Higher National Unit Specification

General information for centres

Unit title: Engineering Science Principles

Unit code: DX49 34

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 HN Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*).

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

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.

General information for centres (cont)

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.

Higher National Unit specification: statement of standards

Unit title: Engineering Science Principles

Unit code: DX49 34

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.

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.

Higher National Unit specification: statement of standards (cont)

Unit title: Engineering Science Principles

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.

Higher National Unit specification: statement of standards (cont)

Unit title: Engineering Science Principles

Outcome 4

Apply the principles of electrical and electronic engineering to circuits

Knowledge and/or skills

- Current, voltage and resistance relationships in a resistive D.C. network
- Power and energy in D.C. 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 D.C. network
- solve problems on power and energy in D.C. 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.

Administrative Information

Unit code: DX49 34

Unit title: Engineering Science Principles

Superclass category: RC

Original date of publication: July 2006

Version: 02 (September 2006)

History of Changes:

Version	Description of change	Date
02	Core Skill information added. Recommended prior knowledge and skills statement reviewed.	1/9/06

Source: SQA

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of Higher National qualifications.

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Customer Contact Centre for further details, telephone 0845 279 1000.

Higher National 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 HNC/D Measurement and Control Engineering award. 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).

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

Outcome 3 (10 hours)

The Gas Laws
(a) Describe the individual laws.
(b) Use the combined gas law. $\frac{PV}{T} = Constant, PV = mRT$
(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.

Outcome 4 (10 hours)

Current, voltage and resistance relationships in a resistive D.C. 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 D.C. 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 $W = Pt$, $W = VIt$, $W = I^2Rt$ and $W = V^2 2t/R$.
Capacitance $C = \frac{Q, \text{ capacitors}}{Vc}$ in parallel and series, Energy stored in capacitor $W = \frac{1}{2}CV_c^2$

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 α where α is the angle through which the loop has rotated at the given instant.
Use of the instantaneous e.m.f. expression $e = E\text{max} \sin \alpha$ volts.
Statement of r.m.s. value of sinusoidal voltage as $E\text{rms} = \frac{1}{\sqrt{2}} E\text{max}$.

Higher National Unit specification: support notes (cont)

Unit title: Engineering Science Principles

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.

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 Higher National 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).*

Candidates with disabilities and/or additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative Outcomes for Units. For information on these, please refer to the SQA document *Guidance on Alternative Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs,* which is available on SQA's website: **www.sqa.org.uk**.

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 static's 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, thee 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.