GCSE

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Part of WJEC

WJEC Eduqas GCSE in

PHYSICS

ACCREDITED BY OFQUAL

SPECIFICATION

Teaching from 2016
For award from 2018

Version 3 January 2019

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This Ofqual regulated qualification is not available for candidates in maintained schools and colleges in Wales.

SUMMARY OF AMENDMENTS

Version	Description	Page number
2	Section 4.1 amended to show the last assessment opportunity for this qualification.	40
3	'Making entries' section has been amended to clarify resit rules.	40

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WJEC Eduqas GCSE (9-1) in PHYSICS

For teaching from 2016
For award from 2018

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GCSE PHYSICS

SUMMARY OF ASSESSMENT

Component 1: Concepts in Physics
Written examination: 2 hours 15 minutes
75% of qualification

A mix of short answer questions, structured questions, extended writing and data response questions, with some set in a practical context

Component 2: Applications in Physics
Written examination: 1 hour 15 minutes
25% of qualification

Section A (FT) / Section B (HT):
A mix of short answer questions, structured questions, extended writing and data response questions, all set in a practical context

Section B (FT) / Section A (HT):
A resource booklet containing an unseen article will provide the basis for a mix of short answer questions, structured questions and data response questions

This linear qualification will be available in May/June each year. It will be awarded for the first time in summer 2018.

Learners entered for this qualification must sit both components at either foundation or higher tier, in the same examination series.

Qualification Accreditation Number: 601/8624/0

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GCSE PHYSICS

1 INTRODUCTION

1.1 Aims and objectives

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

Studying this GCSE in Physics provides the foundations for understanding the material world. Scientific understanding is changing our lives and is vital to the world's future prosperity, and all learners should be taught essential aspects of the knowledge, methods, processes and uses of science. They should be helped to appreciate how the complex and diverse phenomena of the natural world can be described in terms of a small number of key ideas relating to the sciences which are both inter-linked, and are of universal application. These key ideas include:

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

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 scientific principles which will allow them to enjoy a positive learning experience. Practical work is an intrinsic part of science. It is imperative that practical skills are developed throughout this course and that an investigatory approach is promoted.

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1.2 Prior learning and progression

There are no previous learning requirements for this specification. Any requirements set for entry to a course based on this specification are at the school/college's discretion.

This specification builds on subject content which is typically taught at key stage 3 and provides a suitable foundation for the study of Physics at either AS or A level and Level 3 Science qualifications. 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.

1.3 Equality and fair access

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.

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2 SUBJECT CONTENT

This section outlines the knowledge, understanding and skills to be developed by learners studying GCSE 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 GCSE specifications. In practice, this means that learners will be required to draw together different areas of knowledge, skills 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 science. The practical skills developed are also fundamentally important to learners going on to further study in science 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 skills listed in Appendix A. Appendix B lists the practical technique requirements with exemplification in the context of GCSE Physics.

Appendix C lists the mathematical skills that will be assessed. Appendix D provides information on the mathematical equations required. For the foundation tier, the mathematics will be assessed at levels not lower than expected at KS3. For the higher tier, the mathematics will be assessed at levels not lower than that for foundation tier GCSE Mathematics.

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

- develop scientific knowledge and conceptual understanding through the specific discipline of physics
- develop understanding of the nature, processes and methods of science, through different types of scientific enquiries that help them to answer scientific questions about the world around them
- develop and learn to apply observational, practical, modelling, enquiry and problem-solving skills, both in the laboratory, in the field and in other learning environments
- develop their ability to evaluate claims based on science through critical analysis of the methodology, evidence and conclusions, both qualitatively and quantitatively.

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The specification content is organised in topics. Each topic contains the following:

- An **overview** which sums up the content of each topic.
- **Working scientifically** - this section summarises how ‘working scientifically’ may be developed in the topic. The ‘working scientifically’ section forms part of the assessable content. All of the 'working scientifically' skills listed in Appendix A are referred to at least once in one of these sections.
- **Maths skills** - a summary of mathematical skills that should be developed in each topic. The mathematical statements in this section are part of the assessable content. All of the 'mathematical skills' in Appendix B are referred to at least once in one of these sections.
- **Content statements** - ‘Learner’s should be able to …’ These statements clarify the breadth and depth of the content for each topic. In some cases these statements may be grouped into subtopics.
- **Specified practical work -** 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 skills listed in Appendix A. Appendix B lists the practical technique requirements with exemplification in the context of GCSE Physics. Practical work forms part of the assessable content.

Some areas of the content have been selected for assessment at higher tier only. This content is shown in **bold type**. All content may therefore be examined at higher tier but that in bold will not be examined on foundation tier papers.

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2.1 Component 1

CONCEPTS IN PHYSICS

Written examination: 2 hours 15 minutes
75% of qualification
120 marks

Learners should be helped to understand how, through the ideas of physics, the complex and diverse phenomena of the natural world can be described in terms of a small number of key ideas which are of universal application and which can be illustrated in the separate topics covered in this component. These key ideas (which are assessable) include:

- the use of models, as in the particle model of matter or the wave models of light and of sound
- the concept of cause and effect in explaining such links as those between force and acceleration, or between changes in atomic nuclei and radioactive emissions
- the phenomena of 'action at a distance' and the related concept of the field as the key to analysing electrical, magnetic and gravitational effects
- that differences, for example between pressures or temperatures or electrical potentials, are the drivers of change
- that proportionality, for example between weight and mass of an object or between force and extension in a spring, is an important aspect of many models in science
- that physical laws and models are expressed in mathematical form.

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TOPICS

1. Energy

1.1 Energy changes in a system, and in the ways energy is stored before and after such changes
1.2 Conservation, dissipation and national and global energy sources
1.3 Energy transfers

2. Particle model of matter

3. Forces

3.1 Forces and their interactions
3.2 Pressure and pressure differences in fluids
3.3 Moments, levers and gears

4. Forces and motion

4.1 Speed and velocity, speed as distance over time; acceleration; distance-time and velocity-time graphs
4.2 Forces, accelerations and Newton's laws of motion
4.3 Safety in public transport

5. Waves in matter

5.1 Waves in air, fluids and solids
5.2 Waves at material interfaces: applications in exploring structures

6. Light and electromagnetic waves

6.1 Frequency range of the spectrum
6.2 Interactions of electromagnetic radiation with matter and their applications
6.3 Lenses
6.4 Colour and frequency; differential effects in transmission, absorption and diffuse reflection
6.5 Black body radiation (qualitative only)

7. Electricity

7.1 Current, potential difference and resistance
7.2 Series and parallel circuits
7.3 Static electricity – forces and electric fields
7.4 Domestic uses and safety

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8. Magnetism and electromagnetism

- 8.1 Permanent and induced magnetism, magnetic forces and fields
- 8.2 Magnetic effects of currents and the motor effect
- 8.3 Induced potential and transformers
- 8.4 Microphones and speakers; oscillating currents in detection and generation of radiation

9. Atomic structure

- 9.1 Nuclear atom and isotopes
- 9.2 Absorption and emission of ionising radiations and of electrons and nuclear particles
- 9.3 Hazards and uses of radioactive emissions and of background radiation
- 9.4 Nuclear fission and fusion

10. Space physics

- 10.1 Solar system; stability of orbital motions, satellites
- 10.2 Red shift as sources move away; the 'Big Bang' and universal expansion

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1. ENERGY

Overview

This topic explores the relationships between work, energy and power. It develops the conservation of energy and the link between work and energy. It investigates energy changes in a system and the different ways in which energy is stored before and after such changes.

