National Unit specification

General information

Unit title: Introductory Physics (SCQF level 5)

Unit code: HT8R 45

Superclass:	RC
Publication date:	August 2017
Source:	Scottish Qualifications Authority
Version:	1

Unit purpose

This unit is designed to provide learners with an introduction to the key aspects of physics, and to provide a background in physics for those who have no previous knowledge or experience in the subject. The unit is suitable for learners studying at NC level, and will provide the necessary underpinning knowledge and skills to enable progression to further study of physics at Higher level.

Outcomes

On successful completion of the unit the learner will be able to:

1 Explain the principles of waves and lenses laws.
2 Describe the principles and medical applications of radiation.
3 Explain the principles of heat energy.
4 Explain the principles of kinetics.
5 Explain the principles of electricity.

Credit points and level

1 National Unit credit at SCQF level 5: (6 SCQF credit points at SCQF level 5)

Recommended entry to the unit

Entry is at the discretion of the centre.

National Unit specification: General information (cont)

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Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the support notes for this unit specification.

There is no automatic certification of Core Skills or Core Skill components in this unit.

Context for delivery

If this unit is delivered as part of a group award, it is recommended that it should be taught and assessed within the subject area of the group award to which it contributes.

The Assessment Support Pack (ASP) for this unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website **(http://www.sqa.org.uk/sqa/46233.2769.html)**.

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.

Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

National Unit specification: Statement of standards

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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

Explain the principles of waves and lenses laws.

Performance criteria

(a) Explains the difference between transverse or longitudinal waves. Explains the period and frequency of a wave. Performs calculations to determine the period and frequency of the wave. Performs calculations using the wave equation.
(b) Explains how interference of two waves can be constructive or destructive.
(c) Explains the different lens types, concave and convex. Explains and calculates the focal point, focal length and power of a lens.
(d) Draws ray diagrams to show how light travels through a lens. Uses ray diagrams to determine if an image is real or unreal and the size and orientation of an image observed through a single lens.

Outcome 2

Describe the principles and medical applications of radiation.

Performance criteria

(a) Describes the Rutherford model of the atom, including the position and charges on the electron, proton and neutron.
(b) Describes alpha, beta and gamma radiation and their ionisation and absorption levels.
(c) Describes methods of working safely with alpha, beta and gamma radiation. Calculates the activity half-life and half value thickness of a source.
(d) Describes the application of radiation in medicine.
(e) Calculates the absorbed dose and equivalent dose of radiation.

Outcome 3

Explain the principles of heat energy.

Performance criteria

(a) Explains heat energy.
(b) Describes convection, conduction and radiation of heat.
(c) Calculates specific heat capacitance for different materials.
(d) Explains latent heat. Determines the time and/or temperature for a change of state from a temperature heat graph. Performs calculations to determine latent heat energy.

National Unit specification: Statement of standards (cont)

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Outcome 4

Explain the principles of kinetics.

Performance criteria

(a) Explains the relationship between speed, distance and time. Performs calculations using the relationship between speed, distance and time.
(b) Explains the difference between a scalar and a vector and gives an example of each.
(c) Performs calculations to determine distance and/or displacement.
(d) Explains the difference between instantaneous and average speed and/or velocity. Explains a method for determining the instantaneous or average speed or state if the calculated speed or velocity is instantaneous or average.
(e) Describes the acceleration of a body from a velocity time graph.
(f) Performs calculations to determine acceleration and/or deceleration. Applies Newton's first and second laws.

Outcome 5

Explain the principles of electricity.

Performance criteria

(a) Describes the difference between a conductor and an insulator and gives an example of each.
(b) Describes the relationship between charge, current and time. Performs calculations using the relationship.
(c) Draws a circuit using components and meters.
(d) Describes a series or parallel circuit. Performs calculations to determine voltage, current and total resistance within a circuit on series and/or parallel circuits.
(e) Explains how Ohm's law is verified within an experimental setup. Performs calculations using Ohm's law. Performs calculations to determine the output of a potential divider. Explains how the output voltage can be increased or decreased using the rules of a series circuit.

National Unit specification: Statement of standards (cont)

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Evidence requirements for this unit

Evidence is required to demonstrate that learners have achieved all outcomes and performance criteria.

Written and/or oral recorded evidence for Outcomes 1 to 5 should be assessed using a holistic closed-book assessment under supervised conditions. Outcomes may also be assessed individually. It is recommended that the assessment — whether holistically or individually — be completed within 75 minutes. Learners can only have access to the SQA Relationships Sheet for National 5 Physics or any suitable replacement when sitting the assessment.

