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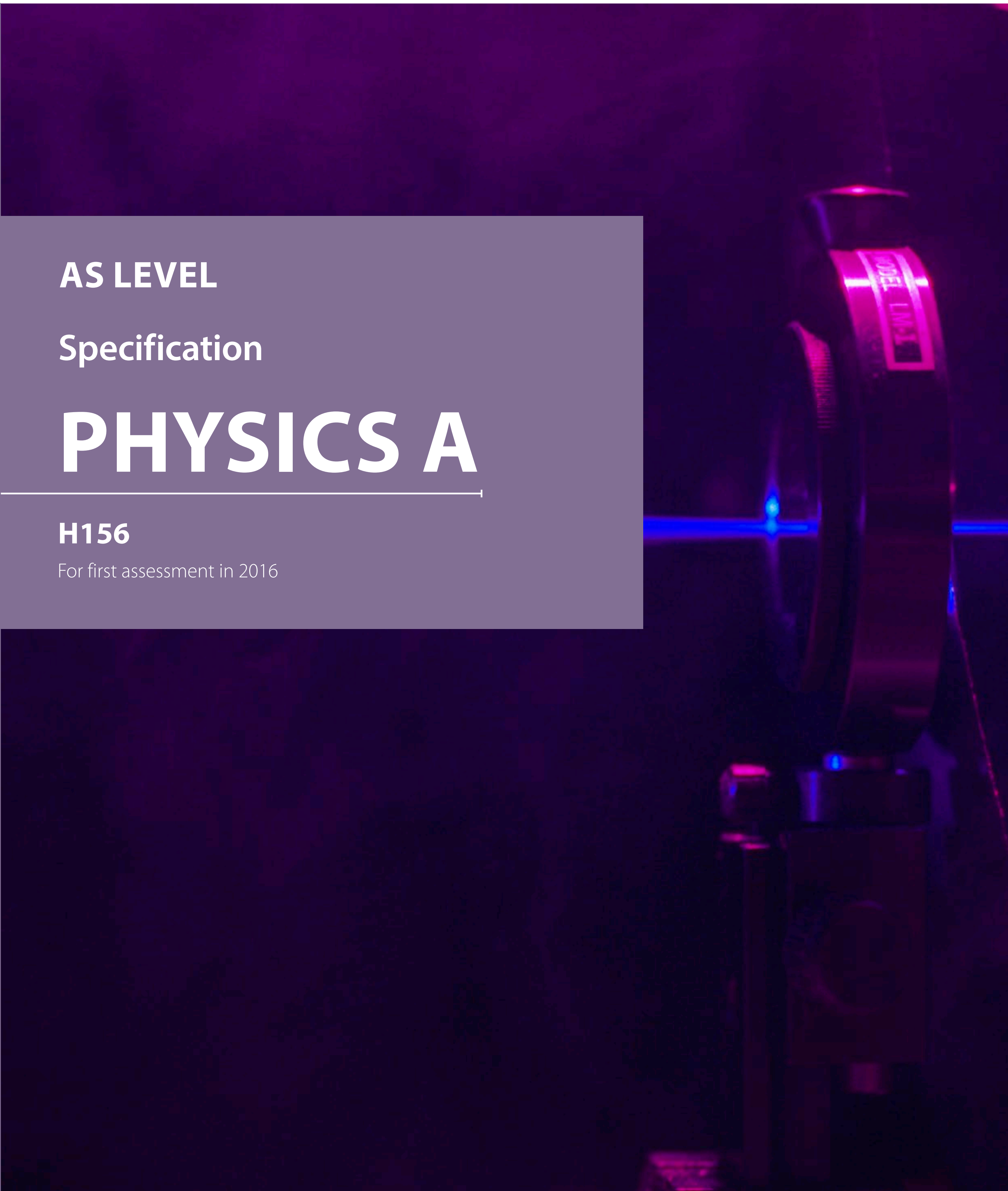

AS LEVEL

Specification

PHYSICS A

H156

For first assessment in 2016

Disclaimer

Specifications are updated over time. Whilst every effort is made to check all documents, there may be contradictions between published resources and the specification, therefore please use the information on the latest specification at all times. Where changes are made to specifications these will be indicated within the document, there will be a new version number indicated, and a summary of the changes. If you do notice a discrepancy between the specification and a resource please contact us at: resources.feedback@ocr.org.uk

We will inform centres about changes to specifications. We will also publish changes on our website. The latest version of our specifications will always be those on our website (ocr.org.uk) and these may differ from printed versions.

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OCR is an exempt charity.

Contents

Introducing…
AS Level Physics A (from September 2015)

Our vision for Science is to create specifications with content that will be up to date, scientifically accurate, developed by subject experts, and allow clear progression pathways (from GCSE to AS/A Level through to higher education, or other post-16 courses and employment). Courses will provide a rewarding experience across the ability range, genuinely challenging the most able learners. The assessment burden will be reduced as much as possible for centres through:

- Carefully designed assessments (straightforward to use for all centre types, large to small)
- Well-laid-out specifications and question papers
- Friendly and prompt support from our team of Subject Advisors
- Quality resource materials that help support a variety of good teaching approaches, drawing on expertise from across the subject community.

Our AS Level Physics A specification takes a content-led approach to the course. This is a flexible approach where the specification is divided into topics, each covering different key concepts of physics. As learners progress through the course, they'll build on their knowledge of the laws of physics, applying their understanding to areas from sub-atomic particles to the entire universe.

We're striving for good science that's straightforward and engaging to teach, with fair, challenging and relevant assessment that works well in centres and promotes practical activity.

Contact the team

We have a dedicated team of Subject Advisors working on our AS Level Physics qualifications.

If you need specialist advice, guidance or support, get in touch as follows:

- **01223 553998**
- **scienceGCE@ocr.org.uk**
- **@OCR_Science**

Vertical black lines indicate a significant change to the previous printed version.

Teaching and learning resources

We recognise that the introduction of a new specification can bring challenges for implementation and teaching. Our aim is to help you at every stage and we're working hard to provide a practical package of support in close consultation with teachers and other experts, so we can help you to make the change.

Designed to support progression for all

Our resources are designed to provide you with a range of teaching activities and suggestions so you can select the best approach for your particular students. You are the experts on how your students learn and our aim is to support you in the best way we can.

We want to…

- Support you with a body of knowledge that grows throughout the lifetime of the specification
- Provide you with a range of suggestions so you can select the best activity, approach or context for your particular students
- Make it easier for you to explore and interact with our resource materials, in particular to develop your own schemes of work
- Create an ongoing conversation so we can develop materials that work for you.

Plenty of useful resources

You'll have four main types of subject-specific teaching and learning resources at your fingertips:

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

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

Skills Guides – we've produced a set of Skills Guides that are not specific to Physics, but each covers a topic that could be relevant to a range of qualifications – for example, communication, legislation and research. Download the guides at **ocr.org.uk/skillsguides**.

Active Results – a free online results analysis service to help you review the performance of individual students or your whole school. It provides access to detailed results data, enabling more comprehensive analysis of results in order to give you a more accurate measurement of the achievements of your centre and individual students. For more details refer to **ocr.org.uk/activeresults**.

Professional development

Take advantage of our improved Professional Development Programme, designed with you in mind. 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.

An introduction to the new specifications

We'll be running events to help you get to grips with our AS Level Physics A qualification.

These events are designed to help prepare you for first teaching and to support your delivery at every stage.

Watch out for details at **cpdhub.ocr.org.uk**.

To receive the latest information about the training we'll be offering, please register for AS Level email updates at **ocr.org.uk/updates**.

1 Why choose an OCR AS Level in Physics A?

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 AS Level in Physics A course has been developed in consultation with teachers, employers and Higher Education to provide students 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 students 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 specifications.
- 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 students 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 AS level qualifications offered by OCR are accredited by Ofqual, the Regulator for qualifications offered in England. The accreditation number for OCR's AS Level in Physics A is QN: 601/4742/8.

