# Engineering Tripos Part IB, 2P2: Structures, 2018-19

## Lecturers

Dr K A Seffen [1]

## Timing and Structure

Weeks 1-8 Michaelmas term (12 lectures) and weeks 1-4 Lent term, 2 lectures/week

# Aims

The aims of the course are to:

- To extend understanding of the behaviour and analysis of structures.
- To introduce concepts of stress-state, strain-state and yield using simple thin-walled structures.
- To explain elastic analysis of statically indeterminate structures and implications of redundancy.
- To introduce plastic theory of structures.

# Objectives

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

- To find, for thin-walled cylinders, the stresses and stress-resultants, strains and displacements resulting from applied loading.
- To understand the concept of stress-state and strain-state using 2-D and 3-D Mohr's Circles.
- To understand the Tresca and von Mises yield criteria.
- To analyse statically indeterminate truss and frame structures.
- To use the method of Virtual Work for beam bending calculations.
- To evaluate the fully plastic moment of a beam cross-section.
- To find upper bound estimates of the failure load of beams, plane portal frames, slabs and continua.
- To find lower bound estimates of the failure load of beams.

# Content

The following material will be taught in the context of design:

### Thin-walled Structures (3L)

- Stresses in cylinders due to axial loading, bending and shear, internal pressure and torsion.
- Strain in three dimensions, stress-strain-temperature relationships.
- Torsional rigidity.

### Analysis of Stress and Strain (4L)

- 2-D stress and strain state, equilibrium equations, 2-D Mohr's circle.
- 3-D stress and strain state, 3-D Mohr's circle.
- Principal stresses, strains and directions.
- Yield criteria: Tresca; von Mises.

**Elastic Structural Analysis (5L)**

- Indeterminate truss structures, analysis by the Force Method.
- Deflections in beams, including curved beams, by Virtual Work.
- Indeterminate frame structures, analysis by the Force Method.
- Symmetry and anti-symmetry.

**Plastic Structural Analysis (8L)**

- Calculation of plastic section modulus Zp and fully plastic moment Mp.
- Collapse mechanisms for a statically determinate beam.
- Concept of an *upper bound* estimate of collapse load.
- Collapse mechanisms for statically indeterminate beams and plane portal frames.
- Yield lines for predicting collapse loads of slabs.
- Slip lines for predicting plane strain failure of continua.
- Equilibrium states for a statically indeterminate beam.
- Concept of a *lower bound* estimate of collapse load.
- Lower bound principle as a justification for elastic analysis.

## Examples papers

There are five examples papers.

## Booklists

Please see the Booklist for Part IB 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:kas14@cam.ac.uk
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364081&chapterid=43341
[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-ahep/
[6] http://teaching.eng.cam.ac.uk/content/output-standards-matrices