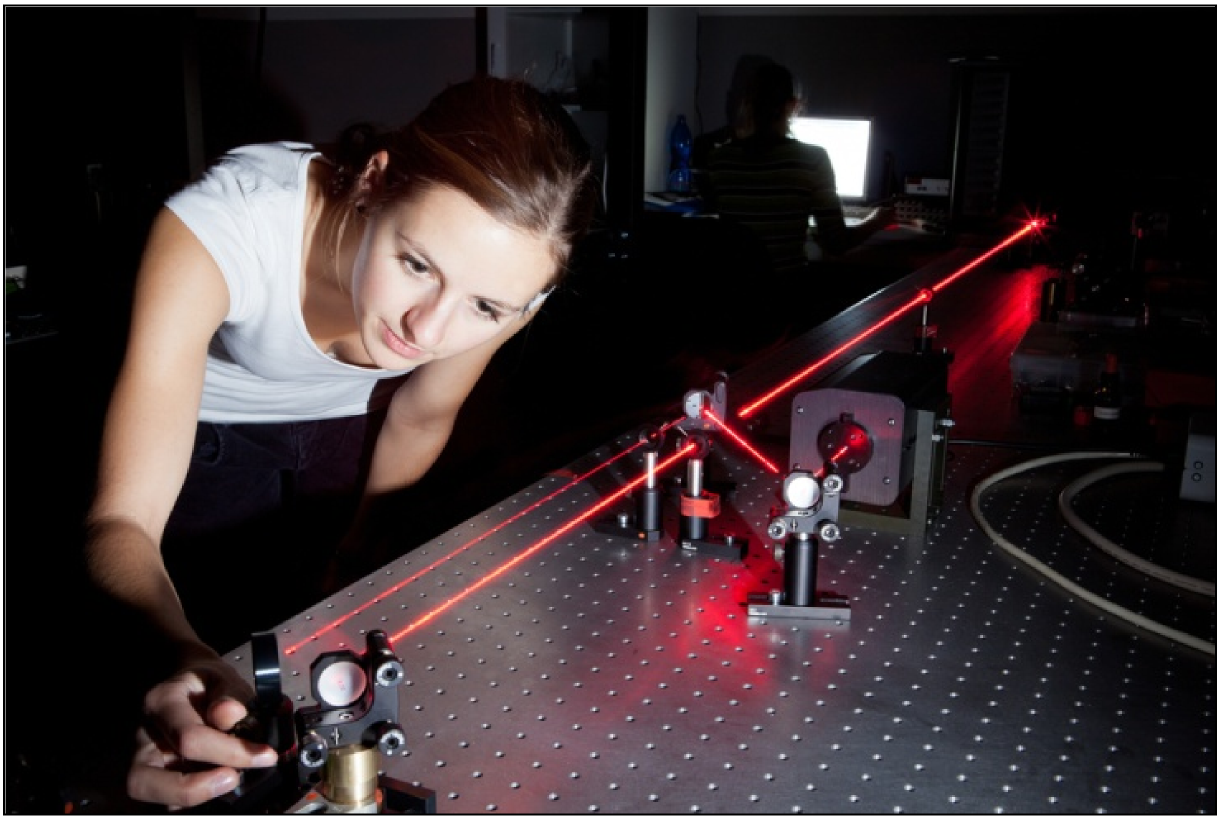
Course Support Notes

Higher Physics Course Support Notes



Please refer to the note of changes at the end of this document for details of changes from previous version (where applicable).

Contents

Introduction

These support notes are not mandatory. They provide advice and guidance on approaches to delivering and assessing the Higher Physics Course. They are intended for teachers and lecturers who are delivering the Course and its Units. They should be read in conjunction with the *Course Specification*, the *Course Assessment Specification* and the *Unit Specifications* for the Units in the Course.

General guidance on the Course

Aims

As stated in the *Course Specification*, the aims of the Course are to enable learners to:

- develop and apply knowledge and understanding of physics
- develop an understanding of the role of physics in scientific issues and relevant applications of physics, including the impact these could make in society and the environment
- develop scientific inquiry and investigative skills
- develop scientific analytical thinking skills, including scientific evaluation, in a physics context
- develop the use of technology, equipment and materials, safely, in practical scientific activities.
- develop planning skills
- develop problem solving skills in a physics context
- use and understand scientific literacy to communicate ideas and issues and to make scientifically informed choices
- develop the knowledge and skills for more advanced learning in physics
- develop skills of independent working

Progression into this Course

Entry to this Course is at the discretion of the centre. However, learners would normally be expected to have attained some relevant skills and knowledge through prior experience.

Skills and knowledge developed through any of the following, while **not mandatory,** are likely to be helpful as a basis for further learning in this Course.

- National 5 Physics Course or relevant component Units

More detail is contained in the Physics Progression Framework.
The Physics Progression framework shows the development of the key areas throughout the suite of Courses

Skills, knowledge and understanding covered in the Course

Note: teachers and lecturers should refer to the *Course Assessment Specification* for mandatory information about the skills, knowledge and understanding to be covered in this Course.

Progression from this Course

This Course or its components may provide progression for the learner to:

- Advanced Higher Physics
- further study, employment and/or training

Hierarchies

Hierarchy is the term used to describe Courses and Units which form a structured sequence involving two or more SCQF levels.

It is important that any content in a Course and/or Unit at one particular SCQF level is not repeated if a learner progresses to the next level of the hierarchy. The skills and knowledge should be able to be applied to new content and contexts to enrich the learning experience. This is for centres to manage.

- Physics Courses from National 3 to Advanced Higher are hierarchical.
- Courses from National 3 to National 5 have Units with the same structure and titles.

Approaches to learning and teaching

The purpose of this section is to provide you with advice and guidance on learning and teaching. It is essential that you are familiar with the mandatory information within the Higher Physics *Course Assessment Specification*.

Teaching should involve an appropriate range of approaches to develop knowledge and understanding and skills for learning, life and work. This can be integrated into a related sequence of activities, centred on an idea, theme or application of physics, based on appropriate contexts, and need not be restricted to the Unit structure. Learning should be experiential, active, challenging and enjoyable, and include appropriate practical experiments/activities and could be learner-led. The use of a variety of active learning approaches is encouraged, including peer teaching and assessment, individual and group presentations, role-playing and game-based learning, with learner-generated questions.

When developing your Physics Course there should be opportunities for learners to take responsibility for their learning. Learning and teaching should build on learners' prior knowledge, skills and experiences. The Units and the key areas identified within them may be approached in any appropriate sequence, at the centre's discretion. The distribution of time between the various Units is a matter for professional judgement and is entirely at the discretion the centre. Each Unit is likely to require an approximately equal time allocation, although this may depend on the learners' prior learning in the different key areas.

Learning and teaching, within a class, can be organised, in a flexible way, to allow a range of learners' needs to be met, including learners achieving at different levels. The hierarchical nature of the new Physics qualifications provides improved continuity between the levels. Centres can, therefore, organise learning and teaching strategies in ways appropriate for their learners.

Within a class, there may be learners capable of achieving at a higher level in some aspects of the Course. Where possible, they should be given the opportunity to do so. There may also be learners who are struggling to achieve in all aspects of the Course, and may only achieve at the lower level in some areas.

Teachers/lecturers need to consider the Course and Unit Specifications, and Course Assessment Specifications to identify the differences between Course levels. It may also be useful to refer to the Physics Progression Framework.

When delivering this Course to a group of learners, with some working towards different levels, it may be useful for teachers to identify activities covering common concepts and skills for all learners, and additional activities required for some learners. In some aspects of the Course, the difference between levels is defined in terms of a higher level of skill.

An investigatory approach is encouraged in Physics, with learners actively involved in developing their skills, knowledge and understanding by investigating a range of relevant physics applications and issues. A holistic approach should be adopted to encourage simultaneous development of learners' conceptual understanding and skills.

Where appropriate, investigative work/experiments, in Physics, should allow learners the opportunity to select activities and/or carry out extended study. Investigative and experimental work is part of the scientific method of working and can fulfil a number of educational purposes.

All learning and teaching should offer opportunities for learners to work collaboratively. Practical activities and investigative work can offer opportunities for group work, which should be encouraged. Group work approaches can be used within Units and across Courses where it is helpful to simulate real life situations, share tasks and promote team working skills. However, there must be clear evidence for each learner to show that the learner has met the required assessment standards for the Unit or Course.

Laboratory work should include the use of technology and equipment that reflects current scientific use in physics.

Learners would be expected to contribute their own time in addition to programmed learning time.

Effective partnership working can enhance the science experience. Where possible, locally relevant contexts should be studied, with visits where this is possible. Guest speakers from eg industry, further and higher education could be used to bring the world of physics into the classroom.

Information and Communications Technology (ICT) can make a significant contribution to practical work in Physics, in addition to the use of computers as a learning tool. Computer interfacing equipment can detect and record small changes in variables allowing experimental results to be recorded over short periods of time completing experiments in class time. Results can also be displayed in real-time helping to improve understanding. Data logging equipment and video cameras can be set up to record data and make observations over periods of time longer than a class lesson which can then be subsequently downloaded and viewed for analysis.

Learning about Scotland and Scottish culture will enrich the learners' learning experience and help them to develop the skills for learning, life and work they will need to prepare them for taking their place in a diverse, inclusive and participative Scotland and beyond. Where there are opportunities to contextualise approaches to learning and teaching to Scottish contexts, teachers and lecturers should consider this.

Assessment should be integral to and improve learning and teaching. The approach should involve learners and provide supportive feedback. Self- and peer-assessment techniques should be encouraged, wherever appropriate. Assessment information should be used to set learning targets and next steps.