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1b. Why choose an OCR AS Level in Physics A?

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

Physics A – a content-led approach. A flexible approach where the specification is divided into topics, each covering different key concepts of physics. As students progress through the course they will build on their knowledge of the laws of Physics, applying their understanding to solve problems on topics ranging from sub-atomic particles to the entire universe. For A level only, the Practical Endorsement will also support the development of practical skills.

Physics B (Advancing Physics) – a context-led approach. Learners study physics in a range of different contexts, conveying the excitement of contemporary physics. The course provides a distinctive structure within which candidates learn about fundamental physical concepts and about physics in everyday and technological settings. 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 representatives from Higher Education (HE) with the aim of including up-to-date relevant content within a framework that is interesting to teach and administer within all centres (large and small).

Our new AS Level in Physics A qualification builds on our existing popular course. We've based the redevelopment of our A level sciences on an understanding of what works well in centres large and small and have updated areas of content and assessment where stakeholders have identified that improvements could be made. 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. Our papers and specifications have been trialled in centres during development to make sure they work well for all centres and learners.

The content changes are an evolution of our legacy offering and will be familiar to centres already following our courses, but are also clear and logically laid out for centres new to OCR, with assessment models that are straightforward to administer. We have worked closely with teachers and HE representatives to provide high quality support materials to guide you through the new qualifications.

Aims and learning outcomes

OCR's AS Level in Physics A specification aims to encourage learners to:

- develop essential knowledge and understanding of different areas of the subject and how they relate to each other
- develop and demonstrate a deep appreciation of the skills, knowledge and understanding of scientific methods
- develop competence and confidence in a variety of practical, mathematical and problem solving skills
- develop their interest in and enthusiasm for the subject, including developing an interest in further study and careers associated with the subject
- understand how society makes decisions about scientific issues and how the sciences contribute to the success of the economy and society (as exemplified in 'How Science Works' (HSW)).

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

Our Physics A specification is designed to inspire your learners. The course will develop their interest in and enthusiasm for the subject, including developing an interest in further study and careers associated with Physics. The specification:

- uses a content-led approach, enabling a flexible approach to the teaching order
- retains and refreshes the popular topics from the legacy OCR Physics A qualification (H158)
- is laid out clearly in a series of teaching modules with Additional guidance added where required to clarify assessment requirements
- is co-teachable with the A level
- embeds practical requirements within the teaching modules. Whilst the Practical Endorsement is not part of AS level Physics A, opportunities for carrying out activities that would count towards the Practical Endorsement are indicated throughout the specification, in the Additional guidance column, by the use of **PAG**, refer to the A level specification, Section 5h, for Practical Endorsement requirements
- exemplifies the mathematical requirements of the course (see Section 5e)
- highlights opportunities for the introduction of key mathematical requirements (see Section 5e and the Additional guidance column for each module) into your teaching
- identifies, within the additional guidance, how the skills, knowledge and understanding of How Science Works (HSW) can be incorporated within teaching.

Teacher support

The extensive support offered alongside this specification includes:

- **delivery guides –** providing information on assessed content, the associated conceptual development and contextual approaches to delivery
- **transition guides –** identifying the levels of demand and progression for different key stages for a particular topic and going on to provide links to high quality resources and 'checkpoint tasks' to assist teachers in identifying learners 'ready for progression'
- **lesson elements –** written by experts, providing all the materials necessary to deliver creative classroom activities
- **Active Results** (see Section 1a)
- **ExamBuilder** (see Section 1a)
- **mock examinations service –** a free service offering a practice question paper and mark scheme (downloadable from a secure location).

Along with:

- Subject Advisors within the OCR science team to help with course queries
- teacher training
- *Science Spotlight* (our termly newsletter)
- OCR Science community
- a consultancy service (to advise on Practical Endorsement requirements)
- Practical Skills Handbook
- Maths Skills Handbook.

1d. How do I find out more information?

Whether new to our specifications, or continuing 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).

Find out more?

Contact the Subject Advisors: ScienceGCE@ocr.org.uk, 01223 553998.

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

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

Follow us on Twitter: @ocr_science

2 The specification overview

2a. Overview of AS Level in Physics A (H156)

Learners must complete both components (01 and 02) to be awarded the OCR AS Level in Physics A.

Content Overview	Assessment Overview	
Content is split into four teaching modules: • Module 1 – Development of practical skills in physics • Module 2 – Foundations of physics • Module 3 – Forces and motion • Module 4 – Electrons, waves and photons Both components assess content from all four modules.	Breadth in physics (01) 70 marks 1 hour 30 minutes written paper	**50%** of total AS level
	Depth in physics (02) 70 marks 1 hour 30 minutes written paper	**50%** of total AS level

Both components include synoptic assessment.

2b. Content of AS Level in Physics A (H156)

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The AS Level in Physics A specification content is divided into four teaching modules. Each module is introduced with a summary of the physics it contains and each topic is also introduced with a short summary text. The assessable content is divided into two columns: **Learning outcomes** and **Additional guidance**.

The Learning outcomes may all be assessed in the examination. The Additional guidance column is included to provide further advice on delivery and the expected skills required from learners.

References to HSW (Section 5d) are included in the guidance to highlight opportunities to encourage a wider understanding of science.

The mathematical requirements in Section 5e are also referenced by the prefix *M* to link the mathematical skills required for AS Level Physics to examples of the physics content where those mathematical skills could be linked to learning.

Module 1 of the specification content relates to the practical skills learners are expected to gain throughout the course, which are assessed throughout the written examinations.

Practical activities are embedded within the learning outcomes of the course to encourage practical activities in the classroom, enhancing learners' understanding of physics theory and practical skills.

The specification has been designed to be co-teachable with the A Level in Physics A qualification. Learners studying the A level study modules 1 to 4 and then continue with the A level only modules 5 and 6 in year 13. The internally assessed Practical Endorsement skills also form part of the full A level (see module 1.2 in the A level specification).

The Data, Formulae and Relationships booklet in section 5c will be available in examinations and learners are expected to become familiar with this booklet throughout the course.

A summary of the content for the AS level course is as follows:

Module 1 – Development of practical skills in physics

1.1 Practical skills assessed in a written examination

Module 2 – Foundations of physics

2.1 Physical quantities and units
2.2 Making measurements and analysing data
2.3 Nature of quantities

Module 3 – Forces and motion

3.1 Motion
3.2 Forces in action
3.3 Work, energy and power
3.4 Materials
3.5 Newton's laws of motion and momentum

Module 4 – Electrons, waves and photons

4.1 Charge and current
4.2 Energy, power and resistance
4.3 Electrical circuits
4.4 Waves
4.5 Quantum physics

2c. Content of modules 1 to 4

Module 1: Development of practical skills in physics

Physics is a practical subject. The development and acquisition of practical skills is fundamental. The Physics A course provides learners with the opportunity to develop experimental methods and techniques for analysing empirical data. Skills in planning, implementing, analysing and evaluating, as outlined in **1.1**, will be assessed in the written papers.

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1.1 Practical skills assessed in a written examination

Practical skills are embedded throughout all the content of this specification.

Learners will be required to develop a range of practical skills throughout their course in preparation for the written examinations.

