SUMMARY OF AMENDMENTS

Version	Description	Page number
2	'Making entries' section has been amended to clarify resit rules.	33

WJEC Eduqas GCE AS in PHYSICS

For teaching from 2015
For award from 2016

AS PHYSICS

SUMMARY OF ASSESSMENT

Component 1: Motion, Energy and Matter Written examination : 1 hour 30 minutes (75 marks) 50% of qualification
A mix of short answer and extended answer structured questions with some set in a practical context.
Component 2: Electricity and Light Written examination : 1 hour 30 minutes (75 marks) 50% of qualification
A mix of short answer and extended answer structured questions with some set in a practical context.

This linear qualification will be available in the months of May and June of each year. It will be awarded for the first time in Summer 2016.

Qualification Accreditation Number: 601/5521/8

AS PHYSICS

1 INTRODUCTION

1.1 Aims and objectives

The WJEC Eduqas AS in Physics provides a broad, coherent, satisfying and worthwhile course of study. It encourages learners to develop confidence in, and a positive attitude towards, physics and to recognise its importance in their own lives and to society.

Studying this AS in Physics encourages 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.

This specification is intended to promote a variety of styles of teaching and learning so that the course is enjoyable for all participants. Learners will be introduced to a wide range of physics principles which will allow them to enjoy a positive learning experience.

Practical work is an intrinsic part of physics, and is highly valued by higher education. It is imperative that practical skills are developed throughout this course and that an investigatory approach is promoted.

1.2 Prior learning and progression

Any requirements set for entry to a course following this specification are at the discretion of centres. It is reasonable to assume that many learners will have achieved qualifications equivalent to Level 2 at KS4. Skills in Numeracy/Mathematics, Literacy/English and Information Communication Technology will provide a good basis for progression to this qualification.

This specification builds on the skills, knowledge and understanding set out in the GCSE criteria/content for science. Some learners will have already gained knowledge, understanding and skills through their study of physics at GCSE.

Mathematical requirements are specified in the subject criteria and repeated in Appendix B of this specification.

This specification provides a suitable foundation for the study of physics at A level. In addition, the specification provides a coherent, satisfying and worthwhile course of study for learners who do not progress to further study in this subject.

This specification is not age specific and, as such, provides opportunities for candidates to extend their life-long learning.

1.3 Equality and fair assessment

This specification may be followed by any learner, irrespective of gender, ethnic, religious or cultural background. It has been designed to avoid, where possible, features that could, without justification, make it more difficult for a learner to achieve because they have a particular protected characteristic.

The protected characteristics under the Equality Act 2010 are age, disability, gender reassignment, pregnancy and maternity, race, religion or belief, sex and sexual orientation.

The specification has been discussed with groups who represent the interests of a diverse range of learners, and the specification will be kept under review.

Reasonable adjustments are made for certain learners in order to enable them to access the assessments (e.g. candidates are allowed access to a Sign Language Interpreter, using British Sign Language). Information on reasonable adjustments is found in the following document from the Joint Council for Qualifications (JCQ): *Access Arrangements and Reasonable Adjustments: General and Vocational Qualifications.*

This document is available on the JCQ website (www.jcq.org.uk). As a consequence of provision for reasonable adjustments, very few learners will have a complete barrier to any part of the assessment.

2 SUBJECT CONTENT

This section outlines the knowledge, understanding and skills to be developed by learners studying AS Physics.

Learners should be prepared to apply the knowledge, understanding and skills specified in a range of theoretical, practical, industrial and environmental contexts. Learners' understanding of the connections between the different elements of the subject and their holistic understanding of the subject is a requirement of all AS specifications. In practice, this means that in each component learners will be required to demonstrate their ability to draw together different areas of knowledge and understanding from across the full course of study.

Practical work is an intrinsic part of this specification. It is vitally important in developing a conceptual understanding of many topics and it enhances the experience and enjoyment of physics. The practical skills developed are also fundamentally important to learners going on to further study in physics and related subjects, and are transferable to many careers.

This section includes **specified practical work** that **must** be undertaken by learners in order that they are suitably prepared for the written examinations. The completion of this practical work will develop the practical skills listed in Appendix A.

Appendix B lists the mathematical requirements with exemplification in the context of AS Physics.

All content in the specification should be introduced in such a way that it develops learners' ability to:

- use theories, models and ideas to develop scientific explanations
- use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas
- use appropriate methodology, including information and communication technology (ICT), to answer scientific questions and solve scientific problems
- carry out experimental and investigative activities, including appropriate risk management, in a range of contexts
- analyse and interpret data to provide evidence, recognising correlations and causal relationships
- evaluate methodology, evidence and data, and resolve conflicting evidence
- know that scientific knowledge and understanding develops over time
- communicate information and ideas in appropriate ways using appropriate terminology
- consider applications and implications of science and evaluate their associated benefits and risks
- consider ethical issues in the treatment of humans, other organisms and the environment
- evaluate the role of the scientific community in validating new knowledge and ensuring integrity
- evaluate the ways in which society uses science to inform decision making.

Appendix C exemplifies the areas of the specification where these skills can be developed.

2.1 Component 1

MOTION, ENERGY AND MATTER

Written examination: 1 hour 30 minutes
50% of qualification

This component covers the following areas of study:

1. Basic physics
2. Kinematics
3. Dynamics
4. Energy concepts
5. Solids under stress
6. Using radiation to investigate stars
7. Particles and nuclear structure

1. BASIC PHYSICS

Overview

This topic covers units, dimensions, basic ideas on scalar and vector quantities and the differences between them. The basic physics in this unit gives learners the ideas and skills they need to progress to further study of Newtonian mechanics, kinetic theory and thermal physics.