Working scientifically

This topic contains opportunities for learners to apply scientific knowledge to practical contexts. It gives learners the opportunity to understand how to use a range of experimental and practical instruments with due consideration for safety. It presents the opportunity for learners to apply the cycle of collecting, presenting and analysing data and presenting observations and other data using appropriate methods. There are opportunities within this topic for learners to carry out experimental activities in a range of topics. Learners can be helped to understand how, through the ideas of physics, physical laws and models are expressed in mathematical form. Learners can apply the conservation of energy to many different situations, including investigating data to be able to compare the efficiency of power stations and explain why transmitting energy from power stations at high voltage is an efficient way of transferring energy.

Mathematical skills

There are a number of opportunities for the development of mathematical skills in this topic. These include performing calculations using compatible units for energy transfers associated with energy changes in a system; recalling or selecting and applying the relevant equations for mechanical, electrical and thermal processes; expressing in quantitative form the overall redistribution of energy within a system e.g. Sankey diagrams; applying the relationship between the change in internal energy of a material and its mass, specific heat capacity and temperature change to calculate the energy change involved; applying the relationship between specific latent heat and mass to calculate the energy change involved in a change of state. These topics afford learners the opportunity to recognise and use expressions in decimal form; to recognize expressions in standard form; to use ratios, fractions and percentages; to change the subject of an equation; to substitute numerical values into algebraic equations using appropriate units for physical quantities and to solve simple algebraic equations.

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1.1 ENERGY CHANGES IN A SYSTEM, AND IN THE WAYS ENERGY IS STORED BEFORE AND AFTER SUCH CHANGES

Learners should be able to:

(a) describe all the changes involved in the way energy is stored when a system changes, for common situations: e.g. an object projected upwards or up a slope, a moving object hitting an obstacle, an object being accelerated by a constant force, a vehicle slowing down, bringing water to a boil in an electric kettle, a change of state

(b) describe how heating a system will change the energy stored within the system and raise its temperature or produce changes of state

(c) define the terms specific heat capacity and specific latent heat

(d) calculate the amounts of energy associated with:

- a moving body (kinetic energy = 0.5 × mass × (velocity)^2 $[E_k = \frac{1}{2}mv^2]$
- a stretched spring (energy transferred in stretching = 0.5 × spring constant × (extension)^2 $[E = \frac{1}{2}kx^2]$
- object raised above ground level (potential energy = mass × gravitational field strength × height $[E_p = mgh]$

(e) calculate the change in energy involved when a system is changed by heating (in terms of temperature change, specific heat capacity $[\Delta Q = mc\Delta\theta]$ and specific latent heat $[Q = mL]$)

(f) calculate the change in energy involved by work done by forces: work done = force × distance (along the line of action of the force) $[W = Fx]$

(g) calculate the change in energy involved by work done when a current flows

- energy transferred = power × time
- energy transferred = charge flow × potential difference $[E = QV]$

(h) explain the definition of power as the rate at which energy is transferred e.g. lifting an object, calculate values for power using $\text{power} = \frac{\text{work done}}{\text{time}}$ and describe the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use e.g. in a kettle how the power is related to the increase in internal energy of the water

SPECIFIED PRACTICAL WORK

- SP1.1 Determination of the specific heat capacity of a material

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1.2 CONSERVATION, DISSIPATION AND NATIONAL AND GLOBAL ENERGY SOURCES

Learners should be able to:

(a) describe how in all system changes, energy is dissipated, so that it is stored in less useful ways

(b) describe where there are energy transfers in a system, that there is no net change to the total energy of a closed system e.g. mass oscillating on a spring

(c) explain ways of reducing unwanted energy transfer e.g. through lubrication, thermal insulation; describe the effects, on the rate of cooling of a building, of thickness and thermal conductivity of its walls (qualitative only)

(d) describe the processes of heat transfer by conduction, convection and radiation including the role of free electrons in thermal conduction in metals

(e) calculate energy efficiency for any energy transfer using:

$$\text{efficiency} = \frac{\text{output energy transfer}}{\text{input energy transfer}}$$

and describe ways to increase efficiency

(f) describe the main energy sources available for use on Earth (e.g. fossil fuels, nuclear fuel, bio-fuel, wind, hydro-electricity, the tides and the Sun), compare the ways in which they are used and distinguish between renewable and non-renewable sources

(g) explain patterns and trends in the use of energy resources

1.3 ENERGY TRANSFERS

Learners should be able to:

(a) recall that, in the National Grid, electrical power is transferred at high voltages from power stations, and then transferred at lower voltages in each locality for domestic use, and explain how this system is an efficient way to transfer energy

(b) describe how, in different domestic devices, energy is transferred from batteries and the a.c. mains to the energy of motors or of heating devices

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2. PARTICLE MODEL OF MATTER

Overview

This topic studies the differences between the three states of matter in terms of the arrangements of the atoms/molecules. Learners will use this knowledge to explain how gases behave under different conditions of temperature and pressure.

Working scientifically

There are opportunities within this topic for learners to use models, as in the particle model of matter to develop the idea that differences between pressure and temperature are the drivers of change. There are also opportunities for learners to use scientific knowledge and understanding to pose scientific questions and present scientific arguments and ideas. There are opportunities within this topic for learners to use theories, models and ideas to develop scientific explanations. For example, the use of the particle model of matter to explain the different properties and behaviour of solids, liquids and gases. There are also opportunities within this topic for learners to carry out experimental activities, using appropriate risk management.

Mathematical skills

There are a number of opportunities for the development of mathematical skills in this topic. These include applying the relationship between density, mass and volume to changes where mass is conserved; applying the relationship between pressure and volume for a fixed mass of gas at constant temperature. These topics afford learners the opportunity to recognize and use expressions in decimal form; to recognize expressions in standard form; to use ratios, fractions and percentages; to change the subject of an equation and to substitute numerical values into algebraic equations using appropriate units for physical quantities.

