C&EE 103 Applied Numerical Computing and Modeling in Civil and Environmental Engineering

Description	This course offers an introduction to numerical computing and modeling in civil and environmental engineering. Its objective is to build on a background in calculus, linear algebra, and differential equations as well as a working knowledge in basic computing and programming to solve relevant problems in civil and environmental engineering.
Instructor	Marcus Rüter, ✉ marcus.ruter@ucla.edu
TA	TBD
Lectures	MW, 12:00 am (video upload time)
Online Sessions	TBD
Online Discussions	TBD
Prerequisites	C&EE M20 (or COM SCI 31) and MATH 33B (or MECH&AE 82)
Grading	Homework: 55% Quizzes: 10% Final Project: 35% Evaluation: 2% (bonus)
Textbook	K.E. Atkinson and W. Han. *Elementary Numerical Analysis*, third edition, John Wiley & Sons, Chichester, 2004
Course Logistics	The class is designed to cover basic theories and demonstrations of concepts during lectures with practice problems. The tentative list of topics to be covered is listed in the course outline and follows Chapters 1 – 9 of the textbook. Before each online session, it is your responsibility to watch the corresponding video lecture and to read the associated sections of the book. The programming tool for this class is Matlab. Hence, during the online sessions, each student should have access to Matlab. A Matlab refresher video lecture will be provided (the textbook also contains a Matlab review in Appendix D). All course materials (lecture videos, recorded online (discussion) sessions, handouts, homework assignments, homework solutions, etc.) will be provided on CCLE.
Final Project	The final project is due by the end of the class, and its topic will be announced in Week 7. The project requires to solve a well-defined problem in engineering using various tools learned in this class. More precisely, it is based on writing computer code and a technical report. The grading is based on accuracy, organization, and efficiency of the code, as well as on clarity and quality of the technical report.
Homeworks	There will be one homework assignment each week following a Monday-Monday schedule. These assignments are designed to cement your basic understanding of the principles covered in class and provide practical experience in solving problems.

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Course Outline

Week	Topic
1	Syllabus, introduction, and motivation; Matlab review; Taylor polynomials (Sections 1.1 – 1.3) Error and computer arithmetic: Floating point numbers, sources of error, error propagation (Sections 2.1 – 2.3)
2	Rootfinding: The bisection method, Newton's method, secant method (Sections 3.1 – 3.3)
3	Interpolation and approximation: Polynomial interpolation, Lagrange basis functions, divided differences, errors in polynomial interpolation, cubic splines (Sections 4.1 – 4.3)
4	Numerical integration and differentiation: Trapezoidal and Simpson's rules, error analysis, Gauss quadrature, differentiation using interpolation (Sections 5.1 – 5.4)
5	Solution of systems of linear equations: Matrix arithmetic, Gaussian elimination, LU-factorization, errors in solving linear systems, iterative methods (Sections 6.1 – 6.6)
6	Advanced numerical linear algebra: The least-squares (LS) method, nonlinear systems (Sections 7.1 and 7.3) Ordinary differential equations (ODEs): Introduction, Euler's method (Sections 8.1 and 8.2)
7	Ordinary differential equations (ODEs): Convergence analysis of Euler's method, numerical stability, implicit methods, Runge-Kutta and multi-step methods, systems of differential equations, two-point boundary value problems (Sections 8.3 – 8.8)
8	Finite difference methods for partial differential equations (PDEs): Poisson's equation, one-dimensional heat and wave equations (Sections 9.1 – 9.3)