Working Scientifically

The specified practical work in this topic gives learners the opportunity to use apparatus to record a range of measurements and to interpolate between scale readings. Learners also have the opportunity to follow written instructions, to make and record observations, keep appropriate records and present information and data in a scientific way.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include identifying the correct units for physical quantities; using physical constants expressed in standard form; using ratios, fractions and percentages; using calculators to handle trigonometrical expressions; calculating mean values for repeated experimental readings.

How Science Works

There are opportunities within this topic for learners to carry out experimental and investigative activities, including appropriate risk management, in a range of contexts.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the 6 essential base SI units (kg, m, s, A, mol, K)

(b) representing units in terms of the 6 base SI units and their prefixes

(c) checking equations for homogeneity using units

(d) the difference between scalar and vector quantities and to give examples of each – displacement, velocity, acceleration, force, speed, time, density, pressure etc

(e) the addition and subtraction of coplanar vectors, and perform mathematical calculations limited to **two** perpendicular vectors

(f) how to resolve a vector into two perpendicular components

(g) the concept of density and how to use the equation $\rho = \frac{m}{V}$ to calculate mass, density and volume

(h) what is meant by the turning effect of a force

(i) the use of the principle of moments

(j) the use of centre of gravity, for example in problems including stability: identify its position in a cylinder, sphere and cuboid (beam) of uniform density

(k) when a body is in equilibrium the resultant force is zero and the net moment is zero, and be able to perform simple calculations

SPECIFIED PRACTICAL WORK

- Measurement of the density of solids
- Determination of unknown masses by using the principle of moments

2. KINEMATICS

Overview

This topic covers rectilinear and projectile motion. Learners study accelerated motion in a straight line; the motion of bodies falling in a gravitational field; the independence of vertical and horizontal motion of a body moving freely under gravity.

Working Scientifically

This unit contains opportunities for learners to use stopwatches or light gates for timing; to use analogue apparatus to record a range of measurements; to make and record observations; to keep appropriate records and to present data in a scientific way.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include recognising and making use of appropriate units in calculations; using expressions in decimal and standard form; changing the subject of an equation; substituting numerical values into algebraic equations using appropriate units for physical quantities.

How Science Works

There are opportunities within this topic for learners to use appropriate methodology, including ICT to answer scientific questions and solve scientific problems; to analyse and interpret data to provide evidence, recognise correlations and causal evidence. Learners can carry out experimental and investigative activities using air tracks, light gates, data loggers and photographic or video techniques to investigate factors affecting terminal velocity, stopping distances and the measuring of the speed of moving objects. Learners can apply these factors to consider the possibility of increasing the legal motorway speed limit to 80 mph by analysing data to provide them with evidence to be able to make an informed judgement of whether to support this possibility, or not.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) what is meant by displacement, mean and instantaneous values of speed, velocity and acceleration

(b) the representation of displacement, speed, velocity and acceleration by graphical methods

(c) the properties of displacement-time graphs, velocity-time graphs, and interpret speed and displacement-time graphs for non-uniform acceleration

(d) how to derive and use equations which represent uniformly accelerated motion in a straight line

(e) how to describe the motion of bodies falling in a gravitational field with and without air resistance - terminal velocity

(f) the independence of vertical and horizontal motion of a body moving freely under gravity

(g) the explanation of the motion due to a uniform velocity in one direction and uniform acceleration in a perpendicular direction, and perform simple calculations

SPECIFIED PRACTICAL WORK

- Measurement of g by freefall

3. DYNAMICS

Overview

This topic covers the concept of force and free body diagrams. Learners study Newton's laws of motion and the concept of linear momentum. The principle of conservation of momentum is used to solve problems involving both elastic and inelastic collisions.

Working Scientifically

The specified practical work within this unit contains opportunities for learners to use appropriate analogue instruments to record a range of measurements; to make and record observations; keep appropriate records; to follow written instructions and to apply investigative approaches to practical work.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include recognising and making use of appropriate units in calculations; using an appropriate number of significant figures; understanding and using mathematical symbols; changing the subject of an equation; solving algebraic equations; plotting two variables from experimental or other data.

How Science Works

There are opportunities within this topic for learners to carry out experimental and investigative activities, including risk management to analyse and interpret data to provide evidence. Learners can use and apply the concept of change in momentum to investigate the importance of crumple zones in car bonnets and air bags, and evaluate their benefits for the safety of passengers.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the concept of force and Newton's 3rd law of motion

(b) how free body diagrams can be used to represent forces on a particle or body

(c) the use of the relationship $\sum F = ma$ in situations where mass is constant

(d) the idea that linear momentum is the product of mass and velocity

(e) the concept that force is the rate of change of momentum, applying this in situations where mass is constant

(f) the principle of conservation of momentum and use it to solve problems in one dimension involving elastic collisions (where there is no loss of kinetic energy) and inelastic collisions (where there is a loss of kinetic energy)

SPECIFIED PRACTICAL WORK

- Investigation of Newton's 2nd law

4. ENERGY CONCEPTS

Overview

This topic covers the relationship between work, energy and power. It develops the conservation of energy, and the link between work and energy via the work-energy relationship.

Working Scientifically

This unit contains opportunities for learners to apply scientific knowledge to practical contexts.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include recognising and making use of appropriate units in calculations; using expressions in decimal and standard form; using ratios, fractions and percentages; using calculators to find and use power functions; solving algebraic equations.