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Learners should be able to:

(a) define density (i.e. $\text{density} = \frac{\text{mass}}{\text{volume}}$) and explain the differences in density between the three states of matter in terms of the arrangements of the atoms or molecules

(b) describe how, when substances melt, freeze, evaporate, condense or sublimate, mass is conserved, but that these physical changes differ from chemical changes because the substance recovers its original properties if the change is reversed

(c) explain how the motion of the molecules in a gas is related both to its temperature and its pressure: hence explain the relationship between the temperature of a gas and its pressure at constant volume (qualitative only)

(d) recall that gases can be compressed or expanded by pressure changes and that the pressure produces a net force at right angles to any surface

(e) explain how increasing the volume in which a gas is contained, at constant temperature can lead to a decrease in pressure

(f) use and apply the relationship for gases: pressure × volume = constant (for a given mass of gas at a constant temperature) [pV = constant]

(g) explain how doing work on a gas can increase its temperature (e.g. bicycle pump)

SPECIFIED PRACTICAL WORK

- SP2A Determination of the density of solids and liquids
- SP2B Investigation of the variation of the volume of a gas with temperature

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3. FORCES

Overview

This topic covers the concept of force and free body diagrams. It investigates the way in which pairs of objects interact and how such ways involve forces acting on each object. The topic investigates how forces can be applied to stretch, bend or compress an object and the difference between elastic and inelastic distortions.

Working scientifically

The specified practical work in this topic gives learners the opportunity to know and understand a range of techniques, practical instruments and equipment appropriate to the knowledge and understanding included in the syllabus; to safely and correctly use practical equipment and materials; to make and record observations; to present information and data in a scientific way. There are opportunities within this topic for learners to use theories, models and ideas to develop scientific explanations. For example, the use of a simple model of the Earth's atmosphere and the concept of pressure to explain why atmospheric pressure varies with height above the surface. Learners can be helped to understand the phenomenon of 'action at a distance' and the related concept of the field, as the key to analysing gravitational, electrical and magnetic effects. Learners can investigate the elastic and inelastic behaviour of a spring by carrying out experimental and investigative activities, including appropriate risk management.

Mathematical skills

There are a number of opportunities for the development of mathematical skills in this topic. These include **using vector diagrams to illustrate the resolution of forces, a net force and equilibrium situations (scale drawings will be required);** calculating relevant values of stored energy and energy transfers; converting between newton-metres and joules; **calculating the pressure differences at different depths in a fluid.** These topics afford learners the opportunity to use ratios, fractions and percentages; to substitute numerical values into algebraic equations using appropriate units for physical quantities; to translate information between graphical and numeric form; to use angular measures in degrees and to visualize and represent 2D and 3D forms, including two dimensional representation of 3D objects.

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3.1 FORCES AND THEIR INTERACTIONS

Learners should be able to:

(a) recall examples of ways in which pairs of objects interact by:
- gravity
- electrostatics
- magnetism and
- contact (including normal contact force and friction)

and describe how such examples involve forces on each object using vector notation

(b) define weight as the gravitational force acting on an object, describe how it is measured and describe the relationship between the weight of that body and the gravitational field strength (weight = mass × gravitational field strength [$W = mg$])

(c) describe examples of the forces acting on an isolated solid object or system; describe, using free body diagrams, examples where several forces lead to a resultant force on an object and the special case of balanced forces when the resultant force is zero: resolve a force into components at right angles

(d) explain that to stretch, bend or compress an object, more than one force has to be applied e.g. a stretched elastic band

(e) describe the difference between elastic and inelastic distortions caused by stretching forces; calculate the work done in stretching; describe the relationship between force and extension for a spring (force = spring constant × extension [$F = kx$]) and other simple systems; describe the difference between linear and non-linear relationships between force and extension, and calculate a spring constant in linear cases

(f) use the relationship between work done, force, and distance moved (along the line of action of the force) i.e. work done = force × distance (along the line of action of the force) [$W = Fx$] and describe the energy transfer involved

SPECIFIED PRACTICAL WORK

- SP3.1 Investigation of the force-extension graph for a spring

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3.2 PRESSURE AND PRESSURE DIFFERENCES IN FLUIDS

Learners should be able to:

(a) recall that the pressure in fluids causes a force normal to any surface, and use the relationship between the force, the pressure, and the area in contact (i.e. $\text{pressure} = \dfrac{\text{force normal to a surface}}{\text{area of that surface}}$)

(b) describe a simple model of the Earth's atmosphere and of atmospheric pressure, and explain why atmospheric pressure varies with height above the surface

(c) explain why pressure in a liquid varies with depth and density and how this leads to an upwards force on a partially submerged object; describe the factors which influence floating and sinking

(d) use and apply the relationship: pressure due to a column of liquid = height of column × density of liquid × gravitational field strength [$p = h\rho g$]

3.3 MOMENTS, LEVERS AND GEARS

Learners should be able to:

(a) describe examples in which forces cause rotation; define and calculate the moment of the force in such examples (moment = force × distance (normal to the direction of the force) [$M = Fd$])

(b) explain how levers and gears transmit the rotational effects of forces

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4. FORCES AND MOTION

Overview

This topic covers rectilinear motion and also looks at circular motion from a qualitative perspective. Learners study accelerated motion in a straight line, the effects of forces upon objects and the concept of momentum and its conservation.

Working scientifically

The specified practical work in this topic gives learners the opportunity to use apparatus to record a range of measurements; to use stopwatches or light gates for timing; to use analogue apparatus to record a range of measurements. Learners have the opportunity to follow written instructions, to make and record observations, keep appropriate records and present information and data in a scientific way. There are opportunities within this topic for learners to use appropriate methodology, including ICT to answer scientific questions and solve scientific problems. Learners can carry out experimental and investigative activities using stopwatches, light gates and data loggers to measure the acceleration of a moving body, to investigate factors affecting stopping distances and to measure the speed of a moving body. Learners can apply these factors to explain the factors which affect the braking distances of moving vehicles and the attendant safety considerations and to explain the dangers caused by large decelerations.

Mathematical skills

There are a number of opportunities for the development of mathematical skills in this topic. These include making calculations using ratios and proportional reasoning to convert units and compute rates; relating changes and differences in motion to appropriate distance-time and velocity-time graphs and interpreting lines and slopes in such graphs; **interpreting enclosed areas in velocity-time graphs**; applying formulae relating distance, time and speed, for uniform motion, and for motion with uniform acceleration, and calculating mean speed for non-uniform motion; estimating how the distances required for road vehicles to stop in an emergency varies over a range of typical speeds; applying formulae relating force, mass and relevant physical constants, including gravitational field strength, to explore how changes in these are inter-related; applying formulae relating force, mass, velocity and acceleration to explain how the changes involved are inter-related; estimating, for every day road transport, the speed, acceleration and forces. These topics afford learners the opportunity to use expressions in decimal form; use ratios, fractions and percentages; make estimates of the results of simple calculations, without using a calculator; construct and interpret frequency tables and diagrams, bar charts and histograms; make order of magnitude calculations; change the subject of an equation; substitute numerical values into algebraic equations using appropriate units for physical quantities; solve simple algebraic equations; translate information between graphical and numeric form; understand that $y = mx + c$ represents a linear relationship; plot two variables from experimental or other data; determine the slope and intercept of a linear graph; understand the physical significance of area between a curve and the x-axis and measure it by counting squares as appropriate.

