SECOND SEMESTER 2021-2022

Course Handout Part II

Date:07-1-2022

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. : **ME G512**
Course Title : **FINITE ELEMENT METHODS**
Instructor-in-Charge : **Pardha Saradhi G V**

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
1-3	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
4-7	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	T1,Chapter3

		natural boundary conditions, thermal stress	
8-10	Finite element modeling of trusses	Finite element modeling of planar trusses, allusion to three-dimensional trusses, assembly of global stiffness matrix	T1,Chapter4
11-15	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
16-22	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
23-26	Modeling of 3-dimensional problems	Formulation of 3D problems, stress calculations, hexahedral elements, solution procedures	T1,Chapter9
27-29	Matrix algebra and Gauss elimination	Row and column operations of a matrix, eigenvalues and eigenvectors, positive definite matrix, cholesky decomposition, Gaussian elimination, conjugate gradient method, implementation of matrix operations in FEM calculations	T1,Chapter2
30-33	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
34-38	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
39-42	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

6. Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of Component

Mid semester test	90 min	25% (50 Marks)	As per Timetable	Open book
Class/Lab Assignment	-	15% (30 Marks)		Open book
Research Seminar/Project *		20% (40 Marks)		Open book
Comprehensive Examination	2 hrs	40% (80 Marks)	As per Timetable	Open book

**Research seminar: Each student/batch of students is assigned a task of solving a specific physical field or multi-physics coupled field problems. The students/batch have to prepare a plan through proper literature survey and have to numerically analyze the task. The progress of the project will be monitored through three time evaluation in the form of project plan proposal, mid-semester and end-semester presentations.

Chamber Consultation Hour: Will be announced in the class

7. **Notices:** All in The CMS and if very important also on the Department Notice Board.

8. **Make-up Policy:** Make-up will be granted only to genuine cases. For cases related to illness, proper documentary evidence is essential. Prior permission is necessary if the student is out of station on the test date.

9. **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