How Science Works

There are opportunities within this topic for learners to use theories, models and ideas to develop scientific explanations; to analyse and interpret data to provide evidence, recognise correlations and causal relationships. Learners can apply the principle of conservation of energy to many different situations, including investigating data to be able to compare the efficiency of power stations and the comparison of the different methods of generating electrical power and evaluate their impact on the consumer.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the idea that work is the product of a force and distance moved in the direction of the force when the force is constant

(b) the calculation of the work done for constant forces, when the force is not along the line of motion (work done = $Fx\cos\theta$)

(c) the principle of conservation of energy including knowledge of gravitational potential energy $(mg\Delta h)$, elastic potential energy $(\frac{1}{2}kx^2)$ and kinetic energy $(\frac{1}{2}mv^2)$

(d) the work-energy relationship: $Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

(e) power being the rate of energy transfer

(f) dissipative forces for example, friction and drag cause energy to be transferred from a system and reduce the overall efficiency of the system

(g) the equation efficiency = $\frac{\text{useful energy transfer}}{\text{total energy input}} \times 100\%$

5. SOLIDS UNDER STRESS

Overview

This topic introduces the behaviour of different solids under stress and introduces the concepts of stress, strain and Young modulus. The work done deforming a solid is related to the strain energy stored. The behaviour under stress for metals, brittle materials and rubber are compared.

Working Scientifically

The specified practical work in this topic gives learners the opportunity to know and understand how to use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in this specification; to safely and correctly use a range of practical equipment and materials; to make and record observations; to present information and data in a scientific way; to use appropriate analogue apparatus to record a range of measurements of length and to interpolate between scale markings; to use callipers and micrometers, using digital or vernier scales.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include recognising and making use of appropriate units in calculations; using an appropriate number of significant figures; making order of magnitude calculations; identifying uncertainties in measurements and using simple techniques to determine uncertainty; translating information between graphical, numerical and algebraic forms; determining the slope and intercept of a linear graph; understanding the possible physical significance of the area between a curve and the x-axis and to be able to calculate it or estimate it by graphical means; calculating areas of triangles, circumferences and areas of circles and volumes of cylinders.

How Science Works

There are opportunities within this topic for learners to use theories, models and ideas to develop scientific explanations; to use appropriate methodology, including ICT to answer scientific questions and solve scientific problems; to communicate information and ideas in appropriate ways using appropriate terminology; to consider applications and implications of science and evaluate their associated benefits and risks. Learners can investigate the behaviour of different solids under stress, for example, metals, rubber, polythene and consider such practical applications as adding carbon to rubber tyres, pre-stressing concrete and the behaviour of building materials under compression and tension.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) Hooke's law and use $F = kx$ where the spring constant k is the force per unit extension

(b) the ideas that for materials the tensile stress, $\sigma = \frac{F}{A}$ and the tensile strain, $\varepsilon = \frac{\Delta l}{l}$ and the Young modulus, $E = \frac{\sigma}{\varepsilon}$ when Hooke's law applies

(c) the work done in deforming a solid being equal to the area under a force-extension graph, which is $\frac{1}{2}Fx$ if Hooke's law is obeyed

(d) the classification of solids as crystalline, amorphous (to include glasses and ceramics) and polymeric

(e) the features of a force-extension (or stress-strain) graph for a metal such as copper, to include
- elastic and plastic strain
- the effects of dislocations, and the strengthening of metals by introducing barriers to dislocation movement, such as foreign atoms, other dislocations, and more grain boundaries
- necking and ductile fracture

(f) the features of a force-extension (or stress-strain) graph for a brittle material such as glass, to include
- elastic strain and obeying Hooke's law up to fracture
- brittle fracture by crack propagation, the effect of surface imperfections on breaking stress, and how breaking stress can be increased by reducing surface imperfections (as in thin fibres) or by putting surface under compression (as in toughened glass or pre-stressed concrete)

(g) the features of a force-extension (or stress-strain) graph for rubber, to include
- Hooke's law only approximately obeyed, low Young modulus and the extension due to straightening of chain molecules against thermal opposition
- hysteresis

SPECIFIED PRACTICAL WORK

- Determination of Young modulus of a metal in the form of a wire
- Investigation of the force-extension relationship for rubber

6. USING RADIATION TO INVESTIGATE STARS

Overview

This topic studies the continuous emission and line absorption spectra of the Sun. It uses Wien's displacement law, Stefan's law, and the inverse square law to also investigate properties of stars, such as luminosity, size, temperature and distance.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include recognising and using expressions in decimal and standard form; estimating results; making order of magnitude calculations; solving algebraic equations, including quadratic equations; calculating surface areas of spheres.

How Science Works

There are opportunities within this topic for learners to use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas; to analyse and interpret data to provide evidence, recognising correlations and causal relationships; to know that scientific knowledge and understanding develops over time.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the idea that the stellar spectrum consists of a continuous emission spectrum, from the dense gas of the surface of the star, and a line absorption spectrum arising from the passage of the emitted electromagnetic radiation through the tenuous atmosphere of the star

(b) the idea that bodies which absorb all incident radiation are known as black bodies and that stars are very good approximations to black bodies

(c) the shape of the black body spectrum and that the peak wavelength is inversely proportional to the absolute temperature (defined by: T (K) = θ (°C) + 273.15)

(d) Wien's displacement law, Stefan's law and the inverse square law to investigate the properties of stars – luminosity, size, temperature and distance [N.B. stellar brightness in magnitudes will not be required]

(e) the meaning of multiwavelength astronomy and that by studying a region of space at different wavelengths (different photon energies) the different processes which took place there can be revealed

7. PARTICLES AND NUCLEAR STRUCTURE

Overview

This topic covers the idea that matter is composed of quarks and leptons. Learners study the quark composition of the neutron and the proton and the idea that quarks and antiquarks are never observed in isolation. The properties of the four interactions experienced by particles are discussed and learners are shown how to apply the conservation of charge, lepton number and quark number to given reactions.

