PHYSICS (Revised)
Higher

Valid from August 2011

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National Course specification

Physics (Revised) Higher

C272 12

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Version: 01

Course structure

The Course has four mandatory Units.

FE42 12	*Our Dynamic Universe (H)*	1 credit (40 hours)
FE43 12	*Particles and Waves (H)*	1 credit (40 hours)
FE44 12	*Electricity (H)*	0.5 credit (20 hours)
FE45 12	*Researching Physics (H)*	0.5 credit (20 hours

All Courses include 40 hours over and above the 120 hours for component Units. This may be used for induction, extending the range of learning and teaching approaches, support, consolidation, integration of learning and preparation for external assessment.

Recommended entry

While entry is at the discretion of the centre, candidates will normally be expected to have the following:

- Standard Grade Physics with Knowledge and Understanding and Problem Solving at grade 1 or 2

or

- Intermediate 2 Physics

and

- Standard Grade Mathematics at 1 or 2 **or** Intermediate 2 Mathematics

Credit value

The Higher Course in Physics is allocated 24 SCQF credit points at SCQF level 6*.

**SCQF points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

National Course specification: (cont)

COURSE Physics (Revised) Higher

Core Skills

Core Skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about Core Skills is published in the Catalogue *Core Skills in National Qualifications (SQA, 2001)*.

National Course specification: Course details (cont)

COURSE Physics (Revised) Higher

Rationale

The Higher Physics Course has been designed to articulate with and provide progression from both the Standard Grade Physics and Intermediate 2 Physics Courses. Through a deeper insight into the structure of the subject, the Course aims to provide an opportunity for reinforcing and extending the candidate's knowledge and understanding of the concepts of Physics and developing the candidate's skills in investigative practical work.

The Course offers opportunities for collaborative and independent learning set within familiar and unfamiliar contexts and seeks to illustrate and emphasise situations where the principles of Physics are used and applied, thus promoting the candidate's awareness that Physics involves interaction between theory and practice. The resulting elements of knowledge and understanding and skills form the basis of the Higher Physics Course.

As a result of following a Higher Physics Course, candidates should acquire:

- an increased knowledge and understanding of facts and ideas, of techniques and of the applications of Physics in society
- skill in applying their knowledge and understanding in a wide variety of theoretical and practical problem solving contexts
- skills associated with carrying out experimental and investigative work in Physics and analysing the information obtained.

The study of Higher Physics should also foster an interest in current developments in, and applications of Physics, the willingness to make critical and evaluative comment, and the acceptance that Physics is a changing subject. Positive attitudes, such as being open-minded and willing to recognise alternative points of view, are promoted.

The Course endeavours to provide learning experiences leading to the acquisition of worthwhile knowledge, skills and attitudes which will assist candidates to make their own reasoned decisions on many issues within a modern society increasingly dependent on science and technology. The Course will also provide those who wish to proceed beyond Higher Physics with a suitable basis for further study.

National Course specification: Course details (cont)

COURSE Physics (Revised) Higher

Course content

The Course is made up of four mandatory Units: *Our Dynamic Universe, Particles and Waves, Electricity* and *Researching Physics*. The *Researching Physics* Unit is a skills development Unit equipping candidates with the investigative skills and reporting skills demanded by employers and Further and Higher Education. Whilst each of the four Units is valuable in its own right, candidates will gain considerable additional benefit from completing this Course, since there will be opportunities for the integration of skills developed through study of the Units, and for tackling problem solving of a more complex nature than that required for attainment of the Performance Criteria of the Units. The Content Tables included in the Unit specifications (not included with the *Researching Physics* Unit) describe what the candidate should be able to do in order to demonstrate the knowledge and understanding associated with the Course. External assessment will sample from across all of the topics of the Content Tables.

National Course specification: Course details (cont)

COURSE Physics (Revised) Higher

Assessment

To gain the award of the Course, the candidate must achieve all the component Units of the Course as well as the external assessment. External assessment will provide the basis for grading attainment in the Course award.

When Units are taken as component parts of a Course, candidates will have the opportunity to demonstrate achievement beyond that required to attain each of the Unit Outcomes. This attainment may, where appropriate, be recorded and used to contribute towards Course estimates, and to provide evidence for appeals. Additional details are provided, where appropriate, with the exemplar assessment materials. Further information on the key principles of assessment are provided in the paper *Assessment* (HSDU, 1996) and in *Managing Assessment* (HSDU, 1998).

Details of the instruments for external assessment

The instrument of assessment will be an externally set question paper of 2 hours 30 minutes duration. The question paper will sample the content and skills developed in all component Units. The question paper will consist of 20 objective questions (each worth 1 mark) and questions requiring:

- a short answer (a few words)
- a response in the form of a numerical calculation
- a restricted or open-ended response (a few sentences or paragraphs).

Candidates will be expected to answer all of the questions.

There will be a total of **90 marks** for the paper. Candidates will be expected to demonstrate that they have retained and can apply knowledge, and use it to explain observations and phenomena. They will also be expected to demonstrate that they have developed physics skills. Questions assessing both knowledge and understanding and skills may be set in a problem solving context.

Mark allocation to Knowledge and Understanding

Approximately **60 marks** will be allocated to questions that require candidates to demonstrate knowledge and understanding. A summary of the marks allocation to knowledge and understanding for the component Units is as follows.

Whole paper	60±5
Our Dynamic Universe	24±4
Particles and Waves	24±4
Electricity	12±2
Researching Physics	0

Assessment of knowledge and understanding will be based on the content as described in the Unit content tables (except for the *Researching Physics* Unit which is a skills based Unit and has no specified content).

The 60±5 marks allocated to knowledge and understanding will be allocated as follows:

a **Make accurate statements about Physics** 6±2 marks (All marks assessing the grade description at grade C.)
b **Use relationships to solve problems** 32±4 marks (Approximately two thirds of the marks assessing the grade description at grade C and approximately one third assessing at grade A.)
c **Use knowledge to explain observations and phenomena** 22±4 marks (Approximately one half of the marks assessing the grade description at grade C and approximately one half assessing at grade A.)

Notes:

- *Knowledge and understanding questions may be set in familiar or unfamiliar contexts.*
- *Knowledge and understanding questions may be included which assess depth of understanding in a problem solving context.*
- *Candidates will be required to demonstrate that they can integrate knowledge and understanding acquired through study of the component Units.*
- *Candidates will be required to demonstrate knowledge and understanding of uncertainties within the context of the content based component Units.*
- *There will be no knowledge and understanding questions set within the context of the Researching Physics Unit which is a skills based Unit and is content non-specific.*

Mark allocation to skills

Approximately **30 marks** will be allocated to questions that require candidates to demonstrate achievement of the skills as described in Outcome 2 for the three content based component Units and all three Outcomes for the *Researching Physics* Unit.

Approximately two thirds of the total marks allocated to skills will assess grade descriptions at grade C.