Outcome 1

The assessment will sample three of the four performance criteria. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Outcome 2

The assessment will sample three of the five performance criteria. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Outcome 3

The assessment will sample three of the four performance criteria. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Outcome 4

The assessment will sample four of the six performance criteria. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Outcome 5

The assessment will sample three of the five performance criteria. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

National Unit Support Notes

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Unit support notes are offered as guidance and 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

This unit is intended as part of the framework for the NC Applied Sciences Group Awards but may be suitable for inclusion in other science awards. It is designed to introduce learners to the key aspects of physics.

Outcome 1 — Explain the principles of waves and lenses laws

- The two different wave types and the direction of particle vibrations and energy. Examples of each type of wave, eg light is a transverse wave and sound is a longitudinal wave. The period (*T*) of the wave is the time taken for one complete wave to pass a point and the frequency (*f*) of the wave is the number of waves to pass a point in one second. The relationship between the period and the frequency of the wave is $f = \frac{1}{T}$. The wave equation $v = f\lambda$ should be introduced and used in the calculation of the different components for light and sound.

- Constructive and destructive interference, showing how two waves interact with each other. Constructive interference is the addition of the amplitudes of the waves and destructive interference is the subtraction of the amplitudes of the waves.

- The converse and convex lenses focus the light at the focal point, allowing the focal length (*f*) to be measured. The power of the lens can then be calculated using the equation $P = \frac{1}{f}$. Discussing the use of lens in the correction of hyperopia and myopia would help learners' understanding.

- Ray diagrams determine the orientation, image size and if the image is real or unreal. Discussing applications for the lens in instruments, telescopes and microscopes would aid learners' understanding.

Outcome 2 — Describe the principles and medical applications of radiation

- The Rutherford model gives a simple model of the atom which includes protons, neutrons and electrons. The position and charges of the protons, neutrons and electrons gives the overall neutral atom. The removal or gain of an electron makes the neutral atom into a positive or negative ion.

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- Alpha radiation is a helium nucleus so contains two protons and two neutrons. It is a heavy, slow moving particle. The fact it is short of two electrons makes the alpha radiation highly ionising. Beta radiation is an electron so has a very small mass and is fast moving with high energy. The electron is emitted when a neutron divides into a proton and an electron, and its ionisation level is low. Gamma radiation consists of high-energy electromagnetic waves emitted from unstable nuclei of some radioactive atoms. It has no mass or charge, and travels at the speed of light. These waves are usually referred to as gamma rays (γ-rays).

  Radiation is absorbed by the medium it passes through. Alpha radiation will travel through a few centimetres of air before being absorbed and will be completely absorbed by a sheet of paper. Beta radiation will travel through a few metres of air before being absorbed and will be completely absorbed by a few millimetres of aluminium. Gamma radiation is only slightly absorbed in air and travels tens of metres or more, and they will be completely absorbed by several centimetres of lead.

- Different levels of protection are required for the safe use of alpha, beta and gamma radiation. Monitoring exposure to radiation is very important. A source must be stored in a locked, marked and lead-lined box. Only authorised people can handle a radiation source, the length of time in use must be monitored and the source must be handled in a safe manner.

  The activity of the source is the number of decays per unit time, and can be calculated using $A = \frac{N}{t}$ and will decrease with time. The time it takes to decrease to half is the half-life and can be determined by the use of an activity time graph (where time is not in seconds) or by calculation.

  Half thickness shielding can also be calculated. This can be explained by the use of a virtual experiment where the different thickness of shielding is placed in front of the source and the radiation measured.

  Background radiation is all around us so must be measured and the counts reduced in order to determine a true half-life of half value thickness.

- Radiation is used in many ways in medicine, such as sterilisation of equipment, x-rays, tracers and cancer treatments.

- In any treatment using radiation it is important that the correct levels are used. The absorbed dose is the amount of energy per unit mass and can be calculated using $D = \frac{E}{m}$. The equivalent dose is the absorbed dose multiplied by the weighting factor of the source. The weighting factor is the ionisation level of the type of radiation. It can be calculated using $H = DW_r$.

National Unit Support Notes (cont)

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Outcome 3 — Explain the principles of heat energy

- Heat energy is measured in joules. Heat and temperature are related but are not the same. If 5kJ of energy is applied to a large bucket of water, the water temperature will increase. If the same amount of energy is applied to a small bucket of water, the water temperature will increase by a greater amount.

