SQA Advanced Unit Specification

General information for centres

Unit title: Engineering Mathematics 2 (SCQF level 7)

Unit code: HP49 47

Superclass: RB

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Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to develop the necessary mathematical skills required of learners seeking to use an SQA Advanced Diploma in Engineering as an exit qualification for an Engineering workplace role or as a pathway to further studies in mathematics at an advanced level. The Unit provides learners with opportunities to develop knowledge, understanding and skills to solve problems involving trigonometric and hyperbolic functions and identities; to differentiate and integrate a wide range of functions and use differentiation and integration techniques to solve Engineering problems.

Outcomes

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

1 Solve trigonometric and hyperbolic function problems.
2 Use differentiation techniques to solve Engineering problems.
3 Use integration techniques to solve Engineering problems.

Credit points and level

1 SQA Unit 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 functions including trigonometrical, log and

exponential functions together with sound algebraic skills. This knowledge and understanding may be evidenced by possession of the SQA Advanced Unit *Engineering Mathematics 1* 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.

Unit specification: statement of standards

Unit title: Engineering Mathematics 2 (SCQF level 7)

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

Solve trigonometric and hyperbolic function problems.

Knowledge and/or Skills

- Inverse trigonometric ratios
- Compound angle formulae
- Basic trigonometric identities
- Hyperbolic functions
- Basic hyperbolic identities

Outcome 2

Use differentiation techniques to solve Engineering problems.

Knowledge and/or Skills

- Differentiation of standards functions
- Chain Rule
- Second derivatives
- Rates of change
- Optimisation

Outcome 3

Use integration techniques to solve Engineering problems.

Knowledge and/or Skills

- Indefinite and definite integrals
- Integration of standard functions
- Applications of integration

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 that they can:

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Outcome 1

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

- Evaluate any two of the following trigonometric functions: $\sec\alpha$, $\operatorname{cosec}\alpha$, or $\cot\alpha$ for a given value (*s*) of α
- Solve one problem using one of the following compound angle formulae $\sin(x \pm \beta)$ or $\cos(x \pm \beta)$
- Solve one problem using one or more of the following trigonometric identities

$$\sin^2\alpha + \cos^2\alpha = 1$$
$$\sin 2\alpha = 2\sin\alpha\cos\alpha$$
$$\cos 2\alpha = 2\cos^2\alpha - 1$$
$$\cos 2\alpha = \cos^2\alpha - \sin^2\alpha$$

- Evaluate any two of the following hyperbolic functions: $\sinh\alpha$, $\cosh\alpha$ or $\tanh\alpha$ for a given value (*s*) of α
- Solve one problem involving hyperbolic identities

Outcome 2

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

- Use standard derivatives to solve two problems involving differentiation (standard derivatives to include ax^n, $(ax+b)^n$, trigonometric, hyperbolic, $\ln(ax+b)$ and $e^{(ax+b)}$)
- Differentiate a function which requires the use of the chain rule
- Apply first and second derivatives to determine the position and nature of a turning point on a curve
- Use differentiation to determine the rate of change of a variable in an Engineering problem
- Apply differentiation techniques to find the optimum solution to a problem

Outcome 3

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

- Solve one indefinite and one definite integral
- Solve two integrals using integrals of standard functions (standard functions to include ax^n, $(ax+b)^n$, trigonometric, hyperbolic, $\ln(ax+b)$ and $e^{(ax+b)}$)
- Apply integration techniques to the solution of an Engineering problem

It is recommended that the assessment for all three 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 all three 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.

Unit specification: support notes

Unit title: Engineering Mathematics 2 (SCQF level 7)

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 (12 hours)

