands of the assessment. Applications for these should be made before the examination series. Detailed information about eligibility for access arrangements can be found in the JCQ *Access Arrangements and Reasonable Adjustments.*

The GCSE (9–1) qualification and subject criteria have been reviewed in order to identify any feature which could disadvantage learners who share a protected Characteristic as defined by the Equality Act 2010. All reasonable steps have been taken to minimise any such disadvantage.

5d. Equations in Physics

Learners are expected to recall and apply the following equations communicating the answer using the appropriate SI unit:

☑ This symbol indicates content that is found only in the physics separate science qualification.

Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes Recall and apply	Symbolic equation (optional)
PM1.1i	density = $\frac{\text{mass}}{\text{volume}}$	$\rho = \frac{m}{V}$
PM2.1i	distance travelled = speed × time	$s = v\,t$
PM2.1ii	acceleration = $\frac{\text{change in velocity}}{\text{time}}$	$a = \frac{v-u}{t}$
PM2.1iv	kinetic energy = $\frac{1}{2}$ × mass × (speed)^2	$E = \frac{1}{2} m\,v^2$
PM2.2i	force = mass × acceleration	$F = m\,a$
PM2.2ii	**momentum = mass × velocity**	$\boldsymbol{p = m\,v}$
PM2.2iii	work done = force × distance (along the line of action of the force)	$W = F\,s$
PM2.2iv	power = $\frac{\text{work done}}{\text{time}}$	$P = \frac{W}{t}$
PM2.3i	force exerted by a spring = spring constant × extension	$F = k\,x$
PM2.3iii	gravitational force = mass × gravitational field strength	$W = m\,g$
PM2.3iv	gravitational potential energy = mass × gravitational field strength × height	$E = m\,g\,h$
PM2.3v ☑	pressure = $\frac{\text{force normal to a surface}}{\text{area of that surface}}$	$p = \frac{F}{A}$
PM2.3vi ☑	moment of a force = force × distance (normal to direction of the force)	$M = F\,d$
PM3.1i	charge flow = current × time	$Q = I\,t$
PM3.2i	potential difference = current × resistance	$V = I\,R$

Reference	Mathematical learning outcomes Recall and apply	Symbolic equation (optional)
PM3.2ii	energy transferred = charge × potential difference	$E = Q\ V$
PM3.2iii	power = potential difference × current	$P = V\ I$
	power = (current $)^2$ × resistance	$P = I^2 R$
PM3.2iv	energy transferred = power × time	$E = P\ t$
PM5.1i	wave speed = frequency × wavelength	$v = f\ \lambda$
PM7.2i	efficiency = $\dfrac{\text{useful output energy transfer}}{\text{input energy transfer}}$	

Learners are expected to select and apply the following equations communicating the answer using the appropriate SI unit:

Reference	Mathematical learning outcomes Select and apply	Symbolic equation (optional)
PM1.2i	change in thermal energy = mass × specific heat capacity × change in temperature	$\Delta E = m\ c\ \Delta\theta$
PM1.2ii	thermal energy for a change in state = mass × specific latent heat	$E = m\ l$
PM1.3i ☑	for a given mass of gas at a constant temperature: pressure × volume = constant	$p\ V$ = constant
PM1.3ii ☑	**pressure due to a column of liquid = height of column × density of liquid × gravitational field strength**	$\boldsymbol{p = h\ \rho\ g}$
PM2.1iii	(final velocity$)^2$ – (initial velocity$)^2$ = 2 × acceleration × distance	$v^2 - u^2 = 2\ a\ s$
PM2.3ii	energy transferred in stretching = $\frac{1}{2}$ × spring constant × (extension$)^2$	$E = \frac{1}{2}\ k\ x^2$
PM4.2i	**force on a conductor (at right angles to a magnetic field) carrying a current: force = magnetic flux density × current × length**	$\boldsymbol{F = B\ I\ l}$
PM4.2ii ☑	$\dfrac{\textbf{potential difference across primary coil}}{\textbf{potential difference across secondary coil}} = \dfrac{\textbf{number of turns in primary coil}}{\textbf{number of turns in secondary coil}}$	$\boldsymbol{\dfrac{V_p}{V_s} = \dfrac{N_p}{N_s}}$
PM8.2i	potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil	$V_p\ I_p = V_s\ I_s$

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5e. Units in science

It is expected that learners will show understanding of the physical quantities and corresponding units, and SI base and derived unites listed below. The tables also include symbols commonly used for these quantities; use of symbols by students is optional. Learners will be able to use them in qualitative work and calculations. These units and their associated quantities are dimensionally independent.