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4.1 SPEED AND VELOCITY, SPEED AS DISTANCE OVER TIME; ACCELERATION; DISTANCE-TIME AND VELOCITY-TIME GRAPHS

Learners should be able to:

(a) explain the vector-scalar distinction as it applies to displacement / distance and velocity / speed

(b) recall typical speeds encountered in everyday experience for wind and sound, and for walking, running, cycling and other transportation systems; recall the acceleration in free fall on Earth (10 m/s^2) and estimate the magnitudes of everyday accelerations

(c) explain with examples that motion in a circular orbit involves a constant speed but changing velocity (qualitative responses only)

(d) recall and apply the relationships:

- distance travelled = speed × time
- $\text{acceleration} = \dfrac{\text{change in velocity}}{\text{time}}$ $\left[a = \dfrac{\Delta v}{t}\right]$

(e) use motion graphs to describe and determine the speed, acceleration and distance travelled

(f) apply the following equations to situations of uniform acceleration only

- final velocity = initial velocity + acceleration × time [$v = u + at$]
- distance = ½ (initial velocity + final velocity) × time [$x = \frac{1}{2}(u + v)t$]
- (final velocity)^2 = (initial velocity)^2 + 2 × acceleration × distance [$v^2 = u^2 + 2ax$]
- **distance = initial velocity × time + ½ × acceleration × time^2 [$x = ut + \frac{1}{2}at^2$]**

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4.2 FORCES, ACCELERATIONS AND NEWTON'S LAWS OF MOTION

Learners should be able to:

(a) recall Newton's First Law and apply it to explain the motion of objects moving with uniform velocity and also objects where the speed and/or direction change

(b) recall Newton's Second Law and apply it in calculations relating forces, masses and accelerations: resultant force = mass × acceleration [$F = ma$]

(c) explain that inertial mass is a measure of how difficult it is to change the velocity of an object and that it is defined as the ratio of force over acceleration

(d) recall and apply Newton's Third Law

(e) define momentum (i.e. momentum = mass × velocity [$p = mv$]), state the principle of conservation of momentum and apply it to one dimensional interactions

SPECIFIED PRACTICAL WORK

- SP4.2 Determination of the acceleration of a moving object

4.3 SAFETY IN PUBLIC TRANSPORT

Learners should be able to:

(a) explain methods of measuring human reaction times and its effect on thinking distances and recall values of typical reaction times

(b) explain the factors which affect the braking distance required for road transport vehicles to come to rest in emergencies and the implications for safety

(c) explain the dangers caused by large decelerations **and estimate the forces involved in everyday situations on a road e.g. vehicle braking to a halt**

(d) apply the principles of forces, motion and energy to an analysis of safety features of cars e.g. air bags and crumple zones

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5. WAVES IN MATTER

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 fundamental ideas and skills they need to study both electromagnetic and sound waves.

Working scientifically

Questions set on this topic will assess learners' abilities to apply scientific knowledge to practical contexts; to present data in appropriate ways; to evaluate results and draw conclusions. The specified practical work in this topic gives learners the opportunity to make and record observations; to keep appropriate records of experimental activities; to apply the cycle of collecting, presenting and analysing data. There are opportunities within this topic for learners to carry out experimental and investigative activities, including appropriate risk management, in a range of contexts.

Mathematical skills

There are a number of opportunities for the development of mathematical skills in this topic. These include applying formulae relating velocity, frequency and wavelength; showing how changes in velocity, frequency and wavelength in transmission of sound waves from one medium to another, are inter-related. These topics afford learners the opportunity to use ratios, fractions and percentages; substitute numerical values into algebraic equations using appropriate units for physical quantities.

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5.1 WAVES IN AIR, FLUIDS AND SOLIDS

Learners should be able to:

(a) describe wave motion in terms of amplitude, wavelength, frequency and period i.e. $\text{period} = \frac{1}{\text{frequency}}$ $\left[T = \frac{1}{f}\right]$; define wavelength and frequency and describe and apply the relationship between these and the wave velocity (wave speed = frequency × wavelength [$v = f\lambda$])

(b) describe the difference between transverse and longitudinal waves

(c) describe how ripples on water surfaces are examples of transverse waves whilst sound waves in air are longitudinal waves; describe evidence that in both cases it is the wave and not the water or air itself that travels

(d) recall that sound requires a medium for transmission

SPECIFIED PRACTICAL WORK

- SP5.1 Investigation of water waves

5.2 WAVES AT MATERIAL INTERFACES: APPLICATIONS IN EXPLORING STRUCTURES

Learners should be able to:

(a) describe the effects of reflection, transmission, and absorption of waves at material interfaces

(b) describe, with examples, processes which convert wave disturbances between sound waves and vibrations in solids, and explain why such processes only work over a limited frequency range, and the relevance of this to human audition; key structures in the human auditory system involved in these processes (i.e. outer ear, ear drum, chain of tiny bones in the middle ear (names not required), the membrane wall of cochlea, the cochlea, auditory nerve)

(c) explain, in qualitative terms, how the differences in velocity, absorption and reflection of ultrasound allow it to be used for detection and exploration purposes in both bodies and in deep water

(d) explain, in qualitative terms, how the differences in velocity, absorption and reflection between P and S waves in solids and liquids can be used both for detection and for the exploration of structures beneath the surface of the Earth

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6. LIGHT AND ELECTROMAGNETIC WAVES

Overview

This topic covers the properties of electromagnetic waves. Learners study the electromagnetic spectrum and the interactions of electromagnetic radiation with matter; the relationship between colour and frequency and the relationship between the temperature of a body and the intensity and wavelength of the radiation emitted. The effect of convex and concave lenses.

Working scientifically

Questions set on this topic will assess learners' abilities to explain every day and technological applications of science; to process and analyse data using appropriate mathematical skills; to present data in appropriate ways. 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 refraction to study the effect of convex and concave lenses on light and to investigate how the appearance of a coloured object changes when viewed under different coloured lights.

Mathematical skills

There are a number of opportunities for the development of mathematical skills in this topic. These include applying the relationships between frequency and wavelength across the electromagnetic spectrum; constructing two-dimensional ray diagrams to illustrate reflection and refraction (qualitatively only). These topics afford learners the opportunity to recognise and use expressions in decimal form; recognise expressions in standard form; use ratios, fractions and percentages; substitute numerical values into algebraic equations using appropriate units for physical quantities; use angular measure in degrees; visualize and represent 2D and 3D forms including two dimensional representations of 3D objects.