Approximately one third of the total marks allocated to skills will assess grade descriptions at grade A.

National Course specification: Course details (cont)

COURSE Physics (Revised) Higher

Grade Descriptions at A and C

Course assessment will be based on achievement of the Outcomes for the component Units but will differ from the Unit assessment in a number of regards. In undertaking the Course assessment, candidates will be expected to demonstrate that the knowledge and understanding and skills, which they acquired through their study of the component Units, have been retained, and can be integrated and applied in contexts which are less familiar and more complex than those associated with study of the Units.

The descriptions below indicate the nature of the achievement which is required for the award of a grade C and a grade A in the Course assessment.

Grade descriptions at 'C'

Candidates can:

- use the appropriate knowledge and understanding and skills acquired through the study of the component Units
- apply knowledge and understanding set in contexts similar to those associated with the component Units
- apply knowledge and understanding and skills to solve problems set in less familiar contexts.
- demonstrate the ability to integrate skills acquired in component Units to solve problems.

Grade descriptions at 'A'

Candidates can:

- solve problems in which the concepts and given information may not be specified in the Content Tables
- apply knowledge and understanding and use skills to solve problems which are less structured or are set in more complex contexts.

Quality Assurance

All National Courses are subject to external marking and/or verification. Externals Markers, visiting Examiners and Verifiers are trained by SQA to apply national standards.

The Units of all Courses are subject to internal verification and may also be chosen for external verification. This is to ensure that national standards are being applied across all subjects.

Courses may be assessed by a variety of methods. Where marking is undertaken by a trained Marker in their own time, Markers meetings are held to ensure that a consistent standard is applied. The work of all Markers is subject to scrutiny by the Examining team.

To assist centres, External Assessment reports and Internal Assessment reports are published on SQA's website **www.sqa.org.uk**.

National Course specification: Course details (cont)

COURSE Physics (Revised) Higher

Guidance on learning and teaching approaches for this Course

The learning and teaching of Physics are most effective when the concepts, principles and theories are set in a relevant context, eg by making reference to applications of Physics and to real-world situations. Appropriate contexts, applications, illustrations and activities relating to the content are provided in the Content Tables.

Practical activities provide opportunities to develop a wide range of skills associated with scientific enquiry and practical problem solving.

Suggested practical activities could include the following:

- Measuring a physical quantity, eg after a class discussion, candidates could be asked to design a circuit to determine the internal resistance of a cell. After completion of the experiment the readings and results could be analysed, the uncertainties discussed and the method evaluated.
- Demonstrating a physical law, eg candidates could be involved in the design of an experiment using a linear air track to illustrate the conservation of kinetic energy in an elastic collision.
- Testing a hypothesis, eg class discussion of the diffraction pattern using monochromatic light could lead to the hypothesis that decreasing the grating spacing increases the distance between maxima. Candidates can then design a suitable experiment to test this hypothesis.
- Open-ended investigative work, eg candidates use web-based research to learn that the suntan protection factor (SPF) of suncreams determines the absorption of UV radiation. They design an investigation to determine the relationship between SPF and absorption of UV.

The use of computers is a powerful aid to learning and experimenting. When interfaced to suitable sensors, the computer can assist investigations where readings have to be taken very rapidly or over a long time, or where several different variables have to be recorded simultaneously. Data obtained can be analysed and presented in graphical format.

Use of the additional 40 hours

This time may be used:

- to provide an introduction to the Course and assessment methods
- to allow candidates to develop their ability to integrate knowledge and understanding and skills acquired through the study of the different component Units
- to allow additional practical work, on an individual basis if appropriate, within the Units to enhance skills and understanding
- for consolidation and integration of learning
- for remediation
- for practice in examination techniques and preparation for the external examination.

National Course specification: Course details (cont)

COURSE Physics (Revised) Higher

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**

Higher Physics: Units, prefixes and uncertainties

The left hand column below details the content in which candidates should develop knowledge and understanding which should be applied in the context of all the component Units of the Course. The right hand column contains notes, which give further details of the content.

Content	Notes
1 Units, prefixes and scientific notation	
a) 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).
b) 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.
c) 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.
2 Uncertainties	
a) 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.
b) 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.

History of changes

Version	Description of change	Date

National Unit specification: general information

Unit title: Our Dynamic Universe (SCQF level 6)

Unit code: FE42 12

COURSE Physics (Revised) Higher

Superclass: RC

Publication date: December 2010

Source: Scottish Qualifications Authority

Version: 01

Summary

This Unit develops knowledge and understanding and skills in physics related to mechanics and astrophysics. The Unit offers opportunities for collaborative and independent learning set within familiar and unfamiliar contexts. It provides opportunities to develop and apply concepts and principles in a wide variety of situations involving forces and motion, as experienced on Earth and from an astronomical perspective. Activities are undertaken which develop experimental, investigative and analytical skills. This Unit is suitable for those who are interested in pursuing a physics related career, as well as those whose interest is more general.

Outcomes

1 Demonstrate and apply knowledge and understanding of mechanics and astrophysics.
2. Demonstrate skills of scientific experimentation, investigation and analysis in mechanics and astrophysics.

Recommended entry

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following, or equivalent:

- Standard Grade Physics with Knowledge and Understanding and Problem Solving at grade 1 or 2

or

- Intermediate 2 Physics

and

- Standard Grade Mathematics at 1 or 2 **or** Intermediate 2 Mathematics

General information (cont)

Unit title: Our Dynamic Universe (SCQF level 6)

Credit points and level

1 National Unit credit at SCQF level 6: (6 SCQF credit points at SCQF level 6*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Core Skills

Core Skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about Core Skills is published in the Catalogue of *Core Skills in National Qualifications (SQA, 2001)*.

National Unit specification: statement of standards

Unit title: Our Dynamic Universe (SCQF level 6)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

Outcome 1

Demonstrate and apply knowledge and understanding of mechanics and astrophysics.

Performance Criteria

(a) Make accurate statements about mechanics and astrophysics facts, concepts and relationships.
(b) Use relationships to solve mechanics and astrophysics problems.
(c) Use knowledge of mechanics and astrophysics to explain observations and phenomena.

Outcome 2

Demonstrate skills of scientific experimentation, investigation and analysis in mechanics and astrophysics.

Performance Criteria

(a) Use a range of data-handling skills in a scientific context.
(b) Use a range of skills related to experimental design.
(c) Use a range of skills related to the evaluation of scientific evidence.

Evidence Requirements for this Unit

Evidence is required to demonstrate that candidates have met the requirements of the Outcomes.

For each of the Unit Outcomes, written and/or recorded oral evidence of the appropriate level of achievement is required. This evidence must be produced under closed-book, supervised conditions within a time limit of 45 minutes.

