Introduction to Numerical Methods of Engineering Analysis

EGM 3344 Sections 293Q, 395R, 499S
Class Periods: MWF 5, 8, 9 (11:45am-12:35pm, 3:00pm-3:50pm, 4:05pm-4:55pm)
Location: TUR 2328, MCCB G086, CSE E121
Academic Term: Fall 2024

Instructor:
Jonathan Brooks
brooks666@ufl.edu
(352) 294-0472
Office Hours: TBD

Student Assistants:
TBD

Course Description
Methods for numerical solution of mathematical problems, with emphasis on engineering applications and computer implementation in MATLAB. Modeling, computers, and error analysis. Roots and optimization. Linear algebraic equations and matrices. Curve fitting. Numerical differentiation and integration. Ordinary differential equations. Credits: 3

Course Pre-Requisites / Co-Requisites

Pre-requisites:	MAC 2313	Analytic Geometry and Calculus 3
	COP 2271 or equivalent	Computer Programming for Engineers MATLAB
Co-requisites:	MAP 2302	Elementary Differential Equations

Course Objectives
The goal of EGM 3344 is to teach you how to apply computational methodologies to solve engineering problems when no closed-form, analytical solution exists. Achievement of this goal requires learning the basics of structured programming as well as learning how to combine engineering knowledge, judgment, and intuition to develop reasonable approximations through the engineering modeling process. Because mathematical judgment and approximations are involved, the material in this course will be somewhat more open-ended than the material covered in other courses. Emphasis will be placed on understanding the concepts behind the various numerical methods studied, implementing basic numerical methods using the MATLAB structured programming environment, and utilizing more sophisticated numerical methods provided as built-in MATLAB functions. This approach is taken since understanding how numerical methods work is essential for choosing the correct method and understanding its limitations. At the same time, the existence of commercial numerical libraries makes it inefficient and unnecessary for students to re-develop complex existing numerical routines.

By the end of this course, you should be able to:

- *Numerical methods:* Understand the most common numerical methods used in engineering analysis, when to use each method, and how to implement basic methods in a structured manner using MATLAB's programming language.
- *Numerical accuracy:* Estimate the amount of error inherent in different numerical methods.
- *Numerical efficiency:* Assess the efficiency of a selected numerical method when more than one option is available to solve a certain class of problem.
- *Numerical stability:* Understand the convergence properties and limitations of different numerical methods.

Materials and Supply Fees
None

Relation to Program Outcomes (ABET):

This course prepares graduates to have a knowledge of a range of numerical methods for solving a variety of engineering problems as well as the critical thinking required for problem solving in life and engineering.

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	
3. An ability to communicate effectively with a range of audiences	Low
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	High

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

Required Textbooks and Software

- Software: MATLAB Student Version (**any recent version** should be fine)
- You may consider using UFApps (not recommended) to access a number of popular software applications for "free" including MATLAB at: http://info.apps.ufl.edu/
- MATLAB is also available for purchase and download at https://www.mathworks.com/products/matlab/student.html
- I recommend against using UFApps and instead purchasing a MATLAB student license because it eliminates friction caused by using UFApps (downloading data files, saving .m files, poor Internet connection, etc.). Furthermore, I highly recommend purchasing the $100 version that comes with Simulink and various toolboxes. While we may not use these in this course explicitly, it is very possible you will need those toolboxes and/or Simulink in future courses (e.g., EML 4312).

Recommended Materials

- Title: *Applied Numerical Methods with MATLAB for Engineers and Scientists*
- Author: Steven C. Chapra
- Publication date and edition: 2017, 4th Edition (McGraw Hill)
- ISBN number: 978-0-07-339796-2
- ***Any recent version*** will suffice for content. However, occasional homework problems may be assigned from the book, and problem numbers sometimes change from one edition to another.

Recommended Reading

We will largely follow the layout of the Chapra book. It is extremely useful. I suggest you read the relevant chapters, especially if you are having issues with the homework.

Tentative Course Schedule

Week	Topics	Book Chapters	Estimated Assignments
1	Mathematical modeling; MATLAB basics	1, 2, 3	
2	Euler's method; floating-point representation; round-off error	1, 4	HW1
3	Taylor series; truncation error; finite-difference approximations	4	HW2
4	Root-finding: bisection, false-position, Newton-Raphson, secant methods	5, 6	HW3
5	Gradient descent method; Newton's method of optimization	**Not in book**	
6	Linear algebra basics; Cramer's rule; Gauss elimination	8, 9	Exam 1, HW4
7	LU factorization; matrix inverse; norms	10, 11	
8	Condition number; Jacobi method; Gauss-Seidel method; generalized Newton-Raphson method	11, 12	HW5
9	Eigenvalues and eigenvectors; linear regression using linear least squares	13, 14	HW6
10	Polynomial regression; multiple linear regression; general linear least squares; nonlinear least squares	14, 15	Exam 2
11	Fourier analysis: Fourier series, frequency-domain representation of functions	16	HW7
12	Fourier analysis: Fourier transform, discrete Fourier transform	16	
13	Interpolation: Newton and Lagrange polynomials, splines	17, 18	HW8
14	Numerical integration: Newton-Cotes formulas, Romberg integration	19, 20	
15	Gauss-Legendre formulas; numerical differentiation; Runge-Kutta methods	20, 21, 22	HW9

Tentatively Online Lecture (In-Person Class Likely Cancelled):
Friday, September 20th
Friday, October 11th

Attendance Policy, Class Expectations, and Make-Up Policy

Attendance

- Regular class attendance is expected although not explicitly included in the grade evaluation.
- The course will be delivered in a hybrid format. A Zoom conference will be created for each lecture for students to attend remotely if they do not wish to come to the classroom.

Homework

- HW will be posted on Canvas along with its due date.
- HW will be turned in on Canvas.
- Some or all assