Unit 17: Further Mathematics for Construction

Delivery guidance

This is an optional unit for learners taking the Diploma or Extended Diploma, and throughout delivery you can motivate learners by relating the content of this unit to work and projects undertaken in other units of the qualification. You should also emphasise at the start of teaching that the skills developed in this unit are transferable and will support learners during higher education as well as in various job roles.

Approaching the unit

Your focus during delivery of this unit will be on learners developing a range of mathematical skills that they can apply to solve construction problems, building on the mathematics covered in Unit 6.

You could use illustrations, images, animations and video clips to help explain the application of mathematics. Such resources are often available online and can be easily incorporated into your tutor presentations. You may find that many construction learners engage well with these resources, rather than other delivery approaches.

You could invite guest speakers – either from planning, structural design, geotechnics, environmental and traffic management businesses, or experts from higher education institutions – who would help learners understand the importance of mathematical skills for further study and the satisfactory performance of various job roles. This would help motivate your learners.

You should appreciate that teaching mathematics at any level is challenging unless you contextualise it within construction related problems. Doing this will ensure that your learners are engaged and motivated to progress through the unit. You could make use of examples drawn from the industry, such as 3-4-5 triangles, as well as from other units of this qualification such as *Unit 10 : Surveying in Construction*.

Delivering the learning aims

Learning aim A

Learning aim A is about developing a comprehensive understanding of algebraic and trigonometric techniques and how to apply these to solve construction problems.

You could start by introducing application of trigonometric techniques such as finding the height of a building or pitch of a roof, to generate interest at the start. Tutor-led activities, presentations and demonstrations can be supported by the use of animations, DVDs, pictures, illustrations or web-based videos as well as physical objects such as cross sections. Once the theory has been introduced by these means, you should then use a number of activity sheets specifically targeting the techniques. Learners will be able to work independently or in pairs to develop the required skills. You could review and summarise activities, sharing correct answers with the class before progressing to further activities that challenge learners' application of the skills to construction-

related problems.

Some of your learners would require more support while others might need to be challenged with more demanding and complex tasks. You could develop activity sheets that contain certain extension activities to provide more challenge for such learners. Engage your learners during delivery through an in-class quiz or on-line interactive tests or paired/group activities to prepare them for the formal controlled assessment.

Learning aim B

Learning aim B is about developing differential and integral calculus skills and applying these to solve construction problems.

You could start by introducing application of differential and integral calculus such as finding maxima and minima or areas and volumes to generate interest at the start. You could give examples of maximizing the load a structural member can carry or minimize the cost of producing a component. Make use of animations, DVDs, pictures, illustrations or web-based videos. You should then use a number of activity sheets aimed to develop required skills followed by their application to construction-related problems.

Engage your learners during delivery through in-class quiz/tests and paired/group activities to prepare them for the formal controlled assessment.

Learning aim C

Introduce learning aim C by using some traffic data and material testing results to demonstrate how such data could be manipulated into useful information to generate interest at the start. Make use of animations, DVDs, pictures, illustrations or web-based videos. You should then use a number of activity sheets aimed to develop required statistical skills followed by their application to construction- related problems.

Assessment model

Learning aim	Key content areas	Recommended assessment approach
A Examine how algebraic and trigonometric techniques can be used to solve a construction problem	**A1** Transposition techniques **A2** Trigonometric techniques **A3** Construction-related problems	A report containing the results of learners' analysis and calculation; carried out under controlled conditions, supported by text and diagrams as appropriate.
B Examine how calculus can be used to solve a construction problem	**B1** Differential calculus **B2** Integral calculus **B3** Numerical integration	A report containing the results of learners' analysis and calculation; carried out under controlled conditions, supported by text and diagrams as appropriate.
C Investigate the use of statistical methods to solve a construction problem	**C1** Statistical methods **C2** Use of statistical methods in construction contexts	A report that includes appropriate graphs and charts to represent collated statistical data for a construction activity.

Assessment guidance

There is a maximum number of three summative assignments for this unit, relating to the content of each learning aim. You should set the assignment briefs within suitable construction contexts or with an overarching construction project brief.

Both assignments 1 and 2 are to be carried out under controlled conditions. You should develop briefs that provide opportunities for learners to demonstrate their skills in algebraic, trigonometric and calculus-related calculations and apply these to solve construction problems.

For assignment 3, you could give learners test results, such as concrete strength, to find characteristic values or traffic data to make informed choices about future needs.

You should ask for assessment evidence that is logically structured and easy to understand in the form of a report containing the results as well as sketches and illustrations. Give clear instructions for learners to use correct mathematical conventions, units and suitable numerical precision using appropriate significant figures or decimal places.

Getting started

This provides you with a starting place for one way of delivering the unit, based around the recommended assessment approach in the specification.

Unit 17: Further Mathematics for Construction
Introduction You could introduce the unit by referring to case studies to demonstrate the application of mathematical and statistical techniques. Interesting problem-solving examples will help engage learners and generate interest at the start. Your aim should be that learners develop a range of mathematical skills to solve construction problems and you will frequently find tutor led activities, demonstrations and presentations an effective way to introduce mathematical theory. Make use of a range of resources where possible, such as animations, DVDs, pictures, illustrations or web-based videos.
Learning aim A – Examine how algebraic and trigonometric techniques can be used to solve a construction problem
Learning aim A1 ● You may wish to introduce this topic with a tutor-led discussion to assess learners' prior knowledge and understanding and encourage learners to suggest a number of ways algebraic and trigonometric techniques are applied in construction projects. ● In a tutor-led individual activity, demonstrate rearranging formulae. Focusing on linear, quadratic and cubic expressions, give learners activity sheets and ask them to work individually or in pairs to complete the exercises. Provide support throughout, and to conclude the session, share correct answers with the class and recap on any areas that learners found particularly challenging. ● You could then move on to introduce learners to how to rearrange and evaluate logarithmic functions and demonstrate how the binomial theorem is applied to errors. **Learning aim A2** ● Moving on, you could introduce the application of trigonometric techniques with specific examples, such as finding height of a building or pitch of a roof. Make use of animations, DVDs, pictures, illustrations or web-based videos to generate interest at the start. ● In a tutor-led individual activity, use a similar approach to develop skills in calculations related to trigonometry by first demonstrating these yourself to the class. You could carry out a practical activity using right angled and non-right angled triangles as well as using data from survey field exercises to demonstrate the application of trigonometry. Activities should be varied and allow learners to use a range of trigonometric methods including the sine and cosine rules. ● Give learners activity sheets covering trigonometric techniques. Learners could individually or in small groups provide support and share correct answers as necessary.

Learning aim A3

● You could make use of a practical activity in another unit such as a setting out an exercise (in *Unit 10: Surveying in Construction*) and use this to demonstrate the application of trigonometric skills in solving a construction problem. You could use illustrations, sections or physical objects while demonstrating the application to properties of sections, such as section modulus and locations of centroids. Follow your demonstrations with similar practical exercises and well-illustrated activity sheets based on construction scenarios. Learners can tackle these, working in small groups to solve the problems, before feeding back their workings to the class. Conclude the session by summarising correct answers as necessary.

● You could upload all the exercises and correct solutions onto a shared folder or provide copies to learners, which they could use as a revision aid.

● To conclude this learning aim, provide an overview of the techniques through tutor-led discussion, highlighting common errors (such as choosing the correct trigonometric function) and outline the assessment requirements with reference to the in-class activities.

Learning aim B – Examine how calculus can be used to solve a construction problem

Learning aim B1

- You may wish to introduce this topic with a tutor-led discussion to assess learners' prior knowledge and understanding of calculus and encourage learners to suggest a number of ways these techniques are applied in construction projects.

- You could introduce the application of differential and integral calculus such as for finding maxima and minima or areas and volumes to generate interest at the start. Make use of animations, DVDs, pictures, illustrations or web-based videos to generate interest at the start.

- In a tutor-led individual activity, demonstrate differentiating polynomial, trigonometric, logarithmic and exponential functions. This demonstration should include the product, quotient and chain rules. Give learners activity sheets covering all the relevant unit content. Learners could work individually or in pairs. Provide support and share correct answers as necessary.

- Use a similar approach by first demonstrating the application of differential calculus, such as finding maxima and minima, in solving a construction problem such as points of contraflexure or maximum areas that could be enclosed. You could use illustrations and animations or other web-based resources. Follow your demonstrations with activity sheets covering all the relevant unit content. Provide support and share correct answers as necessary.

Learning aim B2

- In a tutor-led individual activity, demonstrate integrating polynomial, trigonometric, reciprocal and exponential functions. Give learners activity sheets covering all the relevant unit content. Provide support and share correct answers as necessary.

- In a tutor-led group activity, introduce the application of integral calculus, such as finding area under the curve, in solving a construction problem such as fluid flow or soil bearing capacity, by demonstrating the solution yourself. You could use illustrations and animations or other web-based resources. Follow your demonstrations with activity sheets covering all the

relevant unit content. Provide support and share correct answers as necessary.

Learning aim B3

- In a tutor-led individual activity, introduce numerical integration techniques and demonstrate how these could be used as an alternative method of finding solutions. You could, for example, show validating values using the mid-ordinate rule by comparing them to those achieved using calculus. Learners could work individually or in pairs. Give learners activity sheets covering all the relevant unit content. Provide support and share correct answers as necessary. You may choose to deliver learning aim B3 before B2, or at the same time, so that comparisons can be drawn between numerical integration and calculus.

