

**ENGINEERING MATHEMATICS EE2X**

Course code	7LXV
GU Credits	10
ECTS Credits	5
When taught	First half of session
Prerequisite course(s)	Engineering Mathematics EE1A (3KBU)
Teaching staff (the first has overall responsibility)	Dr M Sorel (telephone 5229, email M.Sorel) Dr S Thoms (telephone 5656; email S.Thoms)
Approximate size of class	100 students
Semester	1

**Description of course**

18 lectures, 3 laboratories, and 4 tutorials

**Notes**

Subjects for projects will be selected from the topics listed; they contain some material in parentheses that is intended only for advanced students.

The course will follow closely the book *Engineering Mathematics* by Croft, Davison and Hargreaves.

**Aims**

To provide an introduction to the mathematical techniques and symbolism required by electronic and electrical engineers in a variety of applications. The analytical work will be supplemented by projects using mathematical software to model engineering systems.

**Objectives****Understanding**

Relation between mathematical model and engineering system. Different regimes of behaviour for a second-order system. Possible sources of instability in numerical solution of systems.

**Knowledge**

Classification of differential equations. Need for boundary conditions and number of conditions required. Difference between partial and total derivatives.

**Skills**

Methods of solution for common differential equations. Use of simple mathematica software (MathCad or Mathematica).

**Syllabus****1. First-order differential equations**

Revision of material to be used in course, particularly calculus. Understand the philosophy of modelling an engineering system: appreciate the process of constructing a physical model, deriving a mathematical description, and solving it.

Derive differential equations for simple engineering systems, e.g. relating input and output for simple first-order and second-order circuits (*LRC* circuits), mass on a spring.

Revision of integration from first year: students should be able to integrate the standard functions (powers, rational fractions, trigonometric and hyperbolic functions and their

inverses, exponential and logarithmic functions), and use the techniques of substitution and integration by parts.

Classify differential equations as to order and degree, ordinary or partial, homogeneous or inhomogeneous, linear, and with constant coefficients. Appreciate the necessity of boundary conditions or initial conditions; know the number of conditions for a given order of equation and the forms in which these might be specified (e.g. function at two points, or function and derivative at one point for second order).

Plot flow diagram for a first-order differential equation and use it to sketch typical solutions.

Recognise trivial differential equations and solve them by integration.

Recognise separable differential equations and solve them by integration of each side.

Recognise linear differential equations, transform into standard form, deduce integrating factor and use this to solve the equation (with particular attention to constant of integration).

Use integrating factor to solve first-order circuit (e.g.  $RC$  filter) for arbitrary input.

Solve a first-order differential equation with the Euler method; know that smaller steps tend to improve accuracy, but that instability is possible.

### ***Practical work (laboratory and project)***

Revision of software to be used throughout course (MathCad or Mathematica).

Explore the behaviour of first-order systems ( $RC/RL$  circuits), e.g. square wave into filter.

Use the Euler method to integrate simple first-order differential equations.

(Investigate accuracy and stability — briefly, on a contrived example.)

## **2. Differential equations with constant coefficients**

Revision of material to be used in course, particularly complex algebra.

Recognise linear differential equations and the use of their special properties: linear independence of solutions, superposition, form of general solution with arbitrary coefficients.

Understand principles behind solution of inhomogeneous equations by particular integral and complementary function; explain relation to steady-state and transient behaviour.

Derive characteristic or auxiliary equation for exponents in complementary function.

Use method of trial solutions to find particular integral; know what type of function to try.

Solve first-order system to demonstrate steady-state and transient behaviour.

Find particular integral for second-order equations from appropriate trial functions; understand that this is identical to phasor analysis.

Analyse steady-state solution and interpret resonance curve.

Recognise different types of complementary function for second-order equations: oscillating, critical and purely decaying behaviour.

Analyse transient behaviour of a resonant system and its dependence on damping; frequency and damping of free oscillations, critical damping, slow decay of overdamped system.

Cast second and higher-order equations into a system of first-order equations.

Solve a set of first-order equations numerically using the Euler method, given a set of initial conditions.

### ***Practical work***

Plot behaviour of  $LCR$  circuits in time, analyse amplitude and phase of steady-state response, and reveal transient and the influence of initial conditions.

Solve behaviour of coupled oscillators to show beating.

(Plot roots of characteristic equation in  $s$ -plane.)

### Recommended books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
A Croft, R Davison and M Hargreaves	Engineering Mathematics (3 ed)	Addison-Wesley	2001	0201877449	£18	A
G James and others	Modern Engineering Mathematics (3 ed)	Addison-Wesley	2001	0201877619	£19	B
G James and others	Advanced Modern Engineering Mathematics (2 ed)	Addison-Wesley	1993	0201565196	£20	C
K A Stroud	Engineering Mathematics (4 ed)	Macmillan	1995	0333620224	£20	C
K A Stroud	Further Engineering Mathematics (3 ed)	Macmillan	1996	0333657411	£24	C

Codes : A = compulsory; B = strongly recommended; C = recommended; D = wider reading

### Study times

Type	Hours
Lectures and tutorials	25
Project and report	15
Tutorial sheets	15
Review and consolidation of course material	30
Revision and examinations	15

These times are a rough estimate of the work required outside formal classes by a typical student. There will be wide variations between individuals, but you will run a grave risk of failure if you spend significantly less time on this course than these guidelines suggest.

### Assessment

%	Type	Details
15	Projects	Projects will be assessed at the end of each block.
10	Class test	A test of straightforward questions to test basic skills will be set at the end of the first 6-week block.
75	Degree Examination	90 minute paper; all questions compulsory.

The degree examinations are held around week 13; a resit is available in August/September.