# FINITE ELEMENT ANALYSIS

| Course | Code | Credits | L-T-P | Assessment | | Exam |
| --- | --- | --- | --- | --- | --- | --- |
| | | | | SEE | CIA | Duration |
| Finite Element Analysis | 15ME61 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**Course Objectives:**

1.To learn basic principles of finite element analysis procedure.

2.To learn the theory and characteristics of finite elements that represent engineering structures.

3.To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

**Module I**
**Introduction to Finite Element Method :**General description of the finite element method. Engineering applications of finite element method. Boundary conditions: homogeneous and nonhomogeneous for structural, heat transfer and fluid flow problems.Potential energy method, Rayleigh Ritz method, Galerkin's method, Displacement method of finite element formulation. Convergence criteria, Discretisation process, Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes. Strain displacement relations, Stress strain relations, Plain stress and Plain strain conditions, temperature effects.

**Interpolation models:** Simplex, complex and multiplex elements, Linear interpolation polynomials in terms of global coordinates 1D, 2D, 3D Simplex Elements.                             **10 Hours**

**Module II**
One-Dimensional Elements-Analysis of Bars and Trusses, Linear interpolation polynomials in terms of localcoordinate's for1D, 2Delements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, , , Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA8), 2D isoparametric element, Lagrange interpolation functions, Numerical integration: Gaussian quadrature one point, two point formulae, 2D integrals. Fore terms: Body force, traction force and point loads,

**Numerical Problems:** Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach, Analysis of trusses.   **10 Hours**

**Module III**
**Beams and Shafts**:Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight and stepped beams using direct stiffness method with concentrated and uniformly distributed load.

**Torsion of Shafts:** Finite element formulation of shafts, determination of stress and twists in circular shafts.                                   **08 Hours**

**Module IV**
**Heat Transfer:** Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, energy generated in solid, energy stored insolid, 1D finite element formulation using vibrational method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins.

**Fluid Flow:** Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic net works. **10 Hours**

**Module V**
**Axi-symmetric Solid Elements:** Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to surface forces, point loads, angular velocity, pressure vessels.

**Dynamic Considerations:** Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element, quadrilateral element, beam element. Lumped mass matrix of bar element, truss element, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

**Course outcomes:**

Upon successful completion of this course you should be able to:
1.Understand the concepts behind formulation methods in FEM.

2.Identify the application and characteristics of FEA elements such as bars, beams, plane and iso-parametric elements.

3.Develop element characteristic equation and generation of global equation.

4.Able to apply suitable boundary conditions to a global equation for bars, trusses, beams, circular shafts, heat transfer, fluid flow, axi symmetric and dynamic problems and solve them displacements, stress and  strains induced. **12Hours**

**Text Books:**
1. Logan, D. L., A first course in the finite element method,6th Edition, Cengage  Learning, 2016.
 2. Rao, S. S., Finite element method in engineering, 5th Edition, Pergaman Int. Library of Science, 2010.
3. Chandrupatla T. R., Finite Elements in engineering, 2nd Edition, PHI, 2013.

**Reference Books:**
   1. J.N.Reddy, "Finite Element Method"- McGraw -Hill International Edition.Bathe K. J. Finite Elements Procedures, PHI.
   2. Cook R. D., et al. "Conceptsand Application of Finite Elements Analysis"- 4th Edition, Wiley & Sons, 2003.