Suggestions for possible contexts and learning activities, to support and enrich learning and teaching, are detailed in the table below.

Suggestions for possible contexts and learning activities, to support and enrich learning and teaching, are detailed in the table below. The **Mandatory Course key areas** are from the ***Course Assessment Specification***. Activities in the **Suggested learning activities** are not mandatory. This offers examples of suggested activities, from which you could select a range of suitable activities. It is not expected that all will be covered. Centres may also devise their own learning activities. **Exemplification of key areas** is not mandatory. It provides an outline of the level of demand and detail of the key areas.

Physics: Our Dynamic Universe (Higher)		
Mandatory Course key areas	**Suggested learning activities**	**Exemplification of key areas**
Motion — equations and graphs Equations of motion for objects moving with constant acceleration in a straight line. Motion-time graphs for motion with constant acceleration in a straight line. Displacement, velocity and acceleration-time graphs and their interrelationship. Graphs for bouncing objects and objects thrown vertically upwards. All graphs restricted to constant acceleration in one dimension, inclusive of change of direction.	Practical experiments to verify the relationships shown in the equations. Light gates, motion sensors and software/hardware to measure displacement, velocity and acceleration. Using software to analyse videos of motion. Motion sensors (including wireless sensors) to enable graphical representation of motion. Displacement-time graphs. Gradient is velocity. Velocity-time graphs. Area under graph is change in displacement during the selected time interval. Gradient is acceleration. Acceleration-time graphs. Investigate the variation of acceleration on a slope with the angle of the slope. Motion of athletes and equipment used in sports. Investigate the initial acceleration of an object projected vertically upwards (eg popper toy). Objects in free-fall and the movement of objects on slopes should be investigated.	$d = \bar{v}t$ $s = \bar{v}t$ $v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $s = \frac{1}{2}(u + v)t$

Forces, energy and power Balanced and unbalanced forces. The effects of friction. Terminal velocity. Forces acting in one plane only. Analysis of motion using Newton's first and second laws. Frictional force as a vector quantity. No reference to static and dynamic friction. Tension as a pulling force exerted by a string or cable on another object. Velocity-time graph of a falling object when air resistance is taken into account, including the effect of changing the area of cross-section of the falling object. Resolving a force into two perpendicular components. Forces acting at an angle to the direction of movement. Resolving the weight of an object on a slope into a component acting down the slope and a component acting normal to the slope. Systems of balanced forces with forces acting in two dimensions. Work done, potential energy, kinetic energy and power in familiar and unfamiliar situations. Conservation of energy.	♦ Forces in rocket motion, jet engine, pile driving, and sport ♦ Space flight ♦ Analysis of skydiving and parachuting, falling raindrops, scuba diving, lifts and haulage systems Analysis of the motion of a rocket may involve a constant force on a changing mass as fuel is used up. Investigation of force parallel to slope with gradient using a Newton balance. Determination of frictional forces acting on a trolley rolling down a slope by the difference between potential and kinetic energy.	$W = mg$ $F = ma$ $W = Fd$ $E_p = mgh$ $E_k = \frac{1}{2}mv^2$ $P = \frac{E}{t}$

Collisions, explosions and impulse Conservation of momentum in one dimension including cases where the objects may move in opposite directions. Kinetic energy in elastic and inelastic collisions. Explosions and Newton's third law. Conservation of momentum in explosions in one dimension only. Force-time graphs during contact of colliding objects. Impulse found from the area under a force-time graph. Equivalence of change in momentum and impulse Newton's third law of motion.	♦ Investigations of conservation of momentum and energy ♦ Propulsion systems — jet engines and rockets ♦ Investigating collisions using force sensors and data loggers ♦ Hammers and pile drivers ♦ Car safety, crumple zones and air bags	$p = mv$ $Ft = mv - mu$
Gravitation Projectiles and satellites. Resolving the motion of a projectile with an initial velocity into horizontal and vertical components and their use in calculations. Comparison of projectiles with objects in free-fall.	♦ Using software to analyse videos of projectiles (Tracker) ♦ Low orbit and geostationary satellites ♦ Satellite communication and surveying ♦ Environmental monitoring of the conditions of the atmosphere ♦ Newton's thought experiment and an explanation of why satellites remain in orbit	

Gravitational field strength of planets, natural satellites and stars. Calculating the force exerted on objects placed in a gravity field. Newton's Universal Law of Gravitation.	♦ Methods for measuring the gravitational field strength on Earth ♦ Using the slingshot effect to travel in space ♦ Lunar and planetary orbits ♦ Formation of the solar system by the aggregation of matter ♦ Stellar formation and collapse ♦ The status of our knowledge of gravity as a force may be explored. The other fundamental forces have been linked but there is as yet no unifying theory to link them to gravity	$F = \frac{Gm_1m_2}{r^2}$
Special relativity The speed of light in a vacuum is the same for all observers, The constancy of the speed of light led Einstein to postulate that measurements of space and time for a moving observer are changed relative to those for a stationary observer. Length contraction and time dilation.	Galilean invariance, Newtonian relativity and the concept of absolute space. Newtonian relativity can be experienced in an intuitive way. Examples include walking in a moving train and moving sound sources. At high speeds, non-intuitive relativistic effects are observed. Length contraction and time dilation can be studied using suitable animations. Experimental verification includes muon detection at the surface of the Earth and accurate time measurements on airborne clocks. The time dilation equation can be derived from the geometrical consideration of a light beam moving relative to a stationary observer.	$t' = \frac{t}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$ $\ell' = \ell\sqrt{1-\left(\frac{v}{c}\right)^2}$

The Expanding Universe		
The Doppler effect is observed in sound and light. The Doppler effect causes shifts in wavelengths of sound and light. The light from objects moving away from us is shifted to longer (more red) wavelengths The redshift of a galaxy is the change in wavelength divided by the emitted wavelength. For slowly moving galaxies, redshift is the ratio of the velocity of the galaxy to the velocity of light.	Doppler effect in terms of terrestrial sources, eg passing ambulances. For sound, the apparent change in frequency as a source moves towards or away from a stationary observer should be investigated. Investigating the apparent shift in frequency using a moving sound source and data logger. Applications include measurement of speed (radar), echocardiogram and flow measurement. (Note that the Doppler effect equations used for sound cannot be used with light from fast moving galaxies because relativistic effects need to be taken into account.)	$f = f_s\left(\frac{v}{v \pm v_s}\right)$
Hubble's law shows the relationship between the recession velocity of a galaxy and its distance from us. Hubble's law allows us to estimate the age of the Universe.	Measuring distances to distant objects. Parallax measurements and data analysis of apparent brightness of standard candles. The Unit 'Particles and Waves' includes an investigation of the inverse square law for light. Centres may wish to include this activity in this topic. In practice, the units used by astronomers include lightyears and parsecs rather than SI units. Data analysis of measurements of galactic velocity and distance.	$v = H_o d$

Evidence for the expanding Universe. We can estimate the mass of a galaxy by the orbital speed of stars within it. Evidence for dark matter from observations of the mass of galaxies. Evidence for dark energy from the accelerating rate of expansion of the Universe.	Measurements of the velocities of galaxies and their distance from us lead to the theory of the expanding Universe. Gravity is the force which slows down the expansion. The eventual fate of the Universe depends on its mass-energy density. The orbital speed of the Sun and other stars gives a way of determining the mass of our galaxy. The Sun's orbital speed is determined almost entirely by the gravitational pull of matter inside its orbit. Measurements of the mass of our galaxy and others lead to the conclusion that there is significant mass which cannot be detected — dark matter. Measurements of the expansion rate of the Universe lead to the conclusion that it is increasing, suggesting that there is something that overcomes the force of gravity — dark energy The revival of Einstein's cosmological constant in the context of the accelerating universe.	
The temperature of stellar objects is related to the distribution of emitted radiation over a wide range of wavelengths. The wavelength of the peak wavelength of this distribution is shorter for hotter objects than for cooler objects. Qualitative relationship between radiation emitted per unit surface area per unit time and the temperature of a star. Cosmic microwave background radiation	Evolution of a star — Hertzsprung-Russell diagram. Remote sensing of temperature. Investigating the temperature of hot objects using infrared sensors. Change in colour of steel at high temperatures. Furnaces and kilns. History of cosmic microwave background (CMB) discovery and measurement. COBE satellite. Other evidence for the big bang includes the	

as evidence for the big bang and subsequent expansion of the universe.	abundance of the elements hydrogen and helium and the darkness of the sky (Olber's paradox). The peak wavelength of cosmic microwave background. This temperature corresponds to that predicted after the big bang.	

Particles and Waves		
Mandatory Course key areas	**Suggested learning activities**	**Exemplification of key areas**
The standard model Orders of magnitude — the range of orders of magnitude of length from the very small (sub-nuclear) to the very large (distance to furthest known celestial objects). The standard model of fundamental particles and interactions. Evidence for the sub-nuclear particles and the existence of antimatter. Fermions, the matter particles, consist of quarks (six types) and leptons (electron, muon and tau, together with their neutrinos). Hadrons are composite particles made of quarks. Baryons are made of three quarks, and mesons are made of quark-antiquark pairs. The force-mediating particles are bosons (photons, W- and Z-bosons, and gluons). Description of beta decay as the first evidence for the neutrino.	The scale of our macro world compared to astronomical and sub-nuclear scales. Sub-atomic Particle Zoo App (and toys). Higgs boson – history, discovery, implications Gravity, electromagnetic, strong and weak forces. LHC at CERN. PET scanner.	

