MODULE DESCRIPTION FORM

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

ME965 FINITE ELEMENT ANALYSIS IN MECHANICAL ENGINERING DESIGN-Online

Module Registrar: Dr Tugrul Comlekci t.comlekci@strath.ac.uk	**Taught To (Course): Cohorts for whom class is optional; MSc Advanced Mechanical Engineering (Distance Learning)**	
Other Lecturers Involved:	**Credit Weighting: 10**	**Semester: 1 (Online learning)**
Compulsory/ optional/ elective class: Optional	**Academic Level: 5**	**Suitable for Exchange: N**

Required prerequisites

<u>Note</u>: It is the responsibility of ALL students to ensure that they satisfy the prerequisite knowledge for this module BEFORE adding as part of curriculum selection. If unsure, please contact the Module Registrar or discuss with your Programme/Year Adviser of Studies.

Knowledge in Engineering Mechanics:
A good background knowledge of engineering mechanics / solid mechanics and the application to engineering design is essential. A solid understanding of structural analysis and basic stress analysis is required such as statics & beams in bending, pressurised cylinders, stress and strain calculations. Also, skills to analyse dynamics problems such as vibrations in basic single degree of freedom problems and beams as well as a good understanding of strength of materials is essential. A background knowledge of fatigue and fracture theory will be desirable, but an introduction will be given.

Numerical Methods:
A background in basic finite element analysis and familiarity with software tools such as ANSYS Mechanical is desirable but this module will give a brief introduction. Other numerical software tools to be used are Excel and / or MathCAD. Some previous experience is essential.

Module Format and Delivery (HOURS i.e. 1 credit = 10hrs of study):

Lecture	Tutorial	Laboratory	Groupwork	External	Online	Project	Assignments	Private Study	**Total**
					14		40	46	100

Educational Aim

This module aims to give an introduction to linear elastic and nonlinear finite element analysis (FEA) and its application to practical mechanical engineering design analysis problems.

Learning Outcomes

On completion of the module the student is expected to be able to:

LO1 Develop a critical understanding of the role of the finite element analysis for mechanical engineering design in the industry.

LO2 Solve practical engineering design problems using advanced finite element analysis techniques and critically assess the solutions.

LO3 Apply linear elastic FEA techniques to analyse engineering design problems involving static, dynamic and linear buckling solutions.

LO4 Apply nonlinear or complex FEA techniques to analyse engineering design problems involving large displacements, material non-linearities or fatigue and fracture.

Syllabus

The module will teach the following:

This module starts with an overview of the finite element analysis techniques and its applications. The module will focus on practical mechanical engineering design problems. Different types of modelling such as 2D and 3D analysis techniques with plane stress, plane strain, axisymmetric, beam, shell and solid type finite elements will be introduced. Modeling strategies, techniques and issues will be discussed such as the use of symmetry, boundary conditions and various assumptions, errors and accuracy, verification and validation, convergence checking and sensitivity studies.

The module will introduce linear elastic finite element analysis for static and dynamic design problems. Framed structures will be analysed using truss and beam type elements. Solid structures such as pressure vessels will be analysed with discussions on the use of 2D plane stress, plane strain, axisymmetric and full 3D modelling techniques. Structural vibration problems will be explored using natural frequency and dynamic analysis of structures subjected to dynamic loading. This will be followed by advanced nonlinear analysis such as large displacements and with material nonlinearities that is required for buckling and limit load type design assessments. Other advanced topics such as fatigue and fracture mechanics analyses and optimisation will be studied with practical design case studies and industrial examples.

Assessment of Learning Outcomes

Criteria

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

LO1 **Develop a critical understanding of the role of the finite element analysis for mechanical engineering design in the industry.**
C1 Awareness of the software packages in order to perform finite element analysis and simulation on various computing platforms and how to select the most appropriate analysis tools for a given problem.
C2 Understand the current state of the art, applicability and limitations of FEA in mechanical engineering design
C3 Assess and identify typical design problems in mechanical engineering that will benefit from FEA simulation resulting in financial savings, standards compliance or a competitive advantage in the industry.

LO2 **Solve practical engineering design problems using advanced finite element analysis techniques and critically assess the solutions.**
C1 Understand and apply the typical FEA modelling workflow of geometry modelling, meshing, load and displacement boundary condition application, solution and postprocessing.
C2 Understand the use of verification, validation, convergence and error checking in critical analysis and evaluation of FEA solutions.