The Instrument of Assessment must sample the content in each of the following areas:

- Equations of Motion
- Forces, energy and power
- Collisions and explosions
- Gravitation
- Special relativity
- The expanding universe
- Big Bang Theory

National Unit specification: statement of standards (cont)

Unit title: Our Dynamic Universe (SCQF level 6)

An appropriate Instrument of Assessment would be a closed-book, supervised test with a time limit of 45 minutes. Items in the test should cover all of the Performance Criteria associated with both Outcomes 1 and 2 and could be set in familiar or unfamiliar contexts.

Further detail on the breadth and depth of content is provided in the content tables included in this specification.

For Outcome 2, PC(a), candidates are required to demonstrate that they can use a range of data-handling skills. These skills include selecting, processing and presenting information. Information can be presented in a number of formats including: line graphs, scatter graphs, bar and pie charts, tables, diagrams and text.

For Outcome 2, PC(b), candidates are required to demonstrate they can use a range of skills associated with experimental design. These skills include planning, designing and evaluating experimental procedures.

For Outcome 2, PC(c), candidates are required to demonstrate they can use a range of skills associated with the evaluation of scientific evidence. These skills include drawing valid conclusions and making predictions.

The standard to be applied and the breadth of coverage are illustrated in the National Assessment Bank items available for this Unit. If a centre wishes to design its own assessments for this Unit they should be of a comparable standard.

National Unit specification: support notes

Unit title: Our Dynamic Universe (SCQF level 6)

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this Unit

The recommended content together with suggestions for possible contexts and activities to support and enrich learning and teaching are detailed in the appendix to this Unit specification.

This Unit builds on candidates' knowledge of forces and movement. The content covered in the early topics of the Unit is set in familiar contexts. The equations of motion, motion-time graphs and resolving vectors are studied. After extending the work to include forces, energy, power and momentum, candidates continue their study by considering motion in space. Satellites and gravitation introduce the astrophysics section. The effects of motion at high speed are considered in an introduction to special relativity. Evidence for the expanding universe and the origin of the universe completes the topics covered in the Unit.

This Unit offers a wide variety of contexts and opportunities for practical work as highlighted in the ‘Contexts’ column of the content tables. Opportunities exist for candidates to learn as part of a group through practical work undertaken in partnership or in teams.

Guidance on learning and teaching approaches for this Unit

General advice on approaches to learning and teaching is contained in the Course specification.

Opportunities for developing Core Skills

This Unit provides opportunities to develop *Communication, Numeracy, Information and Communication Technology* and *Problem Solving* skills in addition to providing contexts and activities within which the skills associated with *Working with Others* can be developed.

Outcome 1, PC(b) and (c) develop a candidate’s ability to communicate effectively key concepts and to explain clearly physics concepts in written media.

Within this Unit candidates will need to extract and process information presented in both tabular and graphical formats developing the Core Skill of *Numeracy*. Candidates will gain experience in a range of calculations building competence in number.

The Content Table, included in this Unit Specification contains a column labelled ‘Contexts’ which include a large number of web based activities, computer simulations and modelling opportunities which all serve to develop higher levels of competence in the key *ICT* skills including; accessing information and providing/creating information. Also included are suggestions for practical investigations which provide candidates with the opportunity of working co-operatively with others.

National Unit specification: support notes (cont)

Unit title: Our Dynamic Universe (SCQF level 6)

Problem Solving skills are central to the sciences and are assessed through Outcome 1, PCs (b) and (c) and also through Outcome 2, PCs (a), (b) and (c).

Guidance on approaches to assessment for this Unit

Outcomes 1 and 2

It is recommended that an holistic approach is taken for assessment of these Outcomes. Outcomes 1 and 2 can be assessed by an integrated end of Unit test with questions covering all the Performance Criteria. Within one question, assessment of knowledge and understanding and skills of experimentation, investigation and analysis can occur. Each question can address a number of Performance Criteria from either Outcome 1 or 2.

Appropriate assessment items are available from the National Assessment Bank.

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003), SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**

National Unit specification: content tables

Unit title: Our Dynamic Universe (SCQF level 6)

The left hand column below details the content in which candidates should develop knowledge and understanding. The middle column contains notes, which give further details of the content.

The right-hand column gives suggested contexts in which knowledge and understanding and skills can be developed.

Content	Notes	Contexts
1 Equations of Motion		
a) Equations of motion for objects with constant acceleration in a straight line.	Candidates should undertake 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.
b) Motion-time graphs for motion with constant acceleration.	Displacement-time graphs. Gradient is velocity. Velocity-time graphs. Area under graph is displacement. Gradient is acceleration. Acceleration-time graphs. Restricted to zero and constant acceleration. Graphs for bouncing objects and objects thrown vertically upwards.	Motion sensors (including wireless sensors) to enable graphical representation of motion.
c) Motion of objects with constant speed or constant acceleration.	Objects in freefall and the movement of objects on slopes should be investigated.	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)

National Unit specification: content tables (cont)

Unit title: Our Dynamic Universe (SCQF level 6)

Content	Notes	Contexts
2 Forces, energy and power		
a) Balanced and unbalanced forces. The effects of friction. Terminal velocity.	Forces acting in one dimension only. Analysis of motion using Newton's First and Second Laws. Friction as a force acting in a direction to oppose motion. 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 falling object when air resistance is taken into account, including changing the surface area of the falling object. Analysis of the motion of a rocket may involve a constant force on a changing mass as fuel is used up.	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.
b) Resolving a force into two perpendicular components.	Forces acting at an angle to the direction of movement. The weight of an object on a slope can be resolved into a component acting down the slope and a component acting normal to the slope. Systems of balanced and unbalanced forces with forces acting in two dimensions.	Vehicles on a slope and ski tows, structures in equilibrium, eg supported masts.
c) Work done, potential energy, kinetic energy and power.	Work done as transfer of energy. Conservation of energy.	Investigating energy lost in bouncing balls. Rollercoasters, objects in freefall. Energy and moving vehicles.

National Unit specification: content tables (cont)

Unit title: Our Dynamic Universe (SCQF level 6)

Content	Notes	Contexts
3 Collisions and explosions		
a) Elastic and inelastic collisions.	Conservation of momentum in one dimension and in which the objects may move in opposite directions. Kinetic energy in elastic and inelastic collisions.	Investigations of conservation of momentum and energy.
b) Explosions and Newton's Third Law.	Conservation of momentum in explosions in one dimension only.	Propulsion systems – jet engines and rockets
c) Impulse.	Force-time graphs during contact of colliding objects. Impulse can be found from the area under a force-time graph.	Investigating collisions using force sensors and dataloggers. Hammers and pile drivers. Car safety, crumple zones and air bags.
4 Gravitation		
a) 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. Newton's thought experiment and an explanation of why satellites remain in orbit.	Using software to analyse videos of projectiles Low orbit and geostationary satellites. Satellite communication and surveying. Environmental monitoring of the conditions of the atmosphere.
b) Gravity and mass.	Gravitational Field Strength of planets, natural satellites and stellar objects. 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 gravity assist to travel in space. Lunar and planetary orbits. Formation of the solar system by the aggregation of matter.