Forces on charged particles Fields exist around charged particles and between charged parallel plates. Examples of electric field patterns for single-point charges, systems of two-point charges and between parallel plates. Movement of charged particles in an electric field. The relationship between potential difference, work and charge gives the definition of the volt. Calculation of the speed of a charged particle accelerated by an electric field. A moving charge produces a magnetic field. The determination of the direction of the force on a charged particle moving in a magnetic field for negative and positive charges (right-hand rule for negative charges). Basic operation of particle accelerators in terms of acceleration, deflection and collision of charged particles.	Hazards, eg lightning, static electricity on microchips. Precipitators. Xerography. Paint spraying. Inkjet printing. Electrostatic propulsion. Demonstrations with Teltron tubes. Accelerators include linear accelerator, cyclotron and synchrotron. Medical applications of cyclotron. Accelerators used to probe structure of matter. The LHC at CERN.	$W = QV$ $E_k = \frac{1}{2}mv^2$
Nuclear reactions Nuclear equations to describe radioactive decay, fission and fusion reactions with reference to mass and energy equivalence, including calculations. Coolant and containment issues in nuclear fusion reactors.	Energy available from chemical and nuclear sources. Magnetic containment of plasma. Joint European Torus (JET) ITER tokamak	$E = mc^2$

Wave particle duality Photoelectric effect as evidence for the particulate nature of light. Photons of sufficient energy can eject electrons from the surface of materials. The threshold frequency is the minimum frequency of a photon required for photoemission. The work function of the material is the minimum energy required to cause photoemission. Determination of the maximum kinetic energy of photoelectrons.	 Light meters in cameras, channel plate image intensifiers, photomultipliers.	 $E = hf$ $E_k = hf - hf_o$ $E_k = \frac{1}{2}mv^2$ $v = f\lambda$
Interference and diffraction Conditions for constructive and destructive interference. Coherent waves have a constant phase relationship and have the same frequency, wavelength and velocity. Constructive and destructive interference in terms of phase between two waves. Interference of waves using two coherent sources. Maxima and minima are produced when the path difference between waves is a whole number of wavelengths or an odd number of half-wavelengths respectively. The relationship between the wavelength, distance between the sources, distance from the	 Interference patterns with microwaves, radio waves, sound, light and electrons. Holography. Industrial imaging of surfaces-curvature and stress analysis. Lens blooming. Interference colours (jewellery, petrol films, soap bubbles). Investigations leading to the relationship between the wavelength, distance between the sources, distance from the sources and the spacing between maxima or minima.	path diff = $m\lambda$ or $(m+\frac{1}{2})\lambda$ where m = 0, 1, 2 …

sources and the spacing between maxima or minima. The relationship between the grating spacing, wavelength and angle to the maxima.	Monochromatic light can be used with a diffraction grating to investigate the relationship between the grating spacing, wavelength and angle to the maxima. Interferometers to measure small changes in path difference. Use a spectroscope/spectrometer/spectrophotometer to examine spectra from a number of light sources.	$d \sin\theta = m\lambda$
Refraction of light Absolute refractive index of a material is the ratio of the sine of angle of incidence in vacuum (air) to the sine of angle of refraction in the material. Refractive index of air treated as the same as that of a vacuum. Situations where light travels from a more dense to a less dense medium. Refractive index can also be found from the ratio of speed of light in vacuum (air) to the speed in the material and the ratio of the wavelengths. Variation of refractive index with frequency. Critical angle and total internal reflection.	Optical instruments using lenses. Dispersion of high-power laser beams due to hot centre with lower refractive index. Design of lenses, dispersion of signals in optical fibres, colours seen in cut diamonds. Semicircular blocks. Reflective road signs, prism reflectors (binoculars, periscopes, SLR cameras). Optical fibres for communications, medicine and sensors. Investigation of total internal reflection, including critical angle and its relationship with refractive index.	$n = \frac{\sin\theta_1}{\sin\theta_2}$ $\frac{\sin\theta_1}{\sin\theta_2} = \frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2}$ $v = f\lambda$ $\sin\theta_c = \frac{1}{n}$

Spectra Irradiance and the inverse square law. Irradiance is the power per unit area reaching a surface. The relationship between irradiance and distance from a point light source. Line and continuous emission spectra, absorption spectra and energy level transitions. The Bohr model of the atom. Movement of electrons between energy levels. The terms ground state, energy levels, ionisation and zero potential energy for the Bohr model of the atom. Emission of photons due to movement of electrons between energy levels and dependence of photon frequency on energy difference between levels. The relationship between photon energy, Planck's constant and photon frequency. Absorption lines in the spectrum of sunlight provide evidence for the composition of the Sun's upper atmosphere.	Galactic distances and Hubble's law. Application to other e-m radiation (eg gamma radiation). Comparing the irradiance from a point light source with a laser. Investigation of irradiance as a function of distance from a point light source. Line and continuous spectra, eg from tungsten filament lamp, electric heater element, fluorescent tube, burning a salt in a Bunsen flame. Discharge lighting, laboratory and extraterrestrial spectroscopy, the standard of length. Lasers.	$I = \frac{P}{A}$ $I = \frac{k}{d^2}$ $E_2 - E_1 = hf$ $E = hf$

Electricity		
Mandatory Course key areas	**Suggested learning activities**	**Exemplification of key areas**
Monitoring and measuring a.c. A.C. as a current which changes direction and instantaneous value with time. Calculations involving peak and r.m.s. values. Determination of frequency, peak voltage and r.m.s. values from graphical data.	Using a multimeter as an ammeter, voltmeter and ohmmeter. Oscilloscope as a voltmeter and waveform monitor. Monitoring a.c. signals with an oscilloscope, including measuring frequency, and peak and r.m.s. values.	$V_{peak} = \sqrt{2}V_{rms}$ $I_{peak} = \sqrt{2}I_{rms}$ $T = \frac{1}{f}$
Current, potential difference, power and resistance Use relationships involving potential difference, current, resistance and power to analyse circuits. Calculations may involve several steps. Calculations involving potential dividers circuits.	Investigating a.c. or d.c. circuits with switches and resistive components. Use of potential dividers in circuits to set and control voltages in electronic circuits.	$V = IR$ $P = IV = I^2R = \frac{V^2}{R}$ $R_T = R_1 + R_2 + \ ...$ $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + ...$

		$V_2 = \left(\frac{R_2}{R_1 + R_2}\right)V_S$ $\frac{V_1}{V_2} = \frac{R_1}{R_2}$
Electrical sources and internal resistance Electromotive force, internal resistance and terminal potential difference. Ideal supplies, short circuits and open circuits. Determining internal resistance and electromotive force using graphical analysis.	Investigating internal resistance of low voltage power supplies. Load matching. Maximum power is transferred when internal and external resistances are equal. Investigate the reduction in t.p.d. when additional components are added in parallel.	$E = V + Ir$
Capacitors Capacitors and the relationship between capacitance, charge and potential difference. The total energy stored in a charged capacitor is the area under the charge against potential difference graph. Use the relationships between energy, charge, capacitance and potential difference. Variation of current and potential difference against time for both charging and discharging. The effect of resistance and capacitance on charging and discharging curves.	Carry out investigations into capacitor charging/discharging using data loggers or otherwise Energy storage. Flash photography. Smoothing and suppressing. Capacitance-based touch screens.	$C = \frac{Q}{V}$ $E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$ $Q = It$
Conductors, semiconductors and insulators		

Solids can be categorised into conductors, semiconductors or insulators by their ability to conduct electricity. The electrons in atoms are contained in energy levels. When the atoms come together to form solids, the electrons then become contained in energy bands separated by gaps. In metals, the highest occupied band is not completely full and this allows the electrons to move and therefore conduct. This band is known as the conduction band. In an insulator, the highest occupied band (called the valence band) is full. The first unfilled band above the valence band is the conduction band. For an insulator, the gap between the valence band and the conduction band is large and at room temperature there is not enough energy available to move electrons from the valence band into the conduction band where they would be able to contribute to conduction. There is no electrical conduction in an insulator. In a semiconductor, the gap between the valence band and conduction band is smaller and at room temperature there is sufficient energy available to move some electrons from the valence band into the conduction band allowing some conduction to take place. An increase in temperature increases the conductivity of a semiconductor.	Conducting cables and insulating material. Breakdown voltage and lightning. Hall effect sensor. Investigating the change in resistance of a negative temperature coefficient thermistor as its temperature is increased.	

p-n junctions During manufacture, the conductivity of semiconductors can be controlled, resulting in two types: p-type and n-type. When p-type and n-type materials are joined, a layer is formed at the junction. The electrical properties of this layer are used in a number of devices. Solar cells are p-n junctions designed so that a potential difference is produced when photons enter the layer. This is the photovoltaic effect. LEDs are forward biased p-n junction diodes that emit photons when electrons 'fall' from the conduction band into the valence band of the p-type semiconductor.	Investigating the output voltage of a solar cell and its dependence on the irradiance and frequency of incident light. Investigating the switch-on voltage of different coloured LEDs.	

Higher Physics: units, prefixes and uncertainties

This table applies to the Course and its component Units.

