Module Code	CE7S09
Module Name	S9: Advanced Theory of Structures
ECTS Weighting[1]	5 ECTS
Semester taught	Semester 1
Module Coordinator/s	Prof Breiffni Fitzgerald (breiffni.fitzgerald@tcd.ie) Lecturer(s): Prof. Roger West, Asst. Prof. Breiffni Fitzgerald
[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: LO1. The student will be able to calculate the principle stresses and strains in a 3-D elastic body. LO2. The student will be able to identify problems in structural mechanics as 2-D plane stress or plane strain elasticity problems, including using Airy stress functions and analyse for stresses and strains. LO3. The student will be able to analyses plate type of structures with in-plane and out-plane forces and solve for deflection, moments and shears of plates with simple boundary conditions subjected to transverse loading. LO4. The student will be able to analyse simple structural systems with material and geometric nonlinearity. LO5. The student will be able to model and solve for static response of Structural systems with arbitrary loading, geometry, material and Boundary conditions using finite element analysis. LO6. The student will be able to exercise the necessary skills to be able to derive and manipulate the various equations which describe structural dynamics, within the scope of the course syllabus. LO7. The student will have an appreciation of the relative importance of the Various parameters which define the dynamic response to prescribed Force histories. LO8. The student will be able to recognize the practical implementation of Solutions to SDOF and MDOF problems.

Graduate Attributes: levels of attainment

To act responsibly - Enhanced

To think independently - Enhanced

To develop continuously - Enhanced

To communicate effectively - Enhanced

Module Content	To provide a foundation in advanced structural analysis to include 3-D elasticity plates, finite element theory, non-linear behaviour and structural dynamics. The aim is to provide students with an appreciation of essential theories and techniques which all structural engineers should have as graduate attributes. It builds on the previous four years of structural analysis courses without overlap.

Module Content

- 3-D Elasticity
  - Stresses and Strains
  - Equilibrium and Compatibility
  - Plane stress/Plane strain problems
  - Airy Stress problems
  - Plate theory

- Structural Dynamics
  - SDOF system, Equation of motion
  - Natural response in free vibration, damped and undamped
  - Response to periodic, transient loads, impulsive loads, Duhamel's integral
  - MDOF systems, free vibration, natural frequencies and mode shapes

- Non-linearity

- o   Non-linear analysis of structures

- o   Geometric/Material non-linearity

- Finite Element Method

  - o   Finite Element Analysis of structures

  - o   Shape functions

  - o   1-D bar element

  - o   Plane stress/Plane strain element

  - o   Beam element

| **Teaching and Learning Methods** | The teaching strategy is a mixture of lectures, tutorial and laboratory exercises designed to provide the student with a better knowledge of some advanced theories in structural analysis. The students attend formal lectures during which they are given handouts on parts of the course, notes with a few gaps that they fill in during the course of the lecture. The basic course material for most parts of the course is uploaded on the web. The emphasis during the lecture is on allowing the student to focus on the concepts discussed in the lecture. The students are encouraged to pose questions on various issues that may arise.

The tutorials are designed with a view to allow the students to develop modelling skills with an aim to problem solving. Th solutions are provided after the attempted tutorials are handed back.

The laboratory exercise is designed to blend and combine three approaches to a technical problem. A problem in structural dynamics is given to them which they first solve analytically. This helps in developing the analytical and conceptual skills. Next, an experiment is designed with the same problem data and students observe and record the experimental results. The data acquisition provides them with a hands on experience, while the report which they submit helps to develop the technical reporting and communication skills. Finally, they analyse the problem numerically by finite element analysis using a commercial software ANSYS, which is quite popular for structural analysis in industrial firms. This part of the exercise exposes the students to commercial packages with a view to introduce them to the experience of industrial application and design in real life situation where complex engineering problems are only possible to be solved numerically using finite elements through software packages. |

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
	Exam	Written examination on campus or on-line [3 hours]	All	80%	End of term
	Coursework	The students are assigned tutorial problems to be completed every week.	All	20%	1 per week

Reassessment Requirements	100% examination, pass mark 50%

Contact Hours and Indicative Student Workload[2]	**Contact hours: 36** **Independent Study (preparation for course and review of materials): 20** **Independent Study (preparation for assessment, incl. completion of assessment): 70**
Recommended Reading List	Dynamics of Structures (Clough & Penzien), Structural Analysis (Ghali, Neville & Browne), Theory of Elasticity (Timeshenko)
Module Pre-requisite	2E4, 3A2, 3A4, 4A6(1), 4A6(2)
Module Co-requisite	N/A
Module Website	N/A
Are other Schools/Departments involved in the delivery of this module? If yes, please provide details.	No
Module Approval Date	
Approved by	
Academic Start Year	1st September 2021
Academic Year of Date	2021/2022