- You should upload all the exercises and correct solutions onto a shared folder or provide copies to learners, which learners could use as a revision aid.

- Guest speaker: Invite guest speakers either from planning, structural design, geotechnics, environmental and traffic management or from higher education institutions who would help learners understand the importance of mathematical skills for further study and satisfactory performance of various job roles. This would help motivate your learners.

- To conclude the learning aim, provide an overview of the techniques, discuss common errors, such as identification of products and application of chain rule, and outline the assessment requirements as well as its relevance with the in-class activities.

Learning aim C – Investigate the use of statistical methods to solve a construction problem

Learning aim C1

- Introduce the application of statistical techniques such as by using some traffic data or material testing results and demonstrate how such data could be manipulated into the best form to show data, for example charts and graphs, to generate interest at the start. Use animations, DVDs, pictures, illustrations or web-based videos.

- In a tutor-led paired activity, demonstrate how statistical data could be manipulated and presented in various ways to convey useful information. For example, material testing results could be presented to convey the characteristic values of strength, or traffic data could be presented to identify peak traffic values. Give learners activity sheets covering all the relevant unit content.

- Provide support and share correct answers as necessary.

Learning aim C2

- In a tutor-led group activity, demonstrate the application of statistical techniques to solve a construction problem. For example, how to use statistical averages to determine the characteristic strength of concrete test cubes. You could also introduce measures of dispersion including range, variance and standard deviation of the test results. Follow your demonstrations with similar practical exercises and well-illustrated activity sheets. Provide support and share correct answers as necessary.

- Learners should also be introduced to different types of data, and the methods to interpret

them. For example, the cube test results could be analysed as grouped or ungrouped data, you could lead a discussion into which would be most appropriate to use.

- You should upload all the exercises and correct solutions onto a shared folder or provide copies to learners, which learners could use as a revision aid.
- To conclude the learning aim, provide an overview of the techniques, discuss common errors, such as choosing the correct presentation technique, and outline the assessment requirements as well as its relevance with the in-class activities.

Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

This unit links to:

- Unit 6: Construction Mathematics
- Unit 10: Surveying in Construction
- Unit 12: Building Surveying in Construction
- Unit 13: Site Engineering in Construction
- Unit 15: Measurement Techniques in Construction
- Unit 20: Quantity Surveying
- Unit 23: Construction in Civil Engineering
- Unit 24: Conversion, Adaptation and Maintenance

Resources

In addition to the resources listed below, publishers are likely to produce Pearson-endorsed textbooks that support this unit of the BTEC International Level 3 Qualifications in Construction and the Built Environment. Check the Pearson website (http://qualifications.pearson.com/endorsed-resources) for more information as titles achieve endorsement.

Textbooks

Graham A, *Statistics: An Introduction*, Quercus, 2017 ISBN 9781473652002 – this book provides good coverage of statistical techniques relevant to this unit.

Virdi S, *Advanced Construction Mathematics*, Routledge 2019, ISBN 9780429683602 - this book covers the algebraic, calculus and statistical topics covered in this unit.

Virdi S, Baker R and Virdi NK, *Construction Mathematics* (2nd edition), Routledge, 2014 ISBN 9780415810784 – this book is written specifically for BTEC learners and covers mathematical principles required for this unit.

YouTube Videos

Both these are good, fun videos to explain fundamentals of statistics:
"A-01 What is Statistics?" and "C1: WHAT IS STATISTICS?"

These videos contain explanations of basic trigonometry, including sine, cosine and tangent:
"Sin Cos Tan - Basic Trigonometry - MathHelp.com"
"Real Life Application of Differentiation"

This video shows differentiation processes and some applications:
"Optimization Calculus - Fence Problems, Cylinder, Volume of Box, Minimum Distance & Norman Window"

This video shows and some applications of integration:

"Applications of Integration (KristaKingMath)"

Websites

Visit the http://www.mathcentre.ac.uk/ for online lessons on every mathematics topic covered in this unit.

Visit wiziq.com and search "Maths mensuration" for free online tests on mensuration.

Purplemath.com has useful resources for algebra and basic mathematics and trigonometry.

Visit aaamath.com for good resources for statistics as well as some basic useful resources.

Thatquiz.org has a range of quizzes that can be selected to cover algebra, trigonometry and calculus.

Pearson is not responsible for the content of any external internet sites. It is essential for tutors to preview each website before using it in class so as to ensure that the URL is still accurate, relevant and appropriate. We suggest that tutors bookmark useful websites and consider enabling learners to access them through the school/college intranet.