Units, prefixes and scientific notation	Notes
Units and prefixes	SI units should be used with all the physical quantities. Prefixes should be used where appropriate. These include pico (p), nano (n), micro (μ), milli (m), kilo (k), mega (M), giga (G) and tera (T).
Significant figures	In carrying out calculations and using relationships to solve problems, it is important to give answers to an appropriate number of significant figures. This means that the final answer can have no more significant figures than the value with least number of significant figures used in the calculation.
Scientific notation	Candidates should be familiar with the use of scientific notation and this may be used as appropriate when large and small numbers are used in calculations.
Uncertainties	
Random and systematic uncertainty	All measurements of physical quantities are liable to uncertainty, which should be expressed in absolute or percentage form. Random uncertainties occur when an experiment is repeated and slight variations occur. Scale reading uncertainty is a measure of how well an instrument scale can be read. Random uncertainties can be reduced by taking repeated measurements. Systematic uncertainties occur when readings taken are either all too small or all too large. They can arise due to measurement techniques or experimental design.
Uncertainties and data analysis	The mean of a set of readings is the best estimate of a ‘true’ value of the quantity being measured. When systematic uncertainties are present, the mean value of measurements will be offset. When mean values are used, the approximate random uncertainty should be calculated. When an experiment is being undertaken and more than one physical quantity is measured, the quantity with the largest percentage uncertainty should be identified and this may often be used as a good estimate of the percentage uncertainty in the final numerical result of an experiment. The numerical result of an experiment should be expressed in the form final value $\pm$uncertainty.

Developing skills for learning, skills for life and skills for work

Learners are expected to develop broad generic skills as an integral part of their learning experience. The *Course Specification* lists the skills for learning, skills for life and skills for work that learners should develop through this Course. These are based on SQA's *Skills Framework: Skills for Learning, Skills for Life and Skills for Work* and must be built into the Course where there are appropriate opportunities. The level of these skills will be appropriate to the level of the Course.

For this Course, it is expected that the following skills for learning, skills for life and skills for work will be significantly developed:

Literacy
Writing means the ability to create texts which communicate ideas, opinions and information, to meet a purpose and within a context. In this context, 'texts' are defined as word-based materials (sometimes with supporting images) which are written, printed, Braille or displayed on screen. These will be technically accurate for the purpose, audience and context.

1.2 Writing
Learners develop the skills to effectively communicate key areas of physics, make informed decisions and describe, clearly, physics issues in various media forms. Learners will have the opportunity to communicate applied knowledge and understanding throughout the Course, with an emphasis on applications and environmental/ethical/social impacts.

There will be opportunities to develop the literacy skills of listening and reading, when gathering and processing information in Physics.

Numeracy
This is the ability to use numbers in order to solve problems by counting, doing calculations, measuring, and understanding graphs and charts. This is also the ability to understand the results.
Learners will have opportunities to extract, process and interpret information presented in numerous formats including tabular and graphical. Practical work will provide opportunities to develop time and measurement skills.

2.1 Number processes
Number processes means solving problems arising in everyday life through carrying out calculations, when dealing with data and results from experiments/investigations and everyday class work, making informed decisions based on the results of these calculations and understanding these results.

2.2 Money, time and measurement
This means using and understanding time and measurement to solve problems and handle data in a variety of physics contexts, including practical and investigative.

2.3 Information handling
Information handling means being able to interpret physics data in tables, charts and other graphical displays to draw sensible conclusions throughout the Course. It involves interpreting the data and considering its reliability in making reasoned deductions and informed decisions. It also involves an awareness and understanding of the chance of events happening.

Thinking skills
This is the ability to develop the cognitive skills of remembering and identifying, understanding and applying.
The Course will allow learners to develop skills of applying, analysing and evaluating. Learners can analyse and evaluate practical work and data by reviewing the process, identifying issues and forming valid conclusions. They can demonstrate understanding and application of key areas and explain and interpret information and data.

5.3 Applying
Applying is the ability to use existing information to solve physics problems in different contexts, and to plan, organise and complete a task such as an investigation.

5.4 Analysing and evaluating
Analysis is the ability to solve problems in physics and make decisions that are based on available information. It may involve the review and evaluation of relevant information and/or prior knowledge to provide an explanation.

It may build on selecting and/or processing information, so is a higher level skill.
5.5 Creating
This is the ability to design something innovative or to further develop an existing thing by adding new dimensions or approaches. Learners can demonstrate their creativity, in particular, when planning and designing physics experiments or investigations. Learners have the opportunity to be innovative in their approach. Learners also have opportunities to make, write, say or do something new.

In addition, learners will also have opportunities to develop working with others and citizenship.

Working with others
Learning activities provide many opportunities, in all areas of the Course, for learners to work with others. Practical activities and investigations, in particular, offer opportunities for group work, which is an important aspect of physics and should be encouraged.

Citizenship
Learners will develop citizenship skills, when considering the applications of physics on our lives, as well as environmental and ethical implications.

Approaches to assessment

Assessment should cover the mandatory skills, knowledge and understanding of the Course. Assessment should be integral to and improve learning and teaching. The approach should involve learners and provide supportive feedback. Self- and peer-assessment techniques should be used, whenever appropriate.

See the *Unit Support Notes* for guidance on approaches to assessment of the Units of the Course.

Added value

At Higher, the added value will be assessed in the Course assessment.

Information given in the *Course Specification* and the *Course Assessment Specification* about the assessment of added value is mandatory.

If the Unit is being taken as part of the Higher Physics Course, the learner will be required to draw on, extend and apply the skills and knowledge they have developed during this Unit within the *Course Assessment* (Question Paper and Assignment).

Preparation for Course assessment

Each Course has additional time which may be used at the discretion of the teacher or lecturer to enable learners to prepare for Course assessment. This time may be used near the start of the Course and at various points throughout the Course for consolidation and support. It may also be used for preparation for Unit assessment, and towards the end of the Course, for further integration, revision and preparation and/or gathering evidence for Course assessment.

During delivery of the Course, opportunities should be found:

- for identification of particular aspects of work requiring reinforcement and support
- to practise skills of scientific inquiry and investigation in preparation for the Assignment
- to practise question paper techniques

OPEN ENDED QUESTIONS

In open ended questions, the candidate is required to draw on his/her understanding of key physics concepts and principles and to apply these in unfamiliar contexts. The 'open-ended' nature of these questions is such that there is no unique correct answer. The less prescriptive marking instructions focus on rewarding students for their understanding of physics. These questions are signposted for candidates by the use of the phrase, '**using your knowledge of physics** printed in bold text within the question stem.

In answering open-ended questions, candidates must apply their skills, knowledge and understanding to respond appropriately to the problem/situation presented. For example, by making a statement of principle(s) involved, and/or a relationship or equation, and applying these to respond to the problem/situation.

They will be rewarded for the breadth and/or depth of their conceptual understanding.

Combining assessment across Units

If an integrated approach to Course delivery is chosen then there may be opportunities for combining assessment across Units. If this approach is used, then it is necessary to be able to track evidence for individual Outcomes and Assessment Standards.

Since the Outcomes and Assessment Standards are the same for the Our Dynamic Universe, Particles and Waves and Electricity Units of the Course (with the exception of the Researching Physics Unit), the Units differing only by context, evidence for Outcome 1 and Assessment Standards 2.2, 2.3 and 2.4 for any one of the above three Units can be used as evidence of the achievement of Outcome 1 and Assessment Standards 2.2, 2.3 and 2.4 for the other two Units of the Course.

Equality and inclusion

The following should be taken into consideration:

Situation	Reasonable adjustment
Carrying out practical activities	Use could be made of practical helpers for learners with: ♦ physical disabilities, especially manual dexterity, when carrying out practical activities ♦ visual impairment who have difficulty distinguishing colour changes or other visual information
Reading, writing and presenting text, symbolic representation, tables, graphs and diagrams.	Use could be made of ICT, enlarged text, alternative paper and/or print colour and/or practical helpers for learners with visual impairment, specific learning difficulties and physical disabilities.
Process information using calculations.	Use could be made of practical helpers for learners with specific cognitive difficulties (eg dyscalculia).
Draw a valid conclusion, giving explanations and making generalisation/predictions.	Use could be made of practical helpers for learners with specific cognitive difficulties or autism.

As far as possible, reasonable adjustments should be made for the Question Paper and/or Assignment, where necessary. All adjustments currently available for the Question Paper would be available for Component 1. Learners will have a choice of Assignment topic for Component 2, for which reasonable adjustments can be made. This includes the use of 'practical helpers', readers, scribes, adapted equipment or assistive technologies.

It is recognised that centres have their own duties under equality and other legislation and policy initiatives. The guidance given in these *Course Support Notes* is designed to sit alongside these duties but is specific to the delivery and assessment of the Course.

It is important that centres are aware of and understand SQA's assessment arrangements for disabled learners, and those with additional support needs, when making requests for adjustments to published assessment arrangements. Centres will find more guidance on this in the series of publications on Assessment Arrangements on SQA's website: www.sqa.org.uk/sqa/14977.html.

Appendix 1: Reference documents

The following reference documents will provide useful information and background.

