FINITE ELEMENT METHOD

Lectures / Tutorials : 4 Periods/Week — Sessional marks: 40
Semester End Exam. : 3 Hours — Semester End Exam. marks: 60
Credits : 4

Course Objectives:

- To introduce basic principles of solid mechanics and energy methods
- To explain the properties of one-dimensional and two-dimensional elements
- Evaluation of element stiffness matrix and nodal load vector
- Assemblage of element stiffness matrices and nodal load vectors to obtain global stiffness matrix and global load vector
- To solve the simultaneous equations of equilibrium
- Solution to one – and two- dimensional problems
- To extend the method to soil / rock mechanics and inviscid and incompressible fluid flows.

Course Outcomes:

- Learn the basic principles of solid mechanics and energy methods
- Know the properties of one-and two- dimensional elements
- Can evaluate element stiffness matrices and element load vectors
- Can obtain global stiffness matrix and nodal load vector
- Able to solve the simultaneous equations of equilibrium
- Able to obtain solutions to one- and two-dimensional problems
- Able to apply the method to soil / rock mechanics and inviscid and incompressible fluid flows

UNIT –I

The standard discrete system and origins of the finite element method

Introduction; The structural element and the structural system; Assembly and analysis of a structure ; The boundary conditions; Electrical and fluid networks ; The general pattern; The standard discrete system

A direct physical approach to problems in elasticity: plane stress

Introduction ; Direct formulation of finite element characteristics; Generalisation to the whole region ; Displacement approach as a minimization of total potential energy; Convergence criteria; Finite element solution process; Numerical examples

UNIT -II

Generalisation of the finite element concepts

Weighted residual methods – Integral or weak statements equivalent to the differential equations ; Approximation to integral formulations ; the Galerkin method ; Partial discretisation ; Convergence Variational principles – What are variational principles ? ; Natural variational principles and their relation to governing differential equations ; Establishment of natural variational principles for linear , self-adjoint , differential equations ; Maximum, minimum or saddle point.

UNIT -III

Standard and hierarchical element shape functions

Standard and hierarchical concepts; Rectangular elements – some preliminary considerations ;

Completeness of polynomials ; Lagrange family ; Serendipity family Triangular element family ; Line elements

Mapped elements and numerical integration

Use of shape functions in the establishment of coordinate transformations ; Geometrical conformity of elements; Variation of the unknown function within distorted, Curvilinear elements – continuity requirements; Evaluation of element matrices – transformation in local natural and area/volume coordinates; Order of convergence for mapped elements ; Numerical integration – One-dimensional and two-dimensional ; Required order of numerical integration

UNIT -IV

Problems in linear elasticity

Governing equations; Finite element approximation; Displacements, strains and stresses; Numerical examples.

Field problems – Heat conduction, electric and magnetic potential and fluid flow

General quasi-harmonic equation ; Finite element solution process ; Partial discretisation - transient problems ; Numerical examples – an assessment of accuracy

NOTE

Two questions of 12 marks each will be given from each unit out of which one is to be answered. Twelve questions of one mark each will be given from entire syllabus which is a compulsory question.

TEXT BOOK

The finite element method – Its basis & Fundamentals by Zienkiewicz , Taylor and Zhu , 6th Edition, Elsevier India Private Ltd, 2007.

REFERENCE BOOKS

1. The finite element method in engineering by S. S.Rao, Butterworth-Heinemann, New Delhi, 1999.
2. Introduction to the finite element method by C.S. Desai and J.F.Abel, CBS Publishers and distributors, 1987.