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6.1 FREQUENCY RANGE OF THE SPECTRUM

Learners should be able to:

(a) recall that light is an electromagnetic wave

(b) recall that electromagnetic waves are transverse, are transmitted through space where all have the same velocity, and explain, with examples, that they transfer energy from a source to an absorber

(c) describe the main groupings of the spectrum – radio, microwave, infra-red, visible (red to violet), ultraviolet, X-rays and gamma rays, that these range from long to short wavelengths and from low to high frequencies, and that our eyes can only detect a limited range

6.2 INTERACTIONS OF ELECTROMAGNETIC RADIATION WITH MATTER AND THEIR APPLICATIONS

Learners should be able to:

(a) recall that radio waves can be produced by or can themselves induce oscillations in electrical circuits

(b) recall that the generation and absorption of radiations over a wide frequency range are associated with changes in atoms and nuclei

(c) give examples of some practical uses of electromagnetic waves in the radio, microwave, infra-red, visible, ultraviolet, X-ray and gamma ray regions and describe how ultraviolet waves, X-rays and gamma rays can have hazardous effects, notably on human bodily tissues

(d) recall that different substances may absorb, transmit, refract, or reflect electromagnetic waves in ways that vary with wavelength; explain how some effects are related to differences in the velocity of the waves in different substances

(e) use ray diagrams to illustrate reflection and refraction at plane surfaces

SPECIFIED PRACTICAL WORK

- SP6.2 Investigation of refraction in a glass block

6.3 LENSES

Learners should be able to:

(a) use ray diagrams to illustrate the effects of convex and concave lenses on light (qualitative only)

(b) construct ray diagrams for convex and concave lenses to determine the image position, size, nature (real or virtual) and orientation, given the focal length, object distance and object size

SPECIFIED PRACTICAL WORK

- SP6.3 Investigation of the images in convex and concave lenses

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6.4 COLOUR AND FREQUENCY; DIFFERENTIAL EFFECTS IN TRANSMISSION, ABSORPTION AND DIFFUSE REFLECTION

Learners should be able to:

(a) explain how colour is related to differential absorption, transmission, specular reflection and scattering e.g. how the appearance of a coloured object changes when viewed under different colour lights or viewed through colour filters

6.5 BLACK BODY RADIATION (QUALITATIVE ONLY)

Learners should be able to:

(a) explain that all bodies emit radiation and that the intensity and wavelength distribution of any emission depends on their temperatures

(b) explain how the temperature of a body is related to the balance between incoming radiation absorbed and radiation emitted; illustrate this balance using everyday examples of the factors which determine the temperature of the earth

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7. ELECTRICITY

Overview

This topic covers the basic ideas of electric charge and electric current. It explores the relationship between current and potential difference and develops the idea of resistance. The phenomenon of static electricity is introduced in terms of transfer of electrons between objects.

Working scientifically

The specified practical work within 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 DC power supplies, cells and a range of circuit components. There are opportunities within this topic for learners to use theories, models and ideas to develop scientific explanations. Learners can carry out experimental and investigative activities, such as the design and use of circuits to explore the variation of resistance in devices such as lamps, diodes, thermistors and LDRs. They can then make informed decisions on the use of energy saving devices in their homes. Learners can investigate electrical circuits and use this experience to learn about the risk management issues involved when handling sources of power and the safety aspects involved in the domestic use of electricity.

Mathematical skills

There are a number of opportunities for the development of mathematical skills in this topic. These include applying the equations relating potential difference, quantity of charge, resistance, power, energy and time to solve problems for circuits which include components in series, using the concept of equivalent resistance; using graphs to explore whether circuit elements are linear or non-linear and relate the curves produced to their function and properties. These topics afford learners the opportunity to use ratios, fractions and percentages; change the subject of an equation; substitute numerical values into algebraic equations using appropriate units for physical quantities; solve simple algebraic equations; plot two variables from experimental or other data; determine the slope and intercept of a linear graph; draw and use the slope of a tangent to a curve as a measure of rate of change.

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7.1 CURRENT, POTENTIAL DIFFERENCE AND RESISTANCE

Learners should be able to:

(a) recall that current is the rate of flow of charge, that for charge to flow, a source of potential difference and a closed circuit are needed and that a current has the same value at any point in a single closed loop

(b) recall and use the relationship between quantity of charge, current and time (charge flow = current × time [$Q = It$])

(c) recall that current (I) depends on both resistance (R) and potential difference (V) and the units in which these are measured

(d) recall and apply the relationship between I, R and V, and know that for some components the value of R remains constant but for lamps it changes as the current changes (potential difference = current × resistance [$V = IR$])

(e) explain how the power transfer in any circuit device is related to the p.d. across it and the current, and to the energy changes over a given time:
- power = potential difference × current = (current)^2 × resistance [$P = IV = I^2R$]
- power $= \dfrac{\text{energy transferred}}{\text{time}}$ and
- energy transferred = charge flow × potential difference [$E = QV$]

(f) explain the design and use of circuits to explore the variation of resistance – including for lamps, diodes, ntc thermistors and LDRs

SPECIFIED PRACTICAL WORK

- SP7.1 Investigation of the current – voltage (I-V) characteristics of a component

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7.2 SERIES AND PARALLEL CIRCUITS

Learners should be able to:

(a) describe the differences between series and parallel circuits, including the properties of currents and potential differences

(b) explain why, if two resistors are in series the net resistance is increased, and calculate the net resistance of two resistors in series

(c) explain why, if two resistors are in parallel the net resistance is decreased **and calculate the net resistance of two resistors in parallel**

(d) calculate the currents, potential differences and total resistance in d.c. series circuits, and explain the design and use of such circuits for measurement and testing purposes; represent them with the conventions of positive and negative terminals, and the symbols that represent common circuit elements, including diodes, LDRs and thermistors

SPECIFIED PRACTICAL WORK

- SP7.2 Investigation of the characteristics of series and parallel circuits

7.3 STATIC ELECTRICITY – FORCES AND ELECTRIC FIELDS

Learners should be able to:

(a) describe the production of static electricity, and sparking, by rubbing surfaces, and evidence that charged objects exert forces of attraction or repulsion on one another when not in contact

(b) explain how the transfer of electrons between objects can explain the phenomena of static electricity

(c) explain the concept of an electric field and how it helps to explain the phenomena of static electricity

(d) describe the effect of points on a charged conductor

7.4 DOMESTIC USES AND SAFETY

Learners should be able to:

(a) recall that the domestic supply in the UK is a.c. at 50 Hz and 230 V, explain the difference between direct and alternating voltage

(b) recall the differences in function between the live, neutral and earth mains wires, and the potential differences between these wires; hence explain that a live wire may be dangerous even when a switch in a mains circuit is open, and explain the dangers of providing any connection between the live wire and earth

(c) explain the function of a fuse and from calculations select an appropriate rating for a particular appliance

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8. MAGNETISM AND ELECTROMAGNETISM

Overview

This topic covers the concept of magnetic fields and investigates the forces on current carrying conductors in magnetic fields. It also explores the production of induced potential differences produced by changing magnetic fields and how this effect is used in alternators, dynamos and transformers.

