

SQA Advanced Unit Specification

General information for centres

Unit title: Engineering Science Principles

Unit code: HV4K 47

Unit purpose: This unit is designed to enable candidates to gain knowledge and understanding of the basic concepts and terminology of engineering science principles.

On completion of the unit the candidate should be able to:

- 1 apply the principles of linear and rotational motion
- 2 apply the principles of statics to beams and stressed components
- 3 apply the principles of engineering thermodynamics and fluid mechanics
- 4 apply the principles of electrical and electronic engineering to circuits

Credit points and level: 1 SQA 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 National 1 to Doctorates.*

Recommended prior knowledge and skills: Access to this unit will be at the discretion of the centre, however it is recommended that candidates are in possession of the NQ course Physics at SCQF level 6 or the core skill Numeracy at SCQF level 6.

Core skills: There are opportunities to develop the core skills of Written Communication (Writing) and Written Communication (Reading) at SCQF level 5. This unit gives automatic certification of the core skill Using Number at SCQF level 6.

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.

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Assessment: Outcomes 1, 2, 3 and 4 in this unit can be assessed separately by an assessment paper lasting one hour for each outcome. Alternatively the assessments for Outcomes 1, 2, 3 and 4 can be integrated into a unit assessment paper lasting no more than three hours. This end test paper should be taken by candidates at one single assessment event. The assessment paper should be composed of a suitable balance of short-answer, restricted-response and structured questions.

This assessment should be conducted under controlled, supervised conditions.

The assessment should be carried out at the end of the delivery of the outcome. If integrating the assessments, the assessment should be carried out at the end of the delivery of the unit.

It should be noted that the candidates must achieve all the minimum evidence specified for each outcome in order to pass the unit.

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SQA Advanced Unit Specification: statement of standards

Unit title: Engineering Science Principles

Unit code: HV4K 47

The sections of the unit stating the outcomes, knowledge and/or skills, and evidence requirements are mandatory.

Where evidence for outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Apply the principles of linear and rotational motion

Knowledge and/or skills

- ◆ Newton's Second Law applied to linear and angular motion
- ◆ Power transfer theory applied to linear and angular systems
- ◆ The kinetics of motion using an energy balance approach
- ◆ Uniform circular motion force systems

Evidence requirements

Evidence for the knowledge and/or skills in this outcome will be provided on a sample basis and be presented in response to specific questions. Each candidate will need to demonstrate that they can answer correctly questions based on a sample of the items shown above. In any assessment of this outcome three out of four knowledge and/or skills should be sampled.

In order to ensure candidates will not be able to foresee the items in which they will be questioned on a different sample of three knowledge and/or skills is to be used each time the outcome is assessed. Candidates must provide a satisfactory response to all three knowledge and/or skills items. When sampling takes place a candidate response can be judged satisfactory where evidence provided is sufficient to meet the requirement for each item by showing that the candidate is able to:

- ◆ solve problems using Newton's Second Law applied to linear and angular motion
- ◆ apply work and power transfer theory to linear and angular systems
- ◆ solve kinetics of motion problems using an energy balance approach
- ◆ analyse uniform circular motion force systems

Evidence should be generated through assessment undertaken in controlled supervised conditions.

Assessment guidelines

Assessments should be conducted under closed-book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment.

Questions used to elicit candidate evidence should take the form of an appropriate balance of short-answer questions, restricted-response questions and structured questions.

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Outcome 1 can be assessed separately by an assessment paper lasting one hour. Alternatively the assessments for Outcome 1 can be integrated with Outcomes 2, 3 and 4 into a unit assessment paper lasting no more than three hours.

Outcome 2

Apply the principles of statics to beams and stressed components

Knowledge and/or skills

- ◆ Support reactions for frame structures in equilibrium
- ◆ Force induced in the members of idealised frame structures
- ◆ Stress and strain
- ◆ Select materials for components

Evidence requirements

Evidence for the knowledge and/or skills in this outcome will be provided on a sample basis and be presented in response to specific questions. Each candidate will need to demonstrate that he/she can answer correctly questions based on a sample of the items shown above. In any assessment of this outcome three out of four knowledge and/or skills should be sampled.

In order to ensure candidates will not be able to foresee the items in which they will be questioned on a different sample of three knowledge and/or skills is to be used each time the outcome is assessed. Candidates must provide a satisfactory response to all two knowledge and/or skills. When sampling takes place a candidate response can be judged satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ calculate the support reactions for frame structures in equilibrium
- ◆ draw vector diagrams and evaluate force induced in the members of idealised frame structures
- ◆ calculate direct stress and strain
- ◆ select materials for components

Assessment guidelines

Assessment should be conducted under closed-book conditions and as such candidates should not be allowed to bring textbooks, handouts or notes to the assessment.

