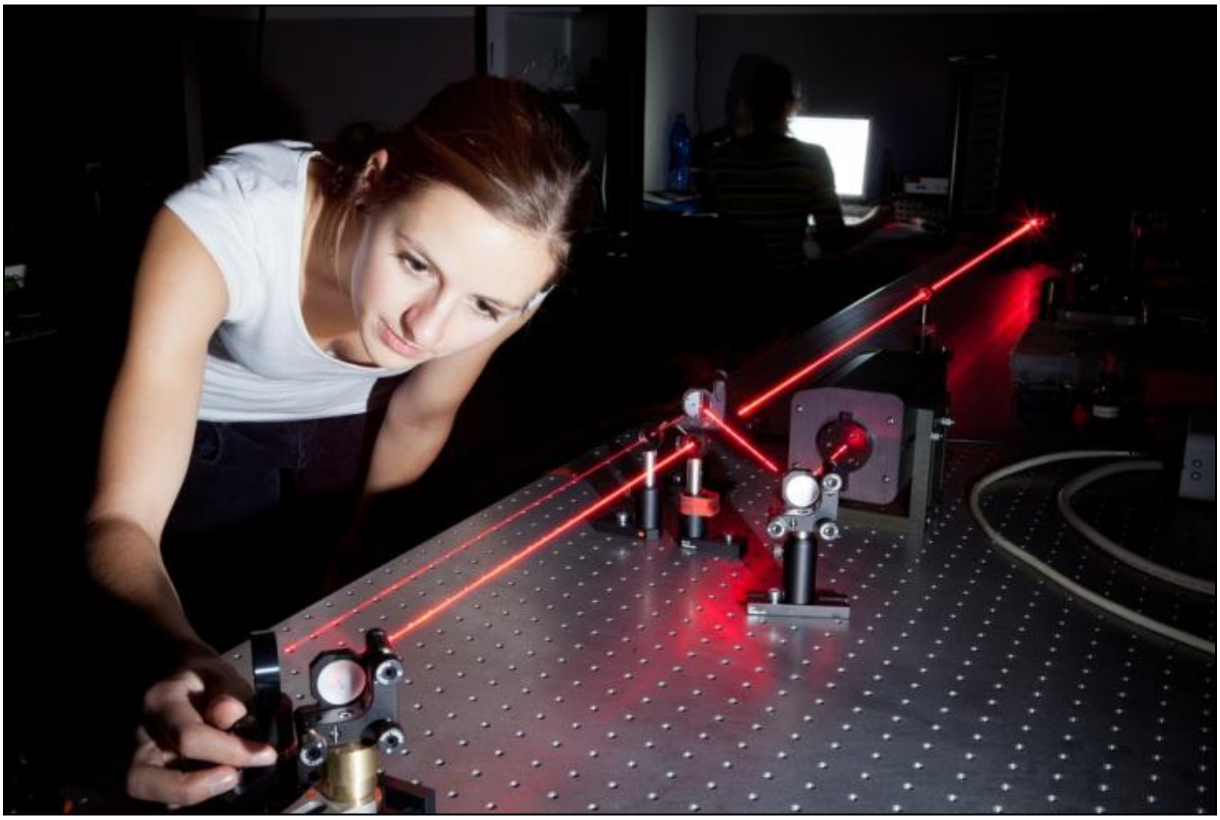
Course
Support
Notes

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** 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 Use of appropriate relationships to solve problems involving displacement, velocity and acceleration for objects moving with constant acceleration in a straight line. Interpretation and drawing of motion-time graphs for motion with constant acceleration in a straight line, including graphs for bouncing objects and objects thrown vertically upwards. Awareness of the interrelationship of displacement, velocity and acceleration-time graphs. Calculation of displacement, velocity and acceleration from appropriate graphs. All graphs restricted to constant acceleration in one dimension, inclusive of change of direction.	Practical experiments to verify the relationships shown in the equations. Use of light gates, motion sensors and software/hardware to measure displacement, velocity and acceleration. Use of software to analyse videos of motion. Use of motion sensors (including wireless sensors) to enable graphical representation of motion. Consideration of displacement-time graphs. Gradient is velocity. Consideration of velocity-time graphs. Area under graph is change in displacement during the selected time interval. Gradient is acceleration. Consideration of acceleration-time graphs. Investigation of the variation of acceleration on a slope with the angle of the slope. Consideration of motion of athletes and equipment used in sports. Investigation of the initial acceleration of an object projected vertically upwards (eg popper toy).	$d = \bar{v}t$ $s = \bar{v}t$ $v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $s = \frac{1}{2}(u + v)t$