Working scientifically

The specified practical work in this topic gives learners the opportunity to investigate the magnetic fields of magnets, coils and wires; to make and record observations; to keep appropriate records of experimental activities. 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 can consider the applications and implications of science and the associated benefits to society by studying the changing flux through a coil rotating in a magnetic field. They can consider how the invention of devices such as the a.c. generator has benefitted society.

Mathematical skills

There are a number of opportunities for the development of mathematical skills in this topic. These include **applying the equations linking the potential differences and numbers of turns in the two coils of a transformer to the currents and power transfers involved, and relating these to the advantages of power transmission at high voltages.** Learners are afforded the opportunity to use ratios, fractions and percentages; change the subject of an equation; substitute numeric values into algebraic equations using appropriate units for physical quantities.

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8.1 PERMANENT AND INDUCED MAGNETISM, MAGNETIC FORCES AND FIELDS

Learners should be able to:

(a) describe the attraction and repulsion between unlike and like poles for permanent magnets and describe the difference between permanent and induced magnets

(b) describe the characteristics of the magnetic field of a bar magnet, showing how strength and direction change from one point to another

(c) explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic

8.2 MAGNETIC EFFECTS OF CURRENTS AND THE MOTOR EFFECT

Learners should be able to:

(a) describe how to show that an electric current can create a magnetic effect and draw the magnetic fields due to currents in a straight conducting wire, a plane coil and a solenoid, including the relationship between the directions of the current and field

(b) recall that the strength of the field depends on the current and the distance from the conductor, and explain how solenoid arrangements can enhance the magnetic effect

(c) describe how a magnet and a current-carrying conductor exert a force on one another and apply Fleming's left-hand rule to the relative orientations of the force, the current in the conductor and the magnetic field

(d) apply the equation that links the force on a conductor to the strength of the field, the current and the length of conductor to calculate the forces involved i.e. force on a conductor (at right angles to a magnetic field) carrying a current = magnetic field strength × current × length [$F = BIl$]

(e) explain how this force is used to cause rotation in electric motors

SPECIFIED PRACTICAL WORK

- SP8.2 Investigation of the force due to the magnetic field of coils

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8.3 INDUCED POTENTIAL AND TRANSFORMERS

Learners should be able to:

(a) **recall that a change in the magnetic field through a coil can give rise to an induced potential difference across its ends which could drive a current, generating a magnetic field that would oppose the original change**

(b) **explain how this effect is used in an alternator to generate a.c. and in a dynamo to generate d.c., and describe how changes to the coil, magnetic field and rate of rotation affect the output potential difference**

(c) **explain how the effect of an alternating current in one circuit in inducing a current in another is used in transformers and how the ratio of the p.d.'s across the two depends on the ratio of the numbers of turns in each:**

$$\frac{\text{potential difference across primary coil}}{\text{potential difference across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$$

$$\left[\frac{V_1}{V_2} = \frac{N_1}{N_2}\right]$$

(d) use the relationship:
potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil $[V_1I_1 = V_2I_2]$

SPECIFIED PRACTICAL WORK

- **SP8.3 Investigation of the output of an iron-cored transformer**

8.4 MICROPHONES AND SPEAKERS; OSCILLATING CURRENTS IN DETECTION AND GENERATION OF RADIATION

Learners should be able to:

(a) **explain the action of the microphone in converting the pressure variations in sound waves into variations in current in electrical circuits and the reverse effect as used in loudspeakers and headphones**

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9. ATOMIC STRUCTURE

Overview

This topic covers the structure of the nuclear atom and its representation using atomic notation. It covers the spontaneous nature of nuclear decay and the nature of alpha, beta and gamma radiation. It introduces the concept of half-life and the random nature of radioactive decay. The physics of fission and fusion is explored, and the idea that in these processes, some of the mass may be converted into energy.

Working scientifically

There are opportunities within this topic for learners to plot and interpret graphs; to process and analyse data using mathematical skills. There are opportunities within this topic for learners to use appropriate methodology to answer scientific questions and to solve scientific problems. Learners have the opportunity to evaluate methodology, evidence and data and resolve conflicting evidence to consider ethical issues in the treatment of humans and the environment, to evaluate the ways in which society uses science to inform decision making.

Mathematical skills

There are a number of opportunities for the development of mathematical skills in this topic. These include balancing equations representing alpha, beta or gamma decay in terms of the mass number and atomic number, and charges of the atoms involved; calculating the net decline, expressed as a ratio, in a radioactive emission after a given number of half-lives. These topics afford learners the opportunity to recognise expressions in standard form; use ratios, fractions and percentages; substitute numerical values into algebraic equations using appropriate units for physical quantities; solve simple algebraic equations.

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9.1 NUCLEAR ATOM AND ISOTOPES

Learners should be able to:

(a) describe how the model of the atom has changed over time i.e. plum pudding and Bohr models

(b) describe the atom as a positively charged nucleus surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atom and with almost all of the mass in the nucleus

(c) recall the typical size (order of magnitude) of nuclei, atoms and small molecules

(d) recall that atomic nuclei are composed of both protons and neutrons, that the nucleus of each element has a characteristic positive charge, but that atoms of the same element can differ in nuclear mass by having different numbers of neutrons

(e) use atomic notation (i.e. $^{A}_{Z}\mathrm{X}$) to relate differences between isotopes of the same and different elements to their charges and masses

9.2 ABSORPTION AND EMISSION OF IONISING RADIATIONS AND OF ELECTRONS AND NUCLEAR PARTICLES

Learners should be able to:

(a) recall that in each atom its electrons are arranged at different distances from the nucleus, that such arrangements may change with absorption or emission of electromagnetic radiation and that atoms can become ions by loss of outer electrons

(b) recall that some nuclei are unstable and may emit alpha particles, beta particles, or neutrons, and electromagnetic radiation as gamma rays; relate these emissions to possible changes in the mass or the charge of the nucleus, or both

(c) use names and symbols of common nuclei and particles to write balanced equations that represent radioactive decay

(d) explain the concept of half-life and how this is related to the random nature of radioactive decay

(e) calculate the net decline in radioactive emission as a ratio by using the half-life

(f) recall the differences in the penetration properties of alpha particles, beta particles and gamma rays

(g) recall the differences between contamination and irradiation effects and compare the hazards associated with these two effects

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9.3 HAZARDS AND USES OF RADIOACTIVE EMISSIONS AND OF BACKGROUND RADIATION

Learners should be able to:

(a) explain why the hazards associated with radioactive material differ according to the half-life involved

(b) describe the different uses of nuclear radiations for exploration of internal organs, and for control or destruction of unwanted body tissue

9.4 NUCLEAR FISSION AND FUSION

Learners should be able to:

(a) recall that some nuclei are unstable and may split and relate such effects to radiation which might emerge, to transfer of energy to other particles and to the possibility of chain reactions

(b) recall that nuclear fission reactions result in the release of energy and explain why nuclear fission reactors need to control the chain reaction (details of control mechanisms not required)

(c) describe the process of nuclear fusion and recall that in this process some of the mass may be converted into the energy of radiation

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10. SPACE PHYSICS

Overview

This topic covers the main features of our solar system and the circular orbits of planets, their moons and artificial satellites. It explores the evidence which leads to the concept of an expanding universe and links this evidence to the Big Bang model.