Working Scientifically

There are opportunities within this topic for learners to present data in appropriate ways; to process and analyse using appropriate mathematical skills.

Mathematical Skills

There is an opportunity for learners to use ratios and fractions in this unit.

How Science Works

There are opportunities within this topic for learners to use theories, models and ideas to develop scientific explanations; to analyse and interpret data to provide evidence, recognise correlations and causal relationships; to evaluate methodology, evidence and data, and resolve conflicting evidence; to know that scientific knowledge and understanding develops over time; to evaluate the role of the scientific community in validating new knowledge and ensuring integrity.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the idea that matter is composed of quarks and leptons and that there are three generations of quarks and leptons, although no questions will be set involving second or third generations

	leptons		quarks	
particle (symbol)	electron (e^-)	electron neutrino (ν_e)	up (u)	down (d)
charge (e)	-1	0	$+\frac{2}{3}$	$-\frac{1}{3}$

(b) the idea that antiparticles exist for the particles given in the table above, that the properties of an antiparticle are identical to those of its corresponding particle apart from having opposite charge, and that particles and antiparticles annihilate

(c) symbols for a positron and for antiparticles of quarks and hadrons

(d) the idea that quarks and antiquarks are never observed in isolation, but are bound into composite particles called hadrons, or three types of baryon (combinations of 3 quarks), or antibaryons (combinations of 3 antiquarks) or mesons (quark-antiquark pairs)

(e) the quark compositions of the neutron and proton

(f) how to use data in the table **on page 16** to suggest the quark make-up of less well known first generation baryons and of charged pions

(g) the properties of the four forces or interactions experienced by particles as summarized in the table below

Interaction	Experienced by	Range	Comments
gravitational	all matter	infinite	very weak – negligible except between large objects such as planets
weak	all leptons, all quarks, so all hadrons	very short	only significant when the e-m and strong interactions do not operate
electromagnetic (e-m)	all charged particles	infinite	also experienced by neutral hadrons, as these are composed of quarks
strong	all quarks, so all hadrons	short	

(h) how to apply conservation of charge, lepton number and baryon number (or quark number) to given simple reactions

(i) the idea that neutrino involvement and quark flavour changes are exclusive to weak interactions

2.2 Component 2

ELECTRICITY AND LIGHT

Written examination: 1 hour 30 minutes
50% of qualification

This component covers the following areas of study:

1. Conduction of electricity
2. Resistance
3. D.C. circuits
4. The nature of waves
5. Wave properties
6. Refraction of light
7. Photons
8. Lasers

1. CONDUCTION OF ELECTRICITY

Overview

This topic covers the basic ideas of electric charge and electric current. The nature of charge carriers in conductors is explored.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include recognising and using expressions in decimal and standard form; using ratios, fractions and percentages; making order of magnitude calculations; calculating areas of circles, surface areas and volumes of rectangular blocks and cylinders.

How Science Works

There are opportunities within this topic for learners to use theories, models and ideas to develop scientific explanations.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the fact that the unit of charge is the coulomb (C), and that an electron's charge, e, is a very small fraction of a coulomb

(b) the fact that charge can flow through certain materials, called conductors

(c) electric current being the rate of flow of charge

(d) the use of the equation $I = \frac{\Delta Q}{\Delta t}$

(e) current being measured in ampères (A), where A = C s^{-1}

(f) the mechanism of conduction in metals as the drift of free electrons

(g) the derivation and use of the equation $I = nAve$ for free electrons

2. RESISTANCE

Overview

This topic covers the relationship between current and potential difference and develops the ideas of resistance and resistivity. The heating effect of an electric current is explored and the variation of resistance with temperature of metals is investigated.

Working Scientifically

The specified practical work in this topic gives learners the opportunity to apply investigative approaches and methods to practical work; to safely and correctly use a range of practical equipment and materials; to keep appropriate records of experimental activities; to correctly construct circuits from circuit diagrams using D.C. power supplies, cells and a range of circuit components.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include recognising and using expressions in decimal and standard form; estimating results; using calculators to find and use power functions; using an appropriate number of significant figures; finding arithmetic means; making order of magnitude calculations; changing the subject of an equation, including non-linear equations; translating information between graphical , numerical and algebraic forms; drawing and using the slope of a tangent to a curve as a measure of rate of change.

How Science Works

There are opportunities within this topic for learners to use theories, models and ideas to develop scientific explanations; to use appropriate methodology, including ICT to answer scientific questions and solve scientific problems; to know that scientific knowledge and understanding develops over time. Learners can carry out experimental and investigative activities, such as the comparison of the I-V characteristics of metal wires, filament lamps, LED lamps and diodes and use spreadsheets to analyse and evaluate their data. They can then make informed decisions on the use of energy saving devices in their homes.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the definition of potential difference

(b) the idea that potential difference is measured in volts (V) where V = J C^{-1}

(c) the characteristics of $I - V$ graphs for the filament of a lamp, and a metal wire at constant temperature

(d) Ohm's law, the equation $V = IR$ and the definition of resistance

(e) resistance being measured in ohms (Ω), where Ω = V A^{-1}

(f) the application of $P = IV = I^2R = \dfrac{V^2}{R}$

(g) collisions between free electrons and ions gives rise to electrical resistance, and electrical resistance increases with temperature

(h) the application of $R = \frac{\rho l}{A}$, the equation for resistivity

(i) the idea that the resistance of metals varies almost linearly with temperature over a wide range

(j) the idea that ordinarily, collisions between free electrons and ions in metals increase the random vibration energy of the ions, so the temperature of the metal increases

(k) what is meant by superconductivity, and superconducting transition temperature

(l) the fact that most metals show superconductivity, and have transition temperatures a few degrees above absolute zero (–273 °C)

(m) certain materials (high temperature superconductors) having transition temperatures above the boiling point of nitrogen (–196 °C)

(n) some uses of superconductors for example, MRI scanners and particle accelerators

SPECIFIED PRACTICAL WORK

- Investigation of the I-V characteristics of the filament of a lamp and a metal wire at constant temperature
- Determination of resistivity of a metal
- Investigation of the variation of resistance with temperature for a metal wire

3. D.C. CIRCUITS

Overview

This topic covers series and parallel electrical circuits including resistor combinations. The use of a potential divider in circuits is investigated. The terms electromotive force and the internal resistance of a source are introduced.

Working Scientifically

The specified practical work in this topic gives learners the opportunity to evaluate results and draw conclusions with reference to measurement uncertainties and errors; to present data in appropriate ways; to make and record observations; to keep appropriate records of experimental activities; to design, construct and check circuits using D.C. power supplies, cells and a range of circuit components.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include recognising and making use of appropriate units in calculations; using ratios, fractions and percentages; finding arithmetic means; identifying uncertainties in measurements and using simple techniques to determine uncertainty; solving algebraic equations, including quadratic equations; translating information between graphical, numerical and algebraic forms; understanding that $y = mx + c$ represents a linear relationship.

How Science Works

There are opportunities within this topic for learners to carry out experimental and investigative activities, including appropriate risk management: to analyse and interpret data to provide evidence, recognise correlations and causal relationships. Learners can investigate electrical circuits and use this experience to learn about the risk management issues involved when handling sources of power. The opportunity to design circuits and carry out fault finding techniques will enable them to evaluate their methodology and to resolve conflicting evidence.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the idea that the current from a source is equal to the sum of the currents in the separate branches of a parallel circuit, and that this is a consequence of conservation of charge

(b) the sum of the potential differences across components in a series circuit is equal to the potential difference across the supply, and that this is a consequence of conservation of energy

(c) potential differences across components in parallel are equal

(d) the application of equations for the combined resistance of resistors in series and parallel

(e) the use of a potential divider in circuits (including circuits which contain LDRs and thermistors)

(f) what is meant by the emf of a source

(g) the unit of emf is the volt (V), which is the same as that of potential difference

(h) the idea that sources have internal resistance and to use the equation $V = E - Ir$

(i) how to calculate current and potential difference in a circuit containing one cell or cells in series

SPECIFIED PRACTICAL WORK

- Determination of the internal resistance of a cell

4. THE NATURE OF WAVES

Overview

This topic covers the basic properties of transverse and longitudinal waves and the differences between them. It introduces the wave equation and gives learners the basic ideas and skills they need to study both electromagnetic and sound waves.

Working Scientifically

Questions set on this unit will assess learners' abilities to apply scientific knowledge to practical contexts; to present data in appropriate ways; to evaluate results and draw conclusions; to plot and interpret graphs. The specified practical work in this topic gives learners the opportunity to make and record observations; to keep appropriate records of experimental activities; to generate and measure waves using a microwave source.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include recognising and using expressions in decimal and standard form; finding arithmetic means; changing the subject of an equation, including non-linear equations.

How Science Works

There are opportunities within this topic for learners to carry out experimental and investigative activities, including appropriate risk management, in a range of contexts.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the idea that a progressive wave transfers energy without any transfer of matter

(b) the difference between transverse and longitudinal waves

(c) the term polarisation

(d) the terms in phase and in antiphase

(e) the terms displacement, amplitude, wavelength, frequency, period and velocity of a wave

(f) graphs of displacement against time, and displacement against position for transverse waves only

(g) the equation $c = f\lambda$

(h) the idea that all points on wavefronts oscillate in phase, and that wave propagation directions (rays) are at right angles to wavefronts

SPECIFIED PRACTICAL WORK

- Measurement of the intensity variations for polarisation

5. WAVE PROPERTIES

Overview

This topic introduces the wave properties of diffraction and interference. Investigation of two source interference patterns and the diffraction grating are carried out. The topic deals with coherent and incoherent sources and the conditions needed for two source interference to be observed. Stationary waves are introduced, and the differences between stationary and progressive waves investigated.

Working Scientifically

The specified practical work in this topic gives learners the opportunity to safely and correctly use a range of practical equipment and materials; to make and record observations; to present information and data in a scientific way; to use a wide range of experimental and practical instruments, equipment and techniques; to generate and measure waves, using a microphone and loudspeaker; to use a laser/light source to investigate interference/diffraction.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include recognising and using expressions in decimal and standard form; using calculators to handle $\sin x$, $\cos x$, $\tan x$ when x is expressed in degrees or radians; using an appropriate number of significant figures; making order of magnitude calculations; understanding and using the symbols: =, <, <<, >>, >, ∝, ≈, Δ; substituting numerical values into algebraic equations using appropriate units for physical quantities; plotting two variables from experimental or other data; using angles in regular 2D structures; visualising and representing 2D forms; using Pythagoras' theorem, and the angle sum of a triangle; using small angle approximations including $\sin\theta \approx \theta$, $\tan\theta \approx \theta$, $\cos\theta \approx 1$ for small θ where appropriate.

