Engineering Tripos Part IIA, 3C7: Mechanics of Solids, 2020-21

Module Leader

Dr G J McShane [1]

Lecturers

Dr G J McShane, Dr C Abadie, Prof G N Wells

Lab Leader

Dr C Abadie [2]

Timing and Structure

Michaelmas Term, 16 lectures

Prerequisites

None

Aims

The aims of the course are to:

- Provide students with an understanding of how the stresses and strains within engineering components are related to both the loads and displacements imposed at their boundaries and to any thermal or inertial loadings to which they are subjected.
- Introduce analytical methods, predominantly for two-dimensional geometries, and for both elastic and plastic material responses.
- Illustrate the methods with a number of engineering case studies.

Objectives

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

- Calculate the stresses in an elastic or plastic axisymmetric system subjected to various loads.
- Use Airy and Prandtl stress functions to find analytical solutions to elastic problems.
- Apply upper- and lower-bound theorems to solid mechanics problems.

Content

Two-Dimensional Elasticity (6L): Dr G J McShane

- Revision of stress and strain in 2D; Mohr's circle.
- Elastic constitutive relationship.
- Concepts of plane stress and plane strain.
- Equilibrium and compatibility equations in 2D; Cartesian and polar coordinates.

- Analysis of problems with circular symmetry: thick-walled tube, spinning disk, thermo-elastic problems.

Torsion, Stress Functions and Plasticity (4L): Prof G N Wells

- Elastic torsion of prismatic bars: Prandtl stress function.
- Plastic torsion of prismatic bars.
- Airy stress function in Cartesian and polar coordinates.
- Stress distribution in an infinite plate with a circular hole or crack.
- Analysis of contact stresses; half-plane under line and distributed loads.

Stress analysis in 3D and Plasticity (6L): Dr C Abadie

- Stress analysis in 3D: principal stresses; stress invariants; hydrostatic and deviatoric stresses; deviatoric stress invariants.
- Yield locus, pi-plane; symmetry; convexity; normality.
- Tresca and von Mises yield criteria; associated flow rules.
- Upper-Bound and Lower-Bound theorems.
- Applications of Upper-Bound and Lower-Bound theorems: thick-walled tubes; rotating disks.
- Revision of rigid block mechanisms: application to forming problems. Elasto-plastic analysis of a thick-walled tube.

Examples papers

There will be four Examples Papers, directly related to the lectures.

Coursework

Experimental Stress Analysis

Use experimental techniques to determine the stress concentration at the edge of a circular hole in finite plates.

Learning objectives:

- To develop an appreciation of errors that occur in experimental measurements of stresses using different experimental techniques.
- To learn about Digital Image Correlation.
- To note that the stress concentrations are sensitive to the location of the hole in the plate.
- To compare measured concentration factors with simple analytical predictions.

Practical information:

- Sessions will take place in the Structures Research Lab, Inglis Ground floor AND online.
- To sign-up go to http://to.eng.cam.ac.uk/teaching/apps/cuedle/index.php?context=3C7 [3].
- Reports should be submitted online no later than 2 weeks after the lab session, before 4pm. There is an excel spreadsheet to submit too. Please, download from the same webpage.

Full Technical Report:

Students will have the option to submit a Full Technical Report.

Booklists

Please refer to the Booklist for Part IIA 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 [4].

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Links
[1] mailto:gjm31@cam.ac.uk
[2] mailto:cna24
[3] http://to.eng.cam.ac.uk/teaching/apps/cuedle/index.php?context=3C7
[4] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations