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

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Customer Contact Centre, telephone 0845 279 1000.