Unit 39: Further Mathematics

Unit code H/615/1507

Unit level 5

Credit value 15

Introduction

The understanding of more advanced mathematics is important within an engineering curriculum to support and broaden abilities within the applied subjects at the core of all engineering programmes. Students are introduced to additional topics that will be relevant to them as they progress to the next level of their studies, advancing their knowledge of the underpinning mathematics gained in *Unit 2: Engineering Maths*.

The unit will prepare students to analyse and model 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 engineering 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 engineering situations, solve systems of linear equations relevant to engineering applications using matrix methods, approximate solutions of contextualised examples with graphical and numerical methods, and review models of engineering systems using ordinary differential equations.

Learning Outcomes

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

1. Use applications of number theory in practical engineering situations.
2. Solve systems of linear equations relevant to engineering applications using matrix methods.
3. Approximate solutions of contextualised examples with graphical and numerical methods.
4. Review models of engineering systems using ordinary differential equations.

Essential Content

LO1 **Use applications of number theory in practical engineering 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 forms 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 engineering 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 the mid-ordinate rule, the trapezium rule and Simpson's rule.

LO4 **Review models of engineering 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 Use applications of number theory in practical engineering situations		**D1** Test the correctness of a trigonometric identity using de Moivre's Theorem.
P1 Apply addition and multiplication methods to numbers that are expressed in different base systems. **P2** Solve engineering 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.	
LO2 Solve systems of linear equations relevant to engineering applications using matrix methods		**D2** Evaluate and validate all analytical matrix solutions using appropriate computer software.
P4 Ascertain the determinant of a given 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.	
LO3 Approximate solutions of contextualised examples with graphical and numerical methods		**D3** Critique the use of numerical estimation methods, commenting on their applicability and the accuracy of the methods.
P6 Estimate solutions of sketched functions using a graphical estimation method. **P7** Calculate the roots of an equation using two different iterative techniques. **P8** Determine the numerical integral of engineering functions using two different methods.	**M3** Solve engineering problems and formulate mathematical models using first-order differential equations.	

Pass	Merit	Distinction
LO4 Review models of engineering systems using ordinary differential equations		**D4** Critically evaluate first and second-order differential equations when generating the solutions to engineering situations using models of engineering systems.
P9 Determine first order differential equations and their application to engineering systems using analytical methods. **P10** Determine second-order homogeneous and non-homogenous differential equations and their application to engineering systems using analytical methods. **P11** Calculate solutions to linear ordinary differential equations using Laplace transforms.	**M4** Evaluate how different models of engineering systems using first-order differential equations solve engineering problems.	

Recommended Resources

Textbooks

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

SINGH, K. (2011) *Engineering Mathematics Trough 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.

Electronic

http://www.mathcentre.ac.uk

http://www.mathtutor.ac.uk

Links

This unit links to the following related unit:

Unit 2: Engineering Maths