Physical quantity	Common symbol(s) (use of these symbols is optional)	SI base unit	Unit abbreviation
length	*d* – perpendicular distance from a pivot to the line of action of a force *h* – height (of a column of liquid) or height raised above ground level (to calculate gravitational potential energy) l – length (eg of a wire) *s* – displacement (or distance travelled); displacement of a force along its direction of action *x* – extension (eg of a spring) λ (lambda) – wavelength	metre	m
mass	*m*	kilogram	kg
time	*t*	second	s
temperature	*T* – for kelvin temperature	kelvin	K
current	I	ampere	A
amount of substance	*n*	mole	mol

The following table includes SI derived or SI accepted units for quantities commonly used in the specification

Physical quantity	Common symbol(s) (use of these symbols is optional)	SI unit / accepted unit	Unit abbreviation
area	*A*	squared metre	m^2
volume	*V*	cubic metre; litre; cubic decimetre	m^3; l; dm^3
density	*ρ (rho)*	kilogram per cubic metre	kg/m^3
temperature	θ (theta) – for Celsius temperature $\Delta\theta$ (theta) – for change in Celsius temperature	degree Celsius	°C

Physical quantity	Common symbol(s) (use of these symbols is optional)	SI unit / accepted unit	Unit abbreviation
pressure	*p*	pascal	Pa
specific heat capacity	*c*	joule per kilogram per degree Celsius	J/kg °C
specific latent heat	*l*	joule per kilogram	J/kg
speed	*v* – (final) speed or velocity *u* – initial speed or velocity	metre per second	m/s
force	*F* – forces generally *W* – weight or gravitational force	newton	N
gravitational field strength	*g*	newton per kilogram	N/kg
acceleration	*a*	metre per squared second	m/s^2
frequency	*f*	hertz	Hz
energy	*E* – energy transferred ΔE – change in (thermal) energy *W* – work done (mechanically or electrically)	joule	J
power	*P*	watt	W
electric charge	*Q*	coulomb	C
electric potential difference	*V*	volt	V
electric resistance	*R*	ohm	Ω
magnetic flux density	*B*	tesla	T
moment	*M*	newton metre	N m
momentum	*p*	kilogram metre per second	kg m/s
periodic time	*T*	second	s
spring constant	*k*	newton per metre	N/m
number of turns	N_p – number of turns on primary coil N_s – number of turns on secondary coil	unitless	
efficiency		unitless	

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5f. Working scientifically

The idea that science progresses through a cycle of hypothesis, experimentation, observation, development and review is encompassed in this section. It covers aspects of scientific thinking and aims to develop the scientific skills and conventions, fundamental to the study of science. The section also includes understanding of theories and applications of science, the practical aspects of scientific experimentation, and objective analysis and evaluation. This section will enable learners to develop an understanding of the processes and methods of science and, through consideration of the different types of scientific enquiry, learners will become equipped to answer scientific questions about the world around them. Learners will also develop and learn to apply skills in observation, modelling and problem-solving, with opportunities for these skills to be shown through links to specification content. Scientific-based claims require evaluative skills and these are also developed in this section with opportunities for contextual development highlighted. Learners should learn to evaluate through critical analysis of methodology, evidence and conclusions, both qualitatively and quantitatively.

Working scientifically is split into concepts (WS1) and practical skills (WS2). Both of these will be assessed in written examinations and WS2 may also be assessed through practical activities.

WS1: Working scientifically assessed in written examinations

Summary
The concepts and skills in this section can be assessed in written examinations.

There are references to specific apparatus and methods throughout the content of the specification. WS1 is split into four parts.

