**CE 504: FINITE ELEMENT METHOD IN STRUCTURAL ENGINEERING (3-0-0: 3)**

**Course objectives: The Finite Element Method (FEM) is widely used in industry for analysing and modelling structures and continua, whose physical behaviour is described by ordinary and partial differential equations. The FEM is particularly useful for engineering problems that are too complicated to be solved by classical analytical methods. The main objective of this course is to introduce the mathematical concepts of the Finite Element Method for obtaining an approximate solution of ordinary and partial differential equations. In this course you will attend lectures on the fundamentals of the Finite Element Method. Your learning process will be enhanced by completing assignments using mathematical software such as Maple. You will also be introduced to a commercial Finite Element software package – ANSYS/Abaqus – during lectures with computer laboratories providing opportunities to practice on, and to complete practical assignments, using ANSYS/Abaqus.**

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**Introduction:** Introduction; Basic Concepts of Finite Element Analysis; Introduction to Elasticity; Steps in Finite Element Analysis.

**Finite Element Formulation Techniques:** Virtual Work and Variational Principle; Galerkin Method; Finite Element Method: Displacement Approach; Stiffness Matrix and Boundary Conditions.

**Element Properties:** Natural Coordinates; Triangular Elements; Rectangular Elements; Lagrange and Serendipity Elements; Solid Elements; Isoparametric Formulation; Stiffness Matrix of Isoparametric Elements; Numerical Integration: One Dimensional; Numerical Integration: Two and Three Dimensional.

**Analysis of Frame Structures:** Stiffness of Truss Members; Analysis of Truss; Stiffness of Beam Members; Finite Element Analysis of Continuous Beam; Plane Frame Analysis.

**FEM for Two and Three Dimensional Solids:** Constant Strain Triangle; Linear Strain Triangle; Rectangular Elements; Numerical Evaluation of Element Stiffness; Computation of Stresses, Geometric Nonlinearity and Static Condensation; Axisymmetric Element; Finite Element Formulation of Axisymmetric Element; Finite Element Formulation for 3 Dimensional Elements.

**FEM for Plates and Shells:** Introduction to Plate Bending Problems; Finite Element Analysis of Thin Plate; Finite Element Analysis of Thick Plate; Finite Element Analysis of Skew Plate; Introduction to Finite Strip Method; Finite Element Analysis of Shell.

**Text Books and References:**

1. J.N. Reddy, J. N., “*An Introduction to the Finite Element Method*”, Tata McGraw Hill, 2nd Ed,

2003.

2. Krishnamoorthy, C. S., “*Finite Elements Analysis: Theory and Programming*”, Tata McGraw

Hill, 2nd Ed, 1994.

3. Cook, R. D., Malkus, D. S., and Plesha, M. E., “*Concepts and Applications of Finite Element Analysis*”, John Wiley & Sons, 4th Ed, 2002.

4. Zienkiewicz, O. C., Taylor, R. L., and Zhu, J. Z., “*Finite Element Method Its Basis and*

 *Fundamentals*”, Elsevier, 6th Ed, 2005.

5. Rao, S. S., “*Finite Element Method in Engineering*”, Butterworth Heinemann, 3rd Ed, 1999.

6. Kanchi, M. B., “*Matrix Method of Structural Analysis*”, Wiley Eastern Limited, 2nd Ed, 1993.

7. Bathe, K. J., “*Finite Element Procedures*”, Prentice Hall of India Pvt. Ltd., 2002.

**Expected outcome:** This course will develop your Technical Competence capability. Upon successful completion of this course, one should:

* Possess a good understanding of the theoretical basis of the weighted residual Finite Element Method.
* Be able to use the commercial Finite Element packages to build Finite Element models and solve a selected range of engineering problems.
* Be able to validate a Finite Element model using a range of techniques.
* Be able to communicate effectively in writing to report (both textually and graphically) the method used, the implementation and the numerical results obtained.
* Be able to discuss the accuracy of the Finite Element solutions.

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