PHYSICS (Revised)

Advanced Higher

First edition — published April 2012

National Course specification

Physics (Revised) Advanced Higher

COURSE CODE C272 13

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Version: 01

Course structure

The Course has four mandatory Units.

H1FL 13	*Rotational Motion and Astrophysics (AH)*	1 credit (40 hours)
H1FM 13	*Quanta and Waves (AH)*	1 credit (40 hours)
H1FN 13	*Electromagnetism (AH)*	0.5 credit (20 hours)
H1FP 13	*Physics Investigation (AH)*	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 would normally be expected to have attained one of the following, or equivalent:

- Higher Physics (Revised)
- Higher Physics
  and
- Higher Maths

Progression

This Course or its Units may provide progression to:

- a study of a science related course in Higher Education
- employment

National Course specification: (cont)

COURSE Physics (Revised) Advanced Higher

Credit value

The Advanced Higher Course in Physics is allocated 32 SCQF credit points at SCQF level 7*.

**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.*

Core Skills

Achievement of this Course gives automatic certification of the following:

Complete Core Skills	Numeracy
Core Skill components	Using Number at SCQF level 6 Using Graphical Information at SCQL Level 6 Critical Thinking at SCQF level 6 Planning and Organising at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of the Unit Specifications for this Course.

National Course specification: Course details (cont)

COURSE Physics (Revised) Advanced Higher

Rationale

The Advanced Higher Physics Course has been designed to articulate with and provide progression from the (Revised) Higher Physics Course. 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. An opportunity for engaging in some independent research is provided. The resulting elements of knowledge and understanding and skills form the basis of the Advanced Higher Physics Course.

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

- a deeper knowledge and understanding of the nature of physics and its applications
- 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 Advanced 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 Advanced Higher Physics with a suitable basis for further study.

National Course specification: Course details (cont)

COURSE Physics (Revised) Advanced Higher

Course content

The Course is made up of four mandatory Units: *Rotational Motion and Astrophysics, Quanta and Waves, Electromagnetism* and *Physics Investigation.* The *Physics Investigation* 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 *Physics Investigation* 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) Advanced Higher

Assessment

To achieve the Course award the candidate must achieve the Units as well as pass the Course 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 is provided in the paper *Assessment* (HSDU, 1996) and in *Managing Assessment* (HSDU, 1998).

Details of the Instruments for External Assessment

The instruments of assessment will be an externally set question paper of 2 hours 30 minutes duration and a completed investigation report.

Question Paper

The question paper will sample the content and skills developed in all three component Units: *Rotational Motion and Astrophysics, Quanta and Waves,* and *Electromagnetism.* The question paper will consist of 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 **100 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 **75 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	75±5
Rotational Motion and Astrophysics	30±5
Quanta and Waves	30±5
Electromagnetism	15±3

National Course specification: Course details (cont)

COURSE Physics (Revised) Advanced Higher

Assessment of knowledge and understanding will be based on the content as described in the Unit content tables.

The 75±5 marks allocated to knowledge and understanding will be allocated as follows:

1 **Make accurate statements about Physics** 4±2 marks (All marks assessing the grade description at grade C.)
2 **Use relationships to solve problems** 45±4 marks (Approximately two thirds of the marks assessing the grade description at grade C and approximately one third assessing at grade A.)
3 **Use knowledge to explain observations and phenomena** 26±3 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.*

Mark allocation to skills

Approximately **25 marks** will be allocated to questions that require candidates to demonstrate achievement of the skills as described in Outcome 2 of the three content based component Units.

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.

Investigation report

The investigation report will be based on the work carried out in the component Unit *Physics Investigation*. It is expected that approximately 10 hours of the 'additional 40 hours' will be required for the candidate to complete the report for the course award.

A total of 25 marks will be allocated to the investigation report. The investigation report will be externally assessed using the following assessment categories and mark allocations:

(a) Introduction (4 marks)
(b) Procedures (6 marks)
(c) Results (6 marks)
(d) Discussion (6 marks)
(e) Presentation (3 marks)

National Course specification: Course details (cont)

COURSE Physics (Revised) Advanced Higher

The grade awarded for the Course will depend on the marks obtained by the candidate (out of 125) for the question paper and the investigation report. The certificate will record an award for overall attainment.

Unit assessment

Further details about Unit assessment for this Course can be found in the Unit specifications and the National Assessment Bank (NAB) materials.

Course assessment

Further details of the Course assessment are given in the Course Assessment specification and in the Specimen Question Paper.

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) Advanced Higher

Grade Descriptions at A and C

The candidate's grade will be based on the total score obtained from the Course assessment. The descriptions below indicate the nature of achievement required for an award at Grade C and A in the Course.

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
- write in a scientific manner which reveals the significance of the physics relating to the investigation

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
- show particular proficiency in writing in a scientific manner which reveals the significance of the findings of the investigation by interpreting the results in a critical and scientific manner and demonstrating depth of knowledge and understanding of physics relating to the investigation

National Course specification: Course details (cont)

COURSE Physics (Revised) Advanced Higher

Estimates and appeals

Estimates

In preparing estimates, evidence must take account of performance across the Course and must be judged against the Grade Descriptions. Further advice on the preparation of estimates is given in the Course Assessment specification.

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 Principal Assessor.

To assist centres, Principal Assessor and Senior Verifier reports are published on SQA's website **www.sqa.org.uk**.