National Unit specification: content tables (cont)

Unit title: Our Dynamic Universe (SCQF level 6)

Content	Notes	Contexts
		Stellar formation and collapse. The status of our knowledge of the force of gravity may be explored. The other fundamental forces have been linked but there is as yet no unifying theory to link them to gravity.
5 Special relativity		
a) Introduction to special relativity.	Relativity introduced through Galilean Invariance, Newtonian Relativity and the concept of absolute space. Experimental and theoretical considerations (details not required) lead to the conclusion that the speed of light is the same for all observers. The constancy of the speed of light led Einstein to postulate that space and time for a moving object are changed relative to a stationary observer. Length contraction and time dilation.	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.

National Unit specification: content tables (cont)

Unit title: Our Dynamic Universe (SCQF level 6)

Content	Notes	Contexts
6 The expanding Universe		
a) The Doppler Effect and redshift of galaxies.	The Doppler Effect is observed in sound and light. For sound, the apparent change in frequency as a source moves towards or away from a stationary observer should be investigated. The Doppler Effect causes similar shifts in wavelengths of light. The light from objects moving away from us is shifted to longer wavelengths — redshift. The redshift of a galaxy is the change in wavelength divided by the emitted wavelength. For galaxies moving at non-relativistic speeds, redshift is the ratio of the velocity of the galaxy to the velocity of light. (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.)	Doppler Effect in terms of terrestrial sources eg passing ambulances. Investigating the apparent shift in frequency using a moving sound source and datalogger. Applications include measurement of speed (radar), echocardiogram and flow measurement.
b) Hubble's Law.	Hubble's Law shows the relationship between the recession velocity of a galaxy and its distance from us. Hubble's Law leads to an estimate of 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.

National Unit specification: content tables (cont)

Unit title: Our Dynamic Universe (SCQF level 6)

Content	Notes	Contexts
c) Evidence for the expanding 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. 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.	In practice, the units used by astronomers include light-years and parsecs rather than SI units. Data analysis of measurements of galactic velocity and distance. The revival of Einstein's cosmological constant in the context of the accelerating universe.

National Unit specification: content tables (cont)

Unit title: Our Dynamic Universe (SCQF level 6)

Content	Notes	Contexts
7 Big Bang Theory		
a) The temperature of stellar objects.	Stellar objects emit radiation over a wide range of wavelengths. Although the distribution of energy is spread over a wide range of wavelengths, each object emitting radiation has a peak wavelength which depends on its temperature. The peak wavelength is shorter for hotter objects than for cooler objects. Also, hotter objects emit more radiation per unit surface area at all wavelengths than cooler objects. Thermal emission peaks allow the temperature of stellar objects to be measured.	Remote sensing of temperature. Investigating the temperature of hot objects using infrared sensors. Change in colour of steel at high temperatures. Furnaces and kilns.
b) Evidence for the Big Bang.	The Universe cools down as it expands. The peak wavelength of cosmic microwave background allows the present temperature of the Universe to be determined. This temperature corresponds to that predicted after the Big Bang, taking into account the subsequent expansion and cooling of the Universe.	History of Cosmic Microwave Background (CMB) discovery and measurement. COBE satellite. Other evidence for the Big Bang includes the observed abundance of the elements hydrogen and helium and the darkness of the sky (Olber's Paradox).

History of changes to Unit

Version	Description of change	Date

National Unit specification: general information

Unit title: Particles and Waves (SCQF level 6)

Unit code: FE43 12

COURSE Physics (Revised) Higher

Superclass: RC

Publication date: December 2010

Source: Scottish Qualifications Authority

Version: 01

Summary

This Unit develops knowledge and understanding and skills in physics related to sub-atomic physics and waves. The Unit offers opportunities for collaborative and independent learning set within familiar and unfamiliar contexts. It provides opportunities to develop and apply concepts and principles in a wide variety of situations involving the study of particle physics and waves, with wave-particle duality as a linking theme. Activities are undertaken which develop experimental, investigative and analytical skills. This Unit is suitable for those who are interested in pursuing a physics related career, as well as those whose interest is more general.

Outcomes

1 Demonstrate and apply knowledge and understanding of sub-atomic physics and waves.
2. Demonstrate skills of scientific experimentation, investigation and analysis in sub-atomic physics and waves.

Recommended entry

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following, or equivalent:

- Standard Grade Physics with Knowledge and Understanding and Problem Solving at grade 1 or 2

or

- Intermediate 2 Physics

and

- Standard Grade Mathematics at 1 or 2 **or** Intermediate 2 Mathematics

General information (cont)

Unit title: Particles and Waves (SCQF level 6)

Credit points and level

1 National Unit credit at SCQF level 6: (6 SCQF credit points at SCQF level 6*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Core Skills

Core Skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about Core Skills is published in the Catalogue of *Core Skills in National Qualifications (SQA, 2001)*.

National Unit specification: statement of standards

Unit title: Particles and Waves (SCQF level 6)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

Outcome 1

Demonstrate and apply knowledge and understanding of sub-atomic physics and waves.

Performance Criteria

(a) Make accurate statements about sub-atomic physics and waves facts, concepts and relationships.
(b) Use relationships to solve sub-atomic physics and waves problems.
(c) Use knowledge of sub-atomic physics and waves to explain observations and phenomena.

Outcome 2

Demonstrate skills of scientific experimentation, investigation and analysis in sub-atomic physics and waves.

Performance Criteria

(a) Use a range of data-handling skills in a scientific context.
(b) Use a range of skills related to experimental design.
(c) Use a range of skills related to the evaluation of scientific evidence.

Evidence Requirements for this Unit

Evidence is required to demonstrate that candidates have met the requirements of the Outcomes.

For each of the Unit Outcomes, written and/or recorded oral evidence of the appropriate level of achievement is required. This evidence must be produced under closed-book, supervised conditions within a time limit of 45 minutes.

The Instrument of Assessment must sample the content in each of the following areas:

- The Standard Model
- Forces on Charged Particles
- Nuclear Reactions
- Wave Particle Duality
- Interference and Diffraction
- Refraction of Light
- Spectra

National Unit specification: statement of standards (cont)

Unit title: Particles and Waves (SCQF level 6)

An appropriate Instrument of Assessment would be a closed-book, supervised test with a time limit of 45 minutes. Items in the test should cover all of the Performance Criteria associated with both Outcomes 1 and 2 and could be set in familiar or unfamiliar contexts.

Further detail on the breadth and depth of content is provided in the content tables included in this specification.

For Outcome 2, PC(a), candidates are required to demonstrate that they can use a range of data-handling skills. These skills include selecting, processing and presenting information. Information can be presented in a number of formats including: line graphs, scatter graphs, bar and pie charts, tables, diagrams and text.

