
Physics: Quanta and Waves

SCQF: level 7 (8 SCQF credit points)

Unit code: J2B7 77

Unit outline

The general aim of this Unit is to develop skills of scientific inquiry, investigation, and analytical thinking, along with knowledge and understanding of quanta and waves. Learners will use these skills when considering how applications of quanta and waves can have impacts on our lives, as well on the environment/society. This application and development of skills can be achieved using a variety of approaches, including investigation and problem solving.

The Unit will cover the key areas of introduction to quantum theory, particles from space, simple harmonic motion, waves, interference, and polarisation.

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

Learners who complete this Unit will be able to:

- 1 Apply skills of scientific inquiry and draw on knowledge and understanding of the key areas of this Unit to carry out an experiment/practical investigation.
- 2 Draw on knowledge and understanding of the key areas of this Unit and apply scientific skills.

This Unit is available as a free-standing Unit. The Unit Specification should be read in conjunction with the *Unit Support Notes*, which provide advice and guidance on delivery, assessment approaches and development of skills for learning, skills for life and skills for work. Exemplification of the standards in this Unit is given in *Unit Assessment Support*.

Recommended entry

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

- ◆ Higher Physics Course or relevant Units

Equality and inclusion

This Unit Specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. For further information please refer to the *Unit Support Notes*.

Standards

Outcomes and Assessment Standards

Outcome 1

The learner will:

- 1 Apply skills of scientific inquiry and draw on knowledge and understanding of the key areas of this Unit to carry out an experiment/practical investigation by:**
 - 1.1 Planning/designing an experiment/practical investigation
 - 1.2 Following procedures safely
 - 1.3 Making and recording observations/measurements correctly
 - 1.4 Analysing and presenting results in an appropriate format
 - 1.5 Drawing valid conclusions and giving explanations supported by evidence
 - 1.6 Evaluating experimental procedures with justification

Outcome 2

The learner will:

- 2 Draw on knowledge and understanding of the key areas of this Unit and apply scientific skills by:**
 - 2.1 Making accurate statements and giving clear descriptions/explanations
 - 2.2 Solving problems

Evidence Requirements for the Unit

Assessors should use their professional judgement, subject knowledge, and experience, and understanding of their learners, to determine the most appropriate ways to generate evidence and the conditions and contexts in which they are used.

Evidence can be drawn from a variety of sources and presented in a variety of formats. Evidence may be presented for individual Outcomes or gathered for the Unit as a whole, by combining assessment holistically in a single activity. If the latter approach is used, it must be clear how the evidence covers each Outcome.

The key areas covered in this Unit are:

Introduction to quantum theory

- ◆ challenges to classical theory
- ◆ black body radiation
- ◆ photoelectric effect
- ◆ Bohr model of the atom
- ◆ wave particle duality
- ◆ de Broglie waves
- ◆ uncertainty principle

Particles from space

- ◆ cosmic rays
- ◆ solar wind

Simple harmonic motion

- ◆ dynamics of simple harmonic motion (SHM)
- ◆ angular frequency and period
- ◆ solutions of the SHM equation
- ◆ kinetic and potential energy in SHM

Waves

- ◆ energy transferred by a wave is directly proportional to the square of the amplitude
- ◆ mathematical representation of travelling waves
- ◆ phase difference and phase angle
- ◆ superposition of waves
- ◆ stationary waves

Interference

- ◆ conditions for constructive and destructive interference
- ◆ coherence

Division of amplitude

- ◆ optical path length, geometrical path length, phase difference, and optical path difference
- ◆ thin film interference
- ◆ wedge fringes

Division of wavelength

- ◆ Young's slits interference

Polarisation

- ◆ plane polarisation of transverse waves
- ◆ Brewster's angle

The table below describes the evidence for the Assessment Standards which require exemplification.