LO3 **Apply linear elastic FEA techniques to analyse engineering design problems involving static, dynamic and linear buckling solutions.**
C1 Apply appropriate modelling techniques, choice of elements and boundary conditions for static analyses of structures.
C2 Understand natural frequency eigenvalue analysis and appropriate load and time stepping technique for a full linear elastic dynamic analysis.
C3 Evaluate eigenvalue buckling loads and buckled mode shapes and critically analyse a structure prone to buckling.

LO4 **Apply nonlinear or complex FEA techniques to analyse engineering design problems involving large displacements, material non-linearities or fatigue and fracture.**
C1 Understand the large displacement nonlinear geometry & material analysis of a structure in a buckling scenario and critically compare with linear solutions.
C2 Apply nonlinear material properties and evaluate plastic failure load of structures such as a pressure vessel and compare with elastic FEA solutions as well as analytical solutions.
C3 Apply high cycle fatigue analysis in a design life analysis using available material S-N properties.
C4 Apply fracture mechanics analysis to evaluate stress intensity factors and compare with material critical values evaluating safety of structures.

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

Principles of Assessment and Feedback
(within Assessment and Feedback Policy at:
*https://www.strath.ac.uk/professionalservices/staff/policies/academic/*http://www.strath.ac.uk/learnteach/informationforstaff/staff/assessfeedback/12principles/ *)*

The class is assessed through two courseworks, to be completed during the semester

Myplace class forums will be used to discuss online lessons, demonstrations and tutorial examples that will be released sequentially. Selected tutorial solutions mini reports will be used for formative feedback.
Summative marking and feedback for the courseworks will be returned to students within the guideline feedback return deadlines. Further individual online feedback will be given on request.

Assessment Method(s) Including Percentage Breakdown and Duration of Exams *(individual weightings)*

Examination				Coursework		Practical		Project	
Number	Month(s)	Duration	***Weighting***	Number	***Weighting***	Number	***Weighting***	Number	***Weighting***
				1 1	40% 60%				
*				LO1, LO2, LO3, LO4		*		*	

* ***L/Os:*** *Indicate which Learning Outcomes (L01, L02, etc) are to be assessed by exam/coursework/practical/project as required.*

Coursework / Submission deadlines (*academic weeks*):
Semester 1 week 6 & week 11

Resit Assessment Procedures:
Submission of alternate extended ^^coursework prior to commencement of the August exam diet.

^^Students must contact the module Registrar for coursework details as soon as they know that they are required to resit this class.

PLEASE NOTE:
Students must gain a summative mark of 50% to pass the module. Students who fail the module at the first attempt will be re-assessed prior to the August diet. This re-assessment will consist entirely of coursework. No marks from any previous attempts will be transferred to a new resit attempt.

Recommended Reading

*****Purchase recommended   **Highly recommended reading   *For reference**

*** ANSYS 2022 R2 or the latest version to be downloaded and installed on students own Windows PC which must be capable of running the software, or alternatively a University Virtual Remote Desktop connection is required.
* Huei-Huang Lee, Finite Element Simulations with ANSYS Workbench 2022
Theory, Applications, Case Studies 2022, SDC Publications, 2022, ISBN-13 : 978-1630575397

Additional Student Feedback
(Please specify details of when additional feedback will be provided)

Date	Time	Room No
N/A		Check timetable webpages for details

Session: 2023/24

Approved:

Course Director Signature: Olga Ganilova

Date of Last Modifications: 25/08/2023

(Updated August 2023)

MODULE TIMETABLE

Module Code:	**ME965**	**Module Title:**	**Finite Element Analysis in Mechanical Engineering Design**

Brief Description of Assessment:

2 Courseworks: CW1 - 40% & CW2 - 60%

Assessment Timing

Indicated on the table below are the start/submission dates for each assignment/project and the timing of each exam/assessment. Dropdowns may be left blank. Add extra notes below the dropdowns where relevant.

Please note: Timings can and will change, this should only be used as a guide.

Semester One	W&D Wk	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
	Choose an item. Choose an item.	Choose an item. Choose an item.	Course work Set	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Course work Submit Course work Set	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Course work Submit	Choose an item.

Semester Two	C&D Wk	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item.