- Assessment Arrangements (for disabled learners and/or those with additional support needs) — various publications on SQA's website: http://www.sqa.org.uk/sqa/14976.html
- *Building the Curriculum 3: A framework for Learning and Teaching*
- *Building the Curriculum 4: Skills for learning, skills for life and skills for work*
- *Building the Curriculum 5: A framework for assessment*
- *Course Specifications*
- Design Principles for National Courses
- *Guide to Assessment* (June 2008)
- *Principles and practice papers for curriculum areas*
- *Research Report 4 — Less is More: Good Practice in Reducing Assessment Time*
- Course*work Authenticity — a Guide for Teachers and Lecturers*
- *SCQF Handbook: User Guide (published 2009)* and SCQF level descriptors (to be reviewed during 2011 to 2012): www.sqa.org.uk/sqa/4595.html
- *SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work*
- SQA Guidelines on e-assessment for Schools
- SQA Guidelines on Online Assessment for Further Education
- SQA e-assessment web page: www.sqa.org.uk/sqa/5606.html

Administrative information

Published: June 2014 (version 1.1)

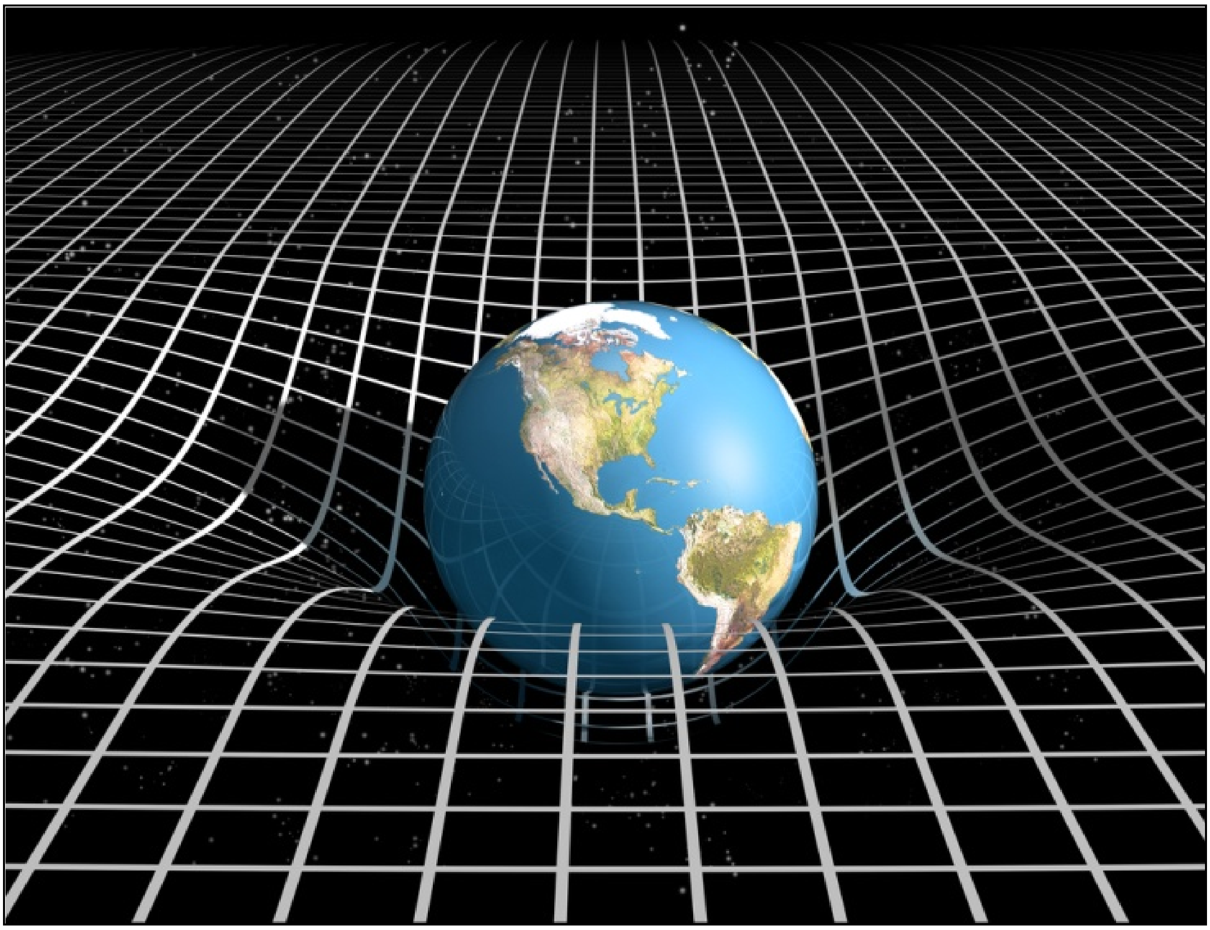
History of changes to Course Support Notes

Course details	Version	Description of change	Authorised by	Date
	1.1	Skills for Learning, Life and Work updated; Transfer of evidence section updated; Sub –headings in content table corrected re key area groupings; Minor changes and clarification to content in the mandatory content tables	Qualifications Development Manager	June 2014

Note: You are advised to check SQA's website (**www.sqa.org.uk)** to ensure you are using the most up-to-date version.

Unit
Support
Notes

Unit Support Notes — Physics: Our Dynamic Universe (Higher)



Please refer to the note of changes at the end of this document for details of changes from previous version (where applicable).

Introduction

These support notes are not mandatory. They provide advice and guidance on approaches to delivering and assessing the Physics: Our Dynamic Universe (Higher) Unit. They are intended for teachers and lecturers who are delivering this Unit. They should be read in conjunction with:

- the *Unit Specification*
- the *Course Specification*
- the *Course Assessment Specification*
- the *Course Support Notes*
- appropriate assessment support materials

General guidance on the Unit

Aims

The general aim of this Unit is to develop skills of scientific inquiry, investigation and analytical thinking, along with knowledge and understanding of Our Dynamic Universe.

Learners will apply these skills when considering the applications of Our Dynamic Universe on our lives, as well as the implications on society/the environment. This can be done by using a variety of approaches, including investigation and problem solving.

The Unit covers the key areas of: kinematics, dynamics and space-time.

Learners will research issues, apply scientific skills and communicate information related to their findings, which will develop skills of scientific literacy.

Progression into this Unit

Entry to this Unit is at the discretion of the centre. However, learners would normally be expected to have attained the skills, knowledge and understanding required by the following or equivalent qualifications and/or experience:

- National 5 Physics Course

Skills, knowledge and understanding covered in this Unit

Information about skills, knowledge and understanding is given in the Higher Physics *Course Support Notes*.

If this Unit is being delivered on a free-standing basis, teachers and lecturers should cover the mandatory skills and key areas in ways which are most appropriate for delivery in their centres.

Progression from this Unit

This Unit may provide progression to:

- other qualifications in physics or related areas
- further study, employment and/or training

Approaches to learning and teaching

Approaches to learning and teaching and suggested learning activities are given in the *Course Support Notes*.

Developing skills for learning, skills for life and skills for work

Information about developing skills for learning, skills for life and skills for work in this Unit, is given in the relevant *Course Support Notes*.

Approaches to assessment and gathering evidence

The purpose of this section is to give advice on approaches to assessment for the Unit. There will be other documents produced for centres to provide exemplification of assessments and guidance on how to write them.

Approaches to the assessment of a Unit when it forms part of a Course may differ from approaches to assessing the same Unit when it is not being delivered as part of a Course. If an integrated approach to Course delivery is chosen, then there may be opportunities for combining assessment across Units.

Assessments must be valid, reliable and fit for purpose for the subject and level, and should fit in with learning and teaching approaches.

Unit assessment should support learning and teaching and where possible enable personalisation and choice for learners in assessment methods and processes. Teachers and lecturers should select the assessment methods they believe are most appropriate, taking into account the needs of their learners and the requirements of the Unit.

There is no mandatory order for delivery of the Outcomes. These should be overtaken throughout the Unit and are an integral part of learning and teaching.

The table below gives guidance and advice on possible approaches to assessment and gathering evidence.

Strategies for gathering evidence
There may be opportunities in the day-to-day delivery of the Units in a Course to observe learners providing evidence which satisfies completely or partially a Unit or Units. This is naturally occurring evidence and can be recorded as evidence for Outcomes or parts of Outcomes. In some cases, additional evidence may also be required to supplement and confirm the naturally occurring evidence. Approaches to assessment might cover the whole Unit or be combined across Outcomes. A holistic approach can enrich the assessment process for the learner

by bringing together different Outcomes and/or Assessment Standards
If a holistic approach is used then it is necessary to be able to track individual Assessment Standard evidence.

Strategies for gathering evidence and ensuring that the learners' work is their own could include:

- personal interviews during which the teacher or lecturer can ask additional questions about completed work
- an oral presentation on their work
- writing reports in supervised conditions
- checklists to record the authenticity
- supplementary sources of evidence, such as witness testimony, film or audio clips

Evidence can be gathered from classwork, experiments, investigations and/or research carried out in this Unit. It can be obtained using one or more of the strategies outlined above or by alternative methods, which could include a test of knowledge, understanding and skills.

Combining assessment within Units

See *Course Support Notes*.

Equality and inclusion

The *Course Support notes* provide full information on equality and inclusion for this Unit.

It is recognised that centres have their own duties under equality and other legislation and policy initiatives. The guidance given in these *Unit Support Notes* is designed to sit alongside these duties but is specific to the delivery and assessment of the Unit.

Alternative approaches to Unit assessment to take account of the specific needs of learners can be used. However, the centre must be satisfied that the integrity of the assessment is maintained and that the alternative approaches to assessment will, in fact, generate the necessary evidence of achievement.

Appendix 1: Reference documents

The following reference documents will provide useful information and background.