For Outcome 2, PC(b), candidates are required to demonstrate they can use a range of skills associated with experimental design. These skills include planning, designing and evaluating experimental procedures.

For Outcome 2, PC(c), candidates are required to demonstrate they can use a range of skills associated with the evaluation of scientific evidence. These skills include drawing valid conclusions and making predictions.

The standard to be applied and the breadth of coverage are illustrated in the National Assessment Bank items available for this Unit. If a centre wishes to design its own assessments for this Unit they should be of a comparable standard.

National Unit specification: support notes

Unit title: Particles and Waves (SCQF level 6)

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this Unit

The recommended content together with suggestions for possible contexts and activities to support and enrich learning and teaching are detailed in the appendix to this Unit specification.

This Unit builds on candidates' knowledge of the sub-atomic world and phenomena which exhibit wave properties. The link between the two topics is wave-particle duality. The Unit starts by introducing the Standard Model of Fundamental Particles and Interactions and continues with a consideration of the forces on charged particles. Particle detectors and accelerators are studied, followed by consideration of nuclear fusion and fission. After the photoelectric effect has been covered, the Unit concludes with topics on interference, diffraction, refraction and spectra.

This Unit offers a wide variety of contexts and opportunities for practical work as highlighted in the ‘Contexts’ column of the content tables. Opportunities exist for candidates to learn as part of a group through practical work undertaken in partnership or in teams.

Guidance on learning and teaching approaches for this Unit

General advice on approaches to learning and teaching is contained in the Course specification.

Opportunities for developing Core Skills

This Unit provides opportunities to develop *Communication, Numeracy, Information and Communication Technology* and *Problem Solving* skills in addition to providing contexts and activities within which the skills associated with *Working with Others* can be developed.

Outcome 1, PC(b) and (c) develop a candidate’s ability to communicate effectively key concepts and to explain clearly physics concepts in written media.

Within this Unit candidates will need to extract and process information presented in both tabular and graphical formats developing the Core Skill of *Numeracy*. Candidates will gain experience in a range of calculations building competence in number.

The Content Table, included in this Unit Specification contains a column labelled ‘Contexts’ which include a large number of web based activities, computer simulations and modelling opportunities which all serve to develop higher levels of competence in the key *ICT* skills including; accessing information and providing/creating information. Also included are suggestions for practical investigations which provide candidates with the opportunity of working co-operatively with others.

National Unit specification: support notes

Unit title: Particles and Waves (Higher)

Problem Solving skills are central to the sciences and are assessed through Outcome 1, PCs (b) and (c) and also through Outcome 2, PCs (a), (b) and (c).

Guidance on approaches to assessment for this Unit

Outcomes 1 and 2

It is recommended that an holistic approach is taken for assessment of these Outcomes. Outcomes 1 and 2 can be assessed by an integrated end of Unit test with questions covering all the Performance Criteria. Within one question, assessment of knowledge and understanding and skills of experimentation, investigation and analysis can occur. Each question can address a number of Performance Criteria from either Outcome 1 or 2.

Appropriate assessment items are available from the National Assessment Bank.

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003), SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**

National Unit specification: content tables

Unit title: Particles and Waves (SCQF level 6)

The left hand column below details the waves content in which candidates should develop knowledge and understanding. The middle column contains notes, which give further details of the content.

The right-hand column gives suggested contexts in which knowledge and understanding and skills can be developed.

Content	Notes	Contexts
1 The Standard Model		
a) 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 scale of our macro world compared to astronomical and sub-nuclear scales.
b) The Standard Model of Fundamental Particles and Interactions.	The evidence for the sub-nuclear particles and the existence of antimatter. Fermions, the matter particles, consist of Quarks (6 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 two Quarks. The force mediating particles are bosons (Photons, W and Z Bosons, and Gluons). Description of beta decay as the first evidence for the neutrino.	Gravity, electromagnetic, strong and weak forces. LHC at CERN. PET scanner.

National Unit specification: content tables (cont)

Unit title: Particles and Waves (SCQF level 6)

Content	Notes	Contexts
2 Forces on charged particles		
a) Electric fields around charged particles and between parallel plates.	Examples of electric field patterns include single point charges, systems of two point charges and the field between parallel plates. No calculation of electric field strength required.	Hazards, eg lightning, static electricity on microchips.
b) Movement of charge in an electric field, p.d. and work, electrical energy.	The relationship between potential difference, work and charge gives the definition of the volt. Calculating the speed of a charged particle accelerated in an electric field.	Precipitators. Xerography. Paint spraying. Ink jet printing. Electrostatic propulsion.
c) Charged particles in a magnetic field.	A moving charge produces a magnetic field. The direction of the force on a charged particle moving in a magnetic field should be described for negative and positive charges (right hand rule for negative charges). No calculations required.	
d) Particle accelerators.	Basic operation of particle accelerators in terms of acceleration, deflection and collision of charged particles.	Accelerators include linear accelerator, cyclotron and synchroton. Medical applications of cyclotron. Accelerators used to probe structure of matter.

National Unit specification: content tables (cont)

Unit title: Particles and Waves (SCQF level 6)

Content	Notes	Contexts
3 Nuclear Reactions		
a) Fission and fusion.	Nuclear equations to describe radioactive decay and fission and fusion reactions. 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
4 Wave Particle Duality		
a) The photoelectric effect and 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 is the minimum energy required to cause photoemission. The maximum kinetic energy of photoelectrons can be determined.	Light meters in cameras, channel plate image intensifiers, photomultipliers.

National Unit specification: content tables (cont)

Unit title: Particles and Waves (SCQF level 6)

Content	Notes	Contexts
5 Interference and diffraction		
a) 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 patterns with microwaves, radio waves, sound, light and electrons. Holography. Industrial imaging of surfaces-curvature and stress analysis.
b) 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. Investigations which lead to the relationship between the wavelength, distance between the sources, distance from the sources and the spacing between maxima or minima.	Lens blooming. Interference colours (jewellery, petrol films, soap bubbles).
c) Gratings	Monochromatic light can be used with a grating to investigate the relationship between the grating spacing, wavelength and angle to the maxima. A white light source may be used with a grating to produce spectra. Compare the spectra produced by gratings and prisms.	Interferometers to measure small changes in path difference. Use a spectroscope/ spectrometer/spectrophotometer to examine spectra from a number of light sources.

National Unit specification: content tables (cont)

Unit title: Particles and Waves (SCQF level 6)

Content	Notes	Contexts
6 Refraction of light		
a) Refraction.	Refractive index of a material as 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. Investigations should include situations where light travels from a more dense to a less dense substance. Refractive index as the ratio of speed of light in vacuum (air) to the speed in the material. Also as the ratio of the wavelengths. Variation of refractive index with frequency.	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.
b) Critical angle and total internal reflection.	Investigating total internal reflection, including critical angle and its relationship with refractive index.	Semicircular blocks. Reflective road signs, prism reflectors (binoculars, periscopes, SLR cameras). Optical fibres for communications, medicine and sensors.

