



## National Unit specification

### General information

**Unit title:** Construction Engineering Mathematics (SCQF level 5)

**Unit code:** HG51 45

**Superclass:** RB

**Publication date:** September 2016

**Source:** Scottish Qualifications Authority

**Version:** 02

### Unit purpose

The unit is intended for those learners who wish to consolidate and develop their knowledge of the Mathematics underpinning studies in civil engineering. The unit develops basic skills in calculation, algebra, solving equations, and includes an introduction to the laws of logarithms and exponentials.

### Outcomes

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

- 1 Apply Algebraic Techniques to Simplify Mathematical Expressions.
- 2 Evaluate and Transpose Engineering Formulae.
- 3 Solve linear, Simultaneous and Quadratic Equations.
- 4 Evaluate and Manipulate Exponential and Logarithmic Functions.

### Credit points and level

1 National unit credit at SCQF level 5: (6 SCQF credit points at SCQF level 5)

### Recommended entry to the unit

Whilst Entry to the course is at the discretion of the centre, learners would normally be expected to have attained one of the following before undertaking this unit:

- ◆ The NQ unit *Mathematics: Craft 1* (SCQF level 5)
- ◆ National 5 Mathematics

## National Unit specification: General information (cont)

**Unit title:** Construction Engineering Mathematics (SCQF level 5)

### 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 5

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of 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](http://www.sqa.org.uk/assessmentarrangements).

## National Unit specification: Statement of standards

**Unit title:** Construction Engineering Mathematics (SCQF level 5)

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.

### Outcome 1

Apply Algebraic Techniques to Simplify Mathematical Expressions.

#### Performance Criteria

- (a) Expand and simplify correctly expressions involving brackets.
- (b) Factorise expressions correctly.
- (c) Manipulate and simplify mathematical expressions containing algebraic fractions correctly.
- (d) Apply the laws of indices correctly.

### Outcome 2

Evaluate and Transpose Engineering formulae.

#### Performance Criteria

- (a) Evaluate engineering formulae correctly, giving appropriate units with results.
- (b) Transpose engineering formulae correctly.

### Outcome 3

Solve linear, Simultaneous and Quadratic Equations.

#### Performance Criteria

- (a) Determine correctly the equation of a straight line from a given or constructed graph.
- (b) Construct appropriate simultaneous equations (two equations in two unknowns) from given data and solve simultaneous equations correctly.
- (c) Determine correctly the roots of quadratic equations using factorisation or formula.
- (d) Solve a pair of simultaneous equations, one linear and one quadratic, correctly using substitution techniques.

### Outcome 4

Evaluate and Manipulate Exponential and Logarithmic Functions.

#### Performance Criteria

- (a) Evaluate mathematical expressions containing exponential and logarithmic functions correctly.
- (b) Apply the appropriate laws of logarithms to mathematical expressions containing exponentials and logarithms.
- (c) Convert between exponential and logarithmic form correctly.

## National Unit specification: Statement of standards (cont)

**Unit title:** Construction Engineering Mathematics (SCQF level 5)

### Evidence Requirements for this Unit

Evidence is required to demonstrate that learners have achieved all Outcomes

Assessment may be carried out:

- ◆ Outcome by Outcome
- ◆ Two or more Outcomes together

Evidence should be produced under closed-book, supervised conditions.

Learners should not have information in advance about the content of the assessment.

A formula sheet containing the quadratic formula may be provided.

Scientific Calculators may be used, but Computer algebra packages, graphical calculators or programmable calculators should not be used.

Sufficient working must be shown to demonstrate the method of solution.

Where reassessment is needed, an alternative instrument of assessment must be used.

Total Assessment time should not exceed three hours.

### Outcome 1

Apply Algebraic Techniques to Simplify Mathematical Expressions.

- ◆ Multiply out brackets using the following forms:
  - $a(b+c)$
  - $(a+b)(c+d)$
  - $a(b+c+d)$
  - $(a+b)(c+d+e)$Both negative and positive terms should be used.  
Terms should be combined in at least one question (eg  $a(b+c)+d(e+f)$ )
- ◆ Factorise expressions of the following forms:
  - Linear (factorise both numbers and symbols)
  - Quadratic with unitary coefficient of  $x^2$Both negative and positive terms should be used.
- ◆ Manipulate and simplify mathematical expressions containing algebraic fractions using the following forms:
  - Adding/Subtracting fractions with the same denominator
  - Adding/Subtracting fractions with a different denominator
  - Multiplying Fractions
  - Dividing fractions
  - Fractions raised to a power

## National Unit specification: Statement of standards (cont)

### Unit title: Construction Engineering Mathematics (SCQF level 5)

- ◆ Manipulate and simplify mathematical expressions containing indices using the following:
  - Multiply terms
  - Divide terms
  - Raise terms to a powerBoth whole number and fractional indices should be used.  
Terms with a constant coefficients should be used.  
A simplification requiring a zero power should be included once.

### Outcome 2

Evaluate and Transpose Engineering formulae.