1.1.1 Planning

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	experimental design, including to solve problems set in a practical context	Including selection of suitable apparatus, equipment and techniques for the proposed experiment. Learners should be able to apply scientific knowledge based on the content of the specification to the practical context. HSW3
(b)	identification of variables that must be controlled, where appropriate	
(c)	evaluation that an experimental method is appropriate to meet the expected outcomes.	HSW6

1.1.2 Implementing

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	how to use a wide range of practical apparatus and techniques correctly	As outlined in the content of the specification and the skills required for the practical endorsement. HSW4
(b)	appropriate units for measurements	*M0.1*
(c)	presenting observations and data in an appropriate format.	HSW8

1.1.3 Analysis

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	processing, analysing and interpreting qualitative and quantitative experimental results	Including reaching valid conclusions, where appropriate. HSW5
(b)	use of appropriate mathematical skills for analysis of quantitative data	Refer to Section 5e for a list of mathematical skills that learners should have acquired competence in as part of their course. HSW3
(c)	appropriate use of significant figures	*M1.1*
(d)	plotting and interpreting suitable graphs from experimental results, including	
	(i) selection and labelling of axes with appropriate scales, quantities and units	*M3.2*
	(ii) measurement of gradients and intercepts.	*M3.3, M3.4, M3.5*

1.1.4 Evaluation

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	how to evaluate results and draw conclusions	Learners should be able to evaluate how the scientific community use results to validate new knowledge and ensure integrity HSW6, 11
(b)	the identification of anomalies in experimental measurements	
(c)	the limitations in experimental procedures	
(d)	precision and accuracy of measurements and data, including margins of error, percentage errors and uncertainties in apparatus	*M1.5*
(e)	the refining of experimental design by suggestion of improvements to the procedures and apparatus.	HSW3

Module 2: Foundations of physics

The aim of this module is to introduce important conventions and ideas that permeate the fabric of physics. Understanding of physical quantities, S.I. units, scalars and vectors helps physicists to effectively communicate their ideas within the scientific community (HSW8, 11).

2.1 Physical quantities and units

This section provides knowledge and understanding of physical quantities and units.

2

2.1.1 Physical quantities

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	physical quantities have a numerical value and a unit	*M0.1*
(b)	making estimates of physical quantities listed in this specification.	*M0.4*

2.1.2 S.I. units

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	Système Internationale (S.I.) base quantities and their units – mass (kg), length (m), time (s), current (A), temperature (K), amount of substance (mol)	HSW8
(b)	derived units of S.I. base units	Examples: momentum $\longrightarrow$ kg m s^{-1} and density $\longrightarrow$ kg m^{-3}
(c)	units listed in this specification	
(d)	checking the homogeneity of physical equations using S.I. base units	
(e)	prefixes and their symbols to indicate decimal submultiples or multiples of units – pico (p), nano (n), micro (μ), milli (m), centi (c), deci (d), kilo (k), mega (M), giga (G), tera (T)	As set out in the ASE publication *Signs, Symbols and Systematics* (*The ASE Companion to 16–19 Science*, 2000).
(f)	the conventions used for labelling graph axes and table columns.	As set out in above, e.g. speed / m s^{-1}. HSW8

2.2 Making measurements and analysing data

This section provides knowledge and understanding of physical measurements and treatment of errors and uncertainties.

2.2.1 Measurements and uncertainties

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	systematic errors (including zero errors) and random errors in measurements	
(b)	precision and accuracy	As discussed in *The Language of Measurement* (ASE 2010).
(c)	absolute and percentage uncertainties when data are combined by addition, subtraction, multiplication, division and raising to powers	As set out in the ASE publication *Signs, Symbols and Systematics* (*The ASE Companion to 16–19 Science*, 2000).
(d)	graphical treatment of errors and uncertainties; line of best fit; worst line; absolute and percentage uncertainties; percentage difference.	A rigorous statistical treatment is not expected. *M1.5*

2.3 Nature of quantities

This section provides knowledge and understanding of scalars and vectors quantities. Vector quantities add and subtract very differently to scalar quantities; hence it is important to know whether a quantity is a vector or a scalar.

2.3.1 Scalars and vectors

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	scalar and vector quantities	Learners will also be expected to give examples of each.
(b)	vector addition and subtraction	
(c)	vector triangle to determine the resultant of any two coplanar vectors	To be done by calculation or by scale drawing *M0.6, M4.2, M4.4*
(d)	resolving a vector into two perpendicular components; $F_x = F\cos\theta$; $F_y = F\sin\theta$.	*M0.6, M4.5*

Module 3: Forces and motion

The term *force* is generally used to indicate a push or a pull. It is difficult to give a proper definition for a force, but in physics we can easily describe what a force can do.

A resultant force acting on an object can accelerate the object in a specific direction. The subsequent motion of the object can be analysed using equations of motion. Several forces acting on an object can prevent the object from either moving or rotating. Forces can also change the shape of an object. There are many other things that forces can do.

In this module, learners will learn how to model the motion of objects using mathematics, understand the effect forces have on objects, learn about the important connection between force and energy, appreciate how forces cause deformation and understand the importance of Newton's laws of motion.

2

3.1 Motion

This section provides knowledge and understanding of key ideas used to describe and analyse the motion of objects in both one dimension and in two dimensions. It also provides learners with opportunities to develop their analytical and experimental skills.

The motion of a variety of objects can be analysed using ICT or data-logging techniques (HSW3). Learners also have the opportunity to analyse and interpret experimental data by recognising relationships between physical quantities (HSW5). The analysis of motion gives many opportunities to link to How Science Works. Examples relate to detecting the speed of moving vehicles, stopping distances and freefall (HSW2, 9, 10, 11, 12).

3.1.1 Kinematics

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	displacement, instantaneous speed, average speed, velocity and acceleration	*M0.1, M1.4, M3.7, M3.9* HSW10, 12
(b)	graphical representations of displacement, speed, velocity and acceleration	*M3.6* *HSW3* Using data-loggers to analyse motion.
(c)	Displacement–time graphs; velocity is gradient	*M3.4, M3.7*
(d)	Velocity–time graphs; acceleration is gradient; displacement is area under graph.	Learners will also be expected to estimate the area under non-linear graphs. *M3.5, M4.3*

3.1.2 Linear motion

		Learning outcomes	Additional guidance
		Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	**(i)**	the equations of motion for constant acceleration in a straight line, including motion of bodies falling in a uniform gravitational field without air resistance $v = u + at$ $\quad s = \frac{1}{2}(u + v)t$ $s = ut + \frac{1}{2}at^2$ $\quad v^2 = u^2 + 2as$	*M2.2, M2.4, M3.3* HSW9
	(ii)	techniques and procedures used to investigate the motion and collisions of objects	**PAG1** Apparatus may include trolleys, air-track gliders, ticker timers, light gates, data-loggers and video techniques. HSW4, 9, 10
(b)	**(i)**	acceleration *g* of free fall	
	(ii)	techniques and procedures used to determine the acceleration of free fall using trapdoor and electromagnet arrangement or light gates and timer	**PAG1** HSW4, 5, 7 Determining *g* in the laboratory.
(c)		reaction time and thinking distance; braking distance and stopping distance for a vehicle.	HSW5, 9, 10, 11, 12

3.1.3 Projectile motion

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	independence of the vertical and horizontal motion of a projectile	
(b)	two-dimensional motion of a projectile with constant velocity in one direction and constant acceleration in a perpendicular direction.	*M0.6, M4.5*

3.2 Forces in action

This section provides knowledge and understanding of the motion of an object when it experiences several forces and also the equilibrium of an object. Learners will also learn how pressure differences give rise to an *upthrust* on an object in a fluid.

There are opportunities to consider contemporary applications of terminal velocity, moments, couples, pressure, and Archimedes principle (HSW6, 7, 9, 11, 12).

Experimental work must play a pivotal role in the acquisition of key concepts and skills (HSW4).

3.2.1 Dynamics

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	net force = mass × acceleration; $F = ma$	Learners will also be expected to recall this equation. *M1.1*
(b)	the newton as the unit of force	
(c)	weight of an object; $W = mg$	Learners will also be expected to recall this equation.
(d)	the terms tension, normal contact force, upthrust and friction	
(e)	free-body diagrams	
(f)	one- and two-dimensional motion under constant force.	

3.2.2 Motion with non-uniform acceleration

		Learning outcomes	Additional guidance
		Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)		drag as the frictional force experienced by an object travelling through a fluid	
(b)		factors affecting drag for an object travelling through air	HSW6
(c)		motion of objects falling in a uniform gravitational field in the presence of drag	HSW9
(d)	**(i)**	terminal velocity	HSW1, 5
	(ii)	techniques and procedures used to determine terminal velocity in fluids.	**PAG1** e.g. ball-bearing in a viscous liquid or cones in air. HSW4 Investigating factors affecting terminal velocity.