Working scientifically

There are opportunities within this topic for learners to understand how scientific methods and theories develop over time. There are opportunities within this topic for learners to use theories, models and ideas to develop scientific questions, to define scientific problems, to present scientific arguments and ideas; to know that scientific knowledge and understanding develops over time and to communicate information and ideas in appropriate ways using appropriate terminology. Learners can be given the opportunity to understand how scientific knowledge and understanding developed over time and how the Big Bang theory developed until its acceptance.

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10.1 SOLAR SYSTEM; STABILITY OF ORBITAL MOTIONS; SATELLITES

Learners should be able to:

(a) recall the main features of our solar system, in terms of their order, size, orbits and composition to include the Sun, terrestrial and gaseous planets, minor planets, comets and asteroids

(b) recall the similarities and differences between planets, their moons and artificial satellites

(c) explain for circular orbits how the force of gravity can lead to changing velocity of an orbiting body but unchanging speed, and explain qualitatively how the orbital speed depends upon the radius of the orbit and the mass of the central object

(d) recall that our Sun was formed from dust and gas drawn together by gravity and explain how this caused fusion reactions, leading to equilibrium between gravitational collapse and expansion due to the fusion energy

10.2 RED SHIFT AS SOURCES MOVE AWAY; THE 'BIG BANG' AND UNIVERSAL EXPANSION

Learners should be able to:

(a) explain the red shift of light from galaxies which are receding (qualitative only), that the change with distance of each galaxy's speed is evidence of an expanding universe and hence explain the link between this evidence and the Big Bang model

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2.2 Component 2

APPLICATIONS IN PHYSICS

Written examination: 1 hour 15 minutes
25% of qualification
60 marks

This component will assess the skills of learners in the context of the content of Component 1.

The assessment of this component will comprise two sections.

Section A Foundation Tier / Section B Higher Tier (45 marks)
This will contain a mix of short answer questions, structured questions, extended writing and data response questions, all set in a practical context. Some of the questions will be based on specified practical work whilst others will be set in a novel context.

Section B Foundation Tier / Section A Higher Tier (15 marks)
A resource booklet containing an unseen article will provide the basis for a mix of short answer questions, structured questions and data response questions.

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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
- scientific techniques and procedures

AO2
Apply knowledge and understanding of:
- scientific ideas
- scientific enquiry, techniques and procedures

AO3
Analyse information and ideas to:
- interpret and evaluate
- make judgements and draw conclusions
- develop and improve experimental 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	30%	30%	15%
Component 2	10%	10%	5%
Overall weighting	**40%**	**40%**	**20%**

For each series:
- The weighting for the assessment of mathematical skills will be a minimum of 30%
- The weighting for the assessment of practical skills will be a minimum of 15%

Learners will be expected to provide extended responses which are of sufficient length to allow them to demonstrate their ability to construct and develop a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.

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3.2 Arrangements for practical work

The assessment of practical skills is a compulsory requirement of the course of study for GCSE Physics qualifications.

The content 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 skills listed in Appendix A.

In addition, by completing the specified practical work learners will experience each of the practical techniques listed in Appendix B which are a requirement of the qualification. Centres must also ensure that learners keep their own records of the practical work that they undertake.

When completing any practical work safety is of paramount concern. It is the responsibility of each centre to ensure that appropriate safety procedures are followed whenever their learners' complete practical work. Risk assessments are required for all practical work whether it takes place in the laboratory or out in the field.

For each assessment series each centre is required to submit a practical science statement (see Appendix E) to WJEC. The statement is confirmation from a centre that it has taken reasonable steps to ensure that each learner entered for that particular assessment series has completed the practical work listed in the specification. Also the centre has made a record of the specified practical work that each learner has undertaken and the knowledge, skills and understanding that the learner has derived from the completion of the practical work. The practical science statement must be submitted to WJEC for learners in a particular cohort before the awarding of their GCSE. This will be on a date published by WJEC and will fall before the end of May.

If a centre fails to submit a practical science statement to WJEC for an assessment series then it will be treated as a case of malpractice and/or maladministration.

Centres must have systems in place that enable them to ensure that private learners have completed the required specified practical work. It will be the responsibility of the centre entering private learners to validate that these learners have covered the full range of practical requirements described in the specification.

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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. Candidates entered for this qualification must sit both components at either foundation or higher tier, in the same examination series. Assessment opportunities will be available in May/June each year, until summer 2020, with a resit opportunity in summer 2021.

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

The entry codes appear below.

WJEC Eduqas GCSE Physics (Foundation tier):	C420PF
WJEC Eduqas GCSE Physics (Higher tier)	C420PH

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

4.2 Grading, awarding and reporting

GCSE qualifications are reported on a nine point scale from 1 to 9, where 9 is the highest grade. Results not attaining the minimum standard for the award will be reported as U (unclassified).

A candidate who takes higher tier assessments will be awarded a grade within the range of 4 to 9, or be unclassified. However, if the mark achieved by such a learner is a small number of marks below the 4/3 grade boundary that learner may be awarded a grade 3.

A candidate who takes foundation tier assessments will be awarded a grade within the range of 1 to 5, or be unclassified.

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APPENDIX A

Working scientifically

1. Development of scientific thinking

- understand how scientific methods and theories develop over time
- use a variety of models such as representational, spatial, descriptive, computational and mathematical to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts
- appreciate the power and limitations of science and consider any ethical issues which may arise
- explain every day and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments
- evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequences
- recognise the importance of peer review of results and of communicating results to a range of audiences.

2. Experimental skills and strategies

- use scientific theories and explanations to develop hypotheses
- plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena
- apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment
- carry out experiments appropriately having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations
- recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative
- make and record observations and measurements using a range of apparatus and methods
- evaluate methods and suggest possible improvements and further investigations.

3. Analysis and evaluation

- apply the cycle of collecting, presenting and analysing data, including:
  - presenting observations and other data using appropriate methods
  - translating data from one form to another
  - carrying out and represent mathematical and statistical analysis
  - representing distributions of results and make estimations of uncertainty
  - interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions
  - presenting reasoned explanations including relating data to hypotheses
  - being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error
  - communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions through paper-based and electronic reports and presentations using verbal, diagrammatic, graphical, numerical and symbolic forms.

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

- use scientific vocabulary, terminology and definitions
- recognise the importance of scientific quantities and understand how they are determined
- use SI units (e.g. kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate
- use prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano)
- interconvert units
- use an appropriate number of significant figures in calculation.

