Course Details

Course Rationale	Most problems in engineering lend themselves to a rational mathematical formulation. Many in fact find this one of the appeals of engineering. For simple problems, these mathematical formulations can be solved on a scientific calculator or spreadsheet. However, these computational tools quickly become inadequate for solving more realistic versions of the problems. Learning how to solve these and other similarly complex computation problems in civil engineering is the main objective of this course. Solution approaches are evaluated in terms of accuracy, robustness, and efficiency. Implementation of the solution approaches is explored via hand calculations, Excel spreadsheets, and Matlab© programs.
Course Description	Exploration of algorithms for solving problems in several important areas of numerical computing: roots of equations; matrix algebra and the systems of linear equations; function approximation, numerical differentiation and integration; and ordinary differential equations. Issues of solution accuracy, robustness, and efficiency are also considered. Numerical techniques are presented in the context of engineering applications, and example problems are solved using a variety of computer-based tools (primarily MATLAB).
Prerequisites	ENES220 and MATH241; and permission of ENGR-Civil and Environmental Engineering department.
Course Schedule	Monday, Wednesday, and Friday 2:00-2:50 PM 2154 Glenn L. Martin Hall
Instructor	Professor Barton Forman 1159 Glenn L. Martin Hall Office Hours: Tuesday and Thursday 3:30 – 4:30 PM (or by appt.) Email: `baforman@umd.edu` ELMS: `https://umd.instructure.com/`
Teaching Assistant:	Jongmin Park Office Location: 0147M Engineering Laboratory Bldg. Office Hours: Tuesday and Thursday 11:30 AM – 12:30 PM (or by appt.) Email: `jmpark1@umd.edu`
Required Reference	S. C. Chapra, *Applied Numerical Methods with Matlab©* (4^{th} Edition)
Additional Recommended References	T. S. Siauw and A. M. Bayen, *An Introduction to Matlab© Programming and Numerical Methods for Engineers and Scientists* (1^{st} Edition) A. Gilat and V. Subramaniam, *Numerical Methods for Engineers and Scientists* (3^{rd} Edition) R. Pratap, *Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers* (7^{th} Edition)

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Grading Basis	Quizzes: 7% Homework: 8% Programming: 15% Exams: 70% **Homework is due by the time listed on the on-line platform.***
Honor Pledge	The university has a nationally recognized Honor Pledge, administered by the Student Honor Council. The Student Honor Council proposed and the university Senate approved an Honor Pledge. The University of Maryland Honor Pledge reads: *"I pledge on my honor that I have not given or received any unauthorized assistance on this assignment/examination."* This pledge was designed to promote academic integrity by the student body and emphasize the importance of the university academic policies. Additional course-related policies established by the University can be found at `http://www.ugst.umd.edu/courserelatedpolicies.html`.
Class Logistics	The tentative class schedule, including topics to be covered, is shown below. The course is organized into three parts: 1) lecture-based survey of the fundamentals of numerical methods, 2) application of numerical methods during regular homework assignments using Matlab© or other relevant software, and 3) independent examinations.

Tentative Course Schedule (subject to change):

#	Lecture Date	Topics Covered
1	Wednesday, January 24	Discussion of course syllabus; introduction to numerical methods; [Read Chapter 1];
2	Friday, January 26	Basics of Matlab© programming; Matlab© environment; Assignments; Mathematical Operators; Built-in Functions; Graphics; [Read Chapter 2];
3	Monday, January 29	M-Files; Input-Output; Structured Programming; [Read Chapter 3];
4	Wednesday, January 31	Structured Programming (continued); Nesting and Indentation; Passing Functions;
5	Friday, February 2	Accuracy vs. Precision; Concept of Error; Roundoff Errors; [Read Chapter 4];
6	Monday, February 5	Truncation Errors; Total Numerical Error;
7	Wednesday, February 7	Introduction to Roots; Bracket Methods and Incremental Search; [Read Chapter 5];
8	Friday, February 9	Bracket Methods and Incremental Search (continued); Roots via Open Methods; [Read Chapter 6];

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*unless due to extenuating circumstances