COURSE Physics (Revised) Advanced 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 an experiment to measure the angular velocity of a rotating object. 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 rotating objects to illustrate the conservation of angular momentum.
- Testing a hypothesis, eg class discussion of the capacitive reactance of a capacitor could lead to the hypothesis that increasing the frequency of an ac supply decreases the capacitive reactance. 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 solar wind is deflected towards the poles of the Earth. They design an investigation to determine the relationship between the direction of the force on charged particle, its velocity and the direction of a magnetic field.

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 a 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 some more 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) Advanced 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**

Advanced 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 physical quantities. Exceptions include the electronvolt (eV) and the light year (ly). 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 should 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	The accuracy of a measurement compares how close the measurement is to the 'true' or accepted value. The precision of a measurement gives an indication of the uncertainty in the measurement. 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. Reading uncertainty is a measure of how well an instrument scale can be read. Calibration uncertainty is a manufacturer's claim for the accuracy of an instrument compared with an approved standard. 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 numerical result of an experiment should be expressed as a value together with its absolute uncertainty, making appropriate use of significant figures. Calibration, reading and random uncertainties should be combined to obtain the total uncertainty in a measurement. When a final value is calculated by combining quantities in a sum, difference, product, quotient, or a quantity is raised to a power, the final uncertainty in the value being calculated should be determined. Where appropriate error bars should be included to represent the absolute uncertainty in measurements represented by points on a graph. The uncertainty in the gradient and intercept of a straight-line graph should be estimated where appropriate. A number of methods may be used to do this, including the use of functions available in graph drawing software.

History of changes

Version	Description of change	Date

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Business Development and Customer Support team, telephone 0303 333 0330.

National Unit Specification: general information

Unit title: Rotational Motion and Astrophysics (SCQF level 7)

Unit code: H1FL 13

Course: Physics (Revised) Advanced Higher

Superclass	RC
Publication date	April 2012
Source	Scottish Qualifications Authority
Version	01

Summary

This Unit develops knowledge and understanding and skills in physics related to rotational motion 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 angular motion. An astronomical perspective is developed through a study of gravitation, leading to work on general relativity and stellar physics. 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 rotational motion and astrophysics.
2 Demonstrate skills of scientific experimentation, investigation and analysis in rotational motion and astrophysics.

Recommended entry

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

♦ Higher Physics (Revised) or the Unit *Our Dynamic Universe (revised Higher)*
and
♦ Higher Mathematics

General information (cont)

Unit title Rotational Motion and Astrophysics (SCQF level 7)

Credit value

1 National Unit credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*)

**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

Achievement of this Unit gives automatic certification of the following:

Complete Core Skill	Numeracy at SCQF level 6
Core Skill component	Critical Thinking at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

National Unit Specification: statement of standards

Unit title: Rotational Motion and Astrophysics (SCQF level 7)

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 rotational motion and astrophysics.

Performance Criteria

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

Outcome 2

Demonstrate skills of scientific experimentation, investigation and analysis in rotational motion 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.

National Unit Specification: statement of standards

Unit title: Rotational Motion and Astrophysics (SCQF level 7)

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:

- ♦ Kinematic relationships
- ♦ Angular motion
- ♦ Rotational dynamics
- ♦ Gravitation
- ♦ Space and time
- ♦ Stellar physics

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 the Performance Criteria associated with both Outcomes 1 and 2 and should 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, 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: Rotational Motion and Astrophysics (SCQF level 7)

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 this Unit specification.

This Unit builds on candidates' knowledge of mechanics and dynamics. The content covered in the first topic consolidates previous work on kinematic relationships by using calculus methods, thus establishing the level of mathematical demand in the Unit. Angular motion is introduced by considering the rotational equivalent of displacement, velocity and acceleration. This work is set in a variety of contexts involving rotation. The turning effect of forces is then studied in rotational dynamics. The link to astrophysics is established through work on gravitation, including the development of the concept of orbital motion. The nature of gravitation is explored through the General Theory of Relativity. The Unit concludes with a study of the properties and evolution of stars.

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.

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.

Unit title: Rotational Motion and Astrophysics (SCQF level 7)

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessment 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 wishing to use e-assessment must ensure that the national standard is applied to all candidate evidence and that the 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).*

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).

This Unit has the Core Skill of Numeracy, and the Critical Thinking component of Problem Solving, embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show that they have achieved Numeracy and Critical Thinking at SCQF level 6.

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 in the SQA website **www.sqa.org.uk/assessmentarrangements**

National Course Specification: content tables

Unit title: Rotational Motion and Astrophysics (SCQF level 7)

The left hand column below details the content in which students 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 Kinematic Relationships		
a) Introduction to calculus methods	Calculus notation used to represent rate of change. Velocity is the rate of change of displacement with time and acceleration is the rate of change of velocity with time. Acceleration is the second differential of displacement with time.	
b) Kinematic relationships for motion in a straight line.	Calculus methods should be used with the kinematic relationships for straight line motion with constant or varying acceleration. Revisiting the familiar relationships in this way allows for an introduction to the increased level of mathematical demand of Advanced Higher.	
	Graphs of motion can provide useful information. The gradient represents instantaneous rate of change and for a displacement-time graph the gradient is the instantaneous velocity. For a velocity-time graph it is the instantaneous acceleration.	Motion sensors (including wireless sensors) to enable graphical representation of motion.
	The area under a graph can be found by integration and for a velocity-time graph the displacement can be found between limits.	

National Course Specification: content tables (cont)

2 Angular Motion		
a) Angular displacement, velocity and acceleration	Angular motion is introduced by considering the rotational equivalents of displacement, velocity and acceleration. Angular displacement is the angle through which an object rotates. The unit of angle is the radian and this is the unit normally used. However, conversion to and from degrees is required. The rate of change of angular displacement is angular velocity. Carry out experiments to determine the angular velocity of objects rotating with constant angular velocity. Angular acceleration is the rate of change of angular velocity. Carry out an experiment to determine the angular acceleration of an object rotating with constant angular acceleration. The relationships for angular and tangential motion can be applied to uniform angular accelerations.	Rotating objects include CDs, hard drives, turntables, wheels, fans and propellers. Satellites and planets may also be studied in context although these are included in the gravitation topic.
b) Centripetal force and acceleration	Angular velocity, period and frequency. Linear (tangential) velocity and angular velocity. Consideration of radial (centripetal) acceleration as the rate of change in tangential velocity leads to the concept of a radial force required to maintain circular motion. Investigating the factors that determine the size of the centripetal force required to maintain circular motion.	Fun fair rides, vehicles on curved tracks and roads. Heel of turning boats and bank of turning aircraft.

National Course Specification: content tables (cont)

3 Rotational Dynamics		
a) Torque, moment of inertia and angular acceleration	Torque is the tendency of a force to cause or change rotational motion of an object. An unbalanced torque produces an angular acceleration. Investigating the relationship between the torque applied to a turntable and the angular acceleration. The moment of inertia of an object is a measure of its resistance to angular acceleration about a given axis. The moment of inertia of an object depends on the mass of the object and the distribution of the mass about a fixed axis. Investigating examples of rotating objects in which the distribution of mass can be changed.	Engine torque, torque wrench. Comparison of mass with moment of inertia. Gymnasts, divers, skaters, aerobatic aircraft and other rotating masses.
b) Angular momentum and rotational kinetic energy	Moment of inertia of rotating bodies and combinations of rotating bodies. Angular momentum of a rotating particle and a rigid body. Carry out an experiment to investigate conservation of angular momentum. Analysis of rigid objects rolling down an incline by consideration of the potential energy and its conversion to linear and rotational kinetic energy.	Spin of Earth (precession of equinoxes), spin stabilizing of satellites, Foucault pendulum, spinning tops, electron orbits.

National Course Specification: content tables (cont)

4 Gravitation		
a) Gravity and orbital motion	Gravitational field strength is a measure of the force exerted on a Unit mass. Field patterns to visualize gravitational fields around a planet and a planet/moon system. Using Newton's Universal Law of Gravitation, the variation of g with height above Earth can be established. Satellites remain in orbit because of the force due to gravity. The period of the satellite depends on the distance from the centre, and the mass of the astronomical object being orbited. Calculations to be restricted to circular orbits.	Measuring G (Cavendish/Boys) and estimating the mass of the Earth (Schiehallion). Gravimetric surveys and geological data. Tides and tidal forces on Earth and other planets. Tidal energy as a sustainable energy source. Low polar orbital and geostationary satellites. Weather, telecommunications and data gathering satellites. Orbital resonance in the solar system
b) Gravitational potential and escape velocity	Gravitational potential at a point is the work done in moving a Unit mass from infinity to the point. Gravitational potential wells can be used as an illustration of the 'capture' of masses. Escape velocity is the minimum velocity that a mass must have to escape the gravitational field. The gravitational potential energy of a mass at infinity is defined as zero. To escape completely, a mass must reach infinity with its kinetic energy greater than or equal to zero. Energy and satellite motion. The energy required to move from one orbit to another requires a consideration of both the changes in gravitational potential energy and the changes in kinetic energy.	Implications for space flight. Planetary atmospheric composition.

National Course Specification: content tables (cont)

5 Space and Time		
a) General Relativity and Spacetime	Special relativity deals with motion in inertial (non-accelerating) frames of reference. General relativity deals with non-inertial (accelerating) frames of reference. The Equivalence Principle. The Equivalence Principle states that there is no way of distinguishing between the effects on an observer of a uniform gravitational field and of constant acceleration. Consideration of clocks in non-inertial frames of reference leads to the conclusion that time passes more slowly at the rear of an accelerating spacecraft. Applying the Equivalence Principle leads to the conclusion that time runs more slowly at lower altitudes than at higher altitudes in a gravitational field. Spacetime as a representation of four dimensional space. It is very difficult to visualize the four dimensions of spacetime, but an insight can be gained by plotting time against distance in one dimension. The worldline of a motion is represented by a line on the spacetime diagram and accelerations are represented by a line of changing gradient.	Both Special and General Relativity changed the way we visualize the Universe. It is useful to consider the revolution to our understanding from an historical perspective. Thought experiments onboard accelerating spacecraft lead to the Equivalence Principle. Two dimensional diagrams to represent space and time can be used to illustrate problems with simultaneity of events. Geodesics. Precession of Mercury's orbit as evidence for General Relativity. Gravitational redshift. Corrections to GPS satellites to account for gravitational time dilation. The rubber sheet analogy is a useful analogy for how mass affects spacetime.
b) Gravity and General Relativity	A force is experienced when accelerating or when in a gravitational field. No forces are 'felt' when in free fall or when travelling at constant velocity. Light or a freely moving object follows a geodesic in spacetime. A geodesic is the shortest distance between two points. General Relativity leads to the interpretation that mass curves spacetime and what we perceive as gravity arises from the curvature of spacetime.	