2

3.2.3 Equilibrium

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	moment of force	
(b)	couple; torque of a couple	
(c)	the principle of moments	
(d)	centre of mass; centre of gravity; experimental determination of centre of gravity	
(e)	equilibrium of an object under the action of forces and torques	
(f)	condition for equilibrium of three coplanar forces; triangle of forces.	*M4.1, M4.2, M4.4*

3.2.4 Density and pressure

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	density; $\rho = \frac{m}{V}$	*M0.1, M4.3*
(b)	pressure; $p = \frac{F}{A}$ for solids, liquids and gases	
(c)	$p = h\rho g$; upthrust on an object in a fluid; Archimedes' principle.	*M2.1* HSW4, 7, 11

3.3 Work, energy and power

Words like *energy*, *power* and *work* have very precise meaning in physics. In this section the important link between work done and energy is explored. Learners have the opportunity to apply the important principle of conservation of energy to a range of situations. The analysis of energy transfers provides the opportunity for calculations of efficiency and the subsequent evaluation of issues relating to the individual and society (HSW2, 5, 8, 9, 10, 11, 12).

2

3.3.1 Work and conservation of energy

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	work done by a force; the unit joule	
(b)	$W = Fx\cos\theta$ for work done by a force	
(c)	the principle of conservation of energy	HSW2
(d)	energy in different forms; transfer and conservation	
(e)	transfer of energy is equal to work done.	

3.3.2 Kinetic and potential energies

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	kinetic energy of an object; $E_k = \frac{1}{2}mv^2$	Learners will also be expected to recall this equation and derive it from first principles. *M0.5*
(b)	gravitational potential energy of an object in a uniform gravitational field; $E_p = mgh$	Learners will also be expected to recall this equation and derive it from first principles.
(c)	the exchange between gravitational potential energy and kinetic energy.	HSW5, 6

3.3.3 Power

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	power; the unit watt; $P = \frac{W}{t}$	
(b)	$P = Fv$	Learners will also be expected to derive this equation from first principles.
(c)	efficiency of a mechanical system; $\text{efficiency} = \frac{\text{useful output energy}}{\text{total input energy}} \times 100\%$	*M0.3* HSW9, 10, 12

2

3.4 Materials

This section examines the physical properties of springs and materials.

Learners can carry out a range of experimental work to enhance their knowledge and skills, including the management of risks and analysis of data to provide evidence for relationships between physical quantities. There are opportunities to consider the selection of appropriate materials for practical applications (HSW5, 6, 8, 9, 12).

3.4.1 Springs

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	tensile and compressive deformation; extension and compression	
(b)	Hooke's law	
(c)	force constant k of a spring or wire; $F = kx$	
(d)	**(i)** force–extension (or compression) graphs for springs and wires	*M3.2*
	(ii) techniques and procedures used to investigate force–extension characteristics for arrangements which may include springs, rubber bands, polythene strips.	**PAG2** HSW5, 6

3.4.2 Mechanical properties of matter

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	force–extension (or compression) graph; work done is area under graph	*M3.1*
(b)	elastic potential energy; $E = \frac{1}{2}Fx$; $E = \frac{1}{2}kx^2$	*M0.5, M3.12*
(c)	stress, strain and ultimate tensile strength	
(d)	**(i)** Young modulus = $\frac{\text{tensile stress}}{\text{tensile strain}}$, $E = \frac{\sigma}{\varepsilon}$	*M3.1*
	(ii) techniques and procedures used to determine the Young modulus for a metal	**PAG2**
(e)	stress–strain graphs for typical ductile, brittle and polymeric materials	*M3.2* HSW8
(f)	elastic and plastic deformations of materials.	HSW4, 5, 9, 12 Investigating the properties of materials **PAG2**

3.5 Newton's laws of motion and momentum

This section provides knowledge and understanding of Newton's laws – fundamental laws that can be used to predict the motion of all colliding or interacting objects in applications such as sport (HSW1, 2). Newton's laws can also be used to understand some of the safety features in cars, such as air bags, and to evaluate the benefits and risks of such features (HSW9). Learners should be aware that the introduction of mandatory safety features in cars is a consequence of the scientific community analysing the forces involved in collisions and investigating potential solutions to reduce the likelihood of personal injury (HSW10, 11, 12).

There are many opportunities for learners to carry out experimental work and analyse data using ICT techniques (HSW3).

2

3.5.1 Newton's laws of motion

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	Newton's three laws of motion	HSW7
(b)	linear momentum; $p = mv$; vector nature of momentum	
(c)	net force = rate of change of momentum; $F = \frac{\Delta p}{\Delta t}$	Learners are expected to know that $F = ma$ is a special case of this equation. *M2.1, M3.9* HSW9, 10
(d)	impulse of a force; impulse = $F\Delta t$	
(e)	impulse is equal to the area under a force–time graph.	Learners will also be expected to estimate the area under non-linear graphs. HSW3 Using a spreadsheet to determine impulse from *F–t* graph. *M3.8, M4.3*

3.5.2 Collisions

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the principle of conservation of momentum	HSW7
(b)	collisions and interaction of bodies in one dimension and in two dimensions	Two-dimensional problems will only be assessed at A level. HSW11, 12
(c)	perfectly elastic collision and inelastic collision.	HSW1, 2, 6

Module 4: Electrons, waves and photons

The aim of this module is to ultimately introduce key ideas of quantum physics. Electromagnetic waves (e.g. light) have a dual nature. They exhibit both wave and particle-like behaviour. The wave–particle dual nature is also found to be a characteristic of all particles (e.g. electrons).

2

Before any sophisticated work can be done on quantum physics, learners need to appreciate what electrons are and how they behave in electrical circuits. A basic understanding of wave properties is also required.

In this module, learners will learn about electrons, electric current, electrical circuits, wave properties, electromagnetic waves and, of course, quantum physics.

Learners have the opportunity to appreciate how scientific ideas of quantum physics developed over time (HSW7) and their validity rested on the foundations of experimental work (HSW1 and HSW2).

4.1 Charge and current

This short section introduces the ideas of charge and current. Understanding electric current is essential when dealing with electrical circuits. This section does not lend itself to practical work but to introducing important ideas. The continuity equation ($I = Anev$) is developed using these key ideas. This section concludes with categorising all materials in terms of their ability to conduct.

4.1.1 Charge

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	electric current as rate of flow of charge; $I = \frac{\Delta Q}{\Delta t}$	
(b)	the coulomb as the unit of charge	
(c)	the elementary charge *e* equals 1.6×10^{-19} C	Learners will be expected to know that an electron has charge −*e* and a proton a charge +*e*. HSW7
(d)	net charge on a particle or an object is quantised and a multiple of *e*	
(e)	current as the movement of electrons in metals and movement of ions in electrolytes	HSW7
(f)	conventional current and electron flow	HSW7
(g)	Kirchhoff’s first law; conservation of charge.	

4.1.2 Mean drift velocity

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	mean drift velocity of charge carriers	
(b)	$I = Anev$, where n is the number density of charge carriers	*M0.2*
(c)	distinction between conductors, semiconductors and insulators in terms of n.	HSW1, 2

2

4.2 Energy, power and resistance

This section provides knowledge and understanding of electrical symbols, electromotive force, potential difference, resistivity and power. The scientific vocabulary developed here is a prerequisite for understanding electrical circuits in **4.3**.

There is a desire to use energy saving devices, such as LED lamps, in homes. Learners have the opportunity to understand the link between environmental damage from power stations and the impetus to use energy saving devices in the home (HSW10) and how customers can make informed decisions when buying domestic appliances (HSW12).

