CE7S07: S7 – A Unified Theory of Structures [5 credits]

Module co-ordinator(s): Associate Prof. Roger P. West, (rwest@tcd.ie)

Lecturer(s): Prof Roger West

Module organisation

<table>
<thead>
<tr>
<th>Semester</th>
<th>Start Week</th>
<th>End Week</th>
<th>Associated Practical Hours</th>
<th>Lectures</th>
<th>Tutorials</th>
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<td>Per Week</td>
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<tr>
<td>2</td>
<td>1</td>
<td>11</td>
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<td>30</td>
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Total Contact Hours: 40

Module description, aims and contribution to programme

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 compliments very well the other structural modules by providing a quite different but fundamental approach.

Learning outcomes

On successful completion of this subject the student will be able to:

1. 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
2. Develop a new and deeper understanding of structural behaviour
3. Understand the underlying concepts behind optimisation theory
4. Develop optimised solutions to practical problems in structural analysis and design

Module content

Mathematical Theory of Optimisation:
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 Complementarity Problems, Karush-Kuhn Tucker conditions for optimality, Primal and Dual linear and quadratic programs.
4. Applications using the Simplex Algorithm

Structural Analysis:
1. Introduction to Static Kinematic Duality, general compatibility relationship, application to elastic statically redundant structures.
2. Introduction to plastic behaviour, uniqueness theorem of plastic collapse, yield conditions for collapse.
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

**Structural Optimisation**

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. Non-holonomic elastoplastic behaviour.

4. Applications to real structural optimisation problems using the simplex algorithm.

**Teaching strategies**

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

**Assessment**

Continuous Assessment (20%), Examination (80%);
Tutorial Assignments, including use of simplex algorithm software

**Required textbook**

None

**Further information**

https://www.tcd.ie/Engineering/