	Investigation of objects in free-fall and the movement of objects on slopes.	
Forces, energy and power Use of appropriate relationships to solve problems involving balanced and unbalanced forces, mass, acceleration, and gravitational field strength. Awareness of the effects of friction on a moving object (no reference to static and dynamic friction.) Explanation, in terms of forces, of an object moving with terminal velocity. Interpretation of velocity-time graphs for a falling object when air resistance is taken into account. Use on Newton's first and second laws to explain the motion of an object. Use of free body diagrams and appropriate relationships to solve problems involving friction and tension (as a pulling force exerted by a string or cable). Resolution of a force into two perpendicular components, including the resolution of the weight of an object on a slope into component forces parallel and normal to the surface of the slope. Use of the principle of conservation of energy and appropriate relationships to solve problems involving work done, potential energy, kinetic energy and power.	Consideration of forces in rocket motion, jet engine, pile driving, and sport. Consideration of forces involved in space flight. Analysis of skydiving and parachuting, falling raindrops, scuba diving, lifts and haulage systems. Investigation into the effect of the cross sectional area of a falling object on its terminal velocity. Analysis of the motion of a rocket involving 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 Use of the principle of conservation of momentum and an appropriate relationship to solve problems involving the momentum, mass and velocity of objects interacting in one dimension. Knowledge of energy interactions involving the total kinetic energy of systems of objects undergoing inelastic collisions, elastic collisions and explosions. Use of appropriate relationships to solve problems involving the total kinetic energy of systems of interacting objects. Use of Newton's third law to explain the motion of objects involved in interactions. Interpretation of force-time graphs during contact of interacting objects. Knowledge that the impulse of a force is equal to the area under a force-time graph and is equal to the change in momentum of an object involved in the interaction. Use data from a force-time graph to solve problems involving the impulse of a force, the average force and its duration. Use of an appropriate relationship to solve problems involving the mass, change in velocity, average acting force and the duration of the force for an object involved in an interaction.	Investigation of the conservation of momentum and energy. Consideration of propulsion systems such as jet engines and rockets. Investigation of collisions using force sensors and data loggers. Consideration of forces in collisions involving hammers and pile drivers. Consideration of the role of crumple zones and airbags in car safety.	$p = mv$ $Ft = mv - mu$

Gravitation Knowledge that satellites are in free fall around a planet/star. Resolution of the initial velocity of a projectile into horizontal and vertical components and their use in calculations Use of appropriate relationships to solve problems involving projectiles. Knowledge that the horizontal motion and vertical motion of a projectile are independent of each other.	Use of software to analyse videos of projectiles. Consideration of low orbit and geostationary satellites Investigation of the use of satellites in communication, surveying and environmental monitoring of the conditions of the atmosphere. Consideration of Newton's thought experiment and an explanation of why satellites remain in orbit	
Use of Newton's Law of Universal Gravitation to solve problems involving, force, masses and their separation.	Consideration of methods for measuring the gravitational field strength on Earth Consideration of the use of the slingshot effect in space travel. Consideration of lunar and planetary orbits, the formation of the solar system by the aggregation of matter and stellar formation and collapse. Exploration of the status of our knowledge of gravity as a force. 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		

Knowledge that the speed of light in a vacuum is the same for all observers. Knowledge that measurements of space and time for a moving observer are changed relative to those for a stationary observer, giving rise to time dilation. Use of appropriate relationships to solve problems involving length contraction, time dilation and speed.	Consideration of 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. Use of suitable animations to study length contraction and time dilation. Consideration of experimental verification of SR including muon detection at the surface of the Earth and accurate time measurements on airborne clocks. Derivation of the time dilation equation 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 Knowledge that the Doppler effect causes shifts in wavelengths of sound and light. Use of an appropriate relationship to solve problems involving the observed frequency, source frequency, source speed and wave speed. Knowledge that the light from objects moving away from us is shifted to longer (more red) wavelengths. Knowledge that 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. Use of an appropriate relationship to solve	Investigation of the Doppler effect in terms of sound, for example the apparent change in frequency as a source moves towards or away from a stationary observer. Investigation of the apparent shift in frequency using a moving sound source and data logger. Consideration of applications including 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.) Consideration of parallax measurements and the data	$f = f_s\left(\frac{v}{v \pm v_s}\right)$

