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 and 3x3 matrix

Using the inverse of a square matrix to solve linear equations

Gaussian elimination to solve systems of linear equations (up t 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** Solve problems using de Moivre's Theorem	
LO2 Solve systems of linear equations relevant to engineering applications using matrix methods		**D2** Validate solutions for the given engineering linear equations using appropriate computer software
P4 Calculate the determinant of a set of given linear equations using a 3x3 matrix **P5** Solve a system of three linear equations using Gaussian elimination	**M2** Determine the solution to a set of given engineering linear equations using the Inverse Matrix Method for a 3x3 matrix	

Pass	Merit	Distinction
LO3 Approximate solutions of contextualised examples with graphical and numerical methods		**D3** Critically evaluate 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 graphical and numerical integration	
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 Formulate and solve first order differential equations related to engineering systems **P10** Formulate and solve second order homogeneous and non-homogeneous differential equations related to engineering systems **P11** Calculate solutions to linear ordinary differential equations using Laplace transforms	**M4** Demonstrate how different models of engineering systems using first-order differential equations can be used to 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.

Websites

http://www.mathcentre.ac.uk/	Maths Centre (Tutorials)
http://www.mathtutor.ac.uk/	Maths Tutor (Tutorials)

Links

This unit links to the following related unit:

Unit 2: Engineering Maths