- ◆ Evaluate at least two engineering formulae. Use should be made of all the following operators, with at least three different ones in each formula:
  - Multiplication
  - Division
  - Addition and/or subtraction
  - PowersAnswers should incorporate units.
- ◆ Transpose at least two engineering formulae. Use should be made of all the following operators, with at least three different ones in each formula:
  - Multiplication
  - Division
  - Addition and/or subtraction
  - Powers
- ◆ Ask at least one question involving the conversion of units using an SI prefix (eg convert Pa to MPa)

### Outcome 3

Solve linear, Simultaneous and Quadratic Equations.

- ◆ Determine correctly the equation of a straight line from at least two given or constructed graphs:
  - One should allow the y-intercept to be read off from the y axis
  - One should require the y-intercept to be calculated by using  $y-b=m(x-a)$  or by substituting a point into  $y=mx+c$  once  $m$  has been calculatedOne problem should have a positive gradient, the other negative.  
Up to three co-ordinates may be given on the straight line for learners to use.  
Final answers should be given in the form  $y=mx+c$  or  $ax+by+c=0$
- ◆ From at least one textual scenario:
  - Construct appropriate simultaneous equations (two equations in two variables)
  - Solve the simultaneous equations algebraically using either elimination or substitution
  - Further calculations using the solutions may be asked if appropriate

## National Unit specification: Statement of standards (cont)

**Unit title:** Construction Engineering Mathematics (SCQF level 5)

- ◆ Determine correctly the roots of at least three quadratic equations algebraically:
  - One which may be solved using factorisation with unitary coefficient of x
  - One which may be solved using factorisation with non-unitary coefficient of x
  - One which must be solved using the quadratic formulaNote that the quadratic equation may be used to solve all cases at the learner's discretion.
- ◆ Solve at least one pair of simultaneous equations, one linear and one quadratic, correctly using substitution techniques.

### Outcome 4

Evaluate and Manipulate Exponential and Logarithmic Functions.

- ◆ Evaluate at least two mathematical expressions containing exponential and logarithmic functions correctly. Arguments should include:
  - Addition or subtraction
  - Multiplication
  - Division
- ◆ Apply the appropriate laws of logarithms to mathematical expressions containing exponentials and logarithms. Questions should be structured to include the following laws
  - $\log a + \log b = \log ab$
  - $\log a - \log b = \log a/b$
  - $a \log b = \log b^a$Both log base 10 and ln should be used.  
Some degree of algebraic simplification should be required.
- ◆ Solve an equation with an unknown base other than 10 or e where the solution is an integer (eg solve  $\log_x 9 = 2$ )
- ◆ Convert between exponential and logarithmic form correctly:
  - At least one question requiring conversion from logarithmic to exponential form
  - At least one question requiring conversion from exponential to logarithmic formAt least one question should use log base 10, the other ln.  
The arguments should involve an expression with at least a division or multiplication.



## National Unit Support Notes

**Unit title:** Construction Engineering Mathematics (SCQF level 5)

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 part of the National Certificate Group Awards in Civil Engineering, but can also be a free-standing unit. This unit aims to build on and extend the learner's mathematical knowledge and skills.

It is envisaged that the content of this unit is delivered in civil engineering contexts appropriate to the learner, whether as a mandatory unit of the Group Award or as a free-standing unit.

Applying the mathematical skills of the unit in meaningful civil engineering scenarios will enable the learner to appreciate that those skills are essential tools for civil engineering.

Consideration of this list of topics alongside the Assessment Support Pack for this unit will provide clear indication of the standard expected.

### Outcome 1

Apply Algebraic Techniques to Simplify Mathematical Expressions.

- ◆ Multiply out single and double brackets with up to three terms:
  - Both negative and positive terms should be used
- ◆ Factorise into single and double brackets:
  - Both negative and positive terms should be used
- ◆ Manipulate and simplify mathematical expressions containing algebraic fractions:
  - Adding/Subtracting fractions with the same denominator
  - Adding/Subtracting fractions with a different denominator
  - Multiplying Fractions
  - Dividing fractions
  - Fractions raised to a power

## National Unit Support Notes (cont)

**Unit title:** Construction Engineering Mathematics (SCQF level 5)

- ◆ Manipulate and simplify mathematical expressions containing indices correctly:
  - Multiply terms
  - Divide terms
  - Raise terms to a power
  - Use Fractional and negative indices
  - Understand and use  $\sqrt[n]{x} = x^{1/n}$
  - Understand and use  $\frac{1}{x^n} = x^{-n}$
  - Understand and use  $x^0 = 1$ , and  $x^1 = x$
  - Simplify multiplication and division of terms with coefficients (eg  $ax^b \cdot cx^d$ )

### Outcome 2

Evaluate and Transpose Engineering formulae.

- ◆ Evaluate and transpose equations containing combinations of:
  - Multiplication
  - Division
  - Addition
  - Subtraction
  - Powers
  - Roots
- ◆ Understand and use of scientific notation and SI prefixes (eg convert Pa to MPa)

### Outcome 3

Solve Linear, Simultaneous and Quadratic Equations.

