Engineering Tripos Part IA, 1P4: Mathematics, 2018-19

Lecturers

Dr J P Longley, Dr S Savory, Dr T Hynes, Dr G Wells, Prof P C Woodland, and Prof M C Smith [1]

Timing and Structure

Michaelmas Term: 3 (standard course) or 2 (fast course) lectures per week, weeks 1-8; Lent Term: 2 lectures per week, weeks 5-8; Easter Vacation: Programmed Learning Exercise: Easter Term 2 lectures weeks 1-3, 1 in week 4: 39/31 Lectures

Aims

The aims of the course are to:

- Instill fluency with the basic mathematical techniques which are needed as tools for engineers.
- Revise, and teach afresh where necessary, those parts of the A-level mathematics syllabuses which are necessary for the first two years of the engineering course, and to introduce those new mathematical techniques which are necessary for these courses.
- Place emphasis throughout upon the grasp of essentials and competency in manipulation.

Objectives

As specific objectives, by the end of the course students should be able to:

- Recognise the appropriate mathematical tools and techniques (from the following syllabus) with which to approach a wide variety of engineering problems.
- Specify a mathematical model of a problem.
- Carry out appropriate mathematical manipulations to solve the modelled problem.
- Interpret the significance of the mathematical result.

Content

Michaelmas term (24/16L)

The Michaelmas term course concerns revision and extension of concepts which most students will have met at school. It will be given in two versions, a standard course at a pace of three lectures per week and a fast course at a pace of two lectures per week. Both will cover the same syllabus and employ the same example sheets. The fast course is aimed primarily at those who have taken double mathematics at A level and who have good mathematical fluency, the standard course at those with less prior training. Examples papers will include exercises to encourage students to practice mathematical skills learnt in their previous studies.

Vectors (5/3L)

- Scalar and vector product.
- Moment of a force and angular velocity vectors.
- Scalar and vector triple product.
- Examples of applications.
- Simple vector geometry, vector equations of lines and planes.
- Determinant of 3x3 matrices

Functions and Complex Numbers (7/5L)

- Definitions and simple properties of the hyperbolic functions.
- Statement of Taylor's theorem, examples including trigonometric and hyperbolic function, exp, ln.
- Simple ideas of series, approximations, limits, L'Hopital's rule.
- Asymptotic behaviour of functions for small and large argument.
- Revision of complex arithmetic and representation in the Argand diagram. Idea of a complex function.
- De Moivre's theorem, use of exp ($i\omega t$)

Introduction to Ordinary Differential Equations (ODE's) (5/3L)

- Linear equations of first order, integrating factor, separation of variables.
- Second order ODE’s: complementary functions, superposition and particular integrals.
- Linear difference equations.
- Notions of a partial derivative.

Matrices (7/5L)

- Matrices as linear transformations: the range and the null space of a matrix.
- The inverse of a 3x3 matrix.
- Change from one orthogonal coordinate system to another, the rotation matrix.
- Symmetric, antisymmetric and orthogonal matrices.
- Eigenvalues and eigenvectors for symmetric matrices.
- Special properties of symmetric matrices: orthogonality of eigenvectors, expansion of an arbitrary vector in eigenvectors.
- Examples, including small vibrations.

Lent Term (8L)

The course in the Lent and Easter terms introduces ideas which will be new to most students, but which find application across the whole range of engineering science.

Steps, impulses and linear system response (3L)

- Introduction to step and impulse functions. Step and impulse response of linear systems represented by ODE's.
- Use of convolution to obtain output given a general input.

Fourier series (4L)

- Fourier sine and cosine series. Full and half range, consideration of symmetries, convergence and discontinuities.
- Complex Fourier series. Physical interpretations, including effect of filtering a general periodic input.

Introduction to probability material in vacation programmed learning text (1L)

Easter vacation - Probability (Programmed learning text, equivalent to four lectures of material)

- Notion of probability. Conditional probability.
- Permutations and combinations.
- Mean,variance and standard deviation of probability distributions.
- Discrete and continuous distributions.
- The Normal distribution and experimental errors

Easter term (7L)

Functions of Several Variables (4L)

- Differentiation of functions of several variables.
- Chain rule, implicit differentiation.

- Introduction to definition of grad(f).
- Stationary values, unconstrained extrema.
- Taylor expansion of f(x,y).

Introduction to Laplace transforms (3L)

- Basic properties of Laplace transforms.
- Laplace transforms as a means of solving ODEs with initial conditions (using tables of transforms for inversion).

Booklists

Please see the Booklist for Part IA Courses [2] for module references

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

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Links
[1] mailto:jpl1000@cam.ac.uk,sjs1001@cam.ac.uk,tph1@cam.ac.uk,gnw20@cam.ac.uk,pw117@cam.ac.uk,mcs1000@cam.ac.uk
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364071&chapterid=42021
[3] https://teaching18-19.eng.cam.ac.uk/content/form-conduct-examinations