How Science Works

There are opportunities within this topic for learners to use appropriate methodology, including ICT to answer scientific questions and to solve scientific problems; to evaluate methodology, evidence and data, and resolve conflicting evidence; to know that scientific knowledge and understanding develops over time; to communicate information and ideas in appropriate ways using appropriate terminology. Learners can be given the opportunity to understand that scientific knowledge and understanding develops over time by considering the historical importance of Young's experiment and how it demonstrated the wave nature of light. Learners can be given the opportunity to carry out investigational activities to determine the wavelength of light using Young's double slits and a diffraction grating and evaluate the relative merits of both methods.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) diffraction occuring when waves encounter slits or obstacles

(b) the idea that there is little diffraction when λ is much smaller than the dimensions of the obstacle or slit

(c) the idea that if λ is equal to or greater than the width of a slit, waves spread as roughly semicircular wavefronts, but if λ is less than the slit width the main beam spreads through less than 180°

(d) how two source interference occurs

(e) the historical importance of Young's experiment

(f) the principle of superposition, giving appropriate sketch graphs

(g) the path difference rules for constructive and destructive interference between waves from in phase sources

(h) the use of $\lambda = \dfrac{a\Delta y}{D}$

(i) the derivation and use of $d \sin\theta = n\lambda$ for a diffraction grating

(j) the idea that for a diffraction grating a very small d makes beams ("orders") much further apart than in Young's experiment, and that the large number of slits makes the bright beams much sharper

(k) the idea that coherent sources are monochromatic with wavefronts continuous across the width of the beam and, (when comparing more than one source) with a constant phase relationship

(l) examples of coherent and incoherent sources

(m) the idea that for two source interference to be observed, the sources must have a zero or constant phase difference and have oscillations in the same direction

(n) the differences between stationary and progressive waves

(o) the idea that a stationary wave can be regarded as a superposition of two progressive waves of equal amplitude and frequency, travelling in opposite directions, and that the internodal distance is $\dfrac{\lambda}{2}$

SPECIFIED PRACTICAL WORK

- Determination of wavelength using Young's double slits
- Determination of wavelength using a diffraction grating
- Determination of the speed of sound using stationary waves

6. REFRACTION OF LIGHT

Overview

This topic covers refraction of light, and how Snell's law relates to the wave model of light propagation. The concept of total internal reflection is studied and its application to multimode optical fibres. This topic also looks at how the introduction of monomode optical fibres has allowed for greater transmission rates and distances.

Working Scientifically

The specified practical work for this topic gives learners the opportunity to make and record observations; to keep appropriate records of experimental activities; to use appropriate analogue and digital apparatus to record a range of measurements; to use laser or light sources to investigate refraction.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include recognising and making use of appropriate units in calculations; estimating results; using calculators to handle $\sin x$, $\cos x$, $\tan x$ when x is expressed in degrees or radians; using an appropriate number of significant figures; changing the subject of an equation, including non-linear equations; solving algebraic equations; translating information between graphical, numerical and algebraic form; determining the slope and intercept of a linear graph; using angles in regular 2D structures; using $\sin$, $\cos$ and $\tan$ in physical problems.

How Science Works

There are opportunities within this topic for learners to consider applications and implications of science and evaluate their associated risks. Learners can be given the opportunity to apply the concept of total internal reflection in optical fibres and use optical fibres to investigate the problem of multimode dispersion.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the refractive index, n, of a medium being defined as $\frac{c}{v}$, in which v is the speed of light in the medium and c is the speed of light in a vacuum

(b) the use of the equations: $n_1 v_1 = n_2 v_2$ and $n_1 \sin\theta_1 = n_2 \sin\theta_2$ (regarded as Snell's law)

(c) how Snell's law relates to the wave model of light propagation and for diagrams of plane waves approaching a plane boundary obliquely, and being refracted

(d) the conditions for total internal reflection

(e) the derivation and use of the equation for the critical angle $n_1 \sin\theta_C = n_2$

(f) how to apply the concept of total internal reflection to multimode optical fibres

(g) the problem of multimode dispersion with optical fibres in terms of limiting the rate of data transfer and transmission distance

(h) how the introduction of monomode optical fibres has allowed for much greater transmission rates and distances

SPECIFIED PRACTICAL WORK

- Measurement of the refractive index of a material

7. PHOTONS

Overview

This topic covers the properties of photons and the photoelectric effect. Learners study the electromagnetic spectrum and how to produce line emission and line absorption spectra from atoms. The wave-like behaviour of particles is studied using electron diffraction and de Broglie's relationship is applied to both particles of matter and to photons.

Working Scientifically

The specified practical work in this topic gives learners the opportunity to use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in this topic; to use appropriate digital instruments, including electrical multimeters, to obtain a range of measurements; to correctly construct circuits from circuit diagrams using D.C. power supplies, cells, and a range of circuit components, including those where polarity is important.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include recognising and using expressions in decimal and standard form; using an appropriate number of significant figures; understanding simple probability; making order of magnitude calculations; translating information between graphical, numerical and algebraic forms; plotting two variables from experimental or other data; determining the slope and the intercept of a linear graph.

How Science Works

There are opportunities within this topic for learners to use theories, models and ideas to develop scientific explanations; to use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas; to carry out experimental and investigative activities, including appropriate risk management, in a range of contexts; to analyse and interpret data to provide evidence, recognise correlations and causal relationships; to know that scientific knowledge and understanding develops over time. Learners can research the difficulties encountered by trying to use the wave theory of light to explain the photoelectric effect and how the photon model of light was developed. Learners can also investigate how the Planck constant can be determined using light emitting diodes.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the fact that light can be shown to consist of discrete packets (photons) of energy

(b) how the photoelectric effect can be demonstrated

(c) how a vacuum photocell can be used to measure the maximum kinetic energy, $E_{k\,\mathrm{max}}$, of emitted electrons in eV and hence in J

(d) the graph of $E_{k\,\mathrm{max}}$ against frequency of illuminating radiation

(e) how a photon picture of light leads to Einstein's equation, $E_{k\,\max} = hf - \phi$, and how this equation correlates with the graph of $E_{k\,\max}$ against frequency

(f) the fact that the visible spectrum runs approximately from 700 nm (red end) to 400 nm (violet end) and the orders of magnitude of the wavelengths of the other named regions of the electromagnetic spectrum