Questions used to elicit candidate evidence should take the form of an appropriate balance of short-answer questions, restricted-response questions and structured questions.

Outcome 2 can be assessed separately by an assessment paper lasting one hour. Alternatively the assessments for Outcome 2 can be integrated with Outcomes 1, 3 and 4 into a unit assessment paper lasting no more than three hours.

Outcome 3

Apply the principles of engineering thermodynamics and fluid mechanics

Knowledge and/or skills

- ◆ The Gas Laws
- ◆ Thermodynamic property tables
- ◆ The steady flow energy equation applications for gases and vapours
- ◆ Mass continuity and Bernoulli's equations applied to flow through pipes
- ◆ The behaviour of liquids at rest

Evidence requirements

Evidence for the knowledge and/or skills in this outcome will be provided on a sample basis and be presented in response to specific questions. Each candidate will need to demonstrate that he/she can answer correctly questions based on a sample of the items above. In any assessment of this outcome three out of five knowledge and/or skills will be sampled.

In order to ensure candidates will not be able to foresee the items in which they will be questioned on a different sample of three knowledge and/or skills will be used each time the outcome is assessed. Candidates must provide a satisfactory response to three knowledge and/or skills. When sampling takes place a candidate response can be judged satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ apply Gas Laws
- ◆ solve problems using data extracted from thermodynamic property tables
- ◆ solve problems associated with steady flow energy equation applications for gases and vapours
- ◆ apply the mass continuity and Bernoulli's equations to flow through pipes
- ◆ solve problems associated with the behaviour of liquids at rest

Evidence should be generated through assessment taken under controlled supervised conditions.

Assessment guidelines

Assessment should be conducted under closed-book conditions and as such candidates should not be allowed to bring textbooks, handouts or notes to the assessment other than thermodynamic property tables.

Questions used to elicit candidate evidence should take the form of an appropriate balance of short-answer questions, restricted-response and structured questions.

Outcome 3 can be assessed separately by an assessment paper lasting one hour. Alternatively the assessments for Outcome 3 can be integrated with Outcomes 1, 2 and 4 into a unit assessment paper lasting no more than three hours.

Outcome 4

Apply the principles of electrical and electronic engineering to circuits

Knowledge and/or skills

- ◆ Current, voltage and resistance relationships in a resistive DC network
- ◆ Power and energy in DC resistive and capacitive elements
- ◆ Force acting on a current-carrying conductor situated in a magnetic field
- ◆ Generation of a sinusoidal voltage waveform

Evidence requirements

Evidence for the knowledge and/or skills in this outcome will be provided on a sample basis and be presented in response to specific questions. Each candidate will need to demonstrate that he/she can answer correctly questions based on a sample of the items shown above. In any assessment of this outcome three out of four knowledge and/or skills should be sampled.

In order to ensure candidates will not be able to foresee the items in which they will be questioned on a different sample of three knowledge and/or skills is to be used each time the outcome is assessed. Candidates must provide a satisfactory response to all three knowledge and/or skills. When sampling takes place a candidate response can be judged satisfactory where evidence provided is sufficient to meet the requirements of each item by showing that the candidate is able to:

- ◆ determine the current, voltage and resistance relationships in a resistive DC network
- ◆ solve problems on power and energy in DC resistive systems and capacitive elements
- ◆ determine the relationship between the factors relating to the force acting on a current-carrying conductor situated in a magnetic field
- ◆ determine the factors which relate to the generation of a sinusoidal voltage waveform

Evidence should be generated through assessment taken in controlled supervised conditions.

Assessment guidelines

Assessment should be conducted under closed-book conditions and as such candidates should not be allowed to bring textbooks, handbooks or notes to the assessment.

Questions used to elicit candidate evidence should take the form of an appropriate balance of short-answer questions, restricted-response questions and structured questions.

Outcome 4 can be assessed separately by an assessment paper lasting one hour. Alternatively the assessments for Outcome 1 can be integrated with Outcomes 1, 2 and 3 into a unit assessment paper lasting no more than three hours.

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Administrative information

Unit code:	HV4K 47
Unit title:	Engineering Science Principles
Superclass category:	RC
Original date of publication:	November
Version:	01

History of changes:

Version	Description of change	Date

Source: SQA

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SQA Advanced Unit Specification: support notes

Unit title: Engineering Science Principles

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

This unit has been written in order to allow candidates to develop knowledge, understanding and skills in the following areas:

- 1 apply the principles of linear and rotational motion
- 2 apply the principles of statics to beams and stressed components
- 3 apply the principles of engineering thermodynamics and fluid mechanics
- 4 apply the principles of electrical and electronic engineering to circuits

The unit is at SCQF level 7 and the unit has been developed as part of the new SQA Advanced Certificate/Diploma in Measurement and Control Engineering. However this does not preclude the use of this unit in other awards where award designers feel it is appropriate.

