Birla Institute of Technology & Science, Pilani
Hyderabad Campus

FIRST SEMESTER 2021-2022

Course Handout

Date:06-08-2021

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

Course No. : **ME G512**
Course Title : **FINITE ELEMENT METHODS**
Instructor-in-Charge : **AMOL VUPPULURI**

1. **Course Description**: Fundamental concepts, matrix algebra and Gauss elimination, one-dimensional problems, trusses, two-dimensional problems using constant strain triangles, axisymmetric solids subjected to axisymmetric loading, two-dimensional isoparametric elements and numerical integration, beams and frames, three-dimensional problems in stress analysis, scalar field problems, dynamic considerations, pre-processing and post processing.

2. **Scope and Objective of the Course:** The course covers intermediate to advanced topics of finite element methods including scalar field problems. The course develops an approach to solve variety of differential equations in integral form. The students are introduced to techniques of finite element discretization, conversion methods of differential equations into algebraic equations and solution procedure of algebraic equations. The students will be equipped with knowledge of solving several physical field problems.

3. **Textbooks:**
   1. T. R. Chandrupatla, A. D. Belegundu, Introduction to Finite Elements in Engineering, 3rd Edition, Prentice Hall of India, New Delhi.

4. **Reference books**
   1. Reddy J. N., An Introduction to Finite Element Method, 3rd Edition, Tata-McGraw Hill Edition, 2006, New Delhi.
   2. Rao S. S., The finite element method in engineering, fourth edition, Elsevier, 2005, MA, USA.

5. **Course Plan:**

Lecture No.	Learning objectives	Topics to be covered	Chapter in the Text Book
1-2	Fundamental Concepts	Historical background, stresses and equilibrium, boundary conditions, strain-displacement relations, stress-strain relations , temperature effects, potential energy and equilibrium, Rayleigh-Ritz method, Galerkin's method	T1,Chapter1
3-4	Matrix algebra and Gauss	Row and column operations of a matrix, eigenvalues	T1,Chapter2

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	elimination	and eigenvectors, positive definite matrix, cholesky decomposition, Gaussian elimination, conjugate gradient method, implementation of matrix operations in FEM calculations	
5-7	Finite element modeling of one-dimensional vector-field problems	Finite element modeling, linear and quadratic shape functions, Rayleigh-Ritz & Galerkin approaches, assembly of equations, application of essential and natural boundary conditions, thermal stress	T1,Chapter3
8-9	Finite element modeling of trusses	Finite element modeling of planar trusses, allusion to three-dimensional trusses, assembly of global stiffness matrix	T1,Chapter4
10-14	Finite element modeling of two-dimensional vector-field problems	Isoparametric representation, CST element, finite element modeling of axisymmetric solids, modeling of orthotropic material system, Four node quadrilateral elements, Numerical integration, Higher order elements, conjugate gradient implementation of the quadrilateral elements	T1,Chapter5-8
15-20	Modeling of fourth order problems	Beams and Frames; Modeling Euler-Bernoulli beam elements using, Rayleigh-Ritz and Galerkin approaches, Load vector and boundary conditions, shear force and bending moment, beams on elastic supports, Plane frames, three-dimensional frames, Modeling using Timoshenko beam elements, Plate bending, Analysis of plates using membrane elements with in-plane loads, Modeling of bending of plates under transverse loads	T1,Chapter5-8 R1,Chapter9-10
21-23	Modeling of 3-dimensional problems	Formulation of 3D problems, stress calculations, hexahedral elements, solution procedures	T1,Chapter9
24-28	Modeling of eigenvalue and dynamic problems	Formulation of Eigen value problems, mass matrices and stiffness matrices, Formulation of time dependent problems, parabolic equations, hyperbolic equations	T1,Chapter11 R1,Chapter6 R2,Chapter12
29-35	Finite element modeling of single variable scalar field problems	Boundary value problems, mesh generation and boundary conditions, applications to heat transfer applications to potential flow, fluid mechanics application to solid mechanics application to torsion	T1,Chapter10 R1,Chapter8 R2,Chapter13-16
36-30	Finite element analysis fluid flow as vector field problems	Equations of fluid mechanics, modeling procedure analysis of inviscid and incompressible fluid flows analysis of viscous and non-Newtonian flows	T1,Chapter10 R2,Chapter 17-19
41-42	Introduction to advanced topics	Solution of Helmholtz equation	R2,Chapter 20-22

6. Lab

S. No	Finite Element Simulations
1	Finite element analysis (1D) using MATLAB programming
2	Finite element analysis of 1D bar problems
3	Finite element analysis of a plate bending
4	Finite element analysis of a beam bending
5	Finite element analysis of a truss
6	Finite Element analysis of plate with circular hole
7	Finite Element analysis of pressure vessels
8	Finite Element analysis of axisymmetric problem
9	Finite Element analysis of heat transfer problem
10	Mode shape analysis using finite element
11	Finite Element Analysis of Linear buckling
12	Finite element analysis of a crack problem

7. Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of Component
Mid semester test	90 min	30%		Open book
Literature Survey / Presentation/Project/ Practicals	-	30%		Open book
Comprehensive Examination	2 hrs	40%		Open book

8. Chamber Consultation Hour: Will be announced in the class

9. Make-up Policy: Will be announced in the class.

10. 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
ME G512