Engineering Tripos Part IB, 2P2: Structures, 2020-21

Course Leader

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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 refer to the Booklist for Part IB Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

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

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA3

Comprehend the broad picture and thus work with an appropriate level of detail.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

US4

An awareness of developing technologies related to own specialisation.

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Links
[1] mailto:kas14@cam.ac.uk
[2] mailto:jml2@eng.cam.ac.uk
[3] https://teaching20-21.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching20-21.eng.cam.ac.uk/content/uk-spec