MNE4005: FINITE ELEMENT ANALYSIS

Effective Term
Semester B 2024/25

Part I Course Overview

Course Title
Finite Element Analysis

Subject Code
MNE - Mechanical Engineering
Course Number
4005

Academic Unit
Mechanical Engineering (MNE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
MNE2109/BME2109 Engineering Mechanics AND
MNE2116 Engineering Graphics or
MNE3007 CAD/CAM or equivalent

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Additional Information
#Prerequisites which are not part of the Major Requirement are waived for students admitted with Advanced Standing.

Part II Course Details

Abstract

The aims of this course are to develop:

- an understanding of basic principles, techniques and issues underlying modelling and computer-aided analysis of parts, products and other engineering systems; and
- a practical awareness of the above through the application of appropriate computer-aided engineering software.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Discuss the basic theory and methods on spline-based modelling.			x	
2	Explain methods and algorithms on mesh generation from a given surface or solid model.			x	
3	Explain properties of geometric models and methods for their evaluation.				
4	Elaborate the basic principles of finite-element analysis and their applications in stress/strain analysis and thermal stress analysis.			x	
5	Use finite-element methods and an appropriate computer aided engineering software to analyse parts, products and other engineering systems.			x	

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Explain key concepts, theories and methods on modelling, mesh generation, property evaluation and finite element analysis.	1, 2, 3, 4	3 hrs/week
2	Laboratory Work	Use finite-element methods and appropriate computer aided engineering software to analyze parts or systems.	5	3 hrs/week for 2 weeks

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Test and Assignments	1, 2, 3	20	
2	Laboratory Exercises	4, 5	20	2 sets of exercises; developed reports should be submitted by students

Continuous Assessment (%)

40

Examination (%)

60

Examination Duration (Hours)

2.5

Additional Information for ATs

For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

Assessment Rubrics (AR)

Assessment Task

Test and Assignments

Criterion

Ability to explain key concepts, theories and methods on topics covered in relevant lectures.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching marginal levels

Assessment Task

Laboratory Exercises

Criterion

Ability to use an appropriate computer aided engineering software to analyse parts or structures.

Excellent (A+, A, A-)

High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Examination

Criterion
Ability to explain key concepts, theories and methods on modelling, mesh generation, property evaluation and finite element analysis.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Additional Information for AR
Note: For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

Part III Other Information

Keyword Syllabus

- Modelling and engineering shape representation: Polynomials and polynomial functions. Spline-based modelling. NURBS for representing commonly used engineering shapes and geometries.
- Mesh generation: Delaunay triangulation. Parametric approaches and direct approaches for mesh generation. Advancing-front method for mesh generation. Surface mesh generation. Volume mesh generation.
- Evaluation of global geometric and mass properties: Curve length. Cross-sectional area. Surface area. Volume. Centroid. Mass. Moment of inertia.
- Finite-element analysis of mechanical structures: Types of elements, such as trusses, beams, and 2D and 3D solids. Model formulation. Boundary and loading conditions. Application in stress/strain analysis.

- Finite-element analysis in heat transfer and thermal stress: Fourier law of heat conduction and governing equation for steady-state conduction. Boundary conditions: specified temperature, specified heat flux and convection. Application in thermal stress calculation.

Reading List

Compulsory Readings

	Title
1	Nil

Additional Readings

	Title
1	David F. Rogers, “An Introduction to NURBS: with Historical Perspectives”, Academic Press, San Francisco, 2001.
2	Ibrahim Zeid, “CAD/CAM Theory and Practice”, McGraw-Hill, New Delhi, 1991.
3	Joe F. Thompson, Bharat K. Soni and Nigel P. Weatherill, “Handbook of Grid Generation”, CRC Press, New York, 1999.
4	Charles E. Knight, “The Finite Element Method in Mechanical Design”, PWS-KENT Publishing Co., 1993.
5	Kenneth H. Huebner, Donald L. Dewhirst, Douglas E. Smith and Ted G. Byrom, The Finite Element Method for Engineers, John Wiley & Sons, Inc., New York, 2001.
6	Thomas J. R. Hughes, “The Finite Element Method: Linear Static and Dynamic Finite Element Analysis”, Dolver Publications Inc, New York, 2012.
7	J. Austin Cottrell, Thomas J. R. Hughes, Yuri Bazilevs, "Isogeometric Analysis: Toward Integration of CAD and FEA", John Wiley & Sons, 2009.