- Heat can be transferred by several methods.

  Convection occurs when particles with a lot of heat energy in a liquid or gas move and take the place of particles with lesser heat energy. Liquids and gases are fluids. The particles in these fluids can move from place to place. Heat energy is transferred from hot places to cooler places by convection.

  Conduction occurs in a conductor when the electrons can leave their atoms and move about as free electrons. The parts of the atoms left behind are now charged ions. The ions are packed closely together and vibrate continually. The hotter the metal, the more kinetic energy these vibrations have. This kinetic energy is transferred from hot parts of the metal to cooler parts by the free electrons. These move through the structure, colliding with ions as they go. The heat transfer moves through the material from the hotter end to the colder end.

  Radiation of heat is the absorbing or emitting of thermal radiation, which is also known as infrared radiation. The higher the temperature of an object the more thermal radiation it will emit. Thermal radiation is a type of electromagnetic radiation so is a wave. This is unlike conduction and convection as no particles are involved.

- The specific heat capacity of a substance is the amount of energy needed to change the temperature of 1kg of the substance by 1°C. Different substances have different specific heat capacities. The heat energy required to increase a material by a certain amount is given by $E = Cm\Delta T$.

- The specific latent heat of a substance is a measure of how much heat energy is needed for it to change its state from solid to liquid or liquid to gas. It is the energy needed to melt or boil 1kg of the substance. Different substances have different specific latent heats. The specific latent heat of a given substance is different for boiling than for melting. The equation to calculate heat energy is $E = ml$. The temperature at which a material changes state can also by determined from a temperature time graph.

Outcome 4 — Explain the principles of kinetics

- The relationship between speed, distance and time is given by the equation $d = vt$. This can be used to determine the distance travelled, average speed or the time taken to complete a journey. This will introduce speed time graphs and should include explanation of the calculation of the distance travelled being the area under the graph.

National Unit Support Notes (cont)

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- A scalar has only magnitude, one example of this being distance. A vector can have magnitude and direction, one example of this being displacement. The scalar shows the distance travelled but the vector shows how far away an object is from a starting point and in which direction. For the direction of travel, three figure bearings should be used. A simple diagram could be drawn to represent the journey.

- Distance is calculated by adding together the distance travelled in each direction. Displacement can be calculated by means of a scale drawing or by Pythagoras' theorem and tangent of the angle.

- Instantaneous speed is the speed over a very short period of time. An example is the speed a formula one car travels a corner, or the speed of a service in tennis. Average speed is calculated over a longer distance. An example is travelling from one city to another where a car does not constantly travel at exactly the same speed. When the speed for this journey is calculated this is the average speed. When looking at the displacement the average and instantaneous velocity should be calculated.

- Acceleration is the change in velocity in a unit of time, $= \frac{v-u}{t}$. Acceleration is a vector and so has direction. This can be shown by the use of velocity time graphs. Newton's first and second laws should be introduced, to show that velocity remains constant when no unbalanced force is applied and a body will accelerate when an unbalanced force is applied.

Outcome 5 — Explain the principles of electricity

- In materials which act as conductors the internal electrons are free to move. Materials which allow the charges to move freely are known as conductors. Materials which do not allow the charge to flow through are known as insulators. Conductors are generally metals, the exception to which is graphite. Examples of insulators include glass, ceramics and polymers.

- When the electrons are free to move they will travel towards a positive charge. This flow of negative charges (Q) is a current (I). The current is the amount of charge per unit time and the relationship between them is given by the equation $Q = It$.

- All the components used to draw a circuit diagram have their own symbol. These symbols must be understood in order to read or draw a circuit diagram. The symbols for the following components should be recognised by learners: cell, battery, resistor, variable resistor, lamp, voltmeter and ammeter.

- A series circuit is a circuit with only one path for charges to flow around. In a series circuit the current is constant and the voltage across the components will add together to be the same as the voltage of the source, $V_s = V_1 + V_2 + \ldots$ The total resistance is calculated by adding the values of the resistors together, $R_T = R_1 + R_2 + \ldots$.

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In a parallel circuit there is more than one path for the charges to flow, so the charge will divide depending on the ratio of the resistance of the paths, $A_1 = A_2 + A_3 + \ldots$ As all the charges leave the source with the same energy they will all reach the parallel section with the same energy, so each path of a parallel section will have the same voltage. $V_s = V_1 + V_2$. The total resistance across a parallel section is calculated using the equation $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$. This answer must then be inverted to give the total resistance R_T.