National Course Specification: content tables (cont)

5 Space and Time (cont)		
	For a black hole, the Schwarzschild radius is the distance from the centre of a black hole at which not even light can escape. Time appears to be frozen at the event horizon of a black hole. Gravitational lensing is the bending of light through space as it passes through curved space.	Einstein rings as light is bent around massive objects.

National Course Specification: content tables (cont)

6 Stellar Physics		
a) Properties of stars	Radius, surface temperature, mass, luminosity and apparent brightness of stars. Stars maintain the extremely high temperatures and densities required for nuclear fusion to take place by gravitational equilibrium. Gravity produces an inward force which is balanced by a thermal pressure pushing out. Hydrogen fusion in a star is a result of a proton-proton chain in which individual protons are fused to make a deuterium nucleus which then fuse with a further proton to form a helium-3 nucleus. Two helium-3 nuclei then fuse to form a helium-4 nucleus, releasing two excess protons in the process. Positrons, neutrinos and gamma rays are also released.	Measuring apparent brightness using detectors such as CCDs. Magnitude systems to classify stars. Balmer thermometer can be used to determine stellar temperatures. The history of classification of stars into the spectral sequence. Solar neutrinos and the solar neutrino problem as an example of a solved problem in astrophysics. Stellar nucleosynthesis as the origin of all elements heavier than helium — hence the expression 'we are stardust'.
b) Stellar evolution	Stars are born in interstellar clouds that are particularly cold and dense (relative to the rest of space). Stars form when gravity overcomes thermal pressure and causes a molecular cloud to contract until the central object becomes hot enough to sustain nuclear fusion. The mass of a new star determines its luminosity and surface temperature. The Hertzsprung-Russell (H-R) diagram is a representation of the classification of stars. The luminosity and surface temperature determine the location of a star in the H-R diagram. The lifetime of a star depends on its mass. During the hydrogen fusing stage, the star is located in the main-sequence. As the fuel is used up, the balance between gravity and thermal pressure changes and the star may change its position on the H-R diagram. The ultimate fate of a star is determined by its mass. Supernovae, neutron stars and black holes can be the eventual fate of some stars.	Interstellar clouds and gravitational contraction can be modelled on a computer simulation. Evidence for our theory of planetary formation is supported by observations of other forming stars. Setting the spectral sequencing in a historical context gives insights into the difficulties of classifying stars.

History of changes

Version	Description of change	Date

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Business Development and Customer Support team, telephone 0303 333 0330.

National Unit specification: general information

Unit title: Quanta and Waves (SCQF level 7)

Unit code: H1FM 13

Course: Physics (Revised) Advanced Higher

Superclass	RC
Publication date	April 2012
Source	Scottish Qualifications Authority
Version	01

Summary

This Unit develops knowledge and understanding and skills in physics related to quanta 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 quantum theory and waves. The Unit introduces non-classical physics and considers the origin and composition of cosmic radiation. Simple harmonic motion is introduced and work on wave theory is developed. 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 quanta and waves.
2 Demonstrate skills of scientific experimentation, investigation and analysis in quanta and waves.

Recommended entry

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

♦ Higher Physics (Revised) or the Unit *Particles and Waves (revised Higher)*

and

♦ Higher Mathematics

General information (cont)

Unit title: Quanta and Waves (SCQF level 7)

Credit value

1 National Unit credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*)

**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

Achievement of this Unit gives automatic certification of the following:

Complete Core Skill	Numeracy at SCQF level 6
Core Skill component	Critical Thinking at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

National Unit Specification: statement of standards

Unit title: Quanta and Waves (SCQF level 7)

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 quanta and waves.

Performance Criteria

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

Outcome 2

Demonstrate skills of scientific experimentation, investigation and analysis in quanta 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:

- Quantum theory
- Particles from space
- Simple harmonic motion
- Waves
- Interference
- Polarisation

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 the Performance Criteria associated with both Outcomes 1 and 2 and should 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: Quanta and Waves (SCQF level 7)

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, 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: Quanta and Waves (SCQF level 7)

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 this Unit specification.

This Unit builds on candidates' knowledge of particle physics and waves. The content covered in the first topic considers a number of phenomena that cannot be explained using classical physics. The Uncertainty Principle is introduced leading to the concept of quantum tunnelling. The Unit shifts focus to consider the nature and effects of cosmic radiation, including an introduction to the solar wind and the protection gained by the Earth's magnetosphere. The topic of simple harmonic motion gives an insight into the motion of vibrating objects, and this is followed by the development of a mathematical model of waves. The many phenomena associated with the interference of waves is studied and the Unit concludes with a consideration of polarisation.

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.

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.

National Unit Specification: support notes (cont)

Unit title: Quanta and Waves (SCQF level 7)

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessment 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 wishing to use e-assessment must ensure that the national standard is applied to all candidate evidence and that the 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).*

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) & (c) and also through Outcome 2, PCs (a), (b) and (c).

This Unit has the Core Skill of Numeracy, and the Critical Thinking component of Problem Solving, embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show that they have achieved Numeracy and Critical Thinking at SCQF level 6.

