SQA Advanced Unit Specification

General information

Unit title: Engineering Mathematics 3 (SCQF level 7)

Unit code: HT1M 47

Superclass: RB

Publication date: August 2017

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to develop a greater breadth mathematical skills required of learners seeking to use a SQA Advanced Diploma in Engineering as a pathway to further studies in mathematics at an advanced level, including articulation to university degree study. The Unit will provide learners with opportunities to develop the knowledge, understanding and skills to apply a range of differential and integral calculus techniques to the solution of mathematical problems.

Outcomes

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

1 Use differentiation techniques to solve mathematical problems.
2 Use integration techniques to solve mathematical problems.

Credit points and level

1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7)

Recommended entry to the Unit

Entry requirements are at the discretion of the centre. However, it would be advantageous if learners had a knowledge and understanding of basic differentiation and integration techniques together with sound algebraic skills. This knowledge and understanding may be evidenced by possession of the SQA Advanced Unit *Engineering Mathematics 2* or *Higher Mathematics*.

Core Skills

Achievement OF this Unit gives automatic certification of the following Core Skills component:

Complete Core Skill	None
Core Skill component	Using Number at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes for this Unit specification.

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**.

SQA Advanced 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.

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. Learners 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

Use differentiation techniques to solve mathematical problems.

Knowledge and/or Skills

- Product and Quotient Rules
- Implicit Differentiation
- Parametric Differentiation
- Differentiation of Inverse Trigonometric Functions
- Optimisation

Outcome 2

Use integration techniques to solve mathematical problems.

Knowledge and/or Skills

- Partial Fractions
- Integrals with infinite limits
- Integration by Substitution
- Integration by Parts
- Volumes of Revolution and Curved Lengths

SQA Advanced Unit Specification: Statement of standards

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Evidence Requirements for this Unit

A sampling approach will be used in the assessment of the Knowledge and/or Skills in this Unit. Learners will need to provide written and/or recorded oral evidence to demonstrate their Knowledge and/or Skills across all Outcomes by showing they can:

Outcome 1

Provide evidence of **three out of five** Knowledge and/or Skills in this Outcome. The following evidence should be provided for the particular Knowledge and/or Skill items sampled:

- Solve one problem that requires the use of the product rule and one problem that needs the use of the quotient rule
- Solve one problem that involves implicit differentiation
- Solve one problem that involves parametric differentiation (either where, t, can be eliminated or cannot be eliminated)
- Solve one problem that involves the differentiation of an inverse trigonometric function
- Solve one optimisation problem using at least one of the techniques shown above

Outcome 2

Provide evidence of **three out of five** *Knowledge and/or Skills* in this Outcome. The following evidence should be provided for the particular Knowledge and/or Skill items sampled:

- Represent in partial fraction form and integrate any two of the following:
  - A proper fraction with linear factors
  - A proper fraction with recurring linear factors
  - A proper fraction containing a quadratic factor
  - Improper fractions
- Solve one definite integral that has an infinite limit
- Solve one indefinite integral or one definite integral by the method of substitution
- Solve one problem involving the integration of the product of two functions using integration by parts (the problem may involve either an indefinite or definite integral)
- Use integration techniques to solve one problem which involves finding the volume of an object or the length of a curve

It is recommended that the assessment for both Outcomes takes places at a single end-of-unit assessment event. Outcomes may also be assessed individually. All re-assessments should be based on a different assessment instrument. This should re-assess both Outcomes or a full individual Outcome reflecting the format of the original assessment. All re-assessments should be based on a different sample of Knowledge and/or Skills.

All assessments should be unseen, closed-book and carried out under supervised, controlled conditions.

Computer algebra must not be used in the assessment of this Unit.

SQA Advanced Unit Specification: 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 one of a suite of five Units in Mathematics developed for SQA Advanced Qualifications across a range of Engineering disciplines. The five Units are:

Engineering Mathematics 1
Engineering Mathematics 2
Engineering Mathematics 3
Engineering Mathematics 4
Engineering Mathematics 5

In the development of this Unit a list of topics expected to be covered by lecturers has been identified. Recommendations have also been made on how much time lecturers should spend on each Outcome. The use of this list of topics is strongly recommended to ensure continuity of teaching and learning and adequate preparation for the assessment of the Unit. Consideration of this list of topics alongside the Assessment Support Pack developed for this Unit will provide clear indication of the standard expected in this Unit.

Outcome 1 (13 hours)

Use differentiation techniques to solve mathematical problems

- State the product and quotient rules: for example:

  For $y(x) = u(x)v(x)$

  $$\frac{dy}{dx} = v\frac{du}{dx} + u\frac{dv}{dx} \quad \text{or} \quad y' = vu' + uv'$$

  and for $y(x) = \frac{u(x)}{v(x)}$

  $$\frac{dy}{dx} = \frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2} \quad \text{or} \quad \frac{vu' - uv'}{v^2}$$

- Solve problems involving the use of the product and quotient rules (eg $x^2 \sin x$, $(4x+9)e^{-3x}$, $\frac{t^2-1}{t^2+1}$, $\frac{e^{2x}\cos x}{x^3}$ etc)
- Explain the difference between y being expressed explicitly in terms of x and y being expressed implicitly in terms of x
- Solve a range of problems involving implicit differentiation (eg $x^2 + 3y^2 + 4x – 5y = 7$)
- Extend to higher order differentials if time allows
- Explain what is meant by a parameter and parametric differentiation
- Solve parametric differentiation problems where t can be eliminated and where it cannot be eliminated (eg $x = 1 – t$, $y = 2t^2 + 5t + 7$, $y = t^3 + \cos t$, $x = e^t + t$)
- Identify the derivatives for inverse trigonometric functions on a table of standard derivatives
- Solve a range of problems involving the differentiation of functions that include inverse trigonometric functions
- Apply differentiation to optimise a parameter or parameters of a problem using at least one of the differentiation techniques used in the Outcome

