Unit 34: Further Mathematics for Construction

Level: 5

Credits: 15

Ofqual Code: M/618/8110

Introduction

The understanding of more advanced mathematics is important in the civil engineering and building services engineering industries. Students will be introduced to additional topics that will be relevant to them as they progress to the next level of their studies; advancing their knowledge of mathematical theory gained in the Level 4 *Unit 8: Mathematics for Construction.*

The aim of this unit is to teach students to analyse and model civil engineering or building services engineering situations using mathematical techniques.

Among the topics included in the unit are: number theory, complex numbers, matrix theory, linear equations, numerical integration, numerical differentiation, and graphical representations of curves for estimation in an engineering context. Students will expand their knowledge of calculus to discover how to model and solve problems using first and second order differential equations.

On successful completion of this, unit students will be able to use applications of number theory in practical construction situations, solve systems of linear equations relevant to construction applications using matrix methods, approximate solutions of contextualised examples with graphical and numerical methods, and review models of construction systems using ordinary differential equations. As a result, they will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit, students will be able to:

LO1 Apply instances of number theory in practical construction situations

LO2 Solve systems of linear equations relevant to construction applications using matrix methods

LO3 Approximate solutions of contextualised examples with graphical and numerical methods

LO4 Review models of construction systems using ordinary differential equations.

Essential Content

LO1 Apply instances of number theory in practical construction situations

Number theory

Bases of a number (e.g., denary, binary, octal, duodecimal, hexadecimal) and converting between bases

Types of numbers (e.g., natural, integer, rational, real, complex)

The modulus, argument and conjugate of complex numbers

Polar and exponential form of complex numbers

The use of de Moivre's Theorem in engineering

Complex number applications (e.g., electric circuit analysis, information and energy control systems)

LO2 Solve systems of linear equations relevant to construction applications using matrix methods

Matrix methods

Introduction to matrices and matrix notation

The process for addition, subtraction and multiplication of matrices

Introducing the determinant of a matrix and calculating the determinant for a 2×2 matrix

Using the inverse of a square matrix to solve linear equations

Gaussian elimination to solve systems of linear equations (up to 3×3)

LO3 Approximate solutions of contextualised examples with graphical and numerical methods

Graphical and numerical methods

Standard curves of common functions, including quadratic, cubic, logarithm and exponential curve

Systematic curve sketching knowing the equation of the curve

Using sketches to approximate solutions of equations

Numerical analysis using the bisection method and the Newton–Raphson method

Numerical integration using mid-ordinate rule, the trapezium rule and Simpson's rule

LO4 **Review models of construction systems using ordinary differential equations**

Differential equations

Formation and solutions of first-order differential equations

Applications of first-order differential equations (e.g., RC and RL electric circuits, Newton’s laws of cooling, charge and discharge of electrical capacitors, complex stresses and strains)

Formation and solutions of second-order differential equations

Applications of second-order differential equations (e.g., mass-spring-damper systems, information and energy control systems, heat transfer, automatic control systems and beam theory and RLC circuits)

Introduction to Laplace transforms for solving linear ordinary differential equations

Applications involving Laplace transforms (e.g., electric circuit theory, load frequency control, harmonic vibrations of beams and engine governors)

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Apply instances of number theory in practical construction situations		
P1 Apply addition and multiplication methods to numbers that are expressed in different base systems. **P2** Solve construction problems using complex number theory. **P3** Perform arithmetic operations using the polar and exponential form of complex numbers.	**M1** Deduce solutions of problems using de Moivre's Theorem.	**D1** Test the correctness of a trigonometric identity using de Moivre's Theorem.
LO2 Solve systems of linear equations relevant to construction applications using matrix methods		
P4 Ascertain the determinant of a 3 × 3 matrix. **P5** Solve a system of three linear equations using Gaussian elimination.	**M2** Determine solutions to a set of linear equations using the inverse matrix method.	**D2** Validate all analytical matrix solutions using appropriate computer software.
LO3 Approximate solutions of contextualised examples with graphical and numerical methods		
P6 Estimate solutions of sketched functions using a graphical estimation method. **P7** Identify the roots of an equation using two different iterative techniques. **P8** Determine the numerical integral of construction functions using two different methods.	**M3** Evaluate construction problems to formulate mathematical models using numerical and graphical methods.	**D3** Critique the use of numerical estimation methods, commenting on their applicability and the accuracy of the methods.

Pass	Merit	Distinction
LO4 Review models of construction systems using ordinary differential equations		**D4** Evaluate first- and second-order differential equations when generating the solutions to construction problems.
P9 Determine first-order differential equations using analytical methods. **P10** Determine second-order homogeneous and non-homogenous differential equations using analytical methods. **P11** Calculate solutions to linear ordinary differential equations using Laplace transforms.	**M4** Analyse how first-order differential equations are used to solve structural or environmental problems.	

Recommended Resources

Print resources

BIRD, J. (2017), *Higher Engineering Mathematics*, Routledge

SINGH, K. (2011), *Engineering Mathematics Through Applications*, Macmillan International Higher Education

STROUD, K., BOOTH, D. (2001), *Engineering Mathematics*, Industrial Press Inc.

Links

This unit links to the following related units:

- Unit 3: Science & Materials
- Unit 7: Surveying, Measuring & Setting-out
- Unit 8: Mathematics for Construction
- Unit 9: Principles of Heating, Ventilation and Air Conditioning
- Unit 10: Measurement & Estimating
- Unit 16: Principles of Public Health Engineering
- Unit 21: Geotechnics & Soil Mechanics
- Unit 31: Advanced Structural Design
- Unit 33: Construction Technology for Complex Buildings Projects
- Unit 37: Advanced Heating, Ventilation and Air Conditioning Design & Installation
- Unit 38: Advanced Quantities for Complex Building Projects
- Unit 41: Highway Engineering
- Unit 43: Advanced Surveying & Measurement
- Unit 49: Advanced Electrical Design & Installation.

