**CE206 STRUCTURAL MECHANICS**

**Coordinator:** Professor D Lloyd Smith (Room 426) d.lloyd-smith@imperial.ac.uk

**Lecturers:** Dr K Ramachandran (KR) (Room 408)
Dr C M Neil Tsang (NT) (Room 328B)
Dr D Lloyd Smith (DLS)

**Structure:** 41 Lectures and 19 Tutorials, divided into separate sections for Mechanics of Materials (Part A) and Structures (Part B)

**Links:** From CE104 Structural Mechanics, and to CE301 Structural Mechanics

**SYLLABUS – Part A**
MECHANICS OF MATERIALS

**Recommended textbooks: (***The following books do not contain the full syllabus)*.
TIMOSHENKO, S.P. and GERE, J.M., Mechanics of Materials, D.Van Nostrand Reinhold Co.
PILKEY, W.D. and PILKEY, O.H., Mechanics of Solids, Quantum Publishers Inc.

**Aims**
This subject deals with the analysis of stresses and strains in solid deformable bodies subjected to bending, shearing and twisting actions. The aim of this course is to provide a basic understanding of the physical behaviour of more complex structural elements than those dealt within the first year Structural Mechanics (CE 104), and to give familiarity with the methods required to analyse them. Discussions in tutorial groups will help you to consolidate your understanding of the material taught in the lectures and consequently, it will be more difficult for you to follow the course if you do not keep up-to-date with tutorial exercises.

**Structure of Half-Module: 21 lectures (KR), 10 tutorials**

- Displacements and strains; strain tensor and compatibility of strains; normal and shear stresses; equilibrium of stresses; index notation; complementary shear stresses. (3 Lectures)
- Transformations of stress and strain with change of Cartesian axes; Mohr circle of stress; pole of normals; principal stresses. (2 Lectures)
- Mohr circle of strain; principal strains; strain gauge rosettes; analysis of strain gauge data. (2 Lectures)
- Centroids of beam cross-sections; second moments of area and product second moment of area; principal second moments of area and principal axes. (2 Lectures)
- Asymmetric bending of beams; generalised flexural formula; stresses and displacements due to flexure. (2 Lectures)
- Shear stress in beams of thin-walled open cross-sections; shear flow distributions; shear centre; bolted and welded connections. (3 Lectures)
- Torsion of solid beams and thin-walled cross-sections; shear stress caused by flexure and torsion in thin-walled cross-sections. (4 Lectures)

• Linear elasticity and elastic constants; isotropy; plane stress and plane strain assumptions. (2 Lectures)

**Learning Outcomes**
At the end of this half-module you should be able to calculate the stresses and strains in, and displacements of, a number of complex but commonly used structural elements which are assumed to deform elastically. Such skills form an essential component of civil engineering design.

**Coursework and Project**
Assessed Work: Week 8. Economical design of a plated-girder cross-section (A joint project with computer application module): Submission Date: Week 18

**SYLLABUS – Part B**
STRUCTURES

**Recommended textbooks**
HULSE, R. and CAIN, J.A., Structural Mechanics, 2nd Ed., Palgrave, 2000.
COATES, R.C., COUTIE, M.G., and KONG, F.K., Structural Analysis, Nelson, 1975.

**Aims**
This half-module continues the aim of the earlier module CE.104. That is to show how structures evolving in design proposals can be modelled and analysed, so as to confirm their satisfactory performance in safely supporting the intended loading with displacements that are acceptable. In this half-module, it is shown how the response of statically indeterminate elastic structures depends on three laws: equilibrium, compatibility and elasticity relations. A specific aim is to show how the resulting equations can be presented and solved in two ways: (a) in terms of a set of internal forces (the flexibility method), or (b) in terms of a set of nodal displacements (the stiffness method).

**Structure of Half-module: 20 lectures (NT and DLS) and 10 tutorials**

VIRTUAL WORK AND THE FLEXIBILITY METHOD (9 Lectures)
VIRTUAL WORK. Virtual displacements and virtual loads. Use in static (equilibrium) and kinematic (deflection) calculations. Influence lines. Unit load method for deflections of trusses and beams. (3 Lectures) (NT)
STATIC INDETERMINACY. Methods for calculating. Concept of compatibility. (1 Lecture) (NT)
FLEXIBILITY METHOD FOR A SINGLE STATIC INDETERMINACY. Beams, trusses and systems in which both bending and axial deformation are significant. Examples. (2 Lectures) (DLS)
FLEXIBILITY METHOD FOR MULTIPLE STATIC INDETERMINACIES. Flexibility matrix and its symmetry. Continuous beams and multi-storey frames. Inclusion of bending, axial and twisting deformations. Choice of efficient release systems. (3 Lectures) (DLS)

THE STIFFNESS METHOD AND MOMENT DISTRIBUTION (11 Lectures)
KINEMATIC INDETERMINACY. Active degrees of freedom. Constraining each freedom, constraint forces. (1 Lecture) (DLS)
BEAM ELEMENT STIFFNESS. Member end forces and displacements. Sign convention. Derivation of stiffness coefficients. (2 Lectures) (DLS)

STRUCTURE STIFFNESS MATRIX AND LOAD VECTOR. Assembly process: summation of structure stiffness from beam element stiffnesses. Stiffness matrix and its symmetry. Nodal loads and equivalent nodal loads from element loads. (2 Lectures) (DLS)
THE STIFFNESS METHOD. Solution of stiffness equations for active degrees of freedom. Calculation of member end forces and member bending moment distribution. Computer methods. (2 Lectures) (DLS)
MOMENT DISTRIBUTION. Iterative method for solving stiffness equations. Distribution factor, carry-over factor, fixed-end moment. Simplifications: symmetry, pinned joints. Sway. (4 Lectures) (NT)

**Learning Outcomes**
By the end of this half-module, you should be able to model a loaded statically indeterminate elastic structure which is basically a bending frame or a truss or a combination of both, and calculate the member stresses and joint displacements.

**Coursework**
None.