- The relationship between the voltage, current and resistance is known as Ohm's law, $V = IR$. Voltage is equal to the current multiplied by the resistance, if the voltage is constant and the total resistance is increased the current must decrease. Along with the rules for a series circuit, Ohm's law can be used to determine the voltage across a single component. If this voltage is then used as the source for a further part of a circuit, this is known as a potential divider. This voltage can be calculated by the ratio of the resistors $\frac{R_1}{R_2} = \frac{V_1}{V_2}$ or by the potential divider equation $V_2 = \frac{R_2}{R_1 + R_2}$ x V_S.

Guidance on approaches to delivery of this unit

There is no particular order in which Outcomes 1 to 5 would be best delivered. While there are no assessed practical activities in this unit, it is envisaged that laboratory work and demonstrations will play a large part in delivery.

It is envisaged that delivery of Outcome 1 could commence with coverage of the basic wave phenomena, wave type, amplitude, wavelength, period and frequency of a wave. The effects of interference on a wave, both constructive and destructive, could be covered using appropriate examples, ie an increase in amplitude of the sound wave changes the pitch of the music.

The effect of putting light through different lenses and determining the focal length of the lens could then be discussed. The use of ray diagrams to determine the position of the image, if the image is real or imaginary or inverted or non-inverted should be covered.

For this outcome the use of a slinky would allow demonstration of the different wave types, where a ripple tank would allow the period and frequency of waves to be calculated. Short experiments using lens would allow the focal length to be determined.

Outcome 2 could commence with an explanation of the Rutherford model of the atom, including the position, charges and mass of each of the parts, followed by ionisation of the atom. A description of three types of radiation: alpha, beta and gamma radiation should include the charge, mass, speed and distance travelled in air. Delivery could then focus on an explanation of ionising and the materials which can be used to absorb each type of radiation.

The safe working procedures for radiation and calculation of the activity of a source could then be covered, as well as an explanation and calculation of the half-life of a source and the determination of the half value thickness. The uses for radiation in medicine, (eg x-ray, radiotherapy, tracers and sterilisation) and the calculation of the absorbed dose and equivalent dose should also be discussed.

For this outcome there are many short videos available and virtual experiments which would enhance learning and teaching. To cover the use of radiation in medicine, a group research activity followed by a short group presentation could be used.

Outcome 3 introduces heat energy measured in joules. The different methods of heat transfer, convection, conduction and radiation should be discussed, along with calculation and description of specific heat capacitance of materials. This could be followed by an explanation of specific latent heat in the change of state of a material, and determining the change of state using temperature time graphs.

For this outcome there are many short experiments which would enhance understanding of the topics, eg the use of a Leslie cube for radiation of heat.

Outcome 4 will introduce the relationship between speed, distance and time, and the calculation of the different components using the equation $d = vt$ and/or by a speed time graph. This should include a description of a scalar and a vector and an explanation what would be in each category, eg distance is a scalar and velocity is a vector. The calculation of distance and direction from two vectors at right angles to each other using scale drawings or by calculation could also be covered.

Learners should understand the difference between instantaneous and average speed and how each can be calculated in an experiment. This could be followed by the calculation of acceleration and deceleration by equation and a speed time or velocity time graph. Newton's first law should be used to develop understanding that a body will stay at rest or move with constant velocity unless an unbalanced force is applied. Newton's second law also states that if an unbalanced force is applied to a body, it will accelerate.

For this outcome the use of a toy car running down a slope using light gates or stopwatches could be used for calculation of the average speed or speed at different points on a slope. A graph could be drawn from this and/or acceleration calculated.

Outcome 5 will introduce the basis of electricity circuits, including the difference between a conductor and insulator and the different materials in each category. The relationship between charge and current and calculations using the appropriate equation could then be covered.

Learners should understand the symbols for different components in order to draw simple circuits. These circuits should include the ammeter and voltmeter in the correct position. The difference between a series and parallel circuit and the rules for determining the current and voltage at different parts of the circuit should be discussed, as well as the calculation of the total resistance of a circuit. This will lead to Ohm's law and the calculation of the voltage, current or total resistance. The calculation of the voltage over the individual components in a series circuit will lead to the use of a potential divider. Simple circuits with meters would demonstrate the rules of the circuit and verifying Ohm's law.

National Unit Support Notes (cont)

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Guidance on approaches to assessment of this unit

Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners.