- Assessment Arrangements (for disabled learners and/or those with additional support needs) — various publications on SQA's website: http://www.sqa.org.uk/sqa/14976.html
- *Building the Curriculum 3: A framework for Learning and Teaching*
- *Building the Curriculum 4: Skills for learning, skills for life and skills for work*
- *Building the Curriculum 5: A framework for assessment*
- *Course Specifications*
- Design Principles for National Courses
- *Guide to Assessment* (June 2008)
- *Principles and practice papers for sciences curriculum area*
- Science: A Portrait of current practice in Scottish Schools (2008)
- *Research Report 4 — Less is More: Good Practice in Reducing Assessment Time*
- Course*work Authenticity — a Guide for Teachers and Lecturers*
- *SCQF Handbook: User Guide (published 2009)* and SCQF level descriptors (to be reviewed during 2011 to 2012): www.sqa.org.uk/sqa/4595.html
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- SQA Guidelines on e-assessment for Schools
- SQA Guidelines on Online Assessment for Further Education
- SQA e-assessment web page: www.sqa.org.uk/sqa/5606.html

Administrative information

Published: June 2014 (version 1.0)

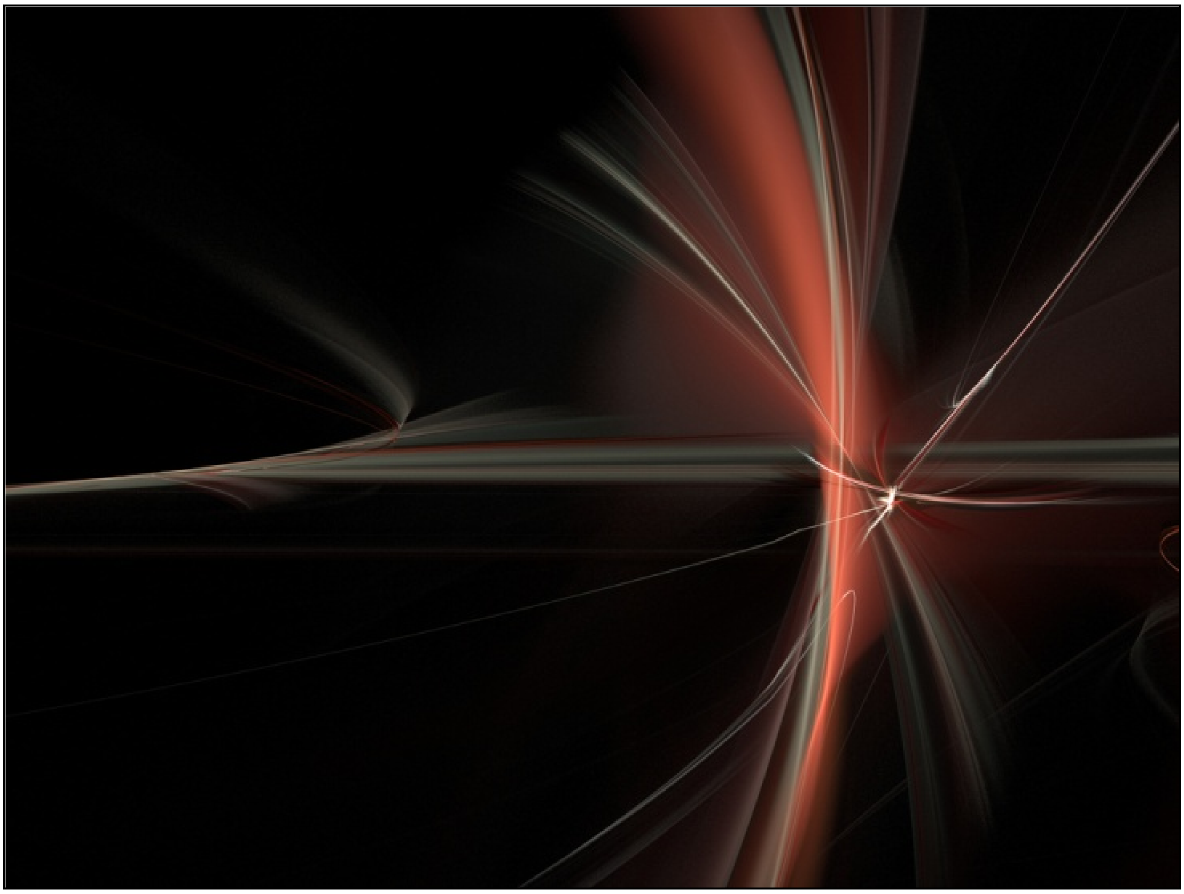
History of changes to Unit Support Notes

Unit details	Version	Description of change	Authorised by	Date

Note: You are advised to check SQA's website (**www.sqa.org.uk**) to ensure you are using the most up-to-date version.

Unit Support Notes

Unit Support Notes — Physics: Particles and Waves (Higher)



Please refer to the note of changes at the end of this document for details of changes from previous version (where applicable).

Introduction

These support notes are not mandatory. They provide advice and guidance on approaches to delivering and assessing the Physics: Particles and Waves (Higher) Unit. They are intended for teachers and lecturers who are delivering this Unit. They should be read in conjunction with:

- the *Unit Specification*
- the *Course Specification*
- the *Course Assessment Specification*
- the *Course Support Notes*
- appropriate assessment support materials

General guidance on the Unit

Aims

The general aim of this Unit is to develop skills of scientific inquiry, investigation and analytical thinking, along with knowledge and understanding of Particles and Waves.

Learners will apply these skills when considering the applications of Particles and Waves on our lives, as well as the implications on society/ the environment. This can be done by using a variety of approaches, including investigation and problem solving.

The Unit covers the key areas of: particles and waves.

Learners will research issues, apply scientific skills and communicate information related to their findings, which will develop skills of scientific literacy.

Progression into this Unit

Entry to this Unit is at the discretion of the centre. However, learners would normally be expected to have attained the skills, knowledge and understanding required by the following or equivalent qualifications and/or experience:

- National 5 Physics Course

Skills, knowledge and understanding covered in this Unit

Information about skills, knowledge and understanding is given in the Higher Physics *Course Support Notes*.

If this Unit is being delivered on a free-standing basis, teachers and lecturers should cover the mandatory skills and key areas in ways which are most appropriate for delivery in their centres.

Progression from this Unit

This Unit may provide progression to:

- other qualifications in physics or related areas
- further study, employment and/or training

Approaches to learning and teaching

Approaches to learning and teaching and suggested learning activities are given in the *Course Support notes*.

Developing skills for learning, skills for life and skills for work

Information about developing skills for learning, skills for life and skills for work in this Unit, is given in the relevant *Course Support Notes*.

Approaches to assessment and gathering evidence

The purpose of this section is to give advice on approaches to assessment for the Unit. There will be other documents produced for centres to provide exemplification of assessments and guidance on how to write them.

Approaches to the assessment of a Unit when it forms part of a Course may differ from approaches to assessing the same Unit when it is not being delivered as part of a Course. If an integrated approach to Course delivery is chosen, then there may be opportunities for combining assessment across Units.

Assessments must be valid, reliable and fit for purpose for the subject and level, and should fit in with learning and teaching approaches.

Unit assessment should support learning and teaching and where possible enable personalisation and choice for learners in assessment methods and processes. Teachers and lecturers should select the assessment methods they believe are most appropriate, taking into account the needs of their learners and the requirements of the Unit.

There is no mandatory order for delivery of the Outcomes. These should be overtaken throughout the Unit and are an integral part of learning and teaching.

The table below gives guidance and advice on possible approaches to assessment and gathering evidence.

Strategies for gathering evidence
There may be opportunities in the day-to-day delivery of the Units in a Course to observe learners providing evidence which satisfies completely or partially a Unit or Units. This is naturally occurring evidence and can be recorded as evidence for Outcomes or parts of Outcomes. In some cases, additional evidence may also be required to supplement and confirm the naturally occurring evidence. Approaches to assessment might cover the whole Unit or be combined across Outcomes. A holistic approach can enrich the assessment process for the learner

by bringing together different Outcomes and/or Assessment Standards.
If a holistic approach is used then it is necessary to be able to track individual Assessment Standard evidence.

Strategies for gathering evidence and ensuring that the learners' work is their own, could include:

- personal interviews during which the teacher or lecturer can ask additional questions about completed work
- an oral presentation on their work
- writing reports in supervised conditions
- checklists to record the authenticity
- supplementary sources of evidence, such as witness testimony, film or audio clips

Evidence can be gathered from classwork, experiments, investigations and/or research carried out in this Unit. It can be obtained using one or more of the strategies outlined above or by alternative methods, which could include a test of knowledge, understanding and skills.

Combining assessment within Units

See *Course Support Notes*.

Equality and inclusion

The *Course Support Notes* provide full information on equality and inclusion for this Unit.

It is recognised that centres have their own duties under equality and other legislation and policy initiatives. The guidance given in this document is designed to sit alongside these duties but is specific to the delivery and assessment of the Unit.

Alternative approaches to Unit assessment to take account of the specific needs of learners can be used. However, the centre must be satisfied that the integrity of the assessment is maintained and where the alternative approach to assessment will, in fact, generate the necessary evidence of achievement.

Appendix 1: Reference documents

The following reference documents will provide useful information and background.