WS1.1 Development of scientific thinking

Assessable Content		
Learning outcomes		**To include**
WS1.1a	understand how scientific methods and theories develop over time	new technology allowing new evidence to be collected and changing explanations as new evidence is found
WS1.1b	use models to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts	representational, spatial, descriptive, computational and mathematical models
WS1.1c	understand the power and limitations of science	how developments in science have led to increased understanding and improved quality of life and questions and problems that science cannot currently answer
WS1.1d	discuss ethical issues arising from developments in science	
WS1.1e	explain everyday and technological applications of science	
WS1.1f	evaluate associated personal, social, economic and environmental implications	
WS1.1g	make decisions based on the evaluation of evidence and arguments	
WS1.1h	evaluate risks both in practical science and the wider societal context	perception of risk in relation to data and consequences
WS1.1i	recognise the importance of peer review of results and of communicating results to a range of audiences	

WS1.2 Experimental skills and strategies

Assessable Content		
Learning outcomes		To include
WS1.2a	use scientific theories and explanations to develop hypotheses	
WS1.2b	plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena	
WS1.2c	apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment	
WS1.2d	recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative	
WS1.2e	evaluate methods and suggest possible improvements and further investigations	

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WS1.3 Analysis and evaluation

Assessable Content		
Learning outcomes		To include
	Apply the cycle of collecting, presenting and analysing data, including:	
WS1.3a	presenting observations and other data using appropriate methods	methods to include descriptive, tabular diagrammatic and graphically
WS1.3b	translating data from one form to another	
WS1.3c	carrying out and representing mathematical and statistical analysis	statistical analysis to include arithmetic means, mode, median
WS1.3d	representing distributions of results and make estimations of uncertainty	
WS1.3e	interpreting observations and other data	data presentations to include verbal, diagrammatic, graphical, symbolic or numerical form interpretations to include identifying patterns and trends, making inferences and drawing conclusions

Assessable Content		
Learning outcomes		To include
WS1.3f	presenting reasoned explanations	relating data to hypotheses
WS1.3g	being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility	
WS1.3h	identifying potential sources of random and systematic error	
WS1.3i	communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions	presentations through paper-based presentations using diagrammatic, graphical, numerical and symbolic forms

WS1.4 Scientific vocabulary, quantities, units, symbols and nomenclature

Assessable Content		
Learning outcomes		To include
WS1.4a	use scientific vocabulary, terminology and definitions	
WS1.4b	recognise the importance of scientific quantities and understand how they are determined	
WS1.4c	use SI units and IUPAC chemical nomenclature unless inappropriate	base units and derived units (Appendix 5e)
WS1.4d	use prefixes and powers of ten for orders of magnitude	tera, giga, mega, kilo, deci, centi, milli, micro and nano
WS1.4e	interconvert units	
WS1.4f	use an appropriate number of significant figures in calculation	

WS2: Working scientifically skills demonstrated

Summary
A range of practical experiences are a vital part of a scientific study at this level. A wide range of practical skills will be addressed throughout the course, skills which are required for the development of investigative skills. Learners should be given the opportunity to practise their practical skills, which will also prepare them for the written examinations.

For further details of the practical activity requirement see Topic P9.

Practical skills to be developed		
Learning outcomes		**To include**
WS2a	carry out experiments	due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations, and following written instructions
WS2b	make and record observations and measurements using a range of apparatus and methods	keeping appropriate records
WS2c	presenting observations using appropriate methods	methods to include descriptive, tabular diagrammatic and graphically
WS2d	communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions	presentations through paper-based and electronic reports and presentations using verbal, diagrammatic, graphical, numerical and symbolic forms

5g. Mathematical skills requirement

In order to be able to develop their skills, knowledge and understanding in GCSE (9–1) in Physics A (Gateway Science), learners need to have been taught, and to have acquired competence in, the appropriate areas of mathematics relevant to the subject as indicated in the table of coverage below.

The questions and tasks used to target mathematical skills will be at a level of demand that is appropriate to GCSE (9–1) Physics A (Gateway Science).

In the Foundation Tier question papers, the questions that assess mathematical skills will not be of a lower demand than that which is expected of learners at Key Stage 3, as outlined in the Department for Education's document "Mathematics programme of study: key stage 3".

In the Higher Tier question papers, the questions that assess mathematical skills will not be of a lower demand than questions and tasks in assessment for the Foundation Tier in a GCSE qualification in Mathematics.

The assessment of quantitative skills would include at least 30% mathematical skills at the appropriate tier for physics.

These skills will be applied in the context of the relevant physics.

All mathematical content will be assessed within the lifetime of the specification.

This list of examples is not exhaustive and is not limited to GCSE examples. These skills could be developed in other areas of specification content as indicated in the opportunities to cover column.