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 in the SQA website **www.sqa.org.uk/assessmentarrangements**

National Course Specification: content tables

Advanced Higher Physics: Quanta and Waves

The left hand column below details the content in which students 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 Quantum Theory		
a) Introduction to quantum theory	Quantum theory can be introduced by consideration of experimental observations that could not be explained by classical physics, together with the various efforts made to resolve these dilemmas. These include:	
	♦ Black-body radiation curves could not be predicted using classical theory. Planck suggested that the absorption and emission of radiation could only take place in 'jumps'.	The ultraviolet catastrophe. Planck's theoretical quantisation of energy.
	♦ The photoelectric effect could not be explained using classical physics. Einstein suggested that the energy of electromagnetic radiation is quantised.	The photoelectric effect. Energy quantisation and electron emission. CCDs, light meters
	♦ The Bohr model of the atom, which explains the characteristics of atomic spectra in terms of electron energy states. Bohr's quantisation of angular momentum.	Line spectra and energy states obtained by comparison with spectral lines. Balmer's trial and error formula for his series in the hydrogen atom. Energy levels of hydrogen atom
	♦ De Broglie suggested that electrons have wave properties. The de Broglie relationship between wavelength and momentum. ♦ Electron diffraction is evidence for wave/particle duality.	Comparison of wavelengths for photons and fast moving electrons. The electron microscope

National Course Specification: content tables (cont)

b) The Uncertainty Principle	Quantum mechanics was developed to resolve the dilemmas that could not be explained by classical physics. It is only with the development of quantum mechanics that the dual nature of matter can be described. At the core of quantum mechanics is the realisation that unpredictability is at the heart of the nature of matter. A Newtonian, mechanistic view, in principle allows all future states of a system to be known if the starting details are known. Quantum mechanics indicates that we can only calculate probabilities. It impossible to simultaneously measure both wave and particle properties. Double slit experiments with single particles (photons or electrons) produce non-intuitive results. Quantum mechanics gives excellent agreement with experimental observations. The Uncertainty Principle can be introduced in terms of location and momentum. To gain precise information about the position of a particle requires the use of short wavelength radiation. This has high energy which changes the momentum of the particle. The Uncertainty Principle in terms of energy and time leads to the concept of quantum tunneling. Potential wells form barriers which would not normally allow particles to escape. 'Borrowing' energy for a short period of time allows particles to escape from the potential well. Mathematical statements of the Uncertainty Principle in terms of Planck's constant.	Young's slits and electron diffraction. Experiments with single photons or electrons and double slits. The historical perspective of the mechanistic Universe versus the modern interpretation of uncertainty and randomness. Radioactive decay and half-life Alpha particle emission in terms of quantum tunneling. Nuclear fusion. Current leakage in electronics. Scanning Tunneling Microscope Virtual particles in space.

National Course Specification: content tables (cont)

2 Particles from space		
a) Cosmic rays	The origin and composition of cosmic rays. Cosmic rays from outer space consist of energetic charged subatomic particles. The variety of particles and range of energies can be compared to those produced in particle accelerators. The interaction of cosmic rays with the Earth's atmosphere produces a shower of particles with lower energies.	Atmospheric screening. Detecting primary and secondary particles. Ground arrays. Ultra high energy cosmic rays have been detected and their source is unknown.
b) Solar wind and the magnetosphere	The solar cycle. Solar flares. Cosmic radiation from the sun. The composition of the solar wind as charged particles in the form of a plasma. The interaction of the solar wind with the Earth's magnetic field. Investigate the motion of charged particles in a magnetic field in terms of the magnitude of the force F acting on a charge q moving with a velocity v perpendicular to a magnetic field B. Helical motion of a charged particle moving at an angle to the magnetic field. The interaction of the solar wind with the Earth's magnetic field and upper atmosphere to explain the production of the aurora.	Planetary magnetic fields. Changes in the axis and polarity of the Earth's magnetic field. Cosmic rays and carbon dating. Forces acting on sub-atomic particles.

National Course Specification: content tables (cont)

3 Simple Harmonic Motion		
a) Dynamics of Simple Harmonic Motion (SHM)	Simple harmonic motion (SHM) in terms of the restoring force and acceleration of the moving object. The restoring force (and hence acceleration) is proportional to the displacement from the rest position and is opposite in direction. Angular frequency and period. The solutions for the SHM equation to find the displacement and velocity at a particular time. Investigating examples of SHM. Investigating the factors affecting the period of oscillation for an object which moves with SHM.	Pendulum, mass on a spring, loudspeaker cones, loaded test tube, eardrums, vibrating crystals and other vibrating objects.
b) Kinetic and potential energy in SHM	Investigating examples of SHM to explain the relationship between kinetic energy and potential energy for an object with SHM. Investigating damped and undamped systems.	Car shock absorbers, trampolines, bungee cords, clocks and bridges.

National Course Specification: content tables (cont)

4 Waves		
a) Mathematical representation of waves	In wave motion, energy is transferred from one position to another with no net transport of mass. The energy transferred by a wave is directly proportional to the square of the amplitude of the wave. The mathematical form of a travelling wave. Phase difference and phase angle. Superposition of waves.	Phase difference and radio astronomy, ultrasound devices and ac circuits. Using a slinky to investigate the superposition of wave pulses. Synthesisers, using computer software to investigate the addition of waves. Fourier analysis.
b) Stationary waves	Stationary waves are formed by the interference of two waves, of the same frequency and amplitude, travelling in opposite directions. A stationary wave can be described in terms of nodes, antinodes. Stationary waves can be used to measure the wavelength of sound waves and microwaves.	Musical instruments, including string and wind instruments. Microwaves to demonstrate stationary waves.