Outcome 2 (10 hours)

Use integration techniques to solve mathematical problems

- Explain that partial fractions involve breaking down complicated fractions into the sum of simpler fractions
- Explain the difference between proper and improper fractions
- Solve a range of integration problems which involve the partial fraction representations of the following forms of fractions:
  - A proper fraction with linear factors
  - A proper fraction with recurring linear factors
  - A proper fraction containing a quadratic factor
  - An improper fractions
- Solve integrals with an infinite limit(s) of integration (eg $\int_0^\infty e^{-x}dx$)
- Solve a range of indefinite and definite integrals using the method of substitution (eg $\int (5x+2)^6 dx$, $\int \cos(4x-1)dx$, $\int x\sqrt{2x+1}dx$, $\int \frac{x}{\sqrt{1-x^2}}dx$ etc)
- Solve problems involving the integration of the product of two functions using the following formula (integration by parts):

$$\int u\left(\frac{dv}{dx}\right)dx = uv - \int v\left(\frac{du}{dx}\right)dx$$

(eg $\int x^2 e^{2x}dx$, $\int e^x \sin x dx$, $\int 3\ln x dx$)

- Solve integration problems involving volumes of revolution (volumes of cones, spheres, etc)
- Solve problems involving the length of curves using the following formula

$$\int_a^b \sqrt{1+\left(\frac{dy}{dx}\right)^2}\,dx$$

Guidance on approaches to delivery of this Unit

This Unit provides many of the core mathematical principles and processes required when studying Engineering at a more advanced level. Given the nature of the subject matter in the Unit it is advisable that the Unit is not delivered until learners have studied *Engineering Mathematics 2*.

Centres may deliver the Outcomes in any order they wish, but given the nature of the subject material in the Unit it is recommended that Outcome 1 is delivered first followed by Outcome 2.

It is recommended that Unit delivery is principally undertaken using a didactic approach. All teaching input should be supplemented by a significant level of formative assessment in which learners are provided with the opportunities to develop their knowledge, understanding and skills of the differentiation and integration techniques covered in the Unit. Computer software and computer algebra may be used to support learning (eg to confirm the solutions of mathematical problems), but it is strongly recommended that such learning resources are only used in a supportive capacity and not as the principal means of delivering Unit content.

Guidance on approaches to assessment of this Unit

Evidence can be generated using different types of assessment.

A recommended approach is the use of an examination question paper. The question paper should be composed of an appropriate balance of short answer, restricted response and structured questions.

All assessment papers should be unseen by learners prior to the assessment event and at all times, the security, integrity and confidentiality of assessment papers must be ensured. Assessment should be conducted under closed-book, controlled and invigilated conditions.

The questions in the examination should not be grouped by Outcome or be labelled in terms of the Outcomes they relate to when a single end-of-unit examination is used.

The summative assessment of both Outcomes — whether individually or at a single assessment event - should not exceed two hours. When assessing a learner's responses to summative assessment lecturers should concentrate principally on the learner's ability to apply the correct mathematical technique and processes when solving problems. Learners should not be penalised for making simple numerical errors. An appropriate threshold score may be set for the assessment of this Unit. If Outcome level assessment is used a threshold score should be used for each assessment.

Learners should be provided with a formulae sheet appropriate to the content of this Unit when undertaking their assessment. Computer algebra should not be used in the assessment of this Unit.

It is the learners' responsibility to ensure that any calculator they use during assessment are not designed or adapted to offer any of the following facilities:

- language translators
- symbolic algebra manipulation
- symbolic differentiation or integration
- communication with other machines or the internet

In addition, any calculator used by learners should have no retrievable information stored in them. This includes:

- databanks
- dictionaries
- mathematic formulae

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

This Unit has the Using Number component of Numeracy embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show that they have achieved Using Number at SCQF level 6.

History of changes to Unit

Version	Description of change	Date

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications.

FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

General information for learners

Unit title: Engineering Mathematics 3 (SCQF level 7)

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.

The *Engineering Mathematics 3* Unit is one of a suite of five Units in Mathematics developed for SQA Advanced Certificates and Diplomas across a range of Engineering disciplines. The five Units help develop the mathematical skills required for workplace roles and for more advanced studies in Engineering, for example, articulation to degree study at university.

The Unit is optional in a number of SQA Advanced Diplomas in Engineering.

This Unit is designed to develop a greater breadth mathematical skills required of learners seeking to use a SQA Advanced Diploma in Engineering as a pathway to further studies in mathematics at an advanced level, including articulation to university degree study. You will learn to use a range of differential calculus techniques such as the product and quotient rules, implicit and parametric differentiation and differentiation involving inverse trigonometical functions. You will use these differentiation techniques to find the optimum solution to problems. In addition, during Unit delivery you will develop the knowledge and skills to break down complicated polynomial fractions into partial fractions which allow such complex fractions to be integrated in a more straightforward way. You will also learn to use the following integration techniques: method of substitution and integration by parts. You will use the integration techniques you have learnt in the Unit to solve volume of revolution and length of a curve problems.

It is likely that Unit delivery will comprise of a significant teaching input from your lecturer. This will be supplemented by tutorial exercises which will allow you to develop the knowledge, understanding and skills to apply the mathematic principles and processes covered in the Unit to a range of Engineering problems.

Depending on which centre you attend, formal assessment may be conducted on an Outcome by Outcome basis or by one holistic assessment. Assessment will be conducted under closed-book, controlled and invigilated conditions.

Learners considering taking this Unit will normally be expected to have passed the *Engineering Mathematics 2* SQA Advanced Unit or equivalent.