SCQF level 7
Unit Specification

Physics: Rotational Motion and Astrophysics

SCQF: level 7 (8 SCQF credit points)

Unit code: J286 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 rotational motion and astrophysics. Learners will use these skills when considering how the applications of rotational motion and astrophysics can have impacts on our lives. This application and development of skills can be achieved using a variety of approaches, including investigation and problem solving.

This Unit covers the key areas of kinematic relationships, angular motion, rotational dynamics, gravitation, general relativity, and stellar physics.

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.

The key areas covered in this Unit are:

- kinematic relationships
- angular motion
- rotational dynamics
- gravitation
- general relativity
- stellar physics

The *Unit Support Notes* (Appendix) provide details of skills, knowledge and understanding sampled in the Unit assessment.

The following table describes the evidence for the Assessment Standards.

Assessment Standard	Evidence Requirements
Planning an experiment or practical investigation	A plan that must include: ♦ a clear statement of the aim ♦ a dependent and independent variable ♦ variables to be kept constant ♦ observations and measurements to be made ♦ necessary equipment and/or materials ♦ a clear and detailed description of how the experiment/practical investigation should be carried out, including safety considerations
Following procedures safely	A record showing the learner was observed following procedures safely
Making and recording observations/measurements correctly	Raw data recorded in a relevant format, for example a table Repeated measurements, where appropriate Where measurements are repeated, averages must be calculated.
Presenting results in an appropriate format	Results presented in a scatter graph
Drawing a valid conclusion	A conclusion that includes reference to the aim, and is supported by the data
Evaluating experimental procedures	Two evaluative statements, with justifications, about the procedures used
Making accurate statements and solving problems	Achievement of at least 50% of the total marks available in a holistic assessment The assessment must **not** be split into smaller sections, such as individual key areas

Exemplification of assessment is provided in *Unit Assessment Support*.

Assessment Standard Thresholds

Outcome 1
Learners are not 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. Learners must be given the opportunity to meet all Assessment Standards.

Outcome 2
Learners are assessed using a holistic test that covers Assessment Standards 2.1 and 2.2. For Outcome 2, learners must achieve 50% or more of the total marks available in the assessment.

Transfer of evidence

Evidence for the achievement of Outcome 1 for this Unit can be used as evidence for the achievement of Outcome 1 in the SCQF level 7 Units: *Physics: Quanta and Waves* (J2B7 77) and *Physics: Electromagnetism* (J2B8 77).

Evidence for the achievement of Outcome 2 for this Unit is **not** transferable between the SCQF level 7 Units: *Physics: Quanta and Waves* (J2B7 77) and *Physics: Electromagnetism* (J2B8 77).

Re-assessment

SQA's guidance on re-assessment is that there should be only one or, in exceptional circumstances, two re-assessment opportunities. Re-assessment must be carried out under the same conditions as the original assessment and must be of equal demand.

Outcome 1
Learners can either re-draft their original Outcome 1 report or carry out a new experiment and/or practical investigation.

Outcome 2
Learners must have a full re-assessment opportunity that consists of a holistic assessment. For Outcome 2, learners must achieve 50% of the total marks available in the re-assessment.

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.*

Appendix: Unit Support Notes

Introduction

These support notes provide advice and guidance on skills, knowledge and understanding for the unit assessment. They should be read in conjunction with:

- *Unit Assessment Support*

Developing skills, knowledge and understanding

Teachers and lecturers are free to select the skills, knowledge and understanding, and contexts that are most appropriate for delivery in their centres.

Skills, knowledge and understanding for the unit assessment

The following provides details of skills, knowledge and understanding sampled in the unit assessment.

Kinematic relationships

- Derivation of equations of motion using calculus methods.

  $v = u + at$

  $s = ut + \frac{1}{2}at^2$

- Use of calculus methods to calculate instantaneous displacement, velocity, and acceleration for straight line motion with a constant or varying acceleration.
- Use of appropriate relationships to carry out calculations involving displacement, velocity, acceleration, and time for straight line motion with constant or varying acceleration.

  $v = \frac{ds}{dt}$

  $a = \frac{dv}{dt} = \frac{d^2s}{dt^2}$

  $\left.\begin{aligned} v &= u + at \\ s &= ut + \frac{1}{2}at^2 \\ v^2 &= u^2 + 2as \end{aligned}\right\}$ for constant acceleration only

- Interpretation of graphs of motion for objects moving in a straight line.
- Calculation of displacement, velocity, or acceleration from graphs.

Angular motion

- Use of the radian as a measure of angular displacement.
- Conversion between degrees and radians.
- Use of appropriate relationships to carry out calculations involving angular displacement, angular velocity, angular acceleration, and time.