National Course Specification: content tables (cont)

5 Interference		
a) Interference by division of amplitude	Coherent sources have a constant phase difference. The relationships between optical path length and geometrical path length and between phase difference and optical path difference. Conditions for constructive and destructive interference. Splitting a single light beam into two beams at a reflective boundary. The transmitted beam and reflected beam produce an interference pattern if they are recombined. Investigating examples of interference caused by division of amplitude. Light undergoes a phase change of π on reflection at an interface where there is an increase in optical density. Interference effects are commonly observed in thin films. Investigating thin film interference using an extended light source, including the conditions for maxima and minima in the observed fringes. Non-reflective coatings and colours in thin films. Fringes caused by wedges. Determining the thickness of a sheet of paper using wedge fringes.	Thin film optical filters. Lens blooming. Butterfly wings. Oil on water and soap bubbles. Low emissivity panes of glass.
b) Interference by division of wavefront	Interference by division of a wavefront into two point sources, Young's slits. Conditions for maxima and minima and the effect of fringe separation. Determining the wavelength of laser light using Young's slits.	Microwaves, sound waves and light.

National Course Specification: content tables (cont)

6 Polarisation		
a) Plane polarisation of transverse waves	The difference between linearly (plane) polarised and unpolarised waves. Investigating polarisation using microwaves and light. A plane polarised wave can be produced by using a filter to absorb the vibrations in all directions except one. Polarisation can also be produced by reflection. Brewster's angle is the angle of incidence that causes reflected light to be linearly polarised. Investigating Brewster's angle.	Polarising lenses, photoelasticity, optical activity and saccharimetry. 3D cinema and TV glasses. Reduction of glare by Polaroid sunglasses. Liquid crystal displays.

History of changes

Version	Description of change	Date

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Business Development and Customer Support team, telephone 0303 333 0330.

National Unit Specification: general information

Unit title: Electromagnetism (SCQF level 7)

Unit code: H1FN 13

Course: Physics (Revised) Advanced Higher

Superclass	RC
Publication date	April 2012
Source	Scottish Qualifications Authority
Version	01

Summary

This Unit develops knowledge and understanding and skills in physics related to electromagnetism. 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 electromagnetism. The Unit develops knowledge and understanding of electric and magnetic fields and capacitors and inductors used in dc and ac circuits. 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 electromagnetism.
2 Demonstrate skills of scientific experimentation, investigation and analysis in electromagnetism.

Recommended entry

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

- Higher Physics (Revised) or the Unit *Electricity (revised Higher)*

and

- Higher Mathematics

General information (cont)

Unit title: Electromagnetism (SCQF level 7)

Credit value

0.5 National Unit credit at SCQF level 7: (4 SCQF credit points at SCQF level 7*)

**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

Achievement of this Unit gives automatic certification of the following:

Complete Core Skill	Numeracy at SCQF level 6
Core Skill component	Critical Thinking at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

National Unit Specification: statement of standards

Unit title: Electromagnetism (SCQF level 7)

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 electromagnetism.

Performance Criteria

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

Outcome 2

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

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.

National Unit Specification: statement of standards (cont)

Unit title: Electromagnetism (SCQF level 7)

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 30 minutes.

The instrument of assessment must sample the content in each of the following areas:

- Fields
- Circuits
- Electromagnetic Radiation

An appropriate Instrument of Assessment would be a closed-book, supervised test with a time limit of 30 minutes. Items in the test should cover all the Performance Criteria associated with both Outcomes 1 and 2 and should 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, 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: Electromagnetism (SCQF level 7)

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 this Unit specification.

This Unit builds on candidates' knowledge of fields and circuits. The content of the first topic develops previous work on electric fields and in particular, a mathematical approach is adopted to describe the interaction of charged particles. Magnetic fields and magnetic induction are treated in a similar way. The nature of electromagnetic radiation is considered. Components used in dc and ac circuits include capacitors and inductors and an understanding of electric and magnetic fields is used to investigate their operation.
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.

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 assessment 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 wishing to use e-assessment must ensure that the national standard is applied to all candidate evidence and that the 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).*

Unit title: Electromagnetism (SCQF level 7)

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) & (c) and also through Outcome 2, PCs (a), (b) and (c).

This Unit has the Core Skill of Numeracy, and the Critical Thinking component of Problem Solving, embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show that they have achieved Numeracy and Critical Thinking at SCQF level 6.

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 in the SQA website **www.sqa.org.uk/assessmentarrangements**

National Course Specification: content tables

Advanced Higher Physics: Electromagnetism
The left hand column below details the content in which students 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 Fields		
a) Electric fields and Coulomb's Law	An electric field is the space that surrounds electrically charged particles and in which a force is exerted on other electrically charged particles. Electric field as the force per Unit positive charge. Coulomb's Inverse Square Law for interacting point charges. Electric potential and electric field strength around a point charge and system of charges. Potential difference and electric field strength for a uniform electric field. Investigate the motion of charged particles in uniform electric fields. The electronvolt is the energy acquired when one electron accelerates through a potential difference of one volt. It is a unit commonly used in high energy particle physics.	Electrostatic spray painting. Electrostatic forces and the structure of matter. Lightning, cosmic rays, Compton scattering, electron gun, oscilloscope deflecting plates Particle accelerators Particle accelerators. Astronomical measurement of the energy of electromagnetic radiation.

