

# ACADEMIC – GRADUATE STUDIES AND RESEARCH DIVISION

**FIRST SEMESTER 2022-2023**

**Course Handout Part II**

**Date:** **23/08/2022**

In addition to Part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

*Course No.* : CE G619

*Course Title* : Finite Element Analysis

*Instructor-in-Charge* : Dr. Raghu Piska

**Course Description :** Fundamentals of Finite Element Method (FEM); basic formulations of FEM; assembly of elements, solution techniques; 2D and 3D problems; review of the isoparametric elements; thin and thick plate elements; introduction to shell formulations; use of newly developed elements; mixed finite element method; material and geometric nonlinear problems; application of FEM to civil engineering problems, programming FEM.

# Scope and Objective of the Course:

Finite element method is the most powerful numerical technique mankind has ever found to solve partial differential equations. The method not only has wide applications in Civil, Mechanical, Aerospace, Electrical Engineering but also in Biomechanics etc. making it a more versatile and efficient numerical technique. Every physical phenomenon is governed by partial differential equations which are difficult to solve for complicated domain and complicated boundary conditions. Whereas Finite elements can easily deal with these difficulties and gives a solution closer to the exact solution in most of the cases. Hence the method offers great scope to analyze the problems in structural engineering. The objective of this course is to impart the knowledge on how to formulate and implement the finite element method to analyze any structure with a specified domain, material, loading and boundary conditions.

**Course Outcomes**: At the end of this course, the students will be able to:

CO1. Develop the finite element formulation of a given problem

CO2. Analyze rods, trusses, beams, frames, plates and shells using finite element method

CO3. Understand how to develop a new FE formulation

CO4. Develop MATLAB codes for the finite element analysis of various structural elements.

Student Learning Outcomes (SLOs) assessed in this course – **(a), (b), (c), (d), (e), (f), (h), (j),** and **(k). Student Learning Outcomes (SLOs):**

SLOs are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.

1. an ability to apply knowledge of mathematics for solving differential equations
2. an ability to understand the mechanics behind the behavior of structures
3. an ability to develop finite element formulation for a given differential equation
4. an ability to analyze structural elements using appropriate finite elements
5. an ability to identify, formulate, and solve engineering problems
6. an ability to develop codes for analyzing a problem using finite elements

Textbook:

1. *JN Reddy, (2009) “An Introduction to the Finite Element Method”. 3rd Edition, McGrawHill*

# Reference books:

1. Robert D Cook, David S Malkus, Michael Plesha and Rober J Witt (2001). “*Concepts and Applications of Finite element analysis*”, Wiley.
2. C S Krishnamoorthy (1994). “*Finite Element Analysis: Theory and Programming”,* McGrawHill
3. Tirupati R Chandrupatla, Ashok D. Belegundu (2011). *“Introduction to Finite Elements in Engineering”*, Pearson

# Course Plan:

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| --- | --- | --- | --- | --- |
| **Lecture No.** | **Learning objectives** | **Topics to be covered** | **Chapter in the Text**  **Book** | **SLO** |
| 1-3 | Introduction | Introduction to Basic Structural Mechanics, Mathematical preliminaries | Ch-1 and Ch-2 | a |
| 4-5 | Finite element formulation – 1D bar problem | Derivation of governing equation of 1D bar problem and the finite element formulation | Ch-3 | a, c |
| 6-7 | Numerical problems | Solving examples involving 1D bar elements | Ch-3 | b |
| 8-10 | Truss elements | Truss element formulation and Numerical problems | Ch-4 | b,d |
| 11-13 | Beam elements | Finite element formulation of Euler Bernoulli and Timoshenko beam theories | Ch-5 | a, b |
| 14-16 | Numerical problems | Numerical problems on beams | Ch-5 | b,d |
| 17-19 | Frame elements | Formulation and Numerical examples | Ch-5 | b,d |
| 20 | Isoperimetric formulation | Isoparametric finite element formulation | Ch-8 | c |
| 21-23 | Introduction 2D finite elements | 2D finite element formulation, plane stress and plane strain formulation, Numerical integration and modeling techniques | Ch - 11 | c |
| 24 | Axisymmetric problems | Finite element formulation of axi-symmetric problems |  | c,d |
| 25-26 | 2D numerical examples | Problem solving of 2D finite elements | Ch-9,11 | a |
| 27-29 | Finite element formulation of plate bending | Finite element formulation of Kirchhoff and Mindlin plate theories | Ch-12 | b,c |
| 30-31 | Shell finite elements | Shell finite element formulation | Material will be supplied during class | a,b,c |
| 32-33 | Mixed Finite elements | Finite element formulation using mixed finite elements | Material will be supplied during class | e |
| 34-35 | Material and Geometric nonlinearity | Finite element formulation considering material and geometric nonlinearity | Material will be supplied during class | e |
| 36-38 | Dynamic analysis using FEM | Free vibration and transient dynamic problems | Ch-6 | e |
| 39-42 | Programming FEM | Developing Finite element codes for bar and beam elements both for static and dynamic problems | Ch-7 | f |

**Evaluation Scheme:**

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| --- | --- | --- | --- | --- |
| **Component** | **Duration** | **Weightage (%)** | **Date & Time** | **Nature of Component** |
| Mid Semester Test | 90 min | 25 | 04/11 9.00 - 10.30AM | Closed book |
| Comprehensive Exam | 180 min | 35 | 27/12 FN | OPEN BOOK |
| Assignments (Theory+Programming) |  | 20 | - | OPEN BOOK |
| Teaching presentation |  | 05 |  | OPEN BOOK |
| Mini Project |  | 15 |  | OPEN BOOK |

**Chamber Consultation Hour:** To be announced in the class

**Notices:** Concerning this course will be displayed on CMS

**Make-up Policy:** Make-up would be granted only for genuine cases with prior permission.

**Academic Honesty and Integrity Policy**: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

# INSTRUCTOR-IN-CHARGE

**CE G619**