problems involving the Hubble constant, the recession velocity of a galaxy and its distance from us. Knowledge that Hubble’s law allows us to estimate the age of the Universe. Awareness of evidence supporting the expanding Universe theory. Knowledge that the mass of a galaxy can be estimated by the orbital speed of stars within it. Knowledge that evidence supporting the existence of dark matter comes from estimations of the mass of galaxies. Knowledge that evidence supporting the existence of dark energy comes from the accelerating rate of expansion of the Universe.	analysis of apparent brightness of standard candles in measuring distances to distant objects. Investigation of the inverse square law for light. Consideration of the units used by astronomers — lightyears and parsecs rather than SI units. Data analysis of measurements of galactic velocity and distance. Consideration of: ♦ Measurements of the velocities of galaxies and their distance from us leading to the theory of the expanding Universe. ♦ Gravity as the force which slows down the expansion. ♦ The eventual fate of the Universe depending on its mass-energy density. ♦ The orbital speed of the Sun and other stars giving a way of determining the mass of our galaxy. ♦ The Sun’s orbital speed being determined almost entirely by the gravitational pull of matter inside its orbit. ♦ Measurements of the mass of our galaxy and others leading to the conclusion that there is significant mass which cannot be detected — dark matter. ♦ Measurements of the expansion rate of the	$v = H_o d$

Knowledge that the temperature of stellar objects is related to the distribution of emitted radiation over a wide range of wavelengths. Knowledge that the wavelength of the peak wavelength of this distribution is shorter for hotter objects than for cooler objects. Awareness of the qualitative relationship between radiation emitted per unit surface area per unit time and the temperature of a star. Awareness of evidence supporting the big bang theory and subsequent expansion of the universe, for example cosmic microwave background radiation, the abundance of the elements hydrogen and helium, the darkness of the sky (Olbers' paradox) and the large number of galaxies showing redshift, rather than blueshift.	Universe leading 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. Use of the Hertzsprung-Russell diagram in the study of stellar evolution. Investigation of the temperature of hot objects using infrared sensors. Consideration of the change in colour of steel at high temperatures. Consideration of the history of cosmic microwave background (CMB) discovery and measurement and the COBE satellite. Consideration of other evidence for the big bang including the abundance of the elements hydrogen and helium, the darkness of the sky (Olbers' paradox) and 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 Use of orders of magnitude and awareness of the range of orders of magnitude of length from the very small (sub-nuclear) to the very large (distance to furthest known celestial objects). Knowledge of the standard model of fundamental particles and interactions. Awareness of evidence supporting the existence of sub-nuclear particles and the existence of antimatter. Knowledge that fermions, the matter particles, consist of quarks (six types) and leptons (electron, muon and tau, together with their neutrinos). Knowledge that hadrons are composite particles made of quarks that baryons are made of three quarks, and that mesons are made of quark-antiquark pairs. Knowledge that the force-mediating particles are bosons (photons, W- and Z-bosons, and gluons). Description of beta decay as the first evidence for the neutrino.	Consideration of the scale of our macro world compared to astronomical and sub-nuclear scales. Use of the sub-atomic Particle Zoo App (and toys). Consideration of the Higgs boson – history, discovery and implications. Consideration of the linking of electromagnetic, strong and weak forces, but not, as yet, of gravity. Consideration of experiments carried out in the LHC at CERN. Consideration of the uses of the PET scanner.	

