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| **Module Code** | CE7S07 |
| **Module Name** | S7: A Unified Theory of Structures |
| **ECTS Weighting**[1] | 5 ECTS |
| **Semester taught** | Semester 2 |
| **Module Coordinator/s** | Associate Prof Roger P. West (rwest@tcd.ie) |
| **Module Learning Outcomes with reference to the Graduate Attributes and how they are developed in discipline** | On successful completion of this module, students should be able to:<br><br>LO1. Develop a theoretical approach to Structural Analysis which combines many of the different aspects into one unified theory governed by fundamental underlying equations and relationships.<br>LO2. Develop a new and deeper understanding of structural behaviour.<br>LO3. Understand the underlying concepts behind optimisation theory.<br>LO4. Develop optimised solutions to practical problems in structural analysis and design.<br><br>**Graduate Attributes: levels of attainment**<br>To act responsibly - Introduced<br>To think independently - Enhanced<br>To develop continuously - Enhanced<br>To communicate effectively - Not embedded |
| **Module Content** | This module will introduce Static Kinematic Duality, on which much of structural analysis and synthesis is based, including plastic analysis using optimisation. The aim of the module is to develop a unified theory of structural analysis, thereby giving the engineer much more confidence when analysing the behaviour of real structures. It complements very well the other structural modules by providing a quite different but fundamental approach.<br><br>**Structural Analysis:**<br>1. Introduction to Static Kinematic Duality, general compatibility relationship, application to elastic statically redundant structures.<br>2. Introduction to plastic behaviour, uniqueness theorem of plastic collapse, yield conditions for collapse.<br>3. Elastic and elastoplastic deformations of skeletal frames, the holonomic condition, classical plastic limit analysis involving, upper and lower bound theorems. |

4. Basic mechanisms and the duality gap, static and kinematic admissibility

**Mathematical Theory of Optimisation:**

Introduction to the basics of Optimisation Theory, including the following:

1. Theory of optimisation, classical and general Lagrangian optimisation, Lagrangian multipliers.
2. Primal and dual, slack and surplus variables and conditions for optimality, Kuhn Tucker multipliers and constraints.
3. Linear complimentarity problems, the conditions for optimality, Primal and Dual linear and quadratic programs.
4. Applications using the Simplex Algorithm.

**Structural Optimisation:**

Solving structural design problems using optimisation theory, thus:

1. Plastic collapse and static/kinematic admissibility as a linear complementary problem, mechanism compatibility.
2. Mesh and nodal dual linear program of plastic limit analysis and synthesis, duality theorem.
3. Applications to real structural optimisation problems using the simplex algorithm.

**Teaching and Learning Methods**

1. Core content via lecture (direct).
2. Weekly personalised individual assignments.

**Assessment Details[2]**
**Please include the following:**

- **Assessment Component**
- **Assessment description**
- **Learning Outcome(s) addressed**
- **% of total**
- **Assessment due date**

| Assessment Component | Assessment Description | LO Addressed | % of total | Week due |
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| | Continuous Assessment | | 25% | Weekly |
| | Examination (3 hours) | | 75% | |
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| **Reassessment Requirements** | Examination [3 hours] – 100% in person examination |
| **Contact Hours and Indicative Student Workload**[2] | **Contact hours:** Lectures – 40 hours; Tutorials – 4 hours<br>**Independent Study (preparation for course and review of materials): 3 x 11 weeks**<br>**Independent Study (preparation for assessment, incl. completion of assessment): Weekly tutorials – 1 x 11 weeks, exam preparation 12 hours** |
| **Recommended Reading List** | None |
| **Module Pre-requisite** | Undergraduate structural analysis module |
| **Module Co-requisite** | |
| **Module Website** | |
| **Are other Schools/Departments involved in the delivery of this module? If yes, please provide details.** | |
| **Module Approval Date** | 2000 |
| **Approved by** | |
| **Academic Start Year** | 1st September 2022 |
| **Academic Year of Date** | 2022/2023 |