Solve trigonometric and hyperbolic function problems

- Definitions of secant, cosecant and cotangent ratios
- Evaluation of secant, cosecant and cotangent ratios for given angles
- Distinguish between secant, cosecant and cotangent and $\cos^{-1}$, $\sin^{-1}$ and $\tan^{-1}$
- State compound angle formulae (eg $\sin(\alpha+\beta)=\sin\alpha\cos\beta\pm\sin\beta\cos\alpha$ and $\cos(\alpha\ \pm\ \beta)=\cos\alpha\cos\beta\mp\sin\alpha\sin\beta$
- Apply compound angle formulae to trigonometrical problems (eg $\sin(180^\circ+\theta)=-\sin\theta$
- State $\sin^2\alpha+\cos^2\alpha=1$, $\sin 2\alpha=2\sin\alpha\cos\alpha$ and $\cos 2\alpha=2\cos^2\alpha-1$ or $1-2\sin^2\alpha$, $\cos 2\alpha=\cos^2\alpha-\sin^2\alpha$
- Use trigonometrical equations in previous bullet point to simplify trigonometrical identities and solve trigonometrical equations
- Define sinh *x*, cosh *x*, tanh *x*, cosech *x*, sech *x* and coth *x*

- Use the following hyperbolic identities to prove identities and modify equations containing e^{x} and e^{-x}:

  $e^{x} = \cosh x + \sinh x$

  $e^{-x} = \cosh x - \sinh x$

  $\cosh^2 x - \sinh^2 x = 1$

  $\sinh(x \pm y) = \sinh x \cosh y \pm \cosh x \sinh y$

  $\cosh(x \pm y) = \cosh x \cosh y \pm \sinh x \sinh y$

  $\sinh 2x = 2\sinh x \cosh x$

  $\cosh 2x = \cosh^2 x + \sinh^2 x$

Outcome 2 (10 hours)

Use differentiation techniques to solve Engineering problems

- Revise indices including negative and fractional indices
- Introduce the concept of differentiation from first principles (not assessable)
- Introduce standard derivatives to include ax^n, $(ax+b)^n$, trigonometric, hyperbolic, $\ln(ax+b)$ and $e^{(ax+b)}$
- Use standard derivatives to find the derivatives of functions containing one or more of the terms in the previous bullet point
- State the chain rule, eg

$$\frac{dy}{dx} = \frac{dy}{du} \times \frac{du}{dx}$$

- Apply the chain rule to functions such as $(3x^4 + 7)^3$; $\sin(t^2 + 1)$; $5e^{\sin u}$ etc.
- Define higher derivatives (ie second, third, etc)
- Use the first and second derivatives to find the maximum and minimum of a function
- Use differentiation to evaluate rates of change problems in Engineering
- Apply differentiation to optimise a parameter or parameters of a problem (eg the condition under which the maximum electrical power will be transferred from a voltage source to load)

Outcome 3 (8 hours)

Use integration techniques to solve Engineering problems

- Define what is meant by integration (eg as anti-differentiation, as the area bounded by curves, etc
- Define indefinite and definite integrals
- Solve indefinite and definite integrals using standard integrals (standard integrals to include ax^n, $(ax+b)^n$, trigonometric, hyperbolic, $\ln(ax+b)$ and $e^{(ax+b)}$)
- Apply integration to solve problems in Engineering (area under a velocity time curve giving distance travelled, work done by an expanding gas, first and second moments of area, centroids, mean values, root mean square values, etc)

Guidance on approaches to delivery of this Unit

This Unit provides core mathematical principles and processes which underpin much of the studies undertaken in a number of SQA Advanced Qualifications across a range of Engineering disciplines. It is recommended that the Unit be delivered towards the beginning of these awards.

Centres may deliver the Outcomes in any order they wish, it is recommended that Outcome 1 is delivered first followed by Outcomes 2 and then Outcome 3.

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 opportunities to develop their knowledge, understanding and skills of the mathematical topics covered in the Unit. Computer software and computer algebra may be used to support learning (egto 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 all three 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. A threshold score should be used for each assessment if Outcome level assessment is used.

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.

Administrative information

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 candidates

Unit title: Engineering Mathematics 2 (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 2* 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 mandatory in a number of SQA Advanced Diplomas in Engineering.

This Unit is designed to develop the necessary mathematical skills required of learners seeking to use an SQA Advanced Diploma in Engineering as an exit qualification for an Engineering workplace role or as a pathway to further studies in mathematics at an advanced level. You will be introduced to differential calculus which is used widely to solve Engineering problems. This will include differentiating functions using standard derivatives, determining rates of change and finding optimum solutions to Engineering problems. You will also be introduced to integral calculus which is in many ways the reverse process of differentiation. You will learn to solve indefinite and definite integrals using standard integrals and use integration to solve Engineering 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 1* SQA Advanced Unit or equivalent.