Forces on charged particles Awareness that charged particles experience a force in an electric field. Knowledge that fields exist around charged particles and between charged parallel plates. Sketch of electric field patterns for single-point charges, systems of two-point charges and between two charged parallel plates. Knowledge of the direction of movement of charged particles in an electric field. Knowledge that the relationship between potential difference, work and charge gives the definition of the volt. Use of appropriate relationships to solve problems involving the charge, mass, speed and energy of a charged particle in an electric field and the potential difference through which it moves. Knowledge that a moving charge produces a magnetic field. Determination of the direction of the force on a charged particle moving in a magnetic field for negative and positive charges (for example, by using the right-hand rule for negative charges). Awareness of the basic operation of particle accelerators in terms of acceleration, deflection and collision of charged particles.	Consideration of electrostatic hazards, eg lightning and potential damage to microchips. Investigation of practical applications using electric fields, for example precipitators, Xerography, paint spraying, inkjet printing and electrostatic propulsion. Demonstration of electron beams using Teltron tubes. Consideration of: ♦ Accelerators, including linear accelerator, cyclotron and synchrotron. ♦ Medical applications of the cyclotron. The use of accelerators to investigate the structure of matter, for example the LHC at CERN.	$W = QV$ $E_k = \frac{1}{2}mv^2$

Nuclear reactions Use of nuclear equations to describe radioactive decay, fission and fusion reactions with reference to mass and energy equivalence. Use of an appropriate relationship to solve problems involving the mass loss and the energy released by a nuclear reaction. Awareness of coolant and containment issues in nuclear fusion reactors.	Comparison of the energy available from chemical and nuclear sources. Consideration of the magnetic containment of plasma, for example in the Joint European Torus (JET) and ITER tokamak.	$E = mc^2$
Wave particle duality Awareness of the photoelectric effect as evidence supporting the particulate model of light. Knowledge that photons of sufficient energy can eject electrons from the surface of materials. Use of an appropriate relationship to solve problems involving the frequency and energy of a photon. Knowledge that the threshold frequency is the minimum frequency of a photon required for photoemission. Knowledge that the work function of a material is the minimum energy required to cause photoemission. Use of an appropriate relationship to solve problems involving the maximum kinetic energy of photoelectrons, the threshold frequency of the material and the frequency of the photon.	Consideration of practical applications, for example 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 Knowledge that coherent waves have a constant phase relationship and have the same frequency, wavelength and velocity. Description of the conditions for constructive and destructive interference in terms of the phase difference between two waves. Knowledge that 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. Use of an appropriate relationship to solve problems involving the path difference between waves, wavelength and order number. Use of an appropriate relationship to solve problems involving grating spacing, wavelength, order number and angle to the maximum.	Investigation of interference patterns with microwaves, radio waves, sound, light and electrons. Consideration of practical applications, for example holography, the industrial imaging of surfaces in stress analysis and the coating of lenses in optical instruments. Observation of interference colours, for example in jewellery, petrol films or 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. Investigations using a grating leading to the relationship between the grating spacing, wavelength and angle to the maxima. Use of interferometers to measure small changes in path difference. Use of a spectroscope /spectrometer/ spectrophotometer to examine spectra from a number of light sources.	path diff = $m\lambda$ or $(m+\frac{1}{2})\lambda$ where m = 0, 1, 2 … $d\sin\theta = m\lambda$

Refraction of light Definition of absolute refractive index of a medium as the ratio of the speed of light in a vacuum to the speed of light in the medium. Use of an appropriate relationship to solve problems involving absolute refractive index, the angle of incidence and the angle of refraction. Use of an appropriate relationship to solve problems involving the angles of incidence and refraction, the wavelength of radiation in each medium and the speed of the radiation in each medium. (Including situations where light is travelling from a more dense to a less dense medium.) Awareness of the variation of refractive index with frequency. Knowledge of critical angle and of total internal reflection. Use of an appropriate relationship to solve problems involving critical angle and refractive index.	Examination optical instruments which use lenses. Consideration of applications of refraction, for example lens design, dispersion of signals in optical fibres/laser beams and colours seen in cut diamonds. Experiments involving semicircular blocks. Consideration of applications of total internal reflection, for example reflective road signs, prism reflectors (binoculars, periscopes, SLR cameras), and the use of 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 Knowledge that irradiance is the power per unit area incident on a surface. Use of an appropriate relationship to solve problems involving irradiance, the power of radiation incident on a surface and the area of the surface. Knowledge that irradiance is inversely proportional to the square of the distance from a point source. Use of an appropriate relationship to solve problems involving irradiance and distance from a point light source. Knowledge of the Bohr model of the atom. Awareness of the terms *ground state*, *energy levels*, *ionisation* and *zero potential energy* in relation to the Bohr model of the atom. Knowledge of the mechanism of production of line emission spectra, continuous emission spectra and absorption spectra in terms of electron energy level transitions. Use of appropriate relationships to solve problems involving energy levels and the frequency of the radiation emitted/absorbed. Awareness that the absorption lines in the spectrum of sunlight provide evidence for the composition of the Sun's upper atmosphere.	Consideration of parallax measurements and the data analysis of apparent brightness of standard candles in measuring distances to distant objects. Application to other e-m radiation (eg gamma radiation). Investigation of irradiance as a function of distance from a point light source. Comparison of irradiance as a function of distance from a point light source with irradiance as a function of distance from a laser. Examination of line and continuous spectra, for example from tungsten filament lamp, electric heater element, fluorescent tube, gas discharge tube or a salt in a Bunsen flame. Consideration of practical uses of spectroscopy, for example in extending our knowledge of space or in defining the definition of the standard unit of length.	$I = \frac{P}{A}$ $I = \frac{k}{d^2}$ $E_2 - E_1 = hf$ $E = hf$