Assessment Standard	Evidence Requirements
Planning an experiment/practical investigation	<p>The plan should include:</p> <ul style="list-style-type: none"> ◆ a clear statement of the aim ◆ a dependent and independent variable ◆ variables to be kept constant ◆ measurements/observations to be made ◆ the equipment/materials ◆ a clear and detailed description of how the experiment/practical investigation should be carried out, including safety considerations
Making and recording observations/measurements correctly	Repeated measurements where appropriate
Presenting results in an appropriate format	One format from: table, scatter graph, or other appropriate format
Drawing valid conclusions	Include reference to the aim
Evaluating experimental procedures	Suggest improvements with justification
Making accurate statements	At least half of the responses should be correct across the key areas for the set of questions provided
Solving problems	<p>One of each:</p> <ul style="list-style-type: none"> ◆ make predictions ◆ process information including calculations, as appropriate ◆ analyse information

Transfer of evidence

Outcome 1 in this Unit can be used as evidence of the achievement of Outcome 1 in the *Physics: Rotational Motion and Astrophysics* and *Physics: Electromagnetism* Units.

Outcome 1 in the Investigating Physics Unit can be used as evidence of the achievement of Outcome 1 in the *Physics: Rotational Motion and Astrophysics*, *Physics: Quanta and Waves* and *Physics: Electromagnetism* Units.

Where Assessment Standard 2.2 is being assessed separately from Assessment Standard 2.1, evidence of achievement of Assessment Standard 2.2 for this Unit

can be used as evidence of achievement of Assessment Standard 2.2 in the *Physics: Rotational Motion and Astrophysics* and *Physics: Electromagnetism* Units.

Note: this does not apply when Outcome 2 is being assessed holistically.

As Assessment Standard 2.1 ('Making accurate statements and giving clear descriptions/explanations') relates specifically to the key areas of each Unit, evidence is **not transferable** between the Units for this Assessment Standard.

Exemplification of assessment is provided in *Unit Assessment Support*. Advice and guidance on possible approaches to assessment is provided in the *Unit Support Notes*.

Assessment Standard Thresholds

Outcome 1

Candidates are no longer required to show full mastery of the Assessment Standards to achieve Outcome 1. Instead, five out of the six Assessment Standards for Outcome 1 must be met to achieve a pass.

There is still the requirement for candidates to be given the opportunity to meet all Assessment Standards. The above threshold has been put in place to reduce the volume of re-assessment where that is required.

Re-assessment

Candidates may be given the opportunity to re-draft their original Outcome 1 report or to carry out a new experiment/practical investigation.

Outcome 2

Assessment Standards 2.1 and 2.2

Assessment Standards 2.1 (making accurate statements) and 2.2 (solving problems) are no longer required to be passed independently. Assessment Standards 2.1 and 2.2 can now be assessed by means of a single assessment for each Unit.

Centres have two possible options when assessing Outcome 2 (AS 2.1 and 2.2).

Option 1: Single assessment

Candidates can be assessed by means of a single test that contains marks and a cut-off score. A suitable Unit assessment will cover all of the key areas (AS 2.1) and assess each of the problem-solving skills (AS 2.2).

Where a candidate achieves 50% or more of the total marks available in a single Unit assessment they will pass Outcome 2 for that Unit. Existing Unit assessment support packs can be used. Guidance on the use of each pack is noted below.

(a) Unit assessment support pack 1 (Unit-by-Unit approach)

As these packages contain questions on all of the key areas (AS 2.1) and questions covering each of the problem solving skills (AS 2.2), Unit assessment support pack 1 **may be adapted** for use as a single assessment for its associated Unit.

The number of marks available for each question should be combined to give the total number of marks available. A cut-off score of 50% should be applied to each of these Unit assessments.

The balance of knowledge and skills in the current Unit assessment support packs does not always reflect the relative importance of these within physics, since they do not all adequately assess physics-based calculations.

Centres should either replace some of the questions in the Unit assessment support packs or supplement the existing questions with additional questions. In particular, centres may wish to replace existing questions with questions testing physics calculations or add additional questions of this type, so that the tests better reflect the relative importance of calculations in physics.

Where a calculation is of the type known as a 'standard three marker', it should be allocated 3 marks and the general marking principles in [Physics General Marking Principles](#) used.