- ◆ Find the equation of a straight line in cases where:
  - the y-intercept to be read off from the y axis
  - the y-intercept to be calculated by using  $y-b=m(x-a)$  or by substituting a point into  $y=mx+c$  once m has been calculated
- ◆ Construct appropriate two variable systems of linear simultaneous equations from descriptions, and solve them using back substitution and/or elimination.
- ◆ Solve quadratic equations using factorisation and/or quadratic equation.
- ◆ Solve simultaneous equations, one linear and one quadratic, using substitution techniques.
- ◆ Comparing algebraic solutions and graphical solutions will help the learners to appreciate the relationship between them (although graphical methods are not assessed).



## National Unit Support Notes (cont)

**Unit title:** Construction Engineering Mathematics (SCQF level 5)

### Outcome 4

Evaluate and Manipulate Exponential and Logarithmic Functions.

Both log base 10 and ln should be used.

- ◆ Evaluate expressions containing exponential and logarithmic functions correctly.  
Arguments should include:
  - Addition
  - Subtraction
  - Multiplication
  - Division
  
- ◆ Understand and use the following laws of logarithms in mathematical expressions:
  - $\log a + \log b = \log ab$
  - $\log a - \log b = \log a/b$
  - $a \log b = \log b^a$
  
- ◆ Understand and solve expressions involving log with bases other than 10 or e (for example by rewriting,  $\log_b x = y$  as  $b^y = x$ , or knowing that  $\log_b x = \frac{\log x}{\log b}$ )
  
- ◆ Convert between exponential and logarithmic form correctly.

### Guidance on approaches to delivery of this unit

This unit provides skills, techniques and processes underpinning studies undertaken in Civil Engineering, and as such, opportunities should be taken to contextualise delivery where possible.

Centres may deliver the Outcomes in any order they wish.

All teaching input should be supplemented by formative assessment in which learners are provided with opportunities to develop their knowledge, understanding and skills.

Computer software, computer algebra, and graphical calculators may be used to support learning (eg to confirm the solutions of mathematical problems).

## National Unit Support Notes (cont)

**Unit title:** Construction Engineering Mathematics (SCQF level 5)

### Guidance on approaches to assessment of this unit

Evidence may be generated using different types of assessment. The following are suggestions only and there may be other methods that would be more suitable to learners.

It is possible to assess learners either on an Outcome by Outcome basis or by combining some or all Outcomes into one assessment event. Centres may assess the Outcomes in any order they wish.

The assessment papers could be composed of an appropriate balance of short answer, restricted response and structured questions. Most parts of this unit lend themselves to assessment using straightforward Civil Engineering contexts, and questions should be contextualised where appropriate. Some part of the unit, however, such as those dealing with basic algebraic skills might be better assessed without context.

Care should be taken to avoid excessively elaborate contexts or language.

### 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](http://www.sqa.org.uk/e-assessment).

### Opportunities for developing Core and other essential skills

This unit allows learners the opportunity to develop their *Numeracy* and *Problem Solving* skills.

This Unit has the Using Number component of Numeracy embedded in it. This means that when learners achieve the Unit, their Core Skills profile will also be updated to show they have achieved Using Number at SCQF level 5.

## History of changes to Unit

Version	Description of change	Date
02	Core Skills Component Using Number at SCQF level 5 embedded.	16/11/2016

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## General information for learners

### Unit title: Construction Engineering Mathematics (SCQF level 5)

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 unit is intended to help you consolidate and develop your knowledge of the Mathematics underpinning studies in civil engineering, and is designed to lead on to the Mathematics units in the Higher National framework for civil engineering and related disciplines. The unit develops basic skills in calculation, algebra, solving equations, and includes an introduction to the laws of logarithms and exponentials.

The unit covers the following topics:

- ◆ Apply Algebraic Techniques to Simplify Mathematical Expressions.  
In this section you'll learn some basic methods of algebra including dealing with brackets, fractions, powers, roots. Algebra is fundamental to problem solving in engineering.
- ◆ Evaluate and Transpose Engineering Formulae.  
In this section you'll learn how to substitute data into engineering formulae to solve problems, and also learn how to transpose equations, developing your algebraic skills further.
- ◆ Solve linear, Simultaneous and Quadratic Equations.  
In this section, you'll learn how to solve two important categories of problem in engineering scenarios, simultaneous equations (solving two interconnected equations at the same time) and quadratic formulae (a quadratic formula defines the shape of a parabola)
- ◆ Evaluate and Manipulate Exponential and Logarithmic Functions.  
In this section you'll learn how to handle problems including exponential functions and logarithms. Related to each other, these functions appear commonly in a wide range of engineering applications.

The assessments for this unit may be distributed throughout the course, or at the end of the unit, and will be closed-book (that is, you cannot take notes into the assessment). You'll be allowed to use a scientific calculator, but not an advanced programmable or graphing calculator. Total assessment time is limited to three hours.

You'll develop skills in *Numeracy* and *Problem Solving*.

This unit has been developed in conjunction with, and has been approved by, the Institution of Civil Engineers (ICE).

This Unit has the Using Number component of Numeracy embedded in it. This means that when you achieve the Unit, your Core Skills profile will also be updated to show you have achieved Using Number at SCQF level 5.