National Unit specification: content tables (cont)

Unit title: Particles and Waves (SCQF level 6)

Content	Notes	Contexts
7 Spectra		
a) Irradiance and the inverse square law.	Investigating irradiance as a function of distance from a point light source. Irradiance as power per Unit area.	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.
b) Line and continuous emission spectra, absorption spectra and energy level transitions.	The Bohr model of the atom. Electrons can be excited to higher energy levels by an input of energy. Ionisation level is the level at which an electron is free from the atom. Zero potential energy is defined as equal to that of the ionisation level, implying that other energy levels have negative values. The lowest energy level is the ground state. A photon is emitted when an electron moves to a lower energy level and its frequency depends on the difference in energy levels. Planck's constant is the constant of proportionality. Absorption lines in the spectrum of sunlight as evidence for the composition of the Sun's upper atmosphere.	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 time. Lasers.

History of changes to Unit

Version	Description of change	Date

National Unit specification: general information

Unit title: Electricity (SCQF level 6)

Unit code: FE44 12

COURSE Physics (Revised) Higher

Superclass: RC

Publication date: December 2010

Source: Scottish Qualifications Authority

Version: 01

Summary

This Unit develops knowledge and understanding and skills in physics related to electricity. The Unit offers opportunities for collaborative and independent learning set within familiar and unfamiliar contexts. It provides opportunities to develop and apply concepts and principles in a wide variety of situations involving the study of electrical circuits and semiconductors. Activities are undertaken which develop experimental, investigative and analytical skills. This Unit is suitable for those who are interested in pursuing a physics related career, as well as those whose interest is more general.

Outcomes

1 Demonstrate and apply knowledge and understanding of electricity.
2. Demonstrate skills of scientific experimentation, investigation and analysis in electricity.

Recommended entry

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following, or equivalent:

- Standard Grade Physics with Knowledge and Understanding and Problem Solving at grade 1 or 2

or

- Intermediate 2 Physics

and

- Standard Grade Mathematics at 1 or 2 **or** Intermediate 2 Mathematics

General information (cont)

Unit title: Electricity (Higher)

Credit points and level

0.5 National Unit credit at SCQF level 3: (6 SCQF credit points at SCQF level 6*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Core Skills

Core Skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about Core Skills is published in the Catalogue of *Core Skills in National Qualifications (SQA, 2001)*.

National Unit specification: statement of standards

Unit title: Electricity (SCQF level 6)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

Outcome 1

Demonstrate and apply knowledge and understanding of electricity.

Performance Criteria

(a) Make accurate statements about electricity facts, concepts and relationships.
(b) Use relationships to solve electricity problems.
(c) Use knowledge of electricity to explain observations and phenomena.

Outcome 2

Demonstrate skills of scientific experimentation, investigation and analysis in electricity.

Performance Criteria

(a) Use a range of data-handling skills in a scientific context.
(b) Use a range of skills related to experimental design.
(c) Use a range of skills related to the evaluation of scientific evidence.

Evidence Requirements for this Unit

Evidence is required to demonstrate that candidates have met the requirements of the Outcomes.

For each of the Unit Outcomes, written and/or recorded oral evidence of the appropriate level of achievement is required. This evidence must be produced under closed-book, supervised conditions within a time limit of 45 minutes.

The Instrument of Assessment must sample the content in each of the following areas:

- Electrons and Energy
- Electrons at Work

An appropriate Instrument of Assessment would be a closed-book, supervised test with a time limit of 45 minutes. Items in the test should cover all of the Performance Criteria associated with both Outcomes 1 and 2 and could be set in familiar or unfamiliar contexts.

Further detail on the breadth and depth of content is provided in the content tables included in this specification.

National Unit specification: statement of standards (cont)

Unit title: Electricity (SCQF level 6)

For Outcome 2, PC(a), candidates are required to demonstrate that they can use a range of data-handling skills. These skills include selecting, processing and presenting information. Information can be presented in a number of formats including: line graphs, scatter graphs, bar and pie charts, tables, diagrams and text.

For Outcome 2, PC(b), candidates are required to demonstrate they can use a range of skills associated with experimental design. These skills include planning, designing and evaluating experimental procedures.

For Outcome 2, PC(c), candidates are required to demonstrate they can use a range of skills associated with the evaluation of scientific evidence. These skills include drawing valid conclusions and making predictions.

The standard to be applied and the breadth of coverage are illustrated in the National Assessment Bank items available for this Unit. If a centre wishes to design its own assessments for this Unit they should be of a comparable standard.

National Unit specification: support notes

Unit title: Electricity (SCQF level 6)

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 20 hours.

Guidance on the content and context for this Unit

The recommended content together with suggestions for possible contexts and activities to support and enrich learning and teaching are detailed in the appendix to this Unit specification.

This Unit builds on candidates' knowledge of electricity. The content covered in the first part of the topic Electrons and Energy is set in the context of alternating current. Candidates study how to monitor and measure a.c. signals. Electrical circuits are studied, including a consideration of d.c. electrical sources of power and internal resistance. The topic is completed with a study of capacitors.

Electrons at Work considers conductors, semiconductors and insulators and in particular, a number of semiconductor devices are studied.

This Unit offers a wide variety of contexts and opportunities for practical work as highlighted in the 'Contexts'column of the content tables. Opportunities exist for candidates to learn as part of a group through practical work undertaken in partnership or in teams.

Guidance on learning and teaching approaches for this Unit

General advice on approaches to learning and teaching is contained in the Course specification.

Opportunities for developing Core Skills

This Unit provides opportunities to develop *Communication, Numeracy, Information and Communication Technology* and *Problem Solving* skills in addition to providing contexts and activities within which the skills associated with *Working with Others* can be developed.

Outcome 1, PC(b) and (c) develop a candidate's ability to communicate effectively key concepts and to explain clearly physics concepts in written media.

Within this Unit candidates will need to extract and process information presented in both tabular and graphical formats developing the Core Skill of numeracy. Candidates will gain experience in a range of calculations building competence in number.

The Content Table, included in this Unit specification contains a column labelled 'Contexts' which include a large number of web based activities, computer simulations and modelling opportunities which all serve to develop higher levels of competence in the key *ICT* skills including; accessing information and providing/creating information. Also included are suggestions for practical investigations which provide candidates with the opportunity of working co-operatively with others.

Problem Solving skills are central to the sciences and are assessed through Outcome 1, PCs (b) and (c) and also through Outcome 2, PCs (a), (b) and (c).

Guidance on approaches to assessment for this Unit

Outcomes 1 and 2

It is recommended that an holistic approach is taken for assessment of these Outcomes. Outcomes 1 and 2 can be assessed by an integrated end of Unit test with questions covering all the Performance Criteria. Within one question, assessment of knowledge and understanding and skills of experimentation, investigation and analysis can occur. Each question can address a number of Performance Criteria from either Outcome 1 or 2.

