GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3730907
ADVANCED FINITE ELEMENT METHODS
SEMESTER: III

Type of course: Program Elective

Prerequisite: Zeal to learn the Subject

Rationale: This course focuses on the fundamentals concepts and formulation of the finite element methods for solving differential equations arising in solid mechanics.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Review of linear FEA:** FE formulation of 1D bar, 3D linear elastic continuum, 2D plane strain, plane stress, and axisymmetric elements; Iso-parametric mapping; numerical integration.	**04**
2	**FE formulation for 1D plasticity:** Elastic-perfectly plastic material; Isotropic and kinematic hardening; Integration algorithms for 1D plasticity; FE formulation; Newton-Raphson method for solving nonlinear equilibrium equations;1D visco-plasticity and integration algorithm.	**07**
3	**Continuum theories of plasticity:** Review of tensor algebra; Yield condition, flow rule and hardening rules; loading and unloading conditions; Drucker's stability postulates; Convexity and normality; J2 flow theory of plasticity and visco-plasticity, Gurson model.	**08**
4	**FE procedures for 2D and 3D plasticity:** Integration algorithms for rate independent plasticity—explicit forward Euler and implicit backward Euler; Return mapping algorithm; visco-plasticity; FE formulation; Consistent linearization; Algorithmic and consistent tangent modulii; Treatment of incompressible deformation (Locking); B-bar method.	**08**
5	**FE procedures for large deformation problems:** Continuum mechanics—deformation gradient, polar decomposition, Green-Lagrange strain, rate of deformation, Cauchy stress, P-K stresses, Balance laws; Principle of objectivity and isotropy; Constitutive equations for hyperelasticity; Neo-Hookean model; FE formulation—Total Lagrangian and updated Lagrangian descriptions; Tangent Stiffness Matrix. Introduction to finite strain plasticity.	**10**
6	**Contact Problems:** Condition of impenetrability; Gap elements for modelling contact; Tangent stiffness matrix and force vectors for 2D frictionless contact problems.	**06**

Reference Books:

1. K. J. Bathe, Finite Element Procedures, Prentice-Hall of India Private Limited, New Delhi.
2. J. C. Simo and T. J. R. Hughes, Computational Inelasticity, Springer-Verlag New York. Inc.,New York.
3. OC Zienkiewicz and RL Taylor, The finite element method, Volume 1 & 2, 5th edition, Butterworth Heinemann, New Delhi
4. T. Belytschko and W. K. Liu and B. Moran, Nonlinear Finite Elements for Continua and Structures, John Wiley & Sons Ltd., England.
5. D. R. J. Owen and E. Hinton, Finite Elements in Plasticity: Theory and Practice, Pineridge Press Ltd.

Course Outcome:

After learning the course :

Sr. No.	**Course Outcome**	**Percentage weightage**
CO-1	Students will be able to demonstrate understanding of FE formulation for linear problems in solid mechanics.	20%
CO-2	Students will be able to understand behaviour of elastic-plastic materials and visco-plasticity, use of Newton- Raphson method for solving nonlinear equations of equilibrium.	20%
CO-3	Students will be able to understand flow rules and strain hardening, loading and unloading conditions, Drucker's stability postulates, J2 flow of theory of plasticity.	20%
CO-4	Demonstrate use of FE formulation to solve the problems of large deformation of structures under loads.	30%
CO-5	Able to solve contact problems using the techniques of non-linear FEM.	10%

List of Open Source Software/learning website:

https://nptel.ac.in/courses/112106130/