(g) typical photon energies for these radiations

(h) how to produce line emission and line absorption spectra from atoms

(i) the appearance of such spectra as seen in a diffraction grating

(j) simple atomic energy level diagrams, together with the photon hypothesis, line emission and line absorption spectra

(k) how to determine ionisation energies from an energy level diagram

(l) the demonstration of electron diffraction and that particles have a wave-like aspect

(m) the use of the relationship $p = \frac{h}{\lambda}$ for both particles of matter and photons

(n) the calculation of radiation pressure on a surface absorbing or reflecting photons

SPECIFIED PRACTICAL WORK

- Determination of h using LEDs

8. LASERS

Overview

This topic covers the process of stimulated emission and how this leads to coherent light emission. The structure of lasers is studied, including how a population inversion is attained. The advantages and disadvantages of different types of laser are compared.

Working Scientifically

Question set on this unit will assess learner's abilities to apply scientific knowledge to practical contexts; to process and analyse data using appropriate mathematical skills; to present data in appropriate ways.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this unit. These include; visualising and representing 2D and 3D forms including 2D representations of 3D objects.

How Science Works

There are opportunities within this topic for learners to communicate information and ideas in appropriate ways using appropriate terminology; to consider applications and implications of science and evaluate their associated benefits and risks.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the process of stimulated emission and how this process leads to light emission that is coherent

(b) the idea that a population inversion ($N_2 > N_1$) is necessary for a laser to operate

(c) the idea that a population inversion is not (usually) possible with a 2-level energy system

(d) how a population inversion is attained in 3 and 4-level energy systems

(e) the process of pumping and its purpose

(f) the structure of a typical laser i.e. an amplifying medium between two mirrors, one of which partially transmits light

(g) the advantages and uses of a semiconductor laser i.e. small, cheap, far more efficient than other types of laser, and it is used for CDs, DVDs, telecommunication etc

3 ASSESSMENT

3.1 Assessment objectives and weightings

Below are the assessment objectives for this specification. Learners must:

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

The table below shows the weighting of each assessment objective for each component and for the qualification as a whole.

	AO1	**AO2**	**AO3**
Component 1	17.5%	22.5%	10%
Component 2	17.5%	22.5%	10%
Overall weighting	35%	45%	20%

For each series:
- The weighting for the assessment of mathematical skills will be a minimum of 40%.
- The weighting for the indirect assessment of practical skills will be a minimum of 15%.

The ability to select, organise and communicate information and ideas coherently using appropriate scientific conventions and vocabulary will be tested across the assessment objectives.

4 TECHNICAL INFORMATION

4.1 Making entries

This is a linear qualification in which all assessments must be taken at the end of the course. Assessment opportunities will be available in the months of May and June each year, from 2016, until the end of the life of this specification.

A qualification may be taken more than once. Candidates must resit all examination components in the same series.

The entry code appears below.

WJEC Eduqas AS Physics: B420QS

The current edition of our *Entry Procedures and Coding Information* gives up-to-date entry procedures.

4.2 Grading, awarding and reporting

AS qualifications are reported as a grade on the scale from A to E. Results not attaining the minimum standard for the award will be reported as U (unclassified).

AS qualifications are free-standing and are awarded in their own right. Assessments at AS cannot contribute to an A level grade.

APPENDIX A

WORKING SCIENTIFICALLY

Practical skills identified for indirect assessment and developed through teaching and learning

Question papers will assess learners' abilities to:

Independent thinking

- solve problems set in practical contexts
- apply scientific knowledge to practical contexts

Use and application of scientific methods and practices

- comment on experimental design and evaluate scientific methods
- present data in appropriate ways
- evaluate results and draw conclusions with reference to measurement uncertainties and errors
- identify variables including those that must be controlled

Numeracy and the application of mathematical concepts in a practical context

- plot and interpret graphs
- process and analyse data using appropriate mathematical skills as exemplified in the mathematical appendix (see Appendix B)
- consider margins of error, accuracy and precision of data

Instruments and equipment

- know and understand how to use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in the specification

APPENDIX B

MATHEMATICAL REQUIREMENTS AND EXEMPLIFICATION

Mathematical skills	Exemplification of mathematical skill in the context of AS Physics (assessment is not limited to the examples given below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
Arithmetic and numerical computation		
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 for example, cm^3 to m^3	1.1(c) 1.2(c) 1.2(d) 1.3(f) 1.4(c) 2.3(i) 2.6(b) 2.7(c)
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(k) 1.6(d) 2.5(h) 1.2(g) 2.1(g) 2.7(m) 1.3(f) 2.2(h) 1.4(c) 2.4(g)
Use ratios, fractions and percentages	Learners may be tested on their ability to • calculate efficiency of devices • calculate percentage uncertainties in measurements	1.4(c) 2.1(g) 2.3(d)
Estimate results	Learners may be tested on their ability to • estimate the effect of changing experimental parameters on measurable values	1.6(c) 2.2(i) 2.2(m) 2.3(h) 2.6(d)

Use calculators to find and use power functions	Learners may be tested on their ability to • solve for unknowns when using the equations which represent uniformly accelerated motion in a straight line	1.4(d) 2.2(f)
Use calculators to handle $\sin x$, $\cos x$, $\tan x$ when x is expressed in degrees or radians	Learners may be tested on their ability to • calculate the direction of resultant vectors	1.1(e) 1.1(f) 1.1(j) 1.4(e) 2.5(i) 2.6(b)
Handling data		
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(i) 1.3(c) 1.5(b) 2.2(c) 2.2(h) 2.5(o) 2.6(a) 2.7(c)
Find arithmetic means	Learners may be tested on their ability to • calculate a mean value for repeated experimental readings	1.1(g) 1.2(a) 2.2(c) 2.3(h) 2.4(e)
Understand simple probability	Learners may be tested on their ability to • use the term probability appropriately	2.7(b)
Make order of magnitude calculations	Learners may be tested on their ability to • evaluate equations with variables expressed in different orders of magnitude	1.5(b) 1.6(d) 2.1(g) 2.2(h) 2.5(h) 2.7(e)

