Finite Element Analysis - Video course

COURSE OUTLINE

Finite Element Method (FEM) is a numerical technique for solving differential equations that describe many engineering problems. Main reason for its popularity is that the method results in computer codes which are versatile in nature that can solve many practical problems with minimum training. Obviously, there is danger in using commercially available computer software without proper understanding of the theory behind them, and that is one of the reasons to have a through understanding of the theory behind FEM.

This video course on finite element analysis covers the fundamental concepts and is designed for a first course on finite elements suitable for upper division undergraduate students and beginning graduate students in civil, mechanical, aerospace, biomedical and industrial engineering, and engineering mechanics; researchers and design engineers in the above fields. The course presents the FEM as a tool to find approximate solution of differential equations and thus can be used by students from a variety of disciplines. Applications include analysis of structural frameworks, stress analysis, heat flow, and fluid flow.

Contents:

1. Approximate solution of boundary value problems-Methods of weighted residuals, Approximate solution using variational method, Modified Galerkin method, Boundary conditions and general comments, Two dimensional example
2. Basic finite element concepts-Basic ideas in a finite element solution, General finite element solution procedure, Finite element equations using modified Galerkin method, Application: Axial deformation of bars, Axial spring element
3. Analysis of trusses-Two dimensional truss element, Three dimensional space truss element, Stresses due to lack of fit and temperature changes
4. Beam bending-Governing differential equation for beam bending, Two node beam element, Exact solution for uniform beams subjected to distributed loads using superposition, Calculation of stresses in beams, Thermal stresses in beams
5. Analysis of structural frames-Plane frame element, Thermal stresses in frames, Three dimensional space frame element
6. General one dimensional boundary value problem and its applications-One dimensional heat flow, Fluid flow between flat plates-Lubrication Problem, Column buckling
7. Higher order elements for one dimensional problems-Shape functions for second order problems, Isoparametric mapping concept, Quadratic isoparametric element for general one dimensional boundary value problem, One dimensional numerical integration, Application: Heat conduction through a thin film
8. Two dimensional boundary value problems using triangular elements, Equivalent functional for general 2D BVP, A triangular element for general 2D BVP, Numerical examples
9. Isoparametric quadrilateral elements-Shape functions for rectangular elements, Isoparametric mapping for quadrilateral elements, Numerical integration for quadrilateral elements, Four node quadrilateral element for 2D BVP, Eight node serendipity element for 2D BVP
10. Isoparametric triangular elements-Natural (or Area) coordinates for triangles, Shape functions for triangular elements, Natural coordinate mapping for triangles, Numerical integration for triangles, Six node triangular element for general 2D BVP
11. Numerical integration-Newton-Cotes rules, Trapezium rule, Simpson's rule, Error term, Gauss-Legendre rules, Changing limits of integration, Gauss-Leguerre rule, Multiple integrals, Numerical integration for quadrilateral elements, Numerical integration for triangular elements
12. Applications based on general two dimensional boundary value problem-Ideal fluid flow around an irregular object, Two dimensional steady state heat flow, Torsion of prismatic bars
13. Two dimensional elasticity-Governing differential equations, Constant strain

NP-TEL

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Civil Engineering

Pre-requisites:

1. Engineering Mathematics.

Additional Reading:

1. Chandrupatla T. R., and Belegundu, A. D., Introduction to Finite Elements in Engineering, Prentice Hall, 2003.
2. Buchanan, G. R., Schaum's Outline of Finite Element Analysis, McGraw-Hill, 1994.
3. Bathe, K-J., Finite Element Procedures, Prentice Hall, 1996.
4. Zienkiewicz, O.C. and Taylor, R.L., The Finite Element Method, 6th Ed., Vol. 1, Elsevier, 2005.
5. Zienkieewicz, O.C. and Taylor, R.L., The Finite Element Method, 6th Ed., Vol. 2, Elsevier, 2005.
6. Zienkiewicz, O. C., Taylor, R. L., Zhu, J. Z., The Finite Element Method: Its

triangular element, Four node quadrilateral element, Eight node isoparametric element

