Higher National Unit Specification

General information for centres

Unit title: Engineering Mathematics

Unit code: DP13 35

Unit purpose: This unit provides the candidate with the opportunity to acquire knowledge of a range of mathematical techniques and will develop his/her understanding of how these techniques can be applied to solve engineering problems. Candidates will also learn the value of mathematics as a method of communicating results.

The knowledge and skills that candidates acquire in this unit will underpin their study of most other units of the Higher National Programme.

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

- Demonstrate a knowledge of the properties of **trigonometric functions**
- Construct and solve **algebraic equations representing engineering problems**
- Use techniques of **calculus to determine maximum and minimum values and to calculate areas and volumes**
- Define **engineering problems using differential equations** and solve these equations using analytical and numerical methods
- Analyse problems using **probability and statistics**.

Credit points and level: 1 HN Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8*)

**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: Candidates should have completed the Numerical Methods unit within this HNC or an equivalent SQA or school mathematics unit that provides suitable background knowledge of the topics covered in this unit.

Core skills: There may be opportunities to gather evidence towards core skills in this Unit, although there is no automatic certification of core skills or core skills components.

Context for delivery: This unit was developed for the HNC Building Services Engineering. If this Unit is delivered as part of another group award, it is recommended that it should be taught and assessed within the subject area of the group award(s) to which it contributes.

General information for centres (cont)

Assessment: It is possible to assess candidates either on an individual Outcome basis, combinations of Outcomes or by a single holistic assessment combining all Outcomes. The assessment paper/s should be composed of an appropriate balance of short answer, restricted response and structured questions. Assessment should be conducted under supervised, controlled conditions. A single assessment covering all outcomes should not exceed 2 hours in duration. It should be noted that candidates must achieve all the minimum evidence specified for each Outcome in order to pass this Unit.

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.

Higher National Unit specification: statement of standards

Unit title: Engineering Mathematics

Unit code: DP13 35

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

(If you think holistic assessment is the best assessment strategy for the Unit and you wish to state *Knowledge and/or Skills* and *Evidence requirements* for the Unit as a whole, please add the following statement here: 'Please refer to *Knowledge and/or skills for the Unit* and *Evidence requirements for the Unit* after the Outcomes.')

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

Demonstrate knowledge of the properties of **trigonometric functions**

Knowledge and/or skills

- Graphs of functions of the form $R\sin(wt+a)$
- Trigonometric identities

Evidence requirements

Candidates will need evidence to demonstrate their knowledge and/or skills by showing that they can:

- produce accurate sketch graphs of functions of the form $R\sin(wt+a)$ including waves of the same frequency
- use of trigonometric identities sin, cos, tan for the analysis of three dimensional models

In any assessment of this Outcome **all** knowledge and/or skills items should be included. Candidates must provide a satisfactory response to all items.

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

Assessment guidelines

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

The assessment for this outcome might be combined with that for Outcomes 2,3,4,5 to form a single assessment paper.

Higher National Unit specification: statement of standards (cont)

Unit title: Engineering Mathematics

Outcome 2

Construct and solve **algebraic equations representing engineering problems**

Knowledge and/or skills

- Simultaneous linear equations
- Inverse matrices
- Gaussian elimination
- Non-linear equation

Evidence requirements

Candidates will need evidence to demonstrate their skills and/or knowledge by showing that they can:

- solve simultaneous linear equations using inverse matrices and Gaussian elimination
- select and use an appropriate method to solve a non-linear equation.

Evidence for the knowledge and /or skills for this Outcome will be provided on a sample basis. In any assessment of this Outcome a minimum of **three out of four** knowledge and/or skills items should be sampled. In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of knowledge/skill items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all three items.

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

Assessment guidelines

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

The assessment for this outcome might be combined with that for Outcomes 1,3,4,5 to form a single assessment paper.

Outcome 3

Use techniques of **calculus to determine maximum and minimum values and to calculate areas and volumes**

Knowledge and/or skills

- Maximum and minimum values
- Partial derivatives
- Stationary points of functions
- Integrals
- Areas and volumes

Higher National Unit specification: statement of standards (cont)

Unit title: Engineering Mathematics

Evidence requirements

Candidates will need evidence to demonstrate their knowledge and/or skills by showing that they can:

- identify and classify maximum and minimum values of functions of one variable
- determine partial derivatives of functions of many variables
- locate and classify stationary points of functions of two variables
- use appropriate techniques to determine integrals
- calculate areas and volumes using definite integrals.

Evidence for the knowledge and /or skills for this Outcome will be provided on a sample basis. In any assessment of this Outcome a minimum of **three out of five** knowledge and/or skills items should be sampled. In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of knowledge/skill items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all three items.

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

Assessment guidelines

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

The assessment for this outcome might be combined with that for Outcomes 1,2,4,5 to form a single assessment paper.

Outcome 4

Define **engineering problems using differential equations** and solve these equations using analytical and numerical methods

Knowledge and/or skills

- Differential equation models
- Boundary value problems
- Analytical and numerical solutions
- Mathematical software

Evidence requirements

Candidates will need evidence to demonstrate their knowledge and/or skills by showing that they can:

- select appropriate differential equation models for engineering problems
- solve linear constant coefficient initial and boundary value problems
- explain the difference between analytical and numerical solutions
- use mathematical software to solve numerically differential equations.

Evidence for the knowledge and /or skills for this Outcome will be provided on a sample basis. In any assessment of this Outcome a minimum of **three out of four** knowledge and/or skills items should be sampled. In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of knowledge/skill items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all three items.

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

Assessment guidelines

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

The assessment for this outcome might be combined with that for Outcomes 1,2,3,5 to form a single assessment paper.

Outcome 5

Analyse problems using **probability and statistics**

Knowledge and/or skills

- Probability distribution
- Discrete and continuous data
- Standard distributions
- Straight line fit
- Statistical quality control

Evidence requirements

Candidates will need evidence to demonstrate their knowledge and/or skills by showing that they can:

- explain the meaning of a probability distribution and distinguish between discrete and continuous data
- use standard distributions to analyse engineering problems
- determine the best straight line fit to a set of data
- use simple statistical quality control.

Evidence for the knowledge and /or skills for this Outcome will be provided on a sample basis. In any assessment of this Outcome a minimum of **three out of five** knowledge and/or skills items should be sampled. In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of knowledge/skill items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all three items.

Higher National Unit specification: statement of standards (cont)

Unit title: Engineering Mathematics

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

Assessment guidelines

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

The assessment for this outcome might be combined with that for Outcomes 1,2,3,4 to form a single assessment paper.

Administrative Information

Unit code: DP13 35

Unit title: Engineering Mathematics

Superclass category: RB

Date of publication: August 2005

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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 Mathematics

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

The content comprises all the mathematics needed to achieve the outcomes. The various topic areas should be addressed as and when they are needed to analyse problems in the discipline the candidate is following. There is therefore no requirement for the content to be covered in its entirety and the content can be taken as a guide.

This unit underpins most of the other units in the Higher National Programme. The techniques covered also have specific application in some units. Importantly, this unit also provides the necessary mathematical skills to enable candidates to progress to higher studies.
Recommended time allocations to each outcome are given as guidance towards the depth of treatment which might be applied to each topic. This guidance has been used in the design of the assessment exemplar material provided with the unit.

1 **Properties of trigonometric functions (6 hours)**

Graphs: sin$x$, cos$x$, tan$x$, sin2x, cos2x, etc. Graph of $R\sin(wt+a)$. Amplitude, phase, frequency, period. Addition of waves ($a\sin x + b\cos x$).

Trigonometric identities: use of sin, cos and tan for resolution of three dimensional models

2 **Algebraic equations representing engineering problems (8 hours)**

Construct algebraic equations representing engineering problems: identify unknowns and derive model equations

Solve algebraic equations: matrix form of simultaneous linear equations. Role of the inverse matrix. Degenerate (singular) cases. Ill-conditioning. Gaussian elimination. Bisection and Newton-Raphson methods for non-linear equations

Construct and solve model equations.

3 **Calculus to determine maximum and minimum values and to calculate areas and volumes (10 hours)**

Techniques of calculus: to determine maximum and minimum values.

Location and classification of stationary points of functions of one variable. Partial differentiation. Location and classification of stationary points of functions of two variables.

Techniques of calculus to calculate areas and volumes: integration by parts, substitution and using partial fractions; calculation of areas and volumes.

4 **Engineering problems using differential equations (8 hours)**

Differential equation models in engineering (eg beam equation). Analytical solution of linear constant coefficient differential equations. Initial and boundary conditions. Basic ideas of numerical solution of differential equations. Euler's method. Solution of differential equations using appropriate software.

5 **Probability and statistics (8 hours)**

Probability distributions: discrete and continuous distributions; binomial, Poisson and normal distributions, linear regression and confidence intervals, sampling. Statistical quality control measures – standard deviation, tolerance, action limits, control charts for sample means.

Guidance on the delivery and assessment of this Unit

Opportunities for developing Core Skills

It is recommended that evidence for learning outcomes is achieved through well-planned course work, assignments and projects. Assessment may be formative and summative and both may feature as part of the process. Although assessments must be focused on the individual achievement of each candidate, group work and role-play activities may contribute to the assessment. Integrative assignments and project work will help to link this unit with other related units.

The volume of evidence required for each assessment should take into account the overall number of assessments being contemplated within this unit and the design of the overall teaching programme.
In designing the assessment instrument/s, opportunities should be taken to generate appropriate evidence to contribute to the assessment of Core Skills units.

Open learning

Given that appropriate materials exist this unit could be delivered by distance learning, which may incorporate some degree of on-line support. However, with regard to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that assessment/s were conducted under controlled, supervised conditions.

Candidates with additional support needs

This Unit specification is intended to ensure that there are no artificial barriers to learning or assessment. 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 Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs*, which is available on the SQA website www.sqa.org.uk

General information for candidates

Unit title: Engineering Mathematics

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- Use techniques of **calculus to determine maximum and minimum values and to calculate areas and volumes**
- Define **engineering problems using differential equations** and solve these equations using analytical and numerical methods
- Analyse problems using **probability and statistics**.

Evidence that you can satisfy the knowledge and skill elements of this unit will be obtained by assessment in controlled, supervised conditions to which you will not be allowed to bring textbooks, handouts or notes to the assessment.