The mathematical skills required for the GCSE (9–1) in Biology (B), Chemistry (C), Physics (P) and Combined Science (CS) are shown in the table below.

	Mathematical skills	Subject			
M1	**Arithmetic and numerical computation**				
a	Recognise and use expressions in decimal form	B	C	P	CS
b	Recognise and use expressions in standard form	B	C	P	CS
c	Use ratios, fractions and percentages	B	C	P	CS
d	Make estimates of the results of simple calculations	B	C	P	CS
M2	**Handling data**				
a	Use an appropriate number of significant figures	B	C	P	CS
b	Find arithmetic means	B	C	P	CS
c	Construct and interpret frequency tables and diagrams, bar charts and histograms	B	C	P	CS
d	Understand the principles of sampling as applied to scientific data	B			
e	Understand simple probability	B			
f	Understand the terms mean, mode and median	B		P	CS
g	Use a scatter diagram to identify a correlation between two variables	B		P	CS
h	Make order of magnitude calculations	B	C	P	CS
M3	**Algebra**				
a	Understand and use the symbols: =, <, <<, >>, >, ∝ , ~	B	C	P	CS
b	Change the subject of an equation		C	P	CS
c	Substitute numerical values into algebraic equations using appropriate units for physical quantities		C	P	CS
d	Solve simple algebraic equations	B		P	CS
M4	**Graphs**				
a	Translate information between graphical and numeric form	B	C	P	CS
b	Understand that y = mx+c represents a linear relationship	B	C	P	CS
c	Plot two variables from experimental or other data	B	C	P	CS
d	Determine the slope and intercept of a linear graph	B	C	P	CS
e	Draw and use the slope of a tangent to a curve as a measure of rate of change		C	P	CS
f	Understand the physical significance of area between a curve and the x-axis and measure it by counting squares as appropriate			P	CS
M5	**Geometry and trigonometry**				
a	Use angular measures in degrees			P	CS
b	Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects		C	P	CS
c	Calculate areas of triangles and rectangles, surface areas and volumes of cubes.	B	C	P	CS

5h. Health and safety

In UK law, health and safety is primarily the responsibility of the employer. In a school or college the employer could be a local education authority, the governing body or board of trustees. Employees (teachers/lecturers, technicians etc.), have a legal duty to cooperate with their employer on health and safety matters. Various regulations, but especially the COSHH Regulations 2002 (as amended) and the Management of Health and Safety at Work Regulations 1999, require that before any activity involving a hazardous procedure or harmful microorganisms is carried out, or hazardous chemicals are used or made, the employer must carry out a risk assessment. A useful summary of the requirements for risk assessment in school or college science can be found at: https://www.ase.org.uk

For members, the CLEAPSS® guide, *PS90*, *Making and recording risk assessments in school science*[1] offers appropriate advice.

Most education employers have adopted nationally available publications as the basis for their Model Risk Assessments.

Where an employer has adopted model risk assessments an individual school or college then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment.

Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate or the skills of the learners were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded in a '*point of use text*', for example on schemes of work, published teachers guides, work sheets, etc. There is no specific legal requirement that detailed risk assessment forms should be completed for each practical activity, although a minority of employers may require this.

Where project work or investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or microorganisms, which are not covered by the employer's model risk assessments. The employer should have given guidance on how to proceed in such cases. Often, for members, it will involve contacting CLEAPSS®.

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[1] These, and other CLEAPSS® publications, are on the CLEAPSS® Science Publications website www.cleapss.org.uk. Note that CLEAPSS® publications are only available to members. For more information about CLEAPSS® go to www.cleapss.org.uk.