Appropriate assessment items are available from the National Assessment Bank.

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003), SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**

National Unit specification: content tables

Unit title: Electricity (SCQF level 6)

The left hand column below details the content in which candidates should develop knowledge and understanding. The middle column contains notes, which give further details of the content.

The right-hand column gives suggested contexts in which knowledge and understanding and skills can be developed.

Content	Notes	Contexts
1 Electrons and Energy		
a) Monitoring and measuring a.c.	a.c. as a current which changes direction and instantaneous value with time. Monitoring a.c. signals with an oscilloscope, including measuring frequency, and peak and r.m.s. values.	Using a multimeter as an ammeter, voltmeter and ohmmeter. Oscilloscope as a voltmeter and waveform monitor.
b) Current, potential difference (p.d.), power and resistance	Current, potential difference and power in series and parallel circuits. Calculations involving p.d., current and resistance may involve several steps. Potential dividers as voltage controllers.	Investigating simple a.c. or d.c. circuits with switches and resistive components. Potential dividers in measurement circuits and used with variable resistors to set and control voltages in electronic circuits.
c) 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 the reduction in voltage as additional devices are connected. Investigating internal resistance of low voltage power supplies. Load matching.

National Unit specification: content tables (cont)

Unit title: Electricity (SCQF level 6)

Content	Notes	Contexts
d) 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.	Energy storage. Flash photography. Smoothing and suppressing. Capacitance based touch screens.
2 Electrons at Work		
a) 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 which are good conductors, 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.	Conducting cables and insulating material.

National Unit specification: content tables (cont)

Unit title: Electricity (SCQF level 6)

Content	Notes	Contexts
	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.	Breakdown voltage and lightning.
	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.	Hall effect sensor. Investigating the change in resistance of a negative temperature coefficient thermistor as its temperature is increased.
b) 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 material 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 p-n junctions which emit photons when a current is passed through the junction.	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.

History of changes to Unit

Version	Description of change	Date

National Unit specification: general information

Unit title: Researching Physics (SCQF level 6)

Unit code: FE45 12

COURSE Physics (Revised) Higher

Superclass: RC

Publication date: December 2010

Source: Scottish Qualifications Authority

Version: 01

Summary

In this Unit candidates will develop the key skills necessary to undertake research in physics and demonstrate the relevance to everyday life by exploring the physics behind a topical issue. The Unit offers opportunities for collaborative and independent learning set within the context of an evaluation of scientific issues. Candidates will develop skills associated with collecting and synthesizing information from a number of different sources. Equipped with a knowledge of standard laboratory apparatus, they will plan and undertake a practical investigation related to the topical issue. Candidates will prepare a scientific communication, presenting the aim, results and conclusions of their practical investigation. This Unit is suitable for candidates who are interested in pursuing a physics related career, as well as those whose interest is more general.

Outcomes

1 Research the physics underlying a topical issue to a given brief.
2 Plan and carry out investigative practical work related to a topical issue in physics.
3 Prepare a scientific communication which presents the aim, results and conclusions from a practical investigation related to a topical issue in physics.

General information (cont)

Unit title: Researching Physics (SCQF level 6)

Recommended entry

Entry for this Unit is at the discretion of the centre. However candidates would normally be expected to have attained the skills and knowledge required by one or more of the following or equivalent:

- Standard Grade Physics with Knowledge and Understanding and Problem Solving at grade 1 or 2

or

- the Intermediate 2 Physics

and

- Mathematics at Credit level or Intermediate 2 Mathematics.

Credit points and level

0.5 National Unit credit at SCQF level 6: (3 SCQF credit points at SCQF level 6*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Core Skills

Core Skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about Core Skills is published in the Catalogue of *Core Skills in National Qualifications (SQA, 2001)*.

National Unit specification: statement of standards

Unit title: Researching Physics (SCQF level 6)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

Outcome 1

Research the physics underlying a topical issue to a given brief.

Performance Criteria

(a) Obtain and record information from suitable sources relating to focus questions from a given brief.
(b) The sources of information selected and recorded are identified.

Outcome 2

Plan and carry out investigative practical work related to a topical issue in physics.

Performance Criteria

(a) An appropriate experimental procedure is planned.
(b) The experimental procedure is carried out effectively.

Outcome 3

Prepare a scientific communication which presents the aim, results and conclusions from a practical investigation related to a topical issue in physics.

Performance Criteria

(a) The aim of the investigative work is clearly stated.
(b) Recorded information is analysed and presented in an appropriate format.
(c) Valid conclusions are drawn.
(d) A valid evaluation of procedures is made.

Unit title: Researching Physics (SCQF level 6)

Evidence Requirements for this Unit

Evidence is required to demonstrate that candidates have met the requirements of the Outcomes. Assessors should use their professional judgement to determine the most appropriate instruments of assessment for generating evidence and the conditions and contexts in which they are used. Exemplification of possible approaches may be found in the Unit support notes.

Outcome 1

Candidates will be provided with a briefing document which contains focus questions relating to key points of background information and/or physics theory likely to be unfamiliar to the candidate. Candidates must produce a brief report which contains:

- Clear and accurate answers to at least two focus questions selected from those contained in the brief.
- A record of at least two sources of information relating to each of the answers provided.

These should be identified in sufficient detail to allow a third party to retrieve the source article.

Outcome 2

Candidates should make an effective contribution to the planning and carrying out of investigative practical work. The teacher/lecturer must attest that this is the case.

Outcome 3

Candidates should produce a single scientific communication describing the investigative activity and its findings. The scientific communication must be the work of the individual candidate. Depending on the activity, the collection of information may involve group work. The scientific communication can take any format in which the results of scientific research are commonly reported including: conference poster format, scientific paper format, PowerPoint presentation, video presentation, web page or traditional lab report.

For this Unit, evidence may be written and/or oral and may be stored electronically. Assessor observation checklists may be used for recording purposes.

Exemplification of possible approaches may be found in topic exemplar material (available from LTS) and the Unit support notes.

National Unit specification: support notes

Unit title: Researching Physics (SCQF level 6)

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 20 hours.

Guidance on the content and context for this Unit

Physics is a subject with significant relevance to many topical issues. This Unit offers an opportunity for candidates to research and investigate the physics underlying a topic which features in the media. The topic chosen should be such that candidates can research physics at an appropriate level. It should also be possible to undertake practical investigative work.

Exemplar investigation briefs containing focus questions are available in the topic exemplars (available from LTS). These allow centres the opportunity to select a topical issue suited to the available resources and/or the interests of their candidates. Centres may wish to develop their own investigation briefs but these must be of a comparable standard.

Outcome 1

Research briefs should allow candidates to investigate the physics underlying an issue or story currently featured in broadcast and publishing media. 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 candidates undertaking the Unit. The focus questions should be constructed to give a clear indication of the information required from the candidate. The information required to answer the questions must also be readily available using printed resources, video or audio materials available to the candidate, or from websites which can be identified by use of a search engine. Candidates must not be provided with extracts from any of these sources compiled by a third party.