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(i) 1.5(b) 2.2(c) 2.3(i) 2.5(i) 2.6(a)
Algebra		
Understand and use the symbols: =, <, <<, >>, >, ∝, ≈, Δ	Learners may be tested on their ability to • recognise the significance of the symbols in the expression: $F \propto \frac{\Delta p}{\Delta t}$	1.1(c) 1.3(e) 1.5(b) 2.1(d) 2.5(h)
Change the subject of an equation, including non-linear equations	Learners may be tested on their ability to • rearrange $v = u + at$ to make a the subject	1.2(d) 1.3(c) 2.2(f) 2.4(g) 2.6(e)
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 $p = mv$	1.1(g) 1.2(g) 1.3(d) 1.4(c) 2.5(h) 2.6(b)
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 $s = ut + \frac{1}{2}at^2$	1.3(e) 1.4(d) 1.6(d) 2.3(h) 2.5(o) 2.6(b)
Graphs		
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	1.2(c) 1.5(c) 2.2(h) 2.3(h) 2.6(a) 2.7(d)

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	1.3(c) 1.5(g) 2.2(c) 2.5(h) 2.7(e)
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 a velocity-time graph in constant acceleration problems	1.2(c) 1.3(c) 1.5(a) 2.2(h) 2.3(h) 2.7(e)
Determine the slope and intercept of a linear graph	Learners may be tested on their ability to • read off and interpret the intercept point from a graph for example, the initial velocity in a velocity-time graph	1.2(b) 1.3(c) 1.5(b) 2.2(h) 2.3(h) 2.6(a) 2.7(d)
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	1.2(b) 1.3(c) 2.2(h) 2.6(a)
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	1.2(c) 2.2(c)
Distinguish between instantaneous rate of change and mean 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 mean velocity	1.2(c)
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 non-uniform acceleration the area under a velocity-time graph is equivalent to the displacement	1.5(c)

Apply the concepts underlying calculus (but without requiring the explicit use of derivatives or integrals) by solving equations involving rates of change, for example $\frac{\Delta x}{\Delta t} = -\lambda x$ using a graphical method or spreadsheet modelling	Learners may be tested on their ability to • determine g from a distance-time plot, projectile motion	1.2(e) 1.2(g)
Sketch relationships which are modelled by: $y = \frac{k}{x}$, $y = kx^2$, $y = \frac{k}{x^2}$, $y = kx$, $y = \sin x$, $y = \cos x$ as applied to physical relationships	Learners may be tested on their ability to • sketch relationships when appropriate	1.2(e) 2.2(c)
Geometry and trigonometry		
Use angles in regular 2D and 3D structures	Learners may be tested on their ability to • interpret force diagrams to solve problems	1.1(f) 2.6(d) 1.1(k) 1.4(b) 2.5(i) 2.6(b)
Visualise and represent 2D and 3D forms including 2D representations of 3D objects	Learners may be tested on their ability to • draw force diagrams to solve mechanics problems	1.1(j) 1.1(k) 1.4(c) 2.5(g) 2.6(f) 2.8(f)
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	1.1(g) 1.5(b) 1.6(d) 2.1(g) 2.2(h)

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	1.1(e) 1.1(k) 2.5(g) 2.6(b)
Use $\sin$, $\cos$ and $\tan$ in physical problems	Learners may be tested on their ability to • resolve forces into components	1.1(f) 2.5(i) 1.1(j) 2.6(e) 1.1(k) 1.4(b)
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	1.4(b) 2.5(i)
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	2.6(b)

APPENDIX C

HOW SCIENCE WORKS

How science works skill	Areas of the specification which exemplify the how science works skill (assessment is not limited to the examples below)
Use theories, models and ideas to develop scientific explanations	1.4(f) 1.5(e) 1.7(a) 2.1(f) 2.2(k) 2.7(m)
Use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas	1.6(e) 1.7(h) 2.2(n) 2.7(e)
Use appropriate methodology, including information and communication technology (ICT), to answer scientific questions and solve scientific problems	1.2(f) 1.5(b) 2.2(i) 2.5(f)
Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts	1.1(g) 1.1(i) 2.2(h) 2.3(c) 2.4(c) 2.5(o) 2.7(c)
Analyse and interpret data to provide evidence, recognising correlations and causal relationships	1.2(c) 1.4(d) 1.6(e) 1.7(a) 2.2(l) 2.3(h) 2.4(f) 2.7(j)
Evaluate methodology, evidence and data, and resolve conflicting evidence	1.7(a) 2.5(e) 2.7(m)
Know that scientific knowledge and understanding develops over time	1.6(a) – (e) 1.7(a) – (k) 2.2(k) – (n) 2.5(e) 2.7(e) 2.7(m)
Communicate information and ideas in appropriate ways using appropriate terminology	1.5(e) – (g) 2.2(j) 2.5(i) 2.7
Consider applications and implications of science and evaluate their associated benefits and risks	1.5(e) – (g) 2.6(f) 2.7(a) – (g)
Consider ethical issues in the treatment of humans, other organisms and the environment	1.4(f)
Evaluate the role of the scientific community in validating new knowledge and ensuring integrity	1.7 2.2(e)(f) 2.7(m)
Evaluate the ways in which society uses science to inform decision making	2.2(n)