National Course Specification: content tables (cont)

b) Magnetic fields and magnetic induction	Magnetic effects arise when electric charges are in motion. An electric current consists of moving electric charges and so produces magnetic effects. Also, electrons are in motion around atomic nuclei and individually produce a magnetic effect. Iron, nickel, cobalt and some rare earths exhibit a magnetic effect called ferromagnetism, in which magnetic dipoles can be made to line up, resulting in the material becoming magnetised.	Electric motors, electromagnetic pump.
	Magnetic field patterns around permanent magnets and electromagnets, including a straight wire and a coil. Magnetic induction at a point is the strength of a magnetic field at the point.	Induction cookers, induction welding
	Investigate the magnitude of the force on a current carrying conductor in a magnetic field. Investigate the magnetic induction at a distance from a long current carrying wire. Comparing gravitational, electrostatic, magnetic and nuclear forces.	Use of Hall Probe to measure magnetic induction.

National Course Specification: content tables (cont)

2 Circuits		
a) Capacitors	Capacitors in dc circuits. Current and potential difference in CR circuits during charging and discharging.	Data logging to capture the current and potential difference relationships for a CR circuit.
	Determining the time constant for a CR circuit.	
	Capacitors in ac circuits. Capacitive reactance.	Filtering and coupling. Energy storage and pulsed power applications.
	Investigating the relationship between current, frequency and capacitive reactance.	Signal coupling and decoupling. Capacitors used as sensors. Condenser microphones, pressure transducers, accelerometers, aircraft fuel gauges.
b) Inductors	Electromagnetic induction. Investigating the factors affecting the size of the induced e.m.f. in a coil. Investigating the growth and decay of current in a dc circuit containing an inductor.	Neon bulb lit from 1.5V cell, linear induction motor, magnetic levitation. Car ignition coil, mutual inductance, transformers, xenon flashlamp circuits.
	Self inductance.	
	Lenz's Law. The magnitude of the induced e.m.f.	Data logging to determine the self-inductance of a coil.
	Determining the self inductance of a coil. Energy stored by an inductor.	Eddy currents, electromagnetic braking, induction heating. Switched-mode power supplies, lightning strike voltage depression, current limiting switches. Traffic light sensors.
	Inductors in ac circuits. Inductive reactance.	
	Investigating the relationship between current, frequency and inductive reactance.	LC filters. Tuned circuits.

National Course Specification: content tables (cont)

3 Electromagnetic Radiation		
The unification of electricity and magnetism	The nature of electromagnetic radiation (EMR). EMR exhibits wave properties as it transfers energy through space. It has both electric and magnetic field components which oscillate in phase, perpendicular to each other and to the direction of energy propagation. The relationship between the speed of light and the permittivity and permeability of free space. Estimate the speed of light by determining permittivity using a parallel plate capacitor and determining permeability using a current balance.	Unification of electricity and magnetism by J C Maxwell Wireless technology. Mobile phones and Bluetooth.

History of changes

Version	Description of change	Date

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Business Development and Customer Support team, telephone 0303 333 0330.

National Unit Specification: general information

Unit title: Physics Investigation (SCQF level 7)

Unit code: H1FP 13

Course: Physics (Advanced Higher)

Summary

In this Unit candidates will develop key investigative skills through the completion of a practical investigation. The Unit offers opportunities for independent learning set within the context of experimental physics. Candidates will develop skills of planning, organising and setting up equipment, requiring self-motivation and independent learning. They will also collect and record data in an appropriate format.

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 Plan and carry out investigative practical work on a chosen physics topic.
2 Collect and record data from the investigative practical work.

Recommended entry

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

- ♦ Higher Physics (Revised) **or** Researching Physics Unit in Revised Higher Physics

and

- ♦ Higher Maths

Credit value

0.5 National Unit credit at SCQF level 7 (4 SCQF credit points at SCQF level 7*).

**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.*

General information (cont)

Unit title: Physics Investigation (SCQF level 7)

Core Skills

Achievement of this Unit gives automatic certification of the following:

Complete Core Skill	None
Core Skill component	Critical Thinking at SCQF level 6 Planning and Organising at SCQF level 6 Using Graphical Information at SCQF level 6

National Unit Specification: statement of standards

Unit title: Physics Investigation (SCQF level 7)

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

Plan and carry out investigative practical work on a chosen physics topic.

Performance Criteria

(a) Appropriate experimental procedures are planned.
(b) The experimental procedures are carried out effectively.

Outcome 2

Collect and record data from the investigative practical work.

Performance Criteria

(a) Appropriate techniques are used to collect experimental data.
(b) Experimental data are recorded in an appropriate format.

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 assessments 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 should plan their investigative practical work after discussion with teachers or lecturers. The plan must be recorded in an appropriate format, which may be electronic, and must include the aim of the investigation and details of the proposed experiments to be undertaken during the investigation. The aims of planned experiments must also be recorded. Planned experimental procedures should allow generation of sufficient, relevant data for analysis.

Outcome 2

The collection of experimental data must be the work of the individual candidate.
The assessor must attest that, other than help from technicians, teachers, lecturers or support staff in setting up equipment, the investigative practical work is the work of the individual candidate.

All raw experimental data and associated uncertainties must be recorded in an appropriate format and this may be paper-based or electronic format.

National Unit Specification: support notes

Unit title: Physics Investigation (SCQF level 7)

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

In this Unit candidates will develop the key skills identified by Higher Education and Industry as being necessary to undertake experimental research in physics.