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#	Lecture Date	Topics Covered
9	Monday, February 12	Roots via Open Methods (continued);
10	Wednesday, February 14	Unidimensional Optimization; [Read Chapter 7];
11	Friday, February 16	Multidimensional Optimization;[†] Linear Algebraic Equations and Matrices; Matrix Algebra Overview; [Read Chapter 8];
12	Monday, February 19	Matrix Algebra Overview (continued); Solving Small Numbers of Equations; [Read Chapter 9];
13	Wednesday, February 21	Solving Small Numbers of Equations (continued);
14	Friday, February 23	Operation Counting; Partial and Complete Pivoting;
15	Monday, February 26	Tridiagonal Systems; LU Factorization; [Read Chapter 10];
16	Wednesday, February 28	LU Factorization with Pivoting; Cholesky Decomposition;
–	Friday, March 2	**Exam #1**
17	Monday, March 5	Matrix Inversion; Error Analysis and System Condition; Vector and Matrix Norms; Matrix Condition Number; [Read Chapter 11];
18	Wednesday, March 7	Linear Systems and Gauss-Seidel; [Read Chapter 12];
19	Friday, March 9	Nonlinear Systems; Newton-Raphson Method;
20	Monday, March 12	Newton-Raphson (continued); Curve Fitting; Statistics Review; [Read Chapter 14];
21	Wednesday, March 14	Statistics Review (continued); Random Numbers and Simulation; Linear Regression;
22	Friday, March 16	Linear Least-Squares Regression (continued); Linearization and Nonlinear Relationships;
–	Monday, March 19	*No Lecture (Spring Break)*
–	Wednesday, March 21	*No Lecture (Spring Break)*
–	Friday, March 23	*No Lecture (Spring Break)*
23	Monday, March 26	Linear Regression in Matlab; Polynomial Regression; [Read Cha. 15];
24	Wednesday, March 28	Multiple Linear Regression; General Least Squares;
25	Friday, March 30	Nonlinear Regression; Introduction to Interpolation; Newton Interpolating Polynomial; [Read Cha. 17];
26	Monday, April 2	General Form of Newton's Interpolating Polynomials; Lagrange Interpolating Polynomial; Extrapolation and Oscillations;
27	Wednesday, April 4	Introduction to Splines; [Read Cha. 18];

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[†]End of Exam #1 material (through Chapter 7)

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#	Lecture Date	Topics Covered
28	Friday, April 6	Piecewise Interpolation in Matlab; Multidimensional Interpolation‡; Numerical Integration; Newton-Cotes Formulas; [Read Chapter 19];
29	Monday, April 9	Trapezoidal Rule; Simpson's Rule;
30	Wednesday, April 11	Integration with Unequal Spacing; Open Methods; Multiple Integrals; Numerical Integration of Functions; [Read Cha. 20];
–	Friday, April 13	**Exam #2 (through Chapter 18)**
31	Monday, April 16	Gauss Quadrature;
32	Wednesday, April 18	Gauss Quadrature (continued); Adaptive Quadrature;
33	Friday, April 20	Numerical Differentiation; High-Accuracy Differentiation Formulas; [Read Cha. 21];
34	Monday, April 23	Richardson Extrapolation; Derivatives of Unequally Spaced Data; Derivatives and Integrals from Erroneous Data;
35	Wednesday, April 25	Partial Derivatives; Numerical Differentiation with Matlab;
36	Friday, April 27	Euler's Method; Improvements to Euler's Method; [Read Cha. 22];
37	Monday, April 30	Runge-Kutta Methods; Systems of Equations;
38	Wednesday, May 2	Adaptive RK Methods; Multistep Methods; [Read Cha. 23];
39	Friday, May 4	System Stiffness; Boundary Value Problems; Shooting Method; [Read Cha. 24];
40	Monday, May 7	Derivative Boundary Conditions; Shooting Method for Nonlinear ODEs; Finite Difference Methods;
41	Wednesday, May 9	Course review and summary;
–	Wednesday, May 16	**Final Examination (1:30 PM – 3:30 PM)**

Homework Assignments

Weekly problem sets will be assigned in accordance with the schedule below. Homework assignments will include both theoretical and applied settings. These assignments are designed to reinforce your basic understanding of the theory covered in the lectures. Due to limited lecture time, some concepts and applications may be introduced in the homework assignments. It is your responsibility to know the material covered not only in lectures, but in all assignments. Several of these assignments will contain problems involving numerical computing using Matlab© or a suitable equivalent. Matlab© access is provided through the Virtual Computing Lab (`http://www.eit.umd.edu/vcl`) and is available for remote use. Additionally, Matlab© is found on the workstations housed in the CEE Design Laboratory located in 1156 Martin Hall or via individual download on TERPware.

‡End of Exam #2 material (through Chapter 18)

Homework Assignment Schedule

#	Subject Matter	Homework Due Date	Programming Due Date
1	Introductory material; basics of programming;	January 31	February 2
2	Loops and branches;	February 7	February 9
3	Modeling, computers, and error analysis;	February 14	February 16
4	Roots	February 21	February 23
5	Optimization;	February 28	March 2
6	Linear algebraic equations;	March 7	March 9
7	Matrix inverse;	March 14	March 16
8	Iterative methods;	March 28	March 30
9	Curve fitting;	April 4	April 6
10	Splines;	April 11	April 13
11	Numerical integration;	April 18	April 20
12	Gauss quadrature;	April 25	April 27
13	Numerical differentiation; initial value problems;	May 2	May 4
14	Adaptive methods; boundary value problems;	May 9	May 9

Instructions for Completing Assignments:

When doing the assigned homework problems, the following guidelines must be followed in order to receive full credit:

1. Put your name in the upper right corner of the paper.
2. Put the problem number in the upper left corner of the paper.
3. Staple all sheets together.
4. Show all calculations to a minimum of three significant digits.
5. Clearly underline or box all of your answers.
6. Write all assumptions at the beginning of the problem and include diagrams where necessary.
7. Show all of your work in an orderly fashion and do not skip steps ... the homework grade is not solely based on the final answer.
8. If you work with someone on the homework, indicate the person's name in the upper left corner of the paper below the problem number.
9. Do not copy someone else's work ... this is plagiarism.