First Semester 2016-2017
Course Handout (Part II)

Date: 28/07/2016

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

Course No.	**:**	**CE G619**
Course Title	**:**	**Finite Element Analysis**
Instructor-in-charge	**:**	**SHUVENDU NARAYAN PATEL**

1. **Course Description:**

Fundamentals of the finite element method (FEM); basic formulations of FEM; steps in FEM; 1-D, 2-D and 3-D elements; axi-symmetric elements, isoparametric formulations; programming aspects in FEM; plate bending elements; shell elements; review of newly developed elements; material and geometric nonlinearity; Buckling and Vibration problems, application of FEM to civil engineering problems.

2**. Scope and Objective of the Course**:

Finite element method is the most powerful numerical method widely used for solving problems in different branches of engineering specially Civil Engineering. This method is usually used to solve complex problems with regard to complexity in material, geometry, boundary, and loading conditions, such as non-homogeneous material, irregular geometry, boundary conditions, and static & dynamic loading conditions. The finite element formulation from the weak form of the governing differential equations is also covered. The course is aimed to enable students to understand the advanced concept of finite element method and its application to Civil Engineering.

3. Text Book

R. D. Cook, D. Malkus, M. E. Plesha, and R. J. Witt, Concepts and Applications of Finite Element Analysis, Wiley India, Fourth Edition, 2003.

4. Reference Books

1. O. C. Zienkiewicz, R. L. Taylor and J. Z. Zhu, The Finite Element Method: Its Basis & Fundamentals, Butterworth-Heinemann, 6th edition, Elsevier India, New Delhi, 2005.
2. Huebner and Thornton, The Finite Element Methods for Engineers, 2nd Edition, Mc-Graw-Hill.
3. Chandrupatla and Belegundu, Introduction to Finite Elements in Engineering, 2nd Edition, Prentice-Hall
4. C.S. Krishnamurthy, Finite Element Analysis: Theory and programming, Second Edition, 1994.
5. C. S. Desai and J.F. Abel, Introduction to Finite Element Method, CBS Publishers & Distributors, New Delhi, 1972.

6. Reddy, J.N., "An Introduction to Finite Element Method, 3rd Edition McGraw-Hill.

5. Course Plan:

Sl No	Learning Objectives	Topics To be Covered	No. of Lects.	Chap./Art. Nos. of TB
1.	Introduction	Need of FEM in solids and structures, basic concept of FEM, advantages of FEM, Steps in FEM, Concepts of compatibility and completeness. Functionals and Governing Differential Equation, Strong and Weak form of Differential Equations, Essential and Natural Boundary Conditions. Finite element formulations(Differential equation based and Non differential equation based)	4	1, RB6
2.	Variational Formulation and Approximation	General introduction, Some mathematical concept and Formulae, Elements of calculus of variation, Integral formulations, Variational methods.	5	4, 5 and [Ch-2 in RB6]
3.	Interpolation function	Interpolation function for basic and higher order elements, criterion for selecting the interpolation function.	2	3
4.	Generalized Force – Displacement Relationship	Principle of virtual work, Derivation of generalized Force-displacement relationship using principal of virtual work, expressions for stiffness matrix and load vectors.	2	3
5.	One-dimensional Elements	Development of Shape functions for one-dimensional elements, Development of stiffness matrix for Bar Element (from weak form of DE and other forms) , Assembly of Elements, properties of structural stiffness matrix, application of boundary conditions, development of load vector, solution to equations, determination of strains, stresses and reactions, analysis of truss structures, Higher order 1-D elements, development of stiffness matrix and load vector for Higher order one-dimensional. Use of this element in other physical problem.	4	3
6.	Two-dimensional Elements	Displacement functions for 2-D elements, Stress-strain relation for plane stress and plane strain problems, stiffness matrix for linear triangular element(in structural mechanics-CST) and quadratic triangular (in structural mechanics-LST) element, Shape functions for	5	3

		higher order Triangular elements, Lagrangian and Serendipity shape functions for linear quadrilateral elements and quadratic quadrilateral elements, stiffness matrix of these elements(from weak form of DE and other forms), defects in quadrilateral elements, Comparison of triangular and quadrilateral elements, Use of these element in other physical problem.		
7.	Axi-symmetric elements	Formulation of axi-symmetric elements and its application.	3	14
8.	Beam elements	Stiffness matrix for beam elements(from weak form of DE and other forms), in 2-D and 3-D, shear deformation in beams, analysis of 2-D and 3-D framed structures.	2	15
9.	3-D elements	Review of various 3-D elements, Lagrangian and Serendipity Shape functions for 3-D elements, constitutive matrix for 3-D elasticity.	2	3
10.	Isoparametric formulations	Introduction to isoparametric elements, linear quadrilateral elements, Quadratic quadrilateral elements, Hexahedral elements, Incompatible modes, static condensation, choice of numerical integration, consideration to various types of loads, stress calculation, effect of element geometry, validity of elements with iso-parametric formulations, Patch Test, Iso-parametric formulations of Triangular and tetrahedral elements.	5	6 and 7
11.	Plate Bending Elements	Plate Behaviour, Kirchhoff Plate Elements(from weak form of DE and other forms), Mindlin Plate Elements(from weak form of DE and other forms), shear locking,	4	15
12.	Shells elements	Shell theory, Arch Elements, Shells of revolution, general three and four node shell elements, curved isoparametric shell elements, shear and membrane locking	4	16

6. **Evaluation Scheme**:

Evaluation Component No	Evaluation Component	Duration	Weightage	Date time and Venue	Nature of component.
1	Mid-Semester Test	1-hour and 30-minutes	25%	<TEST_1>	CB
2	Project, Assignments, Computer Programs, Seminars, Take Home Tests, Class Test		40%	Continuous	OB
3	Comprehensive Examination	3-hours	35%	<TEST_C>	CB

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

8. **Notices**: All notices concerning the course will be displayed on Notice Board of Dept. of Civil Engineering.

9. Make up policies: Makeup will be given only to the genuine cases provided prior permission is taken.

Instructor-In-Charge
CE G619