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APPENDIX B

Practical requirements and exemplification

All learners are expected to have carried out the **specified practical activities**. These develop skills in the use of the following apparatus and techniques.
The apparatus and techniques listed as 1–7 below are common with GCSE Combined Science. Statement 8 is for GCSE Physics only.

code	Practical technique
P1	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, volume and temperature. Use of such measurements to determine densities of solid and liquid objects.
P2	Use of appropriate apparatus to measure and observe the effects of forces including the extension of springs
P3	Use of appropriate apparatus and techniques for measuring motion, including determination of speed and rate of change of speed (acceleration/deceleration)
P4	Making observations of waves in fluids and solids to identify the suitability of apparatus to measure speed/frequency/wavelength. Making observations of the effects of the interaction of electromagnetic waves with matter.
P5	Safe use of appropriate apparatus in a range of contexts to measure energy changes/transfers and associated values such as work done
P6	Use of appropriate apparatus to measure current, potential difference (voltage) and resistance, and to explore the characteristics of a variety of circuit elements
P7	Use of circuit diagrams to construct and check series and parallel circuits including a variety of common circuit elements
P8	Making observations of waves in fluids and solids to identify the suitability of apparatus to measure the effects of the interaction of waves with matter.

The list on the following page cross references the specified practical work against the apparatus and skills listed above. These include opportunities for choice and use of appropriate laboratory apparatus for a variety of experimental problem-solving and/or enquiry based activities.

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

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

Specified practical work	Specification topic	Technique code
SP1.1 Determination of the specific heat capacity of a material	1.1	P1, P5
SP2A Determination of the density of solids and liquids	2	P1
SP2B Investigation of the variation of the volume of a gas with temperature	2	P1, P2
SP3.1 Investigation of the force-extension graph for a spring	3.1	P2
SP4.2 Determination of the acceleration of a moving object	4.2	P1, P3
SP5.1 Investigation of water waves	5.1	P4, P8
SP6.2 Investigation of refraction in a glass block	6.2	P4/P8
SP6.3 Investigation of the images in convex and concave lenses	6.3	P4
SP7.1 Investigation of the current – voltage (I-V) characteristics of a component	7.1	P6, P7
SP7.2 Investigation of the characteristics of series and parallel circuits	7.2	P7, P7
SP8.2 Investigation of the force due to the magnetic field of coils	8.2	P2
SP8.3 Investigation of the output of an iron-cored transformer	**8.3**	P6

Learners are expected to cover the **full** range of practical techniques using the specified practical work. WJEC will publish teacher/technician guidance sheets and learner worksheets for all the specified practical work which centres may use with their learners.. These will ensure that all the techniques referred to in the above table are met. Centres may substitute the exemplar specified practical for another one of comparable standard. In such cases the same techniques cross referenced in the above **must** also be covered by the substituted practical. Learners **must** also be familiar with the same set of skills in this practical as required by the exemplar practical.

Centres should also note that WJEC will:

- review the specified practical work which it has set following any revision by the Secretary of State of the apparatus and/or techniques specified in respect of the qualification
- revise the specified practical work which it has set if appropriate
- promptly publish an amended specification if it makes any revision to the practical work.

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APPENDIX C

Mathematical skills

This table shows the mathematical skills which can be assessed.

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

Please note. Only mathematical skills required for GCSE Physics are shown in the table above.

APPENDIX D

Equations in physics

Equations required for higher tier only are in **bold.**

(a) In solving quantitative problems, learners should be able correctly to recall, and apply the following relationships:

- resultant force = mass × acceleration [$F = ma$]
- kinetic energy = 0.5 × mass × (velocity)^2 [$E_k = \frac{1}{2}mv^2$]
- **momentum = mass × velocity [$p = mv$]**
- work done = force × distance (along the line of action of the force) [$W = Fx$]
- power $= \dfrac{\text{work done}}{\text{time}}$
- efficiency $= \dfrac{\text{output energy transfer}}{\text{input energy transfer}}$
- weight = mass × gravitational field strength [$W = mg$]
- potential energy = mass × gravitational field strength × height [$E_p = mgh$]
- force = spring constant × extension [$F = kx$]
- moment = force × distance (normal to the direction of the force) [$M = Fd$]
- distance travelled = speed × time
- acceleration $= \dfrac{\text{change in velocity}}{\text{time}}$ $\left[a = \dfrac{\Delta v}{t}\right]$
- period $= \dfrac{1}{\text{frequency}}$ $\left[T = \dfrac{1}{f}\right]$
- wave speed = frequency × wavelength [$v = f\lambda$]
- charge flow = current × time [$Q = It$]
- potential difference = current × resistance [$V = IR$]
- power = potential difference × current = (current)^2 × resistance [$P = IV = I^2R$]
- energy transferred = power × time
- energy transferred = charge flow × potential difference [$E = QV$]
- density $= \dfrac{\text{mass}}{\text{volume}}$
- pressure $= \dfrac{\text{force normal to a surface}}{\text{area of that surface}}$

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(b) In addition, learners should be able correctly to select from a list and apply the following relationships:

- final velocity = initial velocity + acceleration × time [$v = u + at$]
- distance = ½ (initial velocity + final velocity) × time [$x = \frac{1}{2}(u + v)t$]
- (final velocity)^2 = (initial velocity)^2 + 2 × acceleration × distance [$v^2 = u^2 + 2ax$]
- **distance = initial velocity × time + ½ × acceleration × time^2 [$x = ut + \frac{1}{2}at^2$]**
- change in thermal energy = mass × specific heat capacity × change in temperature [$\Delta Q = mc\Delta\theta$]
- thermal energy for a change of state = mass × specific latent heat [$Q = mL$]
- energy transferred in stretching = 0.5 × spring constant × (extension)^2 [$E = \frac{1}{2}kx^2$]
- **force on a conductor (at right angles to a magnetic field) carrying a current = magnetic field strength × current × length [$F = BIl$]**
- potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil [$V_1I_1 = V_2I_2$]
- $$\frac{\textbf{potential difference across primary coil}}{\textbf{potential difference across secondary coil}} = \frac{\textbf{number of turns in primary coil}}{\textbf{number of turns in secondary coil}}$$
  $$\left[\frac{V_1}{V_2} = \frac{N_1}{N_2}\right]$$
- for gases: pressure × volume = constant (for a given mass of gas at a constant temperature) [pV = constant]
- **pressure due to a column of liquid = height of column × density of liquid × gravitational field strength [$p = h\rho g$]**

APPENDIX E

Practical science statement

Practical Science Statement
GCSE Physics

Centre Name ....

Centre Number ....

Declaration by head of centre
I confirm that: 1. *This centre has taken reasonable steps to ensure that each learner entered for assessment in this summer series has completed the specified practical work listed in the specification and they have kept a record of their work;* 2. *This centre has made a record of the specified practical work that each learner has undertaken and the knowledge, skills and understanding that the learner has derived from the completion of the practical work.* ***Head of centre's name**:* .... ***Head of centre's signature**:* ....   *Date* ....

Summer 20....

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