Electricity		
Mandatory Course key areas	**Suggested learning activities**	**Exemplification of key areas**
Monitoring and measuring a.c. Knowledge that a.c. is a current which changes direction and instantaneous value with time. Use of appropriate relationships to solve problems involving peak and r.m.s. values. Determination of frequency, peak voltage and r.m.s. values from graphical data.	Use of a multimeter as an ammeter, voltmeter and ohmmeter. Use of an oscilloscope as a voltmeter and waveform monitor. Use of an oscilloscope to monitor a.c. signals, including the measurement of frequency and peak/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 of appropriate relationships to solve problems involving potential difference, current, resistance and power. Solutions may involve several steps. Use of appropriate relationships to solve problems involving potential divider circuits.	Investigation of 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.	$V = IR$ $P = IV = I^2R = \frac{V^2}{R}$ $R_T = R_1 + R_2 + \ ...$ $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + ...$ $V_2 = \left(\frac{R_2}{R_1 + R_2}\right)V_S$ $\quad \frac{V_1}{V_2} = \frac{R_1}{R_2}$

Electrical sources and internal resistance Knowledge of the terms *electromotive force (e.m.f.)*, *internal resistance* and *terminal potential difference (t.p.d.)*, *ideal supplies*, *short circuit* and *open circuit*. Use of an appropriate relationship to solve problems involving e.m.f., t.p.d., current and internal resistance. Determination of internal resistance and e.m.f. using graphical analysis.	Determination of the internal resistance of low voltage power supplies. Investigation of load matching. Maximum power is transferred when internal and external resistances are equal. Investigation of the variation of t.p.d. of a low voltage supply as a function of external resistance, including the addition of resistors connected in parallel with the supply.	$E = V + Ir$
Capacitors Definition of capacitance. Use of an appropriate relationship to solve problems involving capacitance, charge and potential difference. Knowledge that the total energy stored in a charged capacitor is the area under the charge against potential difference graph. Use of data from a charge against potential difference graph Use of appropriate relationships to solve problems involving energy, charge, capacitance and potential difference. Awareness of the variation of current and potential difference with time for both charging and discharging cycles of a capacitor in a CR circuit (charging and discharging curves). Awareness of the effect of resistance and capacitance on charging and discharging curves in a CR circuit.	Investigation of the charging/discharging of a capacitor using data loggers or other methods. Consideration of practical uses of capacitors, for example energy storage, flash bulbs, smoothing and suppressing and in 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 Knowledge that solids can be categorised into conductors, semiconductors or insulators by their ability to conduct electricity. Awareness of the terms *conduction band* and *valance band*. Qualitative explanation of the electrical properties of conductors, insulators and semiconductors using the electron population of the conduction and valance bands and the energy difference between the conduction and valance bands.	Consideration of conducting and insulating materials in terms of the electron population of the conduction band. Consideration of the breakdown voltage of an insulator, for example in the context of lightning. Investigation of the operation of a Hall effect sensor. Investigation of the variation in resistance of a negative temperature coefficient thermistor as a function of its temperature.	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.
p-n junctions Awareness that, during manufacture, the conductivity of semiconductors can be controlled, resulting in two types: p-type and n-type. Knowledge that, 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. Awareness of the terms *forward bias* and *reverse bias*. Knowledge that solar cells are p-n junctions designed so that a potential difference is produced when photons enter the layer. (This is known as the photovoltaic effect.) Knowledge that 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.	Investigation of the variation in the output voltage of a solar cell as a function of the irradiance and frequency of incident light. Investigation of 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
Appropriate use of units and prefixes. Use of the appropriate number of significant figures in final answers. Appropriate use of scientific notation.	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). 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. 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	
Awareness of random and systematic uncertainties in a measured quantity. Use of an appropriate relationship to determine the random uncertainty in a value using repeated measurements. Appropriate use of uncertainties in data analysis.	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. The random uncertainty is calculated by dividing the difference between the largest and smallest measured value by the number of trials. $\Delta x=(max-min)/n$ 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 Standard 2.2 for any one of the above three Units can be used as evidence of the achievement of Outcome 1 and Assessment Standard 2.2 for the other two Units of the Course.

