College of Engineering

Department of Civil Engineering

CE 588 Numerical Methods in Geotechnical Engineering

Credit and Contact hours	3/ 3 (Lectures), 0 (Tutorials), 0 (Laboratory)
Required, or Elective	Required for a MSCE degree
Course Description	Numerical versus analytical solution. Approximation and solution of governing differential equations. Basic principles of finite elements, finite difference, and boundary elements methods. Numerical solutions of typical geotechnical engineering problems.
Prerequisites or Co-requisites	None
Course Learning Outcomes	Students completing this course successfully will be able to

Course Learning Outcomes	*Related Program Outcomes*
CLO1: Recognize the procedures in which a complex problem of large extent is divided, or discretized, into smaller equivalent units, or components,	**K1**
CLO2: Apply the procedures of discretization into smaller equivalent units, or components to solve complex problems	**S1**
CLO3: formulate geotechnical problems as a well posed boundary value problems (boundary and initial conditions, free-surface problems)	**S1**
CLO4: Use in-house and commercial finite difference and finite element codes in solving complex geotechnical problems and interpret results.	**S1**
CLO5: Apply fundamentals of soil mechanics and numerical methods to solve geotechnical problems and understand the limitations	**S1**
CLO6: Verify numerical solutions through comparisons to analytical or graphical solutions.	**C2**

Student Outcomes related to this Course	**K1**. Recognize advanced engineering knowledge, concepts and techniques to identify, interpret and analyze complex and real-life engineering problems. **S1.** Provide solution for complex and real-life engineering problems through critical thinking and using modern engineering tools and identify its impact on social and ethical issues. **C2**. Design novel advanced Civil Engineering systems and evaluate its performance and effectiveness for engineering practice and its impact on society.

Topics Covered	<table><tr><th>List of Topics</th><th>Related CLOs</th></tr><tr><td>1. Introduction</td><td>CLO1</td></tr><tr><td>2. Analytical versus numerical solutions</td><td>CLO1</td></tr><tr><td>3. Historical background</td><td>CLO1</td></tr><tr><td>4. Overview of analytical solutions for typical problems in geotechnical engineering.</td><td>CLO3</td></tr><tr><td>5. Overview of numerical methods and identification of methods commonly applied in geotechnical engineering.</td><td>CLO2</td></tr><tr><td>6. Basic idea of : initial, boundary, and Eigenvalue problems; Dirichlet versus Newmann boundary conditions, primary versus secondary variables</td><td>CLO3</td></tr><tr><td>7. Principle of the finite difference method, the basic idea and basic features</td><td>CLO1</td></tr><tr><td>8. Finite difference solution of elliptic differential equations - application two-dimensional seepage problem.</td><td>CLO3</td></tr><tr><td>9. Finite difference solution of parabolic differential equations - application to Terzaghi's one-dimensional consolidation</td><td>CLO4</td></tr><tr><td>10. Basic principles and concept of finite element method.</td><td>CLO2</td></tr><tr><td>11. Discretization and displacement approximation</td><td>CLO1</td></tr><tr><td>12. Elements and global equations</td><td>CLO2</td></tr><tr><td>13. Shape functions for one and two dimensional elements, isoparametric elements (Triangle, quadrilateral)</td><td>CLO5</td></tr><tr><td>14. Assembly, integration and implementation.</td><td>CLO3</td></tr><tr><td>15. Two-dimensional plane strain and axisymmetric idealization.</td><td>CLO5</td></tr><tr><td>16. Drained, undrained and coupled analysis, modeling of construction and excavation</td><td>CLO6</td></tr><tr><td>17. Overview of boundary element method, formulation, BEM for plane elasticity</td><td>CLO3</td></tr></table>
Textbook(s) and Other Required Material	• Chapra, S. C. and Canale, R.P. (2010)."Numerical Methods for Engineers" McGraw-Hill, New York, 6th Edition. • David M Potts and Lidija Zdravkovic. (1999). "Finite Element Analysis in Geotechnical Engineering – Theory", Thomas Telford Publishing Ltd., U.K. • David M Potts and Lidija Zdravkovic. (1999). "Finite Element Analysis in Geotechnical Engineering – Application", Thomas Telford Publishing Ltd., U.K.
Grading System	Assignments 15%, Term Project 15%, Midterm Exam 30%, Final Exam 40%
Instructors	Prof. Mosleh A. Al-Shamrani (2A54), email; shamrani@ksu.edu.sa
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