There are many opportunities for learners to use spreadsheets in the analysis and presentation of data (HSW3), to carry out practical activities to understand concepts (HSW4) and to analyse data to find relationships between physical quantities (HSW5).

4.2.1 Circuit symbols

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	circuit symbols	As set out in ASE publication *Signs, Symbols and Systematics (The ASE Companion to 16–19 Science, 2000).* HSW8
(b)	circuit diagrams using these symbols.	

4.2.2 E.m.f. and p.d.

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	potential difference (p.d.); the unit volt	

(b)	electromotive force (e.m.f.) of a source such as a cell or a power supply	Epsilon is used as the symbol for e.m.f. to avoid confusion with E which is used for energy and electric field. The ASE guide 'Signs symbols and systematics' details E as the correct symbol for e.m.f. and this will be credited in all examinations.
(c)	distinction between e.m.f. and p.d. in terms of energy transfer	
(d)	energy transfer; $W = VQ$; $W = \mathcal{E}Q$.	
(e)	energy transfer $eV = ½ mv^2$ for electrons and other charged particles.	

2

4.2.3 Resistance

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	resistance; $R = \frac{V}{I}$; the unit ohm	Learners will also be expected to recall this equation.
(b)	Ohm's law	
(c)	**(i)** I–V characteristics of resistor, filament lamp, thermistor, diode and light-emitting diode (LED)	*M3.12* HSW5, 8, 9
	(ii) techniques and procedures used to investigate the electrical characteristics for a range of ohmic and non-ohmic components.	**PAG3** HSW3, 4, 5 Investigating components and analysing data using spreadsheet.
(d)	light-dependent resistor (LDR); variation of resistance with light intensity.	

4.2.4 Resistivity

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	**(i)** resistivity of a material; the equation $R = \frac{\rho L}{A}$	
	(ii) techniques and procedures used to determine the resistivity of a metal.	**PAG3**
(b)	the variation of resistivity of metals and semiconductors with temperature	HSW2
(c)	negative temperature coefficient (NTC) thermistor; variation of resistance with temperature.	HSW5

4.2.5 Power

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the equations $P = VI$, $P = I^2R$ and $P = \frac{V^2}{R}$	*M2.2*
(b)	energy transfer; $W = VIt$	
(c)	the kilowatt-hour (kW h) as a unit of energy; calculating the cost of energy.	Learners will be expected to link this with 3.3.3(c). HSW10, 12

2

4.3 Electrical circuits

This section provides knowledge and understanding of electrical circuits, internal resistance and potential dividers. LDRs and thermistors are used to show how changes in light intensity and temperature respectively can be monitored using potential dividers.

Setting up electrical circuits, including potential divider circuits, provides an ideal way of enhancing experimental skills, understanding electrical concepts and managing risks when using power supplies (HSW4). Learners are encouraged to communicate scientific ideas using appropriate terminology (HSW8). This section provides ample opportunities for learners to design circuits and carry out appropriate testing for faults and there are opportunities to study the many applications of electrical circuits (HSW1, 2, 3, 5, 6, 9, 12).

4.3.1 Series and parallel circuits

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	Kirchhoff's second law; the conservation of energy	
(b)	Kirchhoff's first and second laws applied to electrical circuits	
(c)	total resistance of two or more resistors in series; $R = R_1 + R_2 + .$	
(d)	total resistance of two or more resistors in parallel; $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$	
(e)	analysis of circuits with components, including both series and parallel	
(f)	analysis of circuits with more than one source of e.m.f.	

4.3.2 Internal resistance

	Learning outcomes		Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:		
(a)	source of e.m.f.; internal resistance		HSW9, 12
(b)	terminal p.d.; 'lost volts'		
(c)	**(i)**	the equations $\mathcal{E} = I(R + r)$ and $\mathcal{E} = V + Ir$	HSW5, 6
	(ii)	techniques and procedures used to determine the internal resistance of a chemical cell or other source of e.m.f.	**PAG4** HSW4, HSW8 Investigating the internal resistance of a power supply.

4.3.3 Potential dividers

	Learning outcomes		Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:		
(a)	potential divider circuit with components		Learners will also be expected to know about a potentiometer as a potential divider.
(b)	potential divider circuits with variable components e.g. LDR and thermistor		
(c)	**(i)**	potential divider equations e.g. $V_{out} = \frac{R_2}{R_1 + R_2} \times V_{in}$ and $\frac{V_1}{V_2} = \frac{R_1}{R_2}$	*M2.3*
	(ii)	techniques and procedures used to investigate potential divider circuits which may include a sensor such as a thermistor or an LDR.	**PAG4** HSW4 Designing temperature and light sensing circuits.

4.4 Waves

This section provides knowledge and understanding of wave properties, electromagnetic waves, superposition and stationary waves. The wavelength of visible light is too small to be measured directly using a ruler. However, superposition experiments can be done in the laboratory to determine wavelength of visible light using a laser and a double slit.

There are opportunities to discuss how the double-slit experiment demonstrated the wave-like behaviour of light (HSW7).

The breadth of the topic covering sound waves and the electromagnetic spectrum provides scope for learners to appreciate the wide ranging applications of waves and their properties (HSW1, 2, 5, 8, 9, 12).

2

4.4.1 Wave motion

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	progressive waves; longitudinal and transverse waves	HSW8
(b)	**(i)** displacement, amplitude, wavelength, period, phase difference, frequency and speed of a wave	HSW8
	(ii) techniques and procedures used to use an oscilloscope to determine frequency	**PAG5**
(c)	the equation $f = \frac{1}{T}$	
(d)	the wave equation $v = f\lambda$	
(e)	graphical representations of transverse and longitudinal waves	HSW5
(f)	**(i)** reflection, refraction, polarisation and diffraction of all waves	Learners will be expected to know that diffraction effects become significant when the wavelength is comparable to the gap width.
	(ii) techniques and procedures used to demonstrate wave effects using a ripple tank	HSW1, 4.
	(iii) techniques and procedures used to observe polarising effects using microwaves and light	**PAG5**
(g)	intensity of a progressive wave; $I = \frac{P}{A}$; intensity $\propto$ (amplitude)^2.	

4.4.2 Electromagnetic waves

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	electromagnetic spectrum; properties of electromagnetic waves	
(b)	orders of magnitude of wavelengths of the principal radiations from radio waves to gamma rays	
(c)	plane polarised waves; polarisation of electromagnetic waves	Learners will be expected to know about polarising filters for light and metal grilles for microwaves in demonstrating polarisation. HSW9
(d)	**(i)** refraction of light; refractive index; $n = \frac{c}{v}$; $n \sin\theta =$ constant at a boundary where θ is the angle to the normal	
	(ii) techniques and procedures used to investigate refraction and total internal reflection of light using ray boxes, including transparent rectangular and semi-circular blocks	**PAG6**
(e)	critical angle; $\sin C = \frac{1}{n}$; total internal reflection for light.	

4.4.3 Superposition

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	**(i)** the principle of superposition of waves	
	(ii) techniques and procedures used for superposition experiments using sound, light and microwaves	**PAG5**
(b)	graphical methods to illustrate the principle of superposition	
(c)	interference, coherence, path difference and phase difference	
(d)	constructive interference and destructive interference in terms of path difference and phase difference	
(e)	two-source interference with sound and microwaves	

		Learning outcomes	Additional guidance
(f)		Young double-slit experiment using visible light	Learners should understand that this experiment gave a classical confirmation of the wave-nature of light. HSW7 Internet research on the ideas of Newton and Huygens about the nature of light.
(g)	**(i)**	$\lambda = \frac{ax}{D}$ for all waves where $a \ll D$	*M4.6*
	(ii)	techniques and procedures used to determine the wavelength of light using (1) a double-slit, and (2) a diffraction grating.	**PAG5** d sinθ = nλ and diffraction gratings will only be assessed at A level

2

4.4.4 Stationary waves

		Learning outcomes	Additional guidance
		Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)		stationary (standing) waves using microwaves, stretched strings and air columns	
(b)		graphical representations of a stationary wave	
(c)		similarities and the differences between stationary and progressive waves	
(d)		nodes and antinodes	
(e)	**(i)**	stationary wave patterns for a stretched string and air columns in closed and open tubes	
	(ii)	techniques and procedures used to determine the speed of sound in air by formation of stationary waves in a resonance tube	**PAG5**
(f)		the idea that the separation between adjacent nodes (or antinodes) is equal to $\lambda/2$, where λ is the wavelength of the progressive wave	
(g)		fundamental mode of vibration (1st harmonic); harmonics.	