Evidence of achievement of Outcome 1 and Outcome 2 in the Researching Physics Unit of Higher can be used as evidence of the achievement of Outcome 1 in the Our Dynamic Universe, Particles and Waves, and Electricity Units of Higher. There is no requirement to match Assessment Standards. However, the achievement of Outcome 1 in the Our Dynamic Universe, Particles and Waves, and Electricity Units of Higher **cannot** be used as evidence of the achievement of Outcome 1 and Outcome 2 in the Researching Physics Unit of Higher.

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

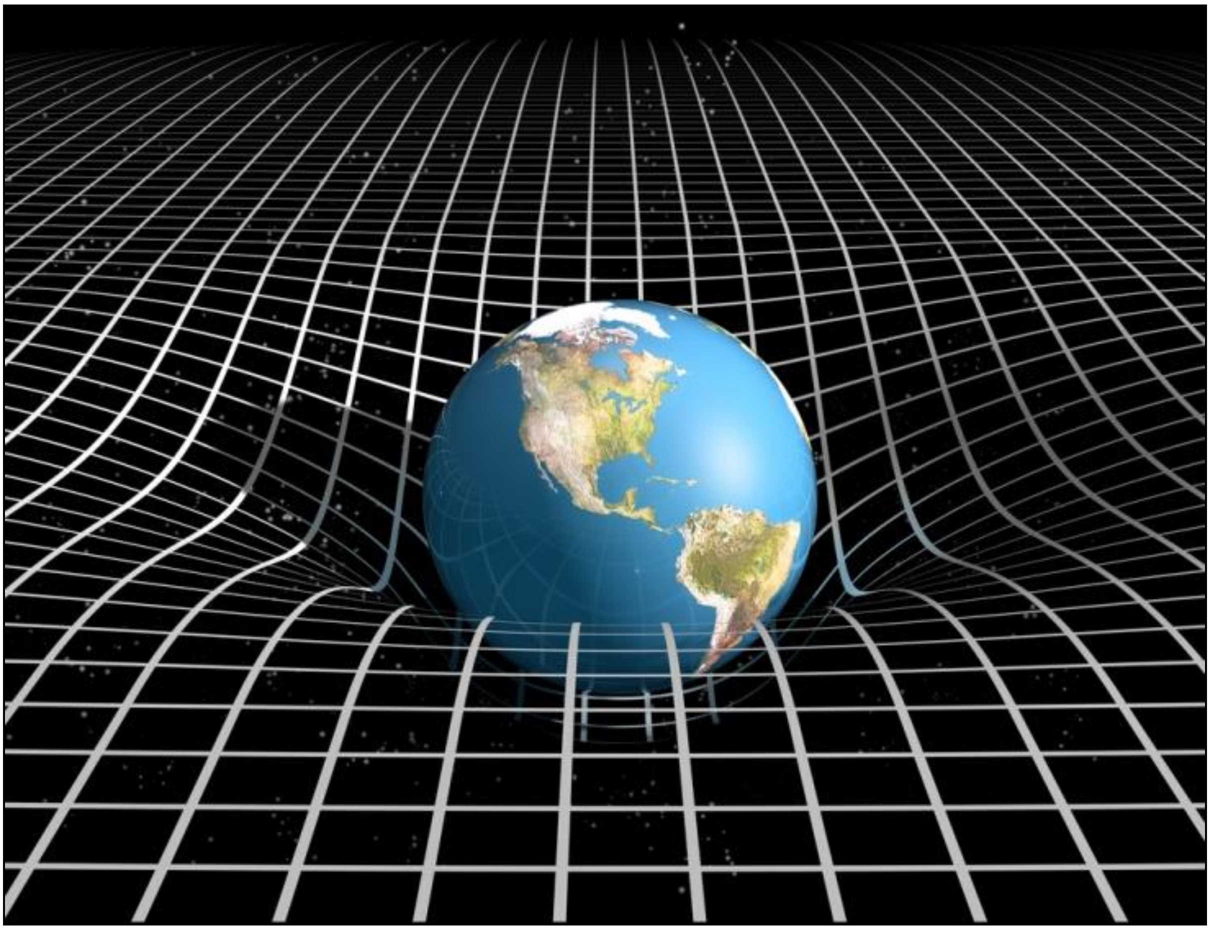
Published: May 2016 (version 3.1)