Outcomes 1 to 5 could be assessed by a single holistic closed-book assessment with an appropriate cut-off score that covers the requirements as detailed in the performance criteria. Outcomes may also be assessed individually. Assessment should be carried out in supervised conditions, and it is recommended that the assessment — whether holistically or individually — be completed within 75 minutes. Learners can only have access to the SQA Relationships Sheet for National 5 Physics or any suitable replacement when sitting the assessment.

Where evidence of Outcomes 1 to 5 is assessed by sampling, the whole of the content listed in the Performance Criteria must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed, and different items should be sampled on each assessment occasion. Any items not sampled in the first assessment must be included in the alternative (re-sit) assessment.

An exemplar instrument of assessment with marking guidelines has been produced to indicate the national standard of achievement at SCQF level 5.

Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education.

Opportunities for e-assessment

E-assessment may be appropriate for some assessments in this unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the evidence requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at **www.sqa.org.uk/e-assessment**.

Opportunities for developing Core and other essential skills

The delivery and assessment of this unit will provide learners with the opportunity to develop the Core Skills of *Numeracy*, *Problem Solving* and *Information and Communication Technology (ICT)* at SCQF level 4.

Numeracy — Using Number at SCQF level 4

Learners will be required to carry out a number of calculations eg performing calculations related to wavelength of light, the calculation of the total resistance of a circuit.

National Unit Support Notes (cont)

Unit title: Introductory Physics (SCQF level 5)

Problem Solving — Critical Thinking at SCQF level 4

Learners will be required to analyse scenarios and decide on the steps and operations to solve problems, eg determining heat capacitance for different materials, doses of radiation and lens focal points.

Information and Communication Technology (ICT) — Accessing Information and Providing/Creating Information at SCQF level 4

Learners may be required to use online resources to research the use of radiation in medicine and choose a suitable medium to present the findings.

History of changes to unit

Version	Description of change	Date

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

General information for learners

Unit title: Introductory Physics (SCQF level 5)

This section will help you decide whether this is the unit for you by explaining what the unit is about, what you should know or be able to do before you start, what you will need to do during the unit and opportunities for further learning and employment.

This is a 1 credit unit at SCQF level 5, which you are likely to be studying as part of a NC Applied Sciences programme. This unit is designed to enable you to understand key aspects of physics, and will introduce you to five areas of physics: principles of waves and lenses laws, radiation, heat, kinetics and electricity.

On completion of the unit you should be able to:

1 Explain the principles of waves and lenses laws.
2 Describe the principles and medical applications of radiation.
3 Explain the principles of heat energy.
4 Explain the principles of kinetics.
5 Explain the principles of electricity.

Outcome 1

In this outcome you will learn about aspects of wave phenomena, the difference between transverse and longitudinal waves and how waves interact with each other constructively or destructively. You will also develop an understanding of how light waves are affected by lenses, this will include the drawing of ray diagrams used to determine the position, size and type of an image. You will also learn about the application of lenses in sight and different optical instruments, eg the telescope.

Outcome 2

In this outcome you will learn about the Rutherford model of an atom and some of the different types of radiation, as well as how radiation can be absorbed. Radiation safety, the use of radiation in medicine and the calculation of dose rates will also be covered.

Outcome 3

In this outcome you will learn about heat energy and the different methods of heat transfer, as well as how heat energy increases the temperature through different materials. You will also carry out calculations to determine heat capacitance and latent heat energy.

Outcome 4

In this outcome you will learn about speed, distance and time and the relationship between these and the difference between scalars and vectors. You will also gain an understanding of the difference between average speed and instantaneous speed and the calculation of these, distance, as well as acceleration and the application of Newton’s first and second laws.

General information for learners (cont)

Unit title: Introductory Physics (SCQF level 5)

Outcome 5

In this outcome you will learn about electricity, covering the differences between conductors and insulators, series and parallel circuits, the rules for calculation of voltage, current and resistance at different parts of a circuit, and the reading and drawing of simple electrical circuits, as well as Ohm's law.

Assessment

For Outcomes 1 to 5, depending on which centre you attend, assessment may be conducted on an outcome by outcome basis or by one single assessment. Assessment will be conducted under closed-book conditions.

Core Skills

Although there is no automatic certification of Core Skills in the unit, you will have opportunities to develop the Core Skills of *Numeracy, Problem Solving and Information and Communication Technology (ICT)* at SCQF level 4.