4.5 Quantum physics

This section provides knowledge and understanding of photons, the photoelectric effect, de Broglie waves and wave–particle duality.

In the photoelectric effect experiment, electromagnetic waves are used to eject surface electrons from metals. The electrons are ejected instantaneously and their energy is independent of the intensity of the radiation.

The wave model is unable to explain the interaction of these waves with matter. This single experiment led to the development of the photon model and was the cornerstone of quantum physics. Learners have the opportunity to carry out internet research into how the ideas of quantum physics developed (HSW1, 2, 7) and how scientific community validates the integrity of new knowledge before its acceptance (HSW11).

4.5.1 Photons

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the particulate nature (photon model) of electromagnetic radiation	
(b)	photon as a quantum of energy of electromagnetic radiation	
(c)	energy of a photon; $E = hf$ and $E = \frac{hc}{\lambda}$	
(d)	the electronvolt (eV) as a unit of energy	
(e)	**(i)** using LEDs and the equation $eV = \frac{hc}{\lambda}$ to estimate the value of Planck constant h	No knowledge of semiconductor theory is required. HSW11
	(ii) Determine the Planck constant using different coloured LEDs.	**PAG6**

4.5.2 The photoelectric effect

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	**(i)** photoelectric effect, including a simple experiment to demonstrate this effect	Learners should understand that photoelectric effect provides evidence for particulate nature of electromagnetic radiation. HSW1, 2, 3, 7, 11 Internet research on the development of quantum physics.
	(ii) demonstration of the photoelectric effect using, e.g. gold-leaf electroscope and zinc plate	
(b)	a one-to-one interaction between a photon and a surface electron	
(c)	Einstein's photoelectric equation $hf = \phi + KE_{max}$	*M2.3*

(d)	work function; threshold frequency	
(e)	the idea that the maximum kinetic energy of the photoelectrons is independent of the intensity of the incident radiation	
(f)	the idea that rate of emission of photoelectrons above the threshold frequency is directly proportional to the intensity of the incident radiation.	

4.5.3 Wave–particle duality

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	electron diffraction, including experimental evidence of this effect	Learners should understand that electron diffraction provides evidence for wave-like behaviour of particles.
(b)	diffraction of electrons travelling through a thin slice of polycrystalline graphite by the atoms of graphite and the spacing between the atoms	
(c)	the de Broglie equation $\lambda = \frac{h}{p}$.	

2

2d. Prior knowledge, learning and progression

This specification has been developed for learners who wish to continue with a study of physics at Level 3. The AS level specification has been written to provide progression from GCSE Science, GCSE Additional Science, GCSE Further Additional Science or from GCSE Physics. Learners who have successfully taken other Level 2 qualifications in Science or Applied Science with appropriate physics content may also have acquired sufficient knowledge and understanding to begin the AS level Physics course.

There is no formal requirement for prior knowledge of physics for entry onto this qualification. Other learners without formal qualifications may have acquired sufficient knowledge of physics to enable progression onto the course.

Some learners may wish to follow a physics course for only one year as an AS, in order to broaden their curriculum, and to develop their interest and understanding of different areas of the subject.

Others may follow a co-teachable route, completing the one-year AS course and/or then moving to the two-year A level developing a deeper knowledge and understanding of physics and its applications.

The A Level Physics course will prepare learners for progression to undergraduate study, enabling them to enter a range of academic and vocational careers in mathematics-related courses, physical sciences, engineering, medicine, computing and related sectors. For learners wishing to follow an apprenticeship route or those seeking direct entry into physical science careers, this A level provides a strong background and progression pathway.

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

3 Assessment of OCR AS Level in Physics A

3a. Forms of assessment

Both externally assessed components (01 and 02) contain some synoptic assessment. Component 02 contains some extended response questions.

Breadth in physics (Component 01)

This component is worth 70 marks and is split into two sections and assesses content from all teaching modules. Learners answer all questions.

Section A contains multiple choice questions. This section of the paper is worth 20 marks.

Section B includes short answer question styles (structured questions, problem solving, calculations, practical). This section of the paper is worth 50 marks.

Depth in physics (Component 02)

This component assesses content from across all teaching modules, 1 to 4. Learners answer all questions. This component is worth 70 marks.

Question styles include short answer (structured questions, problem solving, calculations, practical) and extended response questions.

3b. Assessment objectives (AO)

There are three assessment objectives in OCR's AS Level in Physics A. These are detailed in the table below.

Learners are expected to demonstrate their ability to:

	Assessment Objective
AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling qualitative data • when handling quantitative data.
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation to issues, to: • make judgements and reach conclusions • develop and refine practical design and procedures.

AO weightings in AS Level in Physics A

The relationship between the assessment objectives and the components are shown in the following table:

Component	% of AS level Physics A (H156)		
	AO1	AO2	AO3
Breadth in physics (H156/01)	22–24	19–20	7–9
Depth in physics (H156/02)	13–16	21–24	13–14
Total	**35–40**	**40–44**	**20–23**

3c. Assessment availability

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

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

This specification will be certificated from the June 2016 examination series onwards.

3d. Retaking the qualification

Learners can retake the qualification as many times as they wish. They retake both components of the qualification.

3e. Assessment of extended responses

The assessment materials for this qualification provide learners with the opportunity to demonstrate their ability to construct and develop a sustained and coherent line of reasoning and marks for extended responses are integrated into the marking criteria.

3f. 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 AS level course. The emphasis of synoptic assessment is to encourage the development of the understanding of the subject as a discipline. Both components within Physics A 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 of 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.

3g. Calculating qualification results

A learner's overall qualification grade for AS Level in Physics A will be calculated by adding together their marks from the two components taken to give their total weighted mark.

This mark will then be compared to the qualification level grade boundaries 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 AS Level in Physics A must be entered using the entry code H156.

Entry option		Component		
Entry code	**Title**	**Code**	**Title**	**Assessment type**
H156	Physics A	01	Breadth in physics	External assessment
		02	Depth in physics	External assessment

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.

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

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 of the requirements detailed in the specification.

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.

4b. Accessibility and special consideration

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*.

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 *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 both components. Calculators are subject to the rules in the document *Instructions for Conducting Examinations* published annually by JCQ (**www.jcq.org.uk**).

4d. Results and certificates

Grade scale

Advanced Subsidiary qualifications are graded on the scale: A, B, C, D, E, where A is the highest. Learners who fail to reach the minimum standard for E will be Unclassified (U). Only subjects in which grades A to E 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 results will be recorded on an OCR certificate.

The qualification title will be shown on the certificate as 'OCR Level 3 Advanced Subsidiary GCE in Physics A'.

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 coursework 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 *Suspected Malpractice in Examinations and Assessments: Policies and Procedures* published by JCQ.

5 Appendices

5a. Overlap with other qualifications

There is a small degree of overlap between the content of this specification and those for other AS level/A level Sciences.

Examples of overlap include:

Chemistry

- Atomic structure.

Science

- Atomic structure.
- Electromagnetic spectrum.

5b. Avoidance of bias

The AS level 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.

5c. Physics A data sheet

Data, Formulae and Relationships

The data, formulae and relationships in this data sheet will be printed for distribution with the examination papers.

Data

Values are given to three significant figures, except where more – or fewer – are useful.