14. Axisymmetric elasticity problems-Governing equations for axisymmetric elasticity, Axisymmetric linear triangular element, Axisymmetric four node isoparametric element
15. Three dimensional elasticity-Governing differential equations, Four node tetrahedral element, Eight node hexahedral (brick) element, Twenty node isoparametric solid element, Prestressing, initial strains and thermal effects

COURSE DETAIL

Sl. No	Topic	No. of Hours
1	Approximate solution of boundary value problems-Methods of weighted residuals, Approximate solution using variational method, Modified Galerkin method, Boundary conditions and general comments	04
2	Basic finite element concepts-Basic ideas in a finite element solution, General finite element solution procedure, Finite element equations using modified Galerkin method, Application: Axial deformation of bars, Axial spring element	02
3	Analysis of trusses-Two dimensional truss element, Three dimensional space truss element, Stresses due to lack of fit and temperature changes	02
4	Beam bending-Governing differential equation for beam bending, Two node beam element, Exact solution for uniform beams subjected to distributed loads using superposition, Calculation of stresses in beams, Thermal stresses in beams	04
5	Analysis of structural frames-Plane frame element, Thermal stresses in frames, Three dimensional space frame element	03
6	General one dimensional boundary value problem and its applications-One dimensional heat flow, Fluid flow between flat plates-Lubrication Problem, Column buckling	02
7	Higher order elements for one dimensional problems-Shape functions for second order problems, Isoparametric mapping concept, Quadratic isoparametric element for general one dimensional boundary value problem, One dimensional numerical integration, Application: Heat conduction through a thin film	03
8	Two dimensional boundary value problems using triangular elements, Equivalent functional for general 2D BVP, A triangular element for general 2D BVP, Numerical examples	03
9	Isoparametric quadrilateral elements-Shape functions for rectangular elements, Isoparametric mapping for quadrilateral elements, Numerical integration for quadrilateral elements, Four node quadrilateral element for 2D BVP, Eight node serendipity element for 2D BVP	04

Basis and Fundamentals, Elsevier, 2005.

7. Cook, R. D., Malkus, D. S., Plesha, M. E., and Witt, R.J., Concepts and Applications of Finite Element Analysis, 4th Edition, Wiley-India, 2007.
8. Hughes, T. J. R., The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publications, 2000.
9. Huebner, K. H., Dewhirst, D. L., Smith, D. E., Byrom, T. G., The Finite Element Method for Engineers, 4th Ed., Wiley-Interscience, 2001.

Coordinators:

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10	Isoparametric triangular elements-Natural (or Area) coordinates for triangles, Shape functions for triangular elements, Natural coordinate mapping for triangles, Numerical integration for triangles, Six node triangular element for general 2D BVP	02
11	Numerical integration-Newton-Cotes rules, Trapezium rule, Simpson's rule, Error term, Gauss-Legendre rules, Changing limits of integration, Gauss-Leguerre rule, Multiple integrals, Numerical integration for quadrilateral elements, Numerical integration for triangular elements	02
12	Applications based on general two dimensional boundary value problem-Ideal fluid flow around an irregular object, Two dimensional steady state heat flow, Torsion of prismatic bars	02
13	Two dimensional elasticity-Governing differential equations, Constant strain triangular element, Four node quadrilateral element, Eight node isoparametric element	03
14	Axisymmetric elasticity problems-Governing equations for axisymmetric elasticity, Axisymmetric linear triangular element, Axisymmetric four node isoparametric element	02
15	Three dimensional elasticity-Governing differential equations, Four node tetrahedral element, Eight node hexahedral (brick) element, Twenty node isoparametric solid element, Prestressing, initial strains and thermal effects	02

References:

1. Bhatti, M.A., Fundamental Finite Element Analysis and Applications: with Mathematica and Matlab Computations, Wiley, 2005.
2. Reddy, J. N., An Introduction to the Finite Element Method, 3rd Edition, McGraw-Hill Science/Engineering/Math, 2005.
3. Logan D. L., A First Course in the Finite Element Method, Thomson- Engineering, 3rd edition, 2001.