- Assessment Arrangements (for disabled learners and/or those with additional support needs) — various publications on SQA's website: http://www.sqa.org.uk/sqa/14976.html
- *Building the Curriculum 3: A framework for Learning and Teaching*
- *Building the Curriculum 4: Skills for learning, skills for life and skills for work*
- *Building the Curriculum 5: A framework for assessment*
- *Course Specifications*
- Design Principles for National Courses
- *Guide to Assessment* (June 2008)
- *Principles and practice papers for curriculum areas*
- Science: A Portrait of current practice in Scottish Schools (2008)
- *Research Report 4 — Less is More: Good Practice in Reducing Assessment Time*
- Course*work Authenticity — a Guide for Teachers and Lecturers*
- *SCQF Handbook: User Guide (published 2009)* and SCQF level descriptors (to be reviewed during 2011 to 2012): www.sqa.org.uk/sqa/4595.html
- *SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work*
- SQA Guidelines on e-assessment for Schools
- SQA Guidelines on Online Assessment for Further Education
- SQA e-assessment web page: www.sqa.org.uk/sqa/5606.html

Administrative information

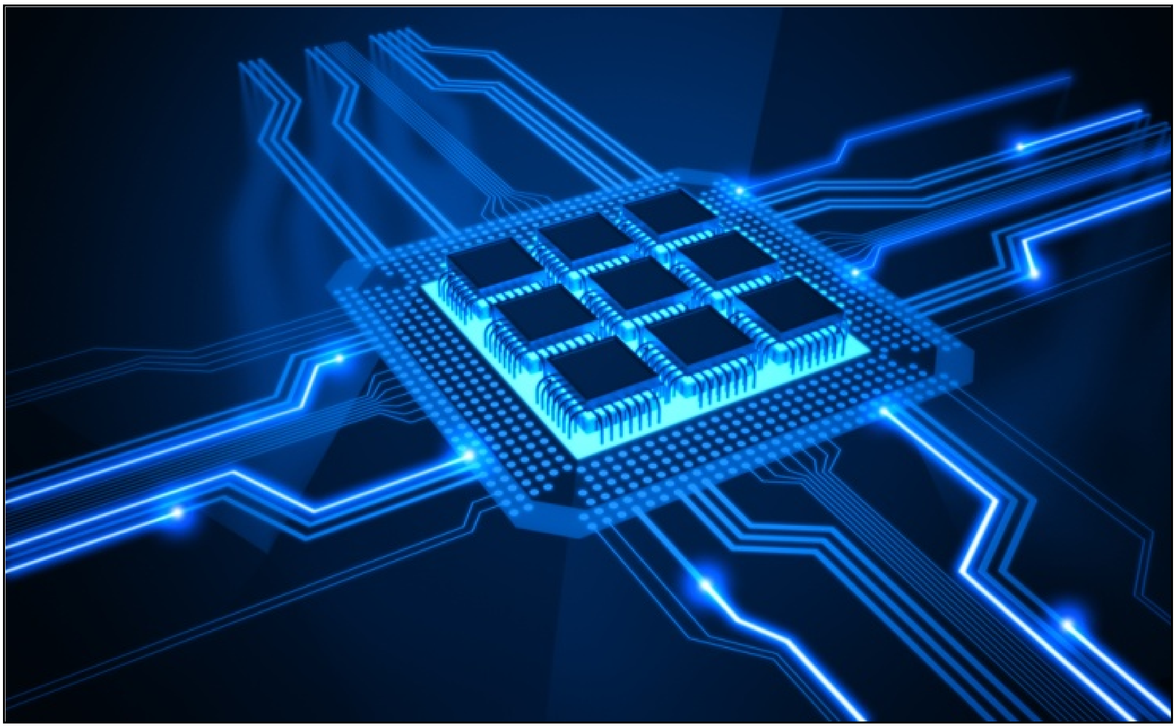
Published: June 2014 (version 1.0)

History of changes to Unit Support Notes

Unit details	Version	Description of change	Authorised by	Date

Unit Support Notes

Unit Support Notes — Physics: Electricity (Higher)



Please refer to the note of changes at the end of this document for details of changes from previous version (where applicable).

Introduction

These support notes are not mandatory. They provide advice and guidance on approaches to delivering and assessing the Physics: Electricity (Higher) Unit. They are intended for teachers and lecturers who are delivering this Unit. They should be read in conjunction with:

- the *Unit Specification*
- the *Course Specification*
- the *Course Assessment Specification*
- the *Course Support Notes*
- appropriate assessment support materials

General guidance on the Unit

Aims

The general aim of this Unit is to develop skills of scientific inquiry, investigation and analytical thinking, along with knowledge and understanding of Electricity.

Learners will apply these skills when considering the applications of Electricity on our lives, as well as the implications on society/ the environment. This can be done by using a variety of approaches, including investigation and problem solving.

The Unit covers the key areas of: electricity, electrical storage and transfer.

Learners will research issues, apply scientific skills and communicate information related to their findings, which will develop skills of scientific literacy.

Progression into this Unit

Entry to this Unit is at the discretion of the centre.
However, learners would normally be expected to have attained the skills, knowledge and understanding required by the following or equivalent qualifications and/or experience:

- National 5 Physics Course

Skills, knowledge and understanding covered in this Unit

Information about skills, knowledge and understanding is given in the Higher Physics *Course Support Notes*.

If this Unit is being delivered on a free-standing basis, teachers and lecturers should cover the mandatory skills and key areas in ways which are most appropriate for delivery in their centres.

Progression from this Unit

This Unit may provide progression to:

- other qualifications in physics or related areas
- further study, employment and/or training

Approaches to learning and teaching

Approaches to learning and teaching and suggested learning activities are given in the *Course Support notes*.

Developing skills for learning, skills for life and skills for work

Information about developing skills for learning, skills for life and skills for work in this Unit, is given in the relevant *Course Support Notes*.

Learners are expected to develop broad generic skills as an integral part of their learning experience. The *Unit Specification* lists the skills for learning, skills for life and skills for work that learners should develop through this Course. These are based on SQA's *Skills Framework: Skills for Learning, Skills for Life and Skills for Work* and must be built into the Unit where there are appropriate opportunities. The level of these skills will be appropriate to the level of the Unit.

Approaches to assessment and gathering evidence

The purpose of this section is to give advice on approaches to assessment for the Unit. There will be other documents produced for centres to provide exemplification of assessments and guidance on how to write them.

Approaches to the assessment of a Unit when it forms part of a Course may differ from approaches to assessing the same Unit when it is not being delivered as part of a Course. If an integrated approach to Course delivery is chosen, then there may be opportunities for combining assessment across Units.

Assessments must be valid, reliable and fit for purpose for the subject and level, and should fit in with learning and teaching approaches.

Unit assessment should support learning and teaching and where possible enable personalisation and choice for learners in assessment methods and processes. Teachers and lecturers should select the assessment methods they believe are most appropriate, taking into account the needs of their learners and the requirements of the Unit.

There is no mandatory order for delivery of the Outcomes. These should be overtaken throughout the Unit and are an integral part of learning and teaching.

The table below gives guidance and advice on possible approaches to assessment and gathering evidence.

Strategies for gathering evidence
There may be opportunities in the day-to-day delivery of the Units in a Course to observe learners providing evidence which satisfies completely or partially a Unit or Units. This is naturally occurring evidence and can be recorded as evidence for Outcomes or parts of Outcomes. In some cases, additional evidence may also be required to supplement and confirm the naturally occurring evidence. Approaches to assessment might cover the whole Unit or be combined across Outcomes. A holistic approach can enrich the assessment process for the learner by bringing together different Outcomes and/or Assessment Standards. If a holistic approach is used then it is necessary to be able to track individual Assessment Standard evidence. Strategies for gathering evidence and ensuring that the learners' work is their own, could include: ♦ personal interviews during which the teacher or lecturer can ask additional questions about completed work ♦ an oral presentation on their work ♦ writing reports in supervised conditions ♦ checklists to record the authenticity ♦ supplementary sources of evidence, such as witness testimony, film or audio clips Evidence can be gathered from classwork, experiments, investigations and/or research carried out in this Unit. It can be obtained using one or more of the strategies outlined above or by alternative methods, which could include a test of knowledge, understanding and skills.

Combining assessment within Units

See *Course Support Notes*.

Equality and inclusion

The *Course Support Notes* provide full information on equality and inclusion for this Unit.

It is recognised that centres have their own duties under equality and other legislation and policy initiatives. The guidance given in this document is designed to sit alongside these duties but is specific to the delivery and assessment of the Unit.

Alternative approaches to Unit assessment to take account of the specific needs of learners can be used. However, the centre must be satisfied that the integrity of the assessment is maintained and that the alternative approaches to assessment will, in fact, generate the necessary evidence of achievement.

Appendix 1: Reference documents

The following reference documents will provide useful information and background.

- Assessment Arrangements (for disabled learners and/or those with additional support needs) — various publications on SQA's website: http://www.sqa.org.uk/sqa/14976.html
- *Building the Curriculum 3: A framework for Learning and Teaching*
- *Building the Curriculum 4: Skills for learning, skills for life and skills for work*
- *Building the Curriculum 5: A framework for assessment*
- *Course Specifications*
- Design Principles for National Courses
- *Guide to Assessment* (June 2008)
- *Principles and practice papers for sciences curriculum area*
- Science: A Portrait of current practice in Scottish Schools (2008)
- *Research Report 4 — Less is More: Good Practice in Reducing Assessment Time*
- Course*work Authenticity — a Guide for Teachers and Lecturers*
- *SCQF Handbook: User Guide (published 2009)* and SCQF level descriptors (to be reviewed during 2011 to 2012): www.sqa.org.uk/sqa/4595.html
- *SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work*
- SQA Guidelines on e-assessment for Schools
- SQA Guidelines on Online Assessment for Further Education
- SQA e-assessment web page: www.sqa.org.uk/sqa/5606.html

Administrative information

Published: June 2014 (version 1.0)

History of changes to Unit Support Notes

Unit details	Version	Description of change	Authorised by	Date

Unit Support Notes

Unit Support Notes — Researching Physics (Higher)

Please refer to the note of changes at the end of this document for details of changes from previous version (where applicable).

Introduction

These support notes are not mandatory. They provide advice and guidance on approaches to delivering and assessing the Researching Physics (Higher) Unit. They are intended for teachers and lecturers who are delivering this Unit. They should be read in conjunction with:

- the Unit *Specification*
- the *Course Specification*
- the *Course Assessment Specification*
- the *Course Support Notes*
- appropriate assessment support materials

General guidance on the Unit

Aims

The general aim of this Unit is to develop skills relevant to undertaking research in physics. Learners will collect and synthesise information from different sources, plan and undertake a practical investigation, analyse results and communicate information related to their findings. They will also consider any applications of the physics involved and implications for society/ the environment.

