

## Engineering Tripos Part IIB, 4M12: Partial Differential Equations & Variational Methods (shared with IIA), 2018-19

### Module Leader

[Dr J S Biggins](#) [1]

### Lecturers

Dr J S Biggins and Prof P Davidson

### Timing and Structure

Lent term. 16 lectures (including examples classes). Assessment: 100% exam

### Aims

The aims of the course are to:

- provide an introduction to the various classes of PDE and the physical nature of their solution
- demonstrate how variational calculus can be used to derive both ordinary and partial differential equations, and also how the technique can be used to obtain approximate solutions to these equations

### Objectives

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

- understand the various types of PDE and the physical nature of their solutions.
- understand various solution methods for PDEs and be able to apply these to a range of problems.
- understand the formulation of various physical problems in terms of variational statements
- estimate solutions using trial functions and direct minimisation;
- calculate an Euler-Lagrange differential equation from a variational statement, and to find the corresponding natural boundary conditions;
- perform vector manipulations using suffix notation.

### Content

Partial differential equations (PDEs) occur widely in all branches of engineering science, and this course provides an introduction to the various classes of PDE and the physical nature of their solution. The second part of the course demonstrates how variational calculus can be used to derive both ordinary and partial differential equations, and also how the technique can be used to obtain approximate solutions to these equations. The final section on the summation convention provides a powerful mathematical tool for the manipulation of equations that arise in engineering analysis

#### Suffix notation and the summation convention (2L Dr J S Biggins)

Index notation for scalar, vector, and matrix products, and for grad, div and curl. Applications including Stokes' theorem and the divergence theorem.

### **Variational methods in engineering analysis (6L DrJ S Biggins)**

Introduction to variational calculus. Functionals and their first variation. Derivation of differential equations and boundary conditions from variational principles. The Euler-Lagrange equations. The effect of constraints. Applications in mechanics, optics, stress analysis, and optimal control.

### **Partial Differential Equations (8L Prof. P. A. Davidson)**

What is a PDE? Classification of PDEs: elliptic/parabolic/hyperbolic types. Canonical examples of each type: Laplace/diffusion/wave equations. Solving the diffusion equation. Solving the wave equation. Solving the Laplace equation.

### **Booklists**

Please see the [Booklist for Group M Courses](#) [2] for references for this module.

### **Examination Guidelines**

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

### **UK-SPEC**

The [UK Standard for Professional Engineering Competence \(UK-SPEC\)](#) [4] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the '[Accreditation of Higher Education Programmes](#)' ([AHEP](#)) document [5] which sets out the standard for degree accreditation.

The [Output Standards Matrices](#) [6] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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### **Links**

[1] <mailto:jsb56@cam.ac.uk>

[2] <https://www.vle.cam.ac.uk/mod/book/view.php?id=364101&chapterid=56231>

[3] <http://teaching.eng.cam.ac.uk/content/form-conduct-examinations>

[4] <http://www.engc.org.uk/ukspec.aspx>

[5] <http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahp/>

[6] <http://teaching.eng.cam.ac.uk/content/output-standards-matrices>