In designing this unit, the writer has identified the range of topics that they would expect to be covered by lecturers. The writer has also given recommendations as to how much time should be spent on each outcome. This is done to help lecturers to decide what depth of treatment should be given to the topics attached to each outcome.

A list of topics for each outcome is given below.

Outcome 1 (10 hours)

Solve problems using Newton's Second Law applied to linear and angular motion

- (a) The elements of motion are accurately defined in accordance with established theory.
- (b) The interrelationships between the elements of motion are analysed in accordance with established theory.
- (c) Problems relating to systems affected by uniform acceleration are solved correctly.

Motion: linear, angular, combined (limited to one linear and one angular influence).

Elements: displacement, velocity, acceleration, time, accelerating force, accelerating torque.

Apply work and power transfer theory to linear and angular systems

- (a) Work and power quantities are defined correctly in accordance with established theory.
- (b) Work and power calculations are performed correctly.
- (c) Problems related in systems affected by constant and variable applied forces are solved accurately.

Systems: linear, angular, combined (limited to one linear and one angular influence).

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Solve kinetics of motion using an energy balance approach

- (a) The influences affecting kinetic energy are defined correctly in accordance with established theory.
- (b) Energy balance principles are applied to motion systems correctly.
- (c) Problems relating to systems affected by uniform acceleration are solved accurately.

Systems: linear, angular, combined (limited to one linear and one angular influence).

Forms of energy: potential, kinetic.

Analyse uniform circular motion force systems

- (a) Centripetal acceleration is defined correctly in terms of the requirement for circular motion in accordance with established theory.
- (b) An experiment to verify the theory of centripetal acceleration is performed satisfactorily.
- (c) The effect of centripetal acceleration on mechanisms is qualitatively described correctly.

Mechanisms: vehicle movement, centrifugal clutch, simple balancing requirements.

Outcome 2 (10 hours)

Calculate the support reactions for frame structures in equilibrium

- (a) Equilibrium in frame structures is analysed in relation to forces induced in the members.
- (b) The general conditions of equilibrium are correctly stated.
- (c) Free body diagrams are accurately produced for frame structures in terms of force equilibrium.
- (d) The reaction forces are calculated correctly for frame structures in equilibrium.

Conditions of equilibrium: force balance, turning effects balance.

Frame structures: simply supported.

Draw vector diagrams and evaluate force induced in the members of idealised frame structures

- (a) All the assumptions made when considering plane frames are in accordance with established practice.
- (b) Frames are analysed correctly to determine all external forces.
- (c) Combined vector diagrams for frames are drawn to a scale which allows accurate determination of forces in members.
- (d) The magnitude and nature of force caused to act on specified members are determined correctly using combined vector diagrams.
- (e) The conditions of redundancy and collapse are indicated correctly during the production of appropriate combined vector diagrams.

Calculate direct stress and strain and select materials for components

- (a) Direct stress and strain are defined accurately in terms of established practice.
- (b) The relationship between stress and strain within the elastic limit is stated in terms of established theory.
- (c) Calculations of stress and strain are accurately performed for loaded components.
- (d) Component materials are correctly selected to meet simple loading requirements.

Components: uniform cross-sectional area, two different cross-sectional areas.

Materials: 3 linear elastic.

Materials selection: ultimate strength, yield stress, modulus of elasticity

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Outcome 3 (10 hours)

The Gas Laws

- (a) Describe the individual laws.
- (b) Use the combined gas law. $\frac{PV}{T} = \text{Constant}$, $PV = mRT$
- (c) Solve problems involving perfect gases
- (d) Solve practical problems
- (e) Practical work

Properties of vapours

- (a) Extract data for thermodynamic property tables.
- (b) Interpolation of values.
- (c) Solve problems using data from tables.

Steady flow energy equation (SFEE)

- (a) Input-output process approach is used to describe common thermodynamic process.
- (b) Solve problems using SFEE.
- (c) Applications of the SFEE to analyse practical situations.

Boyle's law or Charles's law could be used as examples

To include the calculation of properties of gas turbines and nozzles

Fluids should be limited to water

Properties are to include saturation temperature and pressure, internal energy, enthalpy specific Volume in under cooled liquid, saturated liquid, wet vapour, saturated vapour and super heater vapour conditions

Restricted to enthalpy, internal energy and specific volume

Problems should include a change of phase

Calculation of dryness fraction and degree of superheat

Problems should be broken down to simplified Input/Output diagrams: for example boiler, heat exchanger or turbine

Starting with problems that eliminate many of the energy terms and increasing the difficulty to a maximum of three subsystems

Analyse a practical situation using SFEE

Flow through pipes

- (a) Derive Bernoulli's equation from the SFEE
- (b) Mass continuity
- (c) Solve problems using Bernoulli's equation

Static fluid behaviour

- (a) Manometry
- (b) Convert height differences to flow
- (c) Relate pressure on submerged plates to depths

Eliminate irrelevant terms and replace specific volume with density. To include inclined pipe, convergent and divergent pipes, venturimeter, restricted to incompressible flow.

