Department of Civil Engineering

Course Name:

Finite Elements Method II

Course Number: 20-147	**Credit:** 3
Program: Graduate	**Course Type:** Technical Selective
Prerequisite: Finite Elements Method	**Corequisite:** -

Course Description (Objectives):

This course focuses on the extension of finite elements, discussing topics such as large deformations, plastic behavior, and contact problems, among other subjects.

Course Content (outline):

- Chapter 1: Principle of virtual work, principle of minimum potential energy, Galerkin weighting.
- Chapter 2: Rayleigh-Ritz method for solid mechanics problems, shape functions.
- Chapter 3: Isoparametric elements, numerical integration.
- Chapter 4: FE formulation based on displacements for large deformations.
- Chapter 5: Total and updated Lagrangian formulations, strain-displacement relations in large deformations.
- Chapter 6: FE discretization in large deformations, nonlinear iterative strategies for solving nonlinear equilibrium equations.
- Chapter 7: Newton-Raphson approaches, modified Newton, quasi-Newton (Davidon and BFGS).
- Chapter 8: Classical plasticity theory, Elasto-plastic constitutive matrix.
- Chapter 9: Generalized plasticity theory, single-surface and multi-surface plasticity models.
- Chapter 10: Numerical computation of material property matrices, elastic predictor-plastic corrector algorithm, integration of constitutive relation.
- Chapter 11: Physical aspects of friction, frictional plasticity theory, friction modeling.
- Chapter 12: Stress-strain relationships, continuum model for friction techniques, penalty and Lagrangian methods.
- Chapter 13: Interface element formulation

- Chapter 14: Dynamic equilibrium equations, time domain discretization, explicit and implicit time integration.
- Chapter 15: Single-step method, generalized Newmark approach.
- Chapter 16: Error estimation; a priori and a posteriori estimates; 2L projection and SPR techniques, error norms (2L and energy norms).
- Chapter 17: Adaptive mesh refinement, h-, p-, and hp-refinements, adaptive mesh generators.
- Chapter 18: Mapping of variables; error estimation and adaptive time stepping.
- Chapter 19: Causes of localization in solid mechanics, governing equations for incompressible plasticity.
- Chapter 20: Cosserat continuum theory, adaptive strategy for discontinuous displacements, error indicators.
- Chapter 21: Adaptive mesh refinement, element elongation.

References:

- EA de Souza Neto, D Peric, D.J Owen, Computational Methods for Plasticity: Theory and Applications, Wily, UK, 2008.
- A.R. Khoei, Computational Plasticity in Powder Forming Process, Elsevier, UK, 2005.
- OC Zienkiewicz, RL Taylor, The Finite Element Method, McGraw-Hill, London, Vol 2,2000.
- DRJ Owen, E. Hinton, Finite Elements in Plasticity: Theory and Practice, Pineridge Press,1980.