In selecting the focus questions, there are opportunities for personalisation and choice, together with the development of scientific literacy.

Prior to undertaking the assessment Outcome 1, teachers/lecturers should ensure that candidates have experience of literature based research. In particular, if candidates 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.

Unit title: Researching Physics (SCQF level 6)

Outcome 2

Prior to the assessment of Outcome 2, candidates should have had experience of planning and carrying out practical investigative work.

Candidates 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 candidates any unfamiliar equipment that may be useful in carrying out the practical work.

Outcome 3

Prior to the assessment of Outcome 3, candidates should have had experience of analysing results, drawing valid conclusions and making reasoned evaluations, particularly of experimental procedures. Teachers/lecturers may wish to discuss with candidates possible formats for the scientific communication.

In analysing results, candidates 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* $\pm$ *uncertainty*

Candidates may use data-handling software to aid their analysis of results.

Teachers/lecturers should note that the external examination for Higher Physics contains questions requiring candidates to demonstrate their ability to design and evaluate experimental procedures in addition to questions which test a candidate's ability to interpret experimental data. The bullet points for Outcome 3 give a clear indication of the likely contexts and data analysis techniques candidates may be expected to employ.

National Unit specification: support notes (cont)

Unit title: Researching Physics (SCQF level 6)

Guidance on learning and teaching approaches for this Unit

Candidates 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 content tables provide a rich variety of experimental and investigative experiences which would provide the background knowledge and experience required to allow candidates to create appropriate experimental designs.

In order to be able to evaluate the procedures and draw valid conclusions from experimental data, candidates should have an opportunity to analyse and discuss experimental data presented in a variety of formats. The Outcome 3 bullet points mentioned in *Guidance on Content and Contexts* provide an indication of the range and depth of experience expected of candidates.

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 candidates 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 Performance Criteria.

For Outcome 1, it is possible for candidates 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 candidate must contribute to the planning and carrying out of the investigation. If candidates 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 candidates have taken an active part in the work.

For Outcome 3, candidates are likely to analyse results which have been collected in a group activity. Teachers/lecturers should ensure that each individual can meet the Performance Criteria, whilst recognizing that it is likely that there will be similarities between candidates' communications due to them being based on the same raw data.

Candidates should be encouraged to see risk assessment as a natural part of the planning process for any practical activity. Whilst candidates would not be expected to produce a full written risk assessment for their investigation themselves, this Unit provides an excellent opportunity to engage candidates in the process of assessing risks, taking informed decisions, and deciding on appropriate control measures during the planning stage of the practical investigation.

National Unit specification: support notes (cont)

Unit title: Researching Physics (SCQF level 6)

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.

Opportunities for developing Core Skills

This Unit provides opportunities to develop *Communication, Numeracy, Information and Communication Technology* and *Problem Solving* skills in addition to providing contexts and activities within which the skills associated with *Working with Others* can be developed.

Outcome 1 focuses upon a candidate's ability to research a physics topic. *Information and Communication Technology* skills are developed as candidates become proficient in using the internet to retrieve information on a topical science matter.

The planning and execution of the practical investigative work, associated with Outcome 2, provides a highly effective context within which candidates can develop both *Problem Solving* skills and those associated with working co-operatively with others.

In overtaking Outcome 3, the preparation of a scientific communication, candidates will develop *Numeracy* and *Communication* skills as they process their experimental results and communicate these effectively to others.

Guidance on approaches to assessment for this Unit

Outcome 1 is assessed by a written and/or oral report of the candidate's review findings. The candidate's report should be the result of their individual research into a minimum of two of the focus questions contained in the briefing document.

In relation to Performance Criteria (a) for Outcome 1, the candidate's record should contain an extract or summary of information relevant to the focus questions.

In relation to Performance Criteria (b), the candidate's record should clearly state the sources of the information included in the report. 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 candidates to take an active part in planning, designing and carrying out a practical investigation. Teachers/lecturers may find that observation and discussion with the candidates is sufficient to allow them to exercise professional judgement in deciding that each candidate 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.

National Unit specification: support notes (cont)

Unit title: Researching Physics (SCQF level 6)

Outcome 3 requires candidates to produce an individual scientific communication which presents the results of the practical investigation undertaken.

In relation to the Performance Criteria for Outcome 3, the scientific communication should include the following:

- a clear statement of the aim of the practical investigation.
- results of the investigation presented in an appropriate format, with tables and graphs drawn correctly. Also, there should be an analysis of results which interprets tabular and graphical data as appropriate, including an appropriate treatment of uncertainties.
- a conclusion which is valid on the basis of the evidence available to the candidate.
- an evaluation of experimental procedures which should include one or more of the following:
  (i) an assessment of the effectiveness of the procedure
  (ii) suggestions for alternative or modified strategies, further work and predictions
  (iii) an assessment/explanation of the relevance of the results.

Candidates may choose to present their scientific communication using any suitable format. Classroom management issues will determine the variety and number of communications which are undertaken. Whilst candidates may wish to present their scientific communication to a live audience if it is of an appropriate format, time constraints may dictate that this may not be possible for all. For those that do not make a live presentation, the electronic or paper copy of the presentation will be considered suitable evidence for assessment.

The decision of pass or fail is to be made by the professional judgement of the presenting centre (subject to verification) against the Performance Criteria. It is appropriate to support candidates in producing a scientific communication to meet the Performance Criteria. Re-drafting of the communication after necessary supportive criticism is to be encouraged both as part of the learning and teaching process and to produce evidence for assessment. Redrafting and resubmission of the parts requiring attention only is required, ie the entire scientific communication does not need to be redone.

Candidate absence during the Unit assessment

At the conclusion of an investigation conducted for Unit assessment purposes, it is possible that a candidate may fail to have demonstrated attainment in all Outcomes and Performance Criteria. This situation could arise either through absence or by the candidate failing to achieve the required standard at the first attempt. Candidates need only undertake those part(s) of an investigation required to allow them to demonstrate attainment in accordance with the Evidence Requirements stated in the Unit Specification.

National Unit specification: support notes (cont)

Unit title: Researching Physics (SCQF level 6)

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003), SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**

National Unit specification: support notes (cont)

Unit title: Researching Physics (SCQF level 6)

Teacher/lecturer checklist

This grid may be used to record candidates' achievement in the Performance Criteria for each Outcome.

	Literature based research		**Plan and carry out an investigation**		**Scientific Communication**			
	Report		Observation/ discussion		Report in any format			
Name	Information obtained and recorded	Sources of information recorded	Contributed to planning	Contributed to carrying out	Aim clearly identified	Results presented and analysed	Valid conclusion	Evaluation of procedure

History of changes to Unit

Version	Description of change	Date