Marks for questions testing KU would be allocated on a 1 mark for one response basis, using the marking guidance in the Unit assessment support packs.

If centres are replacing questions, it is important that each key area is still sampled.

Centres may wish to adapt the current Unit assessment support pack tests so that the sampling of each Unit is increased, the tests are out of the same total mark and that total is an even number so that the cut-off is actually 50%. Where centres are adding additional questions, care should be taken that these questions are of an appropriate standard for Unit assessment and are not 'A grade' type questions. For example, two stage calculations involving two formulae should be split into two separate parts rather than being presented as a 4- or 5-mark calculation question.

(b) Unit assessment support pack 2 (combined approach)

As these packages contain questions covering only Assessment Standard 2.1 they are not suitable for use as a single assessment for their associated Units.

If a centre wishes to use Unit assessment support pack 2 as a single Unit assessment, questions covering each of the four problem solving skills would need to be added, with an emphasis on 'standard three marker' type calculation questions.

Marks for questions testing KU (AS 2.1) would be allocated on a 1 mark for one response basis, using the marking guidance in the Unit assessment support packs.

The marks available for the key areas (AS 2.1) in each of these Unit assessments should be combined with the marks added to assess the problem-solving skills (AS 2.2) before the 50% cut-off score is applied.

As with the Unit-by-Unit approach, centres may wish to adapt the current Unit assessment support pack tests so that the sampling of each Unit is increased, the tests are out of the same total mark and that total is an even number so that the cut-off is actually 50%.

Where centres are adding additional questions, care should be taken that these questions are of an appropriate standard for Unit assessment and are not 'A grade' type questions.

Option 2: Assessment

Centres can continue to use the Unit assessment support packs from SQA's secure site, or their own centre devised assessments following the guidance in the Unit assessment support packs.

If this option is chosen, 50% or more of the KU statements (AS 2.1) made by candidates must be correct in the Unit assessment and at least one correct response for each problem solving skill (AS 2.2) is required to pass Outcome 2. However, if a candidate is given more than one opportunity in a Unit assessment to provide a response for a problem-solving skill, then they must answer 50% or more correctly.

Re-assessment

SQA's guidance on re-assessment is that there should be one or, in exceptional circumstances, two re-assessment opportunities. Re-assessment should be carried out under the same conditions as the original assessment. It is at a centre's discretion as to how they re-assess their candidates. Candidates may be given a full re-assessment opportunity, or be re-assessed on individual key areas and/or problem solving skills. Regardless of which KU option is chosen, candidates must achieve 50% or more of each re-assessment opportunity.

Development of skills for learning, skills for life and skills for work

It is expected that learners will develop broad, generic skills through this Unit. The skills that learners will be expected to improve on and develop through the Unit are based on SQA's *Skills Framework: Skills for Learning, Skills for Life and Skills for Work* and drawn from the main skills areas listed below. These must be built into the Unit where there are appropriate opportunities.

1 Literacy

- 1.1 Reading
- 1.2 Writing

2 Numeracy

- 2.1 Number processes
- 2.2 Money, time and measurement
- 2.3 Information handling

5 Thinking skills

- 5.3 Applying
- 5.4 Analysing and evaluating
- 5.5 Creating

Amplification of these is given in SQA's *Skills Framework: Skills for Learning, Skills for Life and Skills for Work*. The level of these skills should be at the same SCQF level as the Unit and be consistent with the SCQF level descriptor. Further information on building in skills for learning, skills for life and skills for work is given in the *Unit Support Notes*.

Administrative information

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Superclass: RC

History of changes to National Unit Specification

Version	Description of change	Authorised by	Date
2.0	Significant changes to Outcomes and Assessment Standards. Significant changes to Evidence Requirements.	Qualifications Development Manager	April 2015
3.0	Level changed from Advanced Higher to SCQF level 7 Unit code updated	Qualifications Manager	July 2019
4.0	Information that had been omitted now added regarding assessment methodologies.	Qualifications Manager	October 2020

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