Unit 28: Further Mathematics for Construction

Unit code M/615/1414

Unit level 5

Credit value 15

Introduction

The understanding of more advanced mathematics is important within the civil engineering and building services engineering industries. Students must 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 this unit are: number theory, complex numbers, matrix theory, linear equations, numerical integration, numerical differentiation, and graphical representations of curves for estimation within an engineering context. Finally, 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:

1. Apply instances of number theory in practical construction situations.
2. Solve systems of linear equations relevant to construction applications using matrix methods.
3. Approximate solutions of contextualised examples with graphical and numerical methods.
4. 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 (Denary, Binary, Octal, Duodecimal, Hexadecimal) and converting between bases.

Types of numbers (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 2x2 matrix.

Using the inverse of a square matrix to solve linear equations.

Gaussian elimination to solve systems of linear equations (up to 3x3).

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 curves.

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, and 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, such as 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 3x3 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** Solve construction problems and formulate mathematical models using first-order differential equations.	**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 situations.
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** Evaluate how different models of construction systems use first-order differential equations to solve structural or environmental problems.	

Recommended Resources

BIRD, J. (2014) *Higher Engineering Mathematics*. 7th Ed. London: Routledge.

SINGH, K. (2011) *Engineering Mathematics Through Applications*. Basingstoke: Palgrave Macmillan.

STROUD, K.A. and BOOTH, D.J. (2013) *Engineering Mathematics*. 7th Ed. Basingstoke: Palgrave Macmillan.

Journals

Communications on Pure and Applied Mathematics. Wiley.

Journal of Engineering Mathematics. Springer.

Journal of Mathematical Physics. American Institute of Physics.

Websites

www.mathcentre.ac.uk	MathCentre (General Reference)
www.mathtutor.ac.uk	MathTutor (General Reference)

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 Services Design & Installation

Unit 10: Principles of Ventilation and Air Conditioning Design & Installation

Unit 11: Measurement & Estimating

Unit 17: Principles of Public Health Engineering

Unit 29: Geotechnics & Soil Mechanics

Unit 30: Advanced Structural Design

Unit 31: Advanced Heating, Ventilation and Air Conditioning Design & Installation

Unit 33: Advanced Electrical Design & Installation

Unit 34: Advanced Quantities for Complex Buildings

Unit 42: Highway Engineering

Unit 44: Advanced Surveying & Measuring