Physical constants

acceleration of free fall	g	$9.81\ \text{m s}^{-2}$
elementary charge	e	$1.60 \times 10^{-19}\ \text{C}$
speed of light in a vacuum	c	$3.00 \times 10^{8}\ \text{m s}^{-1}$
Planck constant	h	$6.63 \times 10^{-34}\ \text{J s}$
Avogadro constant	N_A	$6.02 \times 10^{23}\ \text{mol}^{-1}$
molar gas constant	R	$8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
Boltzmann constant	k	$1.38 \times 10^{-23}\ \text{J K}^{-1}$
gravitational constant	G	$6.67 \times 10^{-11}\ \text{N m}^{2}\ \text{kg}^{-2}$
permittivity of free space	ε_0	$8.85 \times 10^{-12}\ \text{C}^{2}\ \text{N}^{-1}\ \text{m}^{-2}\ (\text{F m}^{-1})$
electron rest mass	m_e	$9.11 \times 10^{-31}\ \text{kg}$
proton rest mass	m_p	$1.673 \times 10^{-27}\ \text{kg}$
neutron rest mass	m_n	$1.675 \times 10^{-27}\ \text{kg}$
alpha particle rest mass	m_α	$6.646 \times 10^{-27}\ \text{kg}$
Stefan constant	σ	$5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$

Quarks

up quark	charge = $+\frac{2}{3}e$
down quark	charge = $-\frac{1}{3}e$
strange quark	charge = $-\frac{1}{3}e$

Conversion factors

unified atomic mass unit	$1\ \text{u} = 1.661 \times 10^{-27}$ kg
electronvolt	$1\ \text{eV} = 1.60 \times 10^{-19}$ J
day	$1\ \text{day} = 8.64 \times 10^{4}$ s
year	$1\ \text{year} \approx 3.16 \times 10^{7}$ s
light year	$1\ \text{light year} \approx 9.5 \times 10^{15}$ m
parsec	$1\ \text{parsec} \approx 3.1 \times 10^{16}$ m

Mathematical equations

arc length = $r\theta$

circumference of circle = $2\pi r$

area of circle = πr^2

curved surface area of cylinder = $2\pi rh$

surface area of sphere = $4\pi r^2$

area of trapezium = $\frac{1}{2}(a+b)h$

volume of cylinder = $\pi r^2 h$

volume of sphere = $\frac{4}{3}\pi r^3$

Pythagoras' theorem: $a^2 = b^2 + c^2$

cosine rule: $a^2 = b^2 + c^2 - 2bc\cos A$

sine rule: $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

$\sin\theta \approx \tan\theta \approx \theta$ and $\cos\theta \approx 1$ for small angles

$\log(AB) = \log(A) + \log(B)$

(Note: $\lg = \log_{10}$ and $\ln = \log_e$)

$\log\left(\frac{A}{B}\right) = \log(A) - \log(B)$

$\log(x^n) = n\log(x)$

$\ln(e^{kx}) = kx$

5

Formulae and relationships

Module 2 – Foundations of physics	
vectors	$F_x = F\cos\theta$ $F_y = F\sin\theta$

Module 3 – Forces and motion	
uniformly accelerated motion	$v = u + at$ $s = \frac{1}{2}(u+v)t$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
force	$F = \frac{\Delta p}{\Delta t}$ $p = mv$
turning effects	moment $= Fx$ torque $= Fd$
density	$\rho = \frac{m}{V}$
pressure	$p = \frac{F}{A}$ $p = h\rho g$
work, energy and power	$W = Fx\cos\theta$ $\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100\%$ $P = \frac{W}{t}$ $P = Fv$
springs and materials	$F = kx$ $E = \frac{1}{2}Fx;\ E = \frac{1}{2}kx^2$ $\sigma = \frac{F}{A}$ $\varepsilon = \frac{x}{L}$ $E = \frac{\sigma}{\varepsilon}$

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Module 4 – Electrons, waves and photons	
charge	$\Delta Q = I\Delta t$
current	$I = Anev$
work done	$W = VQ$; $W = \mathcal{E}Q$; $W = VIt$
resistance and resistors	$R = \frac{\rho L}{A}$ $R = R_1 + R_2 + \ldots$ $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$
power	$P = VI$, $P = I^2R$ and $P = \frac{V^2}{R}$
internal resistance	$\mathcal{E} = I(R + r)$; $\mathcal{E} = V + Ir$
potential divider	$V_{out} = \frac{R_2}{R_1 + R_2} \times V_{in}$ $\frac{V_1}{V_2} = \frac{R_1}{R_2}$
waves	$v = f\lambda$ $f = \frac{1}{T}$ $I = \frac{P}{A}$ $\lambda = \frac{ax}{D}$
refraction	$n = \frac{c}{v}$ $n \sin\theta = \text{constant}$ $\sin C = \frac{1}{n}$
quantum physics	$E = hf$ $E = \frac{hc}{\lambda}$ $hf = \phi + KE_{max}$ $\lambda = \frac{h}{p}$

5

5d. How Science Works (HSW)

How Science Works was conceived as being a wider view of science in context, rather than just straightforward scientific enquiry. It was intended to develop learners as critical and creative thinkers, able to solve problems in a variety of contexts.

Developing ideas and theories to explain the operation of the entirety of our existence, from the sub-atomic particles to the Universe, is the basis of Physics. How Science Works develops the critical analysis and linking of evidence to support or refute ideas and theories. Learners should be aware of the importance that peer review and repeatability have in giving confidence to this evidence.

Learners are expected to understand the variety of sources of data available for critical analysis to provide evidence and the uncertainty involved in its measurement. They should also be able to link that evidence to contexts influenced by culture, politics and ethics.

Understanding How Science Works requires an understanding of how scientific evidence can influence ideas and decisions for individuals and society, which is linked to the necessary skills of communication for audience and for purpose with appropriate scientific terminology.

The examples and guidance within the specification are not exhaustive but give a flavour of opportunities for integrating HSW within the course. These references, written in the form HSW1, link to the statements as detailed below:

- **HSW1** Use theories, models and ideas to develop scientific explanations
- **HSW2** Use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas
- **HSW3** Use appropriate methodology, including information and communication technology (ICT), to answer scientific questions and solve scientific problems
- **HSW4** Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts
- **HSW5** Analyse and interpret data to provide evidence, recognising correlations and causal relationships
- **HSW6** Evaluate methodology, evidence and data, and resolve conflicting evidence
- **HSW7** Know that scientific knowledge and understanding develops over time
- **HSW8** Communicate information and ideas in appropriate ways using appropriate terminology
- **HSW9** Consider applications and implications of science and evaluate their associated benefits and risks
- **HSW10** Consider ethical issues in the treatment of humans, other organisms and the environment
- **HSW11** Evaluate the role of the scientific community in validating new knowledge and ensuring integrity
- **HSW12** Evaluate the ways in which society uses science to inform decision making.

5e. Mathematical requirements

In order to be able to develop their skills, knowledge and understanding in AS Level Physics, 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 assessment of quantitative skills will include at least 40% Level 2 (or above) mathematical skills for physics (see later for a definition of Level 2 mathematics). 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 Level 2 examples. These skills could be developed in other areas of specification content from those indicated. For the mathematical requirements for A Level in Physics A see the A level specification.