The Unit offers opportunities for collaborative and for independent learning. Learners will develop knowledge and skills associated with standard laboratory apparatus and in the recording and processing of results. The communication of findings will develop skills in scientific literacy.

Progression into this Unit

Entry to this Unit is at the discretion of the centre. However, learners would normally be expected to have attained the skills, knowledge and understanding required by the following or equivalent qualifications and/or experience:

- National 5 Physics Course

Skills, knowledge and understanding covered in this Unit

Information about skills, knowledge and understanding is given in the Higher Physics *Course Support Notes*.

If this Unit is being delivered on a free-standing basis, teachers and lecturers should cover the mandatory skills and key areas in ways which are most appropriate for delivery in their centres.

Progression from this Unit

This Unit may provide progression to:

- other qualifications in physics or related areas
- further study, employment and/or training

Approaches to learning and teaching

The purpose of this section is to give advice on approaches to assessment for the Unit. There will be other documents produced for centres to provide exemplification of assessments and guidance on how to write them.

Approaches to the assessment of a Unit when it forms part of a Course may differ from approaches to assessing the same Unit when it is not being delivered as part of a Course. If an integrated approach to Course delivery is chosen, then there may be opportunities for combining assessment across Units.

Assessments must be valid, reliable and fit for purpose for the subject and level, and should fit in with learning and teaching approaches.

Unit assessment should support learning and teaching and, where possible, enable personalisation and choice for learners in assessment methods and processes. Teachers and lecturers should select the assessment methods they believe are most appropriate, taking into account the needs of their learners and the requirements of the Unit.

There is no mandatory order for delivery of the Outcomes. These should be overtaken throughout the Unit and are an integral part of learning and teaching.

In this Unit learners will develop the key skills necessary to undertake research in physics and demonstrate the relevance to everyday life by exploring the physics behind a key area. Learners will develop skills associated with collecting and synthesising information from a number of different sources. Equipped with knowledge of standard laboratory apparatus, they will plan and undertake a practical investigation related to the key area. Learners will prepare a scientific communication presenting the aim, results and conclusions of their practical investigation.

Exemplar investigation briefs containing focus questions, will be provided in the National Assessment Resource and allows centres the opportunity to select a key area suited to the available resources and/or the interests of their learners. Centres may wish to develop their own investigation briefs but these must be of a comparable standard.

Outcome 1
Research briefs should allow learners to investigate the physics underlying a key area in more depth. The research brief should contain a number of focus questions relating to key points of background information or physics theory which are likely to be unfamiliar to learners undertaking the Unit. The focus questions should be constructed to give a clear indication of the information required from the learner. The information required to answer the questions must also be readily available using printed resources, video or audio materials available to the learner, or from websites which can be identified by use of a search engine. Learners must not be provided with extracts from any of these sources compiled by a third party. Prior to undertaking the assessment of Outcome 1, teachers/lecturers should ensure that learners have experience of literature-based research. In particular, if learners are carrying out web-based

research, then they should be familiar with issues of reliability and they should be able to clearly state the source of the information they find.

Outcome 2
Prior to carrying out the assessment of Outcome 2, learners should have had experience of planning and carrying out practical investigative work. Learners should be familiar with standard laboratory equipment to enable them to plan and carry out investigative practical work. Teachers/Lecturers may wish to introduce and demonstrate to learners any unfamiliar equipment that may be useful in carrying out the practical work.

Learners should take account of the following:

- Numerical results should be recorded in tables and graphs as appropriate. Headings and axes should be labelled and appropriate scales used.
- Lines of best fit to curves or straight lines should be drawn.
- Relationships should be expressed in the form $y = mx + c$ as appropriate and the gradient and intercept on the y-axis used to find m and c.
- Measurements should be repeated as appropriate and a mean value calculated.
- Scale-reading uncertainties should be estimated and expressed in absolute or percentage form.
- When measuring more than one physical quantity, the quantity with the largest percentage uncertainty should be identified and this can be used as an estimate of the percentage uncertainty in the final result.
- The final numerical result of an experiment should be expressed in the form: final value ± uncertainty

Teachers/lecturers should note that the external examination for this Course contains questions requiring learners to demonstrate their ability to design and evaluate experimental procedures in addition to questions which test a learner‘s ability to interpret experimental data. The bullet points listed give a clear indication of the likely contexts and data analysis techniques learners may be expected to employ.

Learners are likely to become familiar with the experimental techniques and basic laboratory apparatus whilst undertaking practical work associated with the other Units of the Higher Physics Course. The suggested activities indicated in the learning activities tables provide a rich variety of experimental and investigative experiences which would provide the background knowledge and experience required to allow learners to create appropriate experimental designs.

In order to be able to evaluate the procedures and draw valid conclusions from experimental data, learners should have an opportunity to analyse and discuss experimental data presented in a variety of formats.

Whilst centres are free to deliver this Unit at any point during the Higher Physics Course, the suggested activities associated with the other Units of the Course provide ample opportunity for learners to develop the skills required to undertake the activities in this Unit. Many teachers may wish to delay the Unit assessment until the latter stages of the Course in recognition of the considerable exposure to relevant experimental techniques and the development of research skills whilst undertaking the other Higher Physics Units.

Classroom management issues will probably dictate that much of the work in this Unit is undertaken through collaborative learning or group work. Working in this way can be extremely beneficial although consideration needs to be given to ensure that each individual contributes in an appropriate way, and meets the Assessment Standards.

For Outcome 1, it is possible for learners to work in groups and for them to allocate focus questions within the group. It is also possible for a group to produce a single report, as long as each individual clearly identifies the focus questions they have answered and the sources that they have used in answering the questions.

For Outcome 2, each learner must effectively contribute to the planning and carrying out of the investigation. If learners are working as part of a group, it is unlikely that they will take an equal or similar role in the investigation. Teachers/lecturers should exercise professional judgement in deciding if learners have taken an active part in the work.

Safety is integral to all practical work and learners should be encouraged to see risk assessment as a natural part of the planning process for any practical activity. Whilst learners would not be expected to produce a full written risk assessment themselves, the Outcome 2 provides an opportunity to assess risks and take informed decisions regarding the use of appropriate control measures during the planning stage of the practical experiment or investigation.

As with all practical investigative work in Science, centres must ensure that appropriate risk assessments have been carried out for all practical activities and must comply with current health and safety legislation and regulation.

General guidance on assessment

Outcome 1 is assessed by a written and/or oral report of the learner‘s review findings. The learner‘s report should be the result of his/her individual research into one of the focus questions contained in the investigation brief.

The learner‘s record should:

- contain an extract or summary of information relevant to a focus question provided in the briefing document
- mention at least two sources of relevant information. The precise format in which these reference sources are to be recorded is not prescribed and any format that would successfully allow the source to be retrieved by a third party is sufficient

Outcome 2 requires learners to take an active part in planning, designing and carrying out a practical investigation. Teachers/lecturers may find that observation and discussion with the learners is sufficient to allow them to exercise professional judgement in deciding that each learner has taken an active part in the planning and carrying out. In practice, the planning cycle is unlikely to be completed in a single stage. Rather, a preliminary plan may need to be modified in the light of initial practical work. In this way, planning and carrying out can be viewed as an iterative cycle in which the strategy for carrying out the investigation is developed as the work is undertaken.

If learners are working as part of a group, it is unlikely that they will take an equal or similar role in the investigation. Teachers/lecturers should exercise professional judgement in deciding if learners have taken an active part in the work.

Combining assessment within Units

See *Course Support Notes*.

Equality and inclusion

The *Course Support Notes* provide full information on equality and inclusion.

It is recognised that centres have their own duties under equality and other legislation and policy initiatives. The guidance given in these *Unit Support Notes* is designed to sit alongside these duties but is specific to the delivery and assessment of the Unit.

Alternative approaches to Unit assessment to take account of the specific needs of learners can be used. However, the centre must be satisfied that the integrity of the assessment is maintained and that the alternative approaches to assessment will, in fact, generate the necessary evidence of achievement.

Appendix 1: Reference documents

The following reference documents will provide useful information and background.

- Assessment Arrangements (for disabled learners and/or those with additional support needs) — various publications on SQA's website: http://www.sqa.org.uk/sqa/14976.html
- *Building the Curriculum 3: A framework for Learning and Teaching*
- *Building the Curriculum 4: Skills for learning, skills for life and skills for work*
- *Building the Curriculum 5: A framework for assessment*
- *Course Specifications*
- Design Principles for National Courses
- *Guide to Assessment* (June 2008)
- Principles and practice papers for sciences curriculum area
- Science: A Portrait of current practice in Scottish Schools (2008)
- Research Report 4 — Less is More: Good Practice in Reducing Assessment Time
- Coursework Authenticity — a Guide for Teachers and Lecturers
- *SCQF Handbook: User Guide (published 2009)* and SCQF level descriptors (to be reviewed during 2011 to 2012): www.sqa.org.uk/sqa/4595.html
- *SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work*
- SQA Guidelines on e-assessment for Schools
- SQA Guidelines on Online Assessment for Further Education
- SQA e-assessment web page: www.sqa.org.uk/sqa/5606.html

Administrative information

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History of changes to Unit Support Notes

Unit details	Version	Description of change	Authorised by	Date
	1.1	This Unit now has only 2 Outcomes. Outcome 3 deleted.	Qualifications Development Manager	June 2014