  $\omega = \frac{d\theta}{dt}$

  $\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$

  $\left.\begin{aligned} \omega &= \omega_0 + \alpha t \\ \omega^2 &= \omega_0^2 + 2\alpha\theta \\ \theta &= \omega_0 + \frac{1}{2}\alpha t^2 \end{aligned}\right\}$ for constant angular acceleration only

- Use of appropriate relationships to carry out calculations involving angular and tangential motion.

$$s = r\theta$$

$$v = r\omega$$

$$a_t = r\alpha$$

- Use of appropriate relationships to carry out calculations involving constant angular velocity, period, and frequency.

$$\omega = \frac{2\pi}{T}$$

$$\omega = 2\pi f$$

Centripetal force and acceleration

- Consideration of a centripetal (radial or central) force acting on an object to maintain circular motion, and the resulting centripetal (radial or central) acceleration of the object.
- Derivation of centripetal acceleration:

$$a_r = \frac{v^2}{r}$$

$$a_r = r\omega^2$$

- Use of appropriate relationships to carry out calculations involving centripetal acceleration and centripetal force.

$$a_r = \frac{v^2}{r} = r\omega^2$$

$$F = \frac{mv^2}{r} = mr\omega^2$$

Rotational dynamics

- Consideration of an unbalanced torque as causing a change in the angular (rotational) motion of an object.
- Definition of moment of inertia of an object as a measure of its resistance to angular acceleration about a given axis.

- Use of an appropriate relationship to calculate the moment of inertia of discrete masses, rods, discs, and spheres about a given axis.

$I = \Sigma mr^2$

$I = mr^2$

rod about centre $I = \frac{1}{12}ml^2$

rod about end $I = \frac{1}{3}ml^2$

disc about centre $I = \frac{1}{2}mr^2$

sphere about centre $I = \frac{2}{5}mr^2$

- Use of appropriate relationships to carry out calculations involving torque, perpendicular force, distance from axis, angular acceleration, and moment of inertia.

$\tau = Fr$

$\tau = I\alpha$

Angular momentum

- Use of appropriate relationships to carry out calculations involving angular momentum, angular velocity, moment of inertia, tangential velocity, mass and its distance from the axis.

$L = mvr = mr^2\omega$

$L = I\omega$

- Statement of the principle of conservation of angular momentum.
- Use of the principle of conservation of angular momentum to solve problems.

Rotational kinetic energy

- Use of appropriate relationships to carry out calculations involving potential energy, rotational kinetic energy, translational kinetic energy, angular velocity, linear velocity, moment of inertia, and mass.

$E_{k\ (\text{rotational})} = \frac{1}{2}I\omega^2$

$E_P = E_{k\ (\text{translational})} + E_{k\ (\text{rotational})}$

Gravitation

- Definition of gravitational field strength as the gravitational force acting on unit mass.
- Sketch field lines and field line patterns around a planet and a planet-moon system.
- Use of an appropriate relationship to carry out calculations involving gravitational force, masses, and their separation.

$$F = \frac{GMm}{r^2}$$

- Use of appropriate relationships to carry out calculations involving period of satellites in circular orbit, masses, orbit radius, and satellite speed.

$$F = \frac{GMm}{r^2} = \frac{mv^2}{r} = mr\omega^2 = mr\left(\frac{2\pi}{T}\right)^2$$

Gravitational potential and potential energy

- Definition of gravitational potential of a point in space as the work done in moving unit mass from infinity to that point.
- Knowledge that the energy required to move mass between two points in a gravitational field is independent of the path taken.
- Use of appropriate relationships to carry out calculations involving gravitational potential, gravitational potential energy, masses and their separation.

$$V = -\frac{GM}{r}$$

$$E_p = Vm = -\frac{GMm}{r}$$

Escape velocity

Definition of escape velocity as the minimum velocity required to allow a mass to escape a gravitational field or as the minimum velocity required to achieve zero kinetic energy and maximum (zero) potential energy.

- Derivation of the relationship:

$$v = \sqrt{\frac{2GM}{r}}$$

- Use of an appropriate relationship to carry out calculations involving escape velocity, mass, and distance.

$$v = \sqrt{\frac{2GM}{r}}$$

- Consideration of the energy required by a satellite to move from one orbit to another.

General relativity

Knowledge that special relativity deals with motion in inertial (non-accelerating) frames of reference, and that general relativity deals with motion in non-inertial (accelerating) frames of reference.

- Statement of the equivalence principle (that it is not possible to distinguish between the effects on an observer of a uniform gravitational field and of a constant acceleration) and knowledge of its consequences.

Spacetime diagrams

- Consideration of spacetime as a representation of four-dimensional space.
- Knowledge that light or a freely moving object follows a geodesic (the shortest distance between two points) in spacetime.
- Knowledge that GR leads to the interpretation that mass curves spacetime, and that gravity arises from the curvature of spacetime.
- Representation of world lines for objects that are stationary, moving with constant velocity, and accelerating.

Black holes

- Use of an appropriate relationship to solve problems relating to the Schwarzschild radius of a black hole

$$r_{Schwarzschild} = \frac{2GM}{c^2}$$

- Knowledge that time appears to be frozen at the event horizon of a black hole.

Stellar physics

- Properties of stars.
- Use of appropriate relationships to solve problems relating to luminosity, apparent brightness, power per unit area, stellar radius, and stellar surface temperature (using the assumption that stars behave as black bodies).

$$b = \frac{L}{4\pi d^2}$$

$$\frac{P}{A} = \sigma T^4$$

$$L = 4\pi r^2 \sigma T^4$$

- Knowledge of the stages in the proton-proton chain (p-p chain) in stellar fusion reactions that convert hydrogen to helium.

Stellar evolution

- Knowledge and understanding of the stages in stellar evolution and position in Hertzsprung-Russell (H-R) diagram.
- Classification of stars and position in H-R diagram.
- Prediction of colour of stars from their position in the Hertzsprung-Russell (H-R) diagram.

Advanced Higher Physics: Units, prefixes and uncertainties

Mandatory course key area	Exemplification of key areas
Knowledge and use of appropriate units, prefixes and scientific notation, eg electronvolt, light year. SI units used for all standard physical quantities.	Use of electronvolt (eV) as an alternative unit of energy in appropriate contexts. Light year (ly) as a measure of distance in appropriate contexts.
Use of an appropriate number of significant figures in final answers.	The final answer should have no more significant figures than the data with the fewest number of significant figures given in the question.
Knowledge and use, where appropriate, of uncertainties, including systematic uncertainties, scale reading uncertainties, random uncertainties, and calibration uncertainties. Calculations involving absolute uncertainties and fractional/percentage uncertainties	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. Calibration uncertainty is a manufacturer's claim for the accuracy of an instrument compared with an approved standard.
Appropriate use of significant figures in absolute uncertainties.	Absolute uncertainty should be rounded to one significant figure (two if the first number is small).
Data analysis Combination of various types of uncertainties to obtain the total uncertainty in a measurement. $\Delta W = \sqrt{\Delta X^2 + \Delta Y^2 + \Delta Z^2}$	

Mandatory course key area	Exemplification of key areas
Data analysis (continued) Combination of uncertainties in measured values to obtain the total uncertainty in a calculated value. $\Delta W = \sqrt{\Delta X^2 + \Delta Y^2 + \Delta Z^2}$ $\frac{\Delta W}{W} = \sqrt{\left(\frac{\Delta X}{X}\right)^2 + \left(\frac{\Delta Y}{Y}\right)^2 + \left(\frac{\Delta Z}{Z}\right)^2}$ $\left(\frac{\Delta W^n}{W^n}\right) = n\left(\frac{\Delta W}{W}\right)$	
Graphical interpretation Use of error bars to represent absolute uncertainties on graphs. Estimation of uncertainty in the gradient and intercept of a linear graph.	Various methods possible including the use of functions available in graph drawing software, for example linest and trendline functions in Excel.
Understanding the meaning of the terms accuracy and precision with reference to the comparison of an obtained value with a true value.	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.

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. Assessment standard threshold added. Unit code updated	Qualifications Manager	July 2019
4.0	Information that had been omitted now added regarding assessment methodologies.	Qualifications Manager	October 2020
5.0	Refined guidance on Evidence Requirements; removed option for assessment-standard-specific evidence for Outcome 2. Added 'Assessment Standards thresholds' heading to existing information. Refined guidance on re-assessment. Content statements and relationships added. Some changes made to the format throughout the document to improve accessibility. **What you need to do differently** ♦ If you are already assessing outcome 2 holistically at the end of the unit, by using the assessment as a single test with marks and a cut-off score, you don't need to do anything differently.	Qualifications Manager	August 2025

Version	Description of change	Authorised by	Date
5.0 (cont)	♦ If you have been assessing outcome 2 atomistically, by assessing each key area and each problem-solving skill separately, you must change to using the holistic approach for outcome 2. You must do this by administering the test in a single sitting, at the end of the unit, and applying the marks and cut-off score in the unit assessment support pack.	Qualifications Manager	August 2025