Summary of updates

Date	Version	Section	Title of section	Change
December 2017	2	Multiple		Changes to generic wording and OCR website links throughout the specification. No changes have been made to any assessment requirements.
April 2018	2.1	i) Front cover ii) 4d	i) Disclaimer ii) Results and certificates: Results	i) Addition of Disclaimer ii) Amend to Certification Titling
May 2018	2.2	2c and 4c	Practical Science Statement and Head of Centre Annual Declaration	Update in line with new NEA Centre Declaration form.
October 2018	3	3b	Assessment Objectives (AO)	Addition of Assessment Objective elements
December 2018	3.2	i) 2c ii) 3c	i) Content of topics P1 to P9 ii) Command words	i) Learning outcome P3.2b – 'To include' column updated for clarification. ii) Command words
April 2020	3.3	i) 1d ii) 4e	i) How do I find out more information? ii) Post-results services	i) Insertion of link to the new Online Support Centre. ii) Enquiry about results changed to Review of results.
May 2020	3.4	2c	Content of topics P1 to P9	Wording in table updated for clarification Update to specification covers to meet digital accessibility standards
April 2022	3.5	2c	Content of Topics P1 to P9	Correction of errors and typos and correction of 'force' to 'gravitational force' (PM2.3iii) and 'gravity' to 'gravitational field' (PM2.3iv) on page 24

Date	Version	Section	Title of section	Change
May 2022	4	2c. and 5d Equations in Physics tables.	P1.1 The particle model PM1.1i PM1.3i and PM1.3i P2.1 Motion PM2.1ii and PM2.1iv P2.2 Newton's laws PM2.2iv (page 20) PM2.3 Forces in action PM2.3i, PM2.3ii, PM2.3iii, PM2.3iv, PM2.3v, PM2.3vi P3.2 Simple circuits PM3.2iii, PM3.2iv P4.2 Uses of magnetism PM4.2i, PM4.2ii PM7.2i Power and efficiency PM7.2i P8.2 Powering Earth PM8.2i	We have reformatted some of our word equations to improve readability and consistency: • horizontal fraction in place of solidus. • replaced 0.5 with $\frac{1}{2}$ fraction • started the fraction on a new line from 'recall and apply' • removed unnecessary or repetitive wording
		2c. and 5d Equations in Physics tables.	P1.3 Pressure PM1.3i and PM1.3ii PM2. 3 Forces in action PM2.3i, PM2.3iv	Reworded equations so they are consistent with the new symbol equations. We have replaced g in word equations with 'gravitational field strength', and deleted the symbol g where it appeared in the word equation in addition to gravitational field strength
		2c. and 5d Equations in Physics tables.	P1.3 Pressure P1.3j P2.3 Forces in action P2.3h, P2.3j P3.2c Simple circuits P3.2c, P3.2d, P3.2e	Use of italics to clearly differentiate symbols from units

Date	Version	Section	Title of section	Change
		5 Appendices	5d. Equations in Physics	Removed repetition of 'recall and apply' and 'apply' within the table to improve readability. Updated the column header in the table. Added a new column with optional symbol equations. Removed symbols from the word equations.
		5 Appendices	5e. Units in Science	Added a reference to symbol equations in the text above the table. Added a new column to the table with symbols. Added rows at the end of the table to reflect quantities mentioned elsewhere in the specification e.g. momentum, spring constant
		Various	Various	Corrected minor grammatical, typo or spacing corrections
February 2023	4.1	3	Assessment of GCSE (9-1) in Physics A (Gateway Science)	Insertion of new section 3e. Total qualification time.
February 2024	4.2	3f and 3g	Qualification availability and Language	Inclusion of disclaimer regarding availability and language
		4a	Pre-assessment	Update to include resilience guidance
		Checklist		Inclusion of Teach Cambridge

YOUR CHECKLIST

Our aim is to provide you with all the information and support you need to deliver our specifications.

- ☐ Bookmark OCR website for all the latest information and news on GCSE (9-1) Gateway Science Physics A
- ☐ Sign up to Teach Cambridge: our personalised and secure website that provides teachers with access to all planning, teaching and assessment support materials
- ☐ Be among the first to hear about support materials and resources as they become available – register for Gateway Science Physics A updates
- ☐ Find out about our professional development
- ☐ View our range of skills guides for use across subjects and qualifications
- ☐ Discover our new online past paper service
- ☐ Learn more about Active Results
- ☐ Visit our Online Support Centre

Download high-quality, exciting and innovative GCSE (9-1) Gateway Science Physics A resources from ocr.org.uk/gcsegatewayphysics

Resources and support for our GCSE (9-1) Gateway Science Physics A qualification, developed through collaboration between our Physics Subject Advisors, teachers and other subject experts, are available from our website. You can also contact our Physics Subject Advisors who can give you specialist advice, guidance and support.

Contact the team at:

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To stay up to date with all the relevant news about our qualifications, register for email updates at **ocr.org.uk/updates**

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