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
	2.0	Assessment Standard 2.2 & 2.3 removed	Qualifications Development Manager	June 2014
	3.0	In both the 'Mandatory Course key areas' column and the 'Suggested Learning Activities' column of table, detail has been added to increase clarity.	Qualifications Manager	May 2015
	3.1	Transfer of evidence has been amended — Achieving Outcome 1 and Outcome 2 in the *Researching Physics* Unit can be used as evidence of achieving Outcome 1 in *Our Dynamic Universe*, *Particles and Waves*, and *Electricity* Units of this Course. However the reverse does not apply.	Qualifications Manager	May 2016

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*
- Cours*ework 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

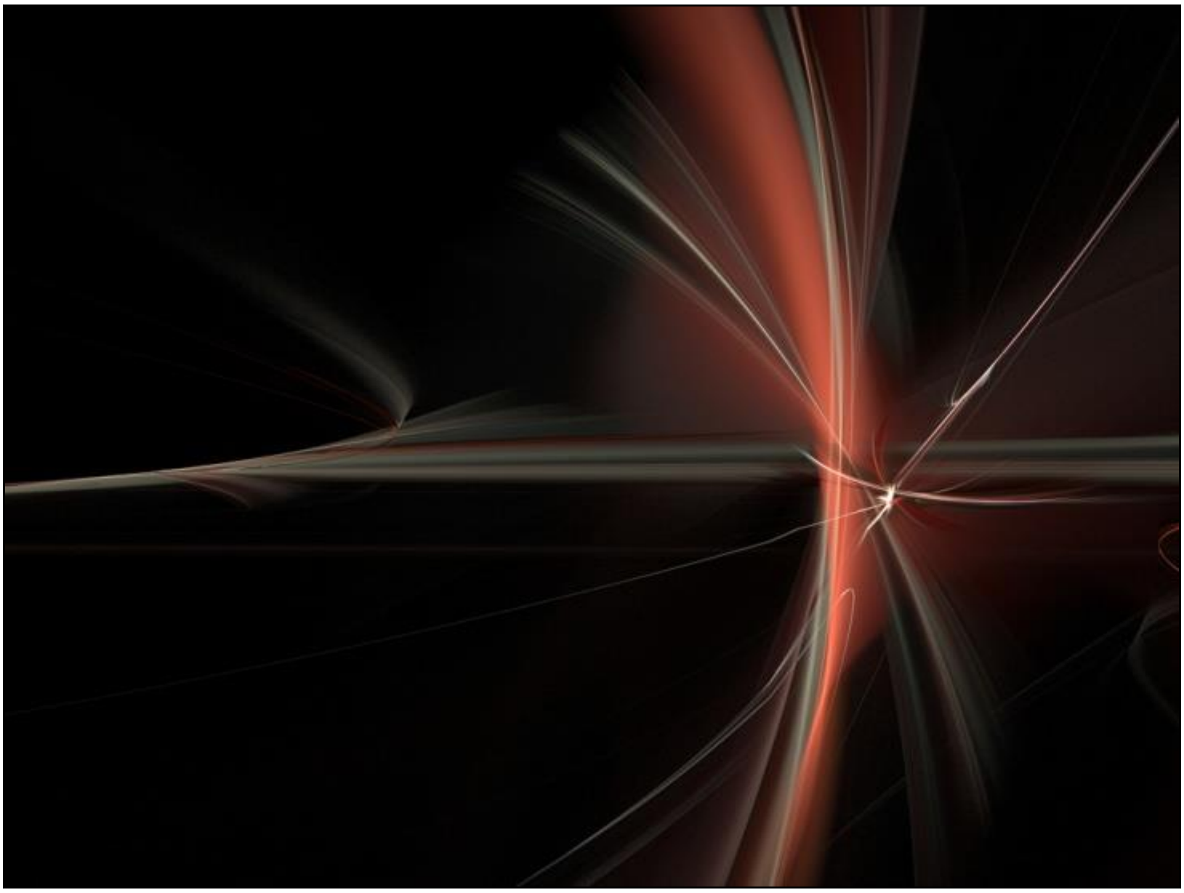
Published: June 2014 (version 1.0)