Piezometer tube, U-tube manometers only

Calculation of thrust on submerged areas and position of centre of pressure on submerged and partially submerged plates. Restricted to pressure on one side only, and rectangular and round plates only

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Outcome 4 (10 hours)

Current, voltage and resistance relationships in a resistive DC network

Essential parts of a basic circuit, i.e. source, load, conductors

Concept of current flow round a circuit. Potential difference

Relationship between circuit current, voltage and resistance, ie $I = V/R$

Series resistive circuits, i.e. resultant resistance, voltage distribution and current

Parallel resistive networks, i.e. resultant resistance, current distribution and voltage

Combined series-parallel resistive networks, i.e. resultant resistance, branch currents, series potential differences, etc

Power and energy in DC resistive and capacitive elements

Concepts of power and energy

Units of power: watt and kilowatt, etc

Units of energy: joule and kilowatt hour, etc

Calculation of power in electrical systems from the expressions $P = VI$, $P = I^2R$,

$P = V^2/R$ and $P = W/t$

Calculation of voltage, current and resistance from the power expressions

Calculation of energy using expressions $W = Pt$, $W = Vit$, $W = I^2 Rt$ and $W = V^2 t/R$

Capacitance $C = \frac{Q}{V_c}$, capacitors in parallel and series, Energy stored in capacitor $W = \frac{1}{2}CV^2$.

Force acting on a current-carrying conductor situated in a magnetic field

Elements required to set up magnetic fields

Permanent and electromagnetic field patterns

Factors relating to the interaction of two magnetic fields

Concept of force acting on a current-carrying conductor situated in a magnetic field as the result of interaction between two fields

Factors determining the magnitude and direction of the force

Calculation of force on a straight conductor using the expression $F = BIl$

Generation of a sinusoidal voltage waveform

Concept of e.m.f. and its generation by the movement of a straight conductor at the perpendicular through a magnetic field

Factors determining the magnitude of the generated e.m.f. and the direction in which it acts

Calculation of generated e.m.f. using the expression $e = Blu$ volts

Generation of e.m.f. by the rotation of a single loop of conductor in a magnetic field

Generated e.m.f. at any instant as a function of $\sin \alpha$ where α is the angle through which the loop has rotated at the given instant

Use of the instantaneous e.m.f. expression $e = E_{\max} \sin \alpha$ volts

Statement of r.m.s. value of sinusoidal voltage as $E_{\text{rms}} = \frac{1}{\sqrt{2}}E_{\max}$

Outcomes 1, 2, 3 and 4 in this unit can be assessed separately by an assessment paper lasting one hour for each outcome. Alternatively the assessments for Outcomes 1, 2, 3 and 4 can be integrated into a unit assessment paper lasting no more than three hours.

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Guidance on the delivery and assessment of this unit

This is an optional unit for candidates requiring a basic knowledge and understanding of the basic concepts and terminology of engineering science principles.

The content of the outcomes means that they preferably should be delivered in order but this is not a necessity.

Details on approaches to assessment are given under evidence requirements and assessment guidelines under each outcome in the SQA Advanced Unit Specification: statement of standards section. It is recommended that these sections be read carefully before proceeding with assessment of candidates.

Opportunities for developing core skills

There are opportunities to develop the core skills of Written Communication (Writing) and Written Communication (Reading) at SCQF level 5 in this unit. This unit gives automatic certification of the core skill Using Number at SCQF level 6.

Open learning

This unit could be delivered by distance learning, which may incorporate some degree of on-line support. With regard to assessment, planning would be required of the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that assessments were conducted under controlled, supervised conditions.

For information on open learning, please refer to *SQA guide assessment and quality assurance of open and distance learning (A1030, Feb 2001)*.

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.

General information for candidates

Unit title: Engineering Science Principles

This unit has been designed to allow you to develop knowledge and understanding and skills associated with engineering science principles.

The unit will also enable you to gain an understanding about engineering science principles in the following areas:

- ◆ the principles of linear and rotational motion
- ◆ the principles of statics applied to beams and stressed components
- ◆ the principles of engineering thermodynamics and fluid mechanics
- ◆ the principles of electrical and electronic engineering to applied circuits

The formal assessment for this unit will consist of a written assessment. Outcome one, two, three and four will be a written assessment paper that will last for not more than three hours. This assessment will take place under controlled, supervised conditions in which you will not be allowed to take notes, handouts, textbooks etc into the assessment.

The written assessments will normally be carried out at the end of the delivery of the unit.