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of AS Level Physics (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
***M0* – Arithmetic and numerical computation**			
M0.1	Recognise and make use of appropriate units in calculations	Learners may be tested on their ability to: • identify the correct units for physical properties such as m s^{-1}, the unit for velocity; • convert between units with different prefixes e.g. cm^3 to m^3.	1.1.2(b), 2.1.1(a), 3.1.1(a) 3.2.4(a)
M0.2	Recognise and use expressions in decimal and standard form	Learners may be tested on their ability to: • use physical constants expressed in standard form such as $c = 3.00 \times 10^8$ m s^{-1}.	1.1.3(c), 4.1.2(b)
M0.3	Use ratios, fractions and percentages	Learners may be tested on their ability to: • calculate efficiency of devices; • calculate percentage uncertainties in measurements.	3.3.3(c)
M0.4	Estimate results	Learners may be tested on their ability to: • estimate the effect of changing experimental parameters on measurable values.	2.1.1(b)

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of AS Level Physics (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M0.5	Use calculators to find and use power functions	Learners may be tested on their ability to: • calculate kinetic energy • calculate elastic potential energy.	3.3.2(a), 3.4.2(b)
M0.6	Use calculators to handle $\sin x$, $\cos x$ and $\tan x$ when x is expressed in degrees or radians	Learners may be tested on their ability to: • calculate the direction of resultant vectors.	2.3.1(c)(d), 3.1.3(b)
***M1* – Handling data**			
M1.1	Use an appropriate number of significant figures	Learners may be tested on their ability to: • report calculations to an appropriate number of significant figures given raw data quoted to varying numbers of significant figures; • understand that calculated results can only be reported to the limits of the least accurate measurement.	1.1.3(c), 3.2.1(a)
M1.2	Find arithmetic means	Learners may be tested on their ability to: • calculate a mean value for repeated experimental readings.	1.1.3(a)
M1.3	Understand simple probability	Learners may be tested on their ability to: • electron diffraction provides evidence for wave-like behaviour of particles.	4.5.3(a)
M1.4	Make order of magnitude calculations	Learners may be tested on their ability to: • evaluate equations with variables expressed in different orders of magnitude.	3.1.1(a)

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of AS Level Physics (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M1.5	Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined by addition, subtraction, multiplication, division and raising to powers	Learners may be tested on their ability to: • determine the uncertainty where two readings for length need to be added together.	1.1.4(d), 2.2.1(c)(d)
***M2* – Algebra**			
M2.1	Understand and use the symbols: $=, <, \ll, \gg, >, \propto, \approx, \Delta$	Learners may be tested on their ability to: • recognise the significance of the symbols in the expression $F \propto \Delta p / \Delta t$.	3.2.4(c), 3.5.1(c)
M2.2	Change the subject of an equation, including non-linear equations	Learners may be tested on their ability to: • rearrange $E = mc^2$ to make m the subject.	3.1.2(a), 4.2.5(a)
M2.3	Substitute numerical values into algebraic equations using appropriate units for physical quantities	Learners may be tested on their ability to: • calculate the momentum p of an object by substituting the values for mass m and velocity v into the equation $p = mv$.	4.3.3(c), 4.5.2(c)
M2.4	Solve algebraic equations, including quadratic equations	Learners may be tested on their ability to: • solve kinematic equations for constant acceleration such as $v = u + at$ and $s = ut + \frac{1}{2}at^2$.	3.1.2(a)
***M3* – Graphs**			
M3.1	Translate information between graphical, numerical and algebraic forms	Learners may be tested on their ability to: • calculate Young modulus for materials using stress–strain graphs.	1.1.3(d), 3.4.2

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of AS Level Physics (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M3.2	Plot two variables from experimental or other data	Learners may be tested on their ability to: • plot graphs of extension of a wire against force applied.	1.1.3(d), 3.4.1(d)
M3.3	Understand that $y = mx + c$ represents a linear relationship	Learners may be tested on their ability to: • rearrange and compare v = u + at with y = mx + c for velocity–time graphs in constant acceleration problems.	1.1.3(d), 3.1.2(a)
M3.4	Determine the slope and intercept of a linear graph	Learners may be tested on their ability to: • read off and interpret intercept point from a graph e.g. the initial velocity in a velocity–time graph.	1.1.3(d), 3.1.1(c)
M3.5	Calculate rate of change from a graph showing a linear relationship	Learners may be tested on their ability to: • calculate acceleration from a linear velocity–time graph.	3.1.1(d)
M3.6	Draw and use the slope of a tangent to a curve as a measure of rate of change	Learners may be tested on their ability to: • draw a tangent to the curve of a displacement–time graph and use the gradient to approximate the velocity at a specific time.	3.1.1(b)
M3.7	Distinguish between instantaneous rate of change and average rate of change	Learners may be tested on their ability to: • understand that the gradient of the tangent of a displacement–time graph gives the velocity at a point in time which is a different measure to the average velocity.	3.1.1(a), 3.1.1(c)

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of AS Level Physics (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M3.8	Understand the possible physical significance of the area between a curve and the *x* axis and be able to calculate it or estimate it by graphical methods as appropriate	Learners may be tested on their ability to: • recognise that for a capacitor the area under a voltage–charge graph is equivalent to the energy stored.	3.5.1(e)
M3.9	Apply the concepts underlying calculus (but without requiring the explicit use of derivatives or integrals) by solving equations involving rates of change, e.g. $\Delta x/\Delta t = -\lambda x$ using a graphical method or spreadsheet modelling	Learners may be tested on their ability to: • determine g from distance–time plot, projectile motion.	3.1.1(a), 3.5.1(c)
M3.12	Sketch relationships which are modelled by $y = k/x$, $y = kx^2$, $y = k/x^2$, $y = kx$, $y = \sin x$ and $y = \cos x$	Learners may be tested on their ability to: • sketch graphs of force against extension • sketch I–V characteristic of resistor.	3.4.2(b), 4.2.3(c)
***M4* – Geometry and trigonometry**			
M4.1	Use angles in regular 2D and 3D structures	Learners may be tested on their ability to: • interpret force diagrams to solve problems.	3.2.3(f)
M4.2	Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects	Learners may be tested on their ability to: • draw force diagrams to solve mechanics problems.	2.3.1(c), 3.2.3(f)
M4.3	Calculate areas of triangles, circumferences and areas of circles, surface areas and volumes of rectangular blocks, cylinders and spheres	Learners may be tested on their ability to: • calculate the area of the cross section to work out the resistance of a conductor given its length and resistivity.	3.1.1(d), 3.2.4, 3.5.1(e)

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of AS Level Physics (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M4.4	Use Pythagoras' theorem, and the angle sum of a triangle	Learners may be tested on their ability to: • calculate the magnitude of a resultant vector, resolving forces into components to solve problems.	2.3.1(c), 3.2.3(f)
M4.5	Use sin, cos and tan in physical problems	Learners may be tested on their ability to: • resolve forces into components.	2.3.1(d), 3.1.3(b)
M4.6	Use of small angle approximations including $\sin\theta \approx \theta$, $\tan\theta \approx \theta$, $\cos\theta \approx 1$ for small θ where appropriate	Learners may be tested on their ability to: • calculate fringe separations in interference patterns.	4.4.3(h)
M4.7	Understand the relationship between degrees and radians and translate from one to the other	Learners may be tested on their ability to: • convert angle in degrees to angle in radians.	4.4.2(d)(i)

Definition of Level 2 mathematics

Within AS Level Physics, 40% of the marks available within written examinations will be for assessment of mathematics (in the context of physics) at a Level 2 standard, or higher. Lower level mathematical skills will still be assessed within examination papers but will not count within the 40% weighting for physics.

The following will be counted as Level 2 (or higher) mathematics:

- application and understanding requiring choice of data or equation to be used
- problem solving involving use of mathematics from different areas of maths and decisions about direction to proceed
- questions involving use of A level mathematical content (as of 2012), e.g. use of logarithmic equations.

The following will not be counted as Level 2 mathematics:

- simple substitution with little choice of equation data
- structured question formats using GCSE mathematics (based on 2012 GCSE mathematics content).

Additional guidance on the assessment of mathematics within physics is available on the OCR website as a separate resource, the Maths Skills Handbook.

5f. 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 **http://www.ase.org.uk/resources/health-and-safety-resources/risk-assessments/**

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 candidates 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®.

[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
May 2018	1.1	Front cover	Disclaimer	Addition of Disclaimer
May 2020	1.2	1d	How do I find out more information?	Insertion of Online support centre link
		4d	Post-results services	Enquiries about results changed to Review of results
				Update to specification covers to meet digital accessibility standards

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