History of changes to Unit Support Notes

Unit details	Version	Description of change	Authorised by	Date

Unit Support Notes

Unit Support Notes — Physics: 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

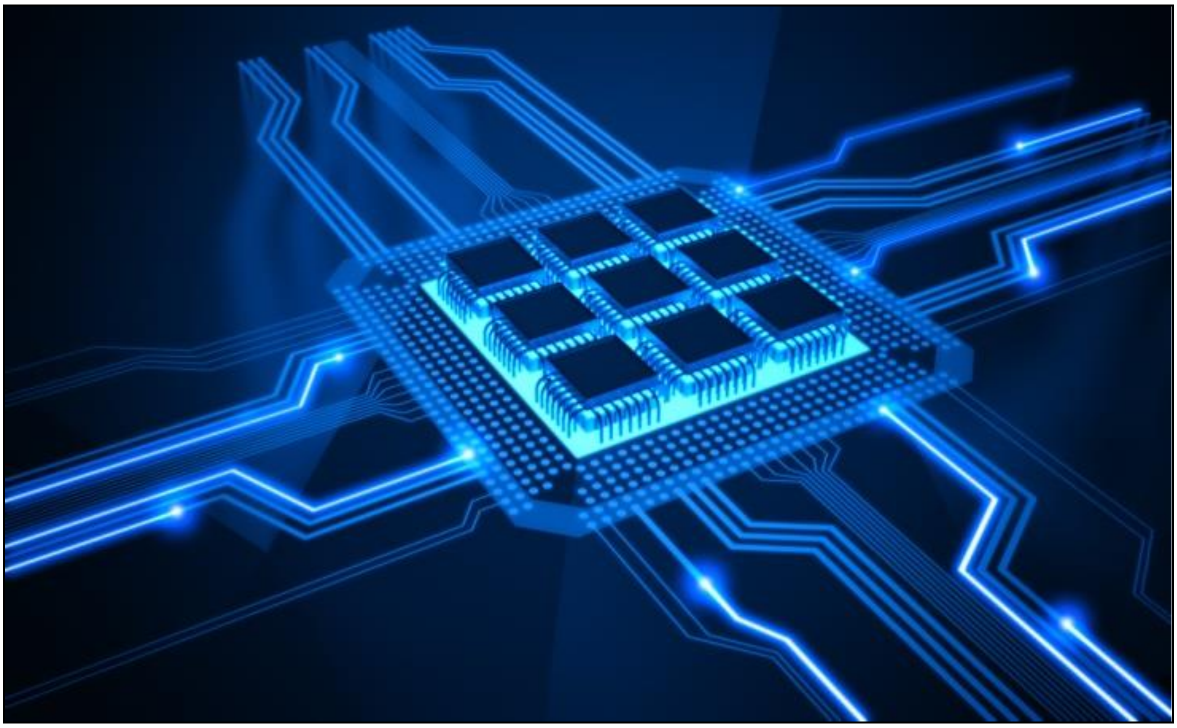
Published: June 2014 (version 1.0)

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
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- *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

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 — 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 small 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, to clearly show that each candidate has individually met the Assessment Standards.

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

Published: May 2016 (version 1.2)

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
	1.2	Clarification that candidates can work in small groups but each candidate must show that they have individually met the Assessment Standard.	Qualifications Manager	May 2016