Candidates can select any suitable topic for investigation provided the physics is at an appropriate level of demand. The topic chosen may be outwith the physics covered in the other Units of the Advanced Higher Physics Course.

Candidates should normally undertake a number of experiments within the investigation, illustrating a range of experimental techniques. The number undertaken will depend on the complexity of the experiments. It is possible to undertake a successful investigation which consists of one experiment. However, in this case, the single experiment should take a significant proportion of the time allocated to the Unit. One situation that should be avoided is that in which a significant amount of time is spent building a piece of equipment to allow a single experiment to be undertaken. In summary, the largest proportion of time spent on the Unit should be allocated to undertaking practical experimental work, together with the associated planning.

Initial plans should be discussed and trials undertaken to verify that equipment is likely to be suitable and experiments are likely to generate valid data. Issues and challenges met, together with proposed amendments to the plan must be recorded.

Candidates should be encouraged to see risk assessment as an important and necessary part of the planning process for any practical activity. Whilst not required as evidence for the Unit, each candidate should, in discussion with teachers/lecturers, assess the risk for the equipment and procedures to be used in the Investigation. This Unit provides an excellent opportunity to assess risks and to make informed decisions regarding the use of appropriate control measures during the planning stage of the Investigation.

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

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Guidance on learning and teaching approaches for this Unit

Candidates may consider a variety of approaches to the activities associated with the Unit. Independent management of both time and resources should be encouraged although candidates may need considerable support in the early stages of their planning. Furthermore, it is recommended that candidates are given support as they make a record of their plan and then record their results. It is appropriate for candidates to discuss their results with teachers/lecturers during and after the collection of data and if necessary experimental procedures can be repeated or modified to generate further data. It may also be good practice to carry out an initial analysis of results obtained to check for trends, unexpected results, etc but this is not part of the assessment of this Unit. This will avoid the situation where inappropriate procedures and techniques are not discovered until a later stage in the work when it may be difficult or even too late to make the necessary corrections.

Candidates should be encouraged to select topics for investigation in which they are interested. However, an important consideration is the equipment available and teachers/lecturers may need to offer advice on the suitability of a particular topic, given local considerations. External assessment reports from time to time offer advice on the suitability of investigation topics. Candidates must work independently and it is likely that those from the same centre will undertake distinct investigations.

Guidance on approaches to assessment for this Unit

For Outcome 1(a) candidates are required to record the details of the planning cycle. Planning experimental work is likely to involve a certain amount of trialling, with subsequent amendments being made to the initial plan. Candidates should be advised to follow good practice and maintain a record of work or diary in which they record all the stages of the planning process, including the issues and challenges met, together with reasons for proposed amendments. The record of work may be considered to be a diary of the planning stages, together with a record of the results of the experimental work. As such, it does not need to include formal statements and diagrams of the experimental procedures adopted, these being more appropriately included in the investigation report produced as part of the course assessment. Any evidence of assessing risks that has been undertaken during the planning stage should be included. The record of work may be used as evidence for the achievement of Outcome 1(a).

In relation to Outcome 1(b), the candidate should have regular discussions with teachers/lecturers on the difficulties and challenges of carrying out the practical work. By observation and discussion, teachers/lecturers should attest that the candidate has carried out the experimental procedures effectively. They may like to consider the following in making their judgement.

- Candidates should use equipment properly, taking account of any precautions in setting up the equipment.
- Candidates should take responsibility for collecting and putting away equipment as appropriate.

Outcome 2(a) requires candidates to use equipment correctly. Meters and measuring devices should be selected to generate experimental data that is within a suitable range and of a suitable accuracy. Where appropriate, readings should be repeated and checked for spurious results.

In relation to Outcome 2(b), experimental data may be recorded in any suitable format and this may be paper based or electronic. Candidates who maintain a record of work (and they should be strongly advised to do this) may present this as their evidence for recording their experimental data.

All measurements should be recorded. If a mean value is calculated, the data used to calculate the mean should be available. Tables should normally include headings and units as appropriate.

The uncertainties associated with measurements should be included in the record. The analysis and combination of uncertainties is not required to be included in the record.

Appropriate formative assessment methods may be used here. It is good practice for the assessor to check the record of work/day book of each candidate on a regular basis and sign and date the relevant part. Candidates should use the record of work/day book to record aims, planning, risk assessments, observations and results of the Investigation. It is also good practice for the assessor to take this opportunity to write appropriate comments and advice in the candidate's record of work/day book.

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 plan and carry out a physics investigation. *Communication* skills and skills of *Working with Others* are developed during discussion with technicians and teachers/lecturers in considering equipment requirements and developing a suitable strategy for carry out the investigation.

The collection and recording of experimental data for Outcome 2 provides a highly effective context within which candidates can develop both Numeracy and Information and Communication Technology skills.

This Unit has the Using Graphical Information component of Numeracy, and the Critical Thinking and Planning and Organising components of Problem Solving, embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show that they have achieved Using Graphical Information, Critical Thinking and Planning and Organising at SCQF level 6.

National Unit Specification: support notes (cont)

Unit title: Physics Investigation (SCQF level 7)

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 alternative Outcomes for Units. Further advice can be found in the SQA document *Guidance on Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs* **(www.sqa.org)**

History of changes

Version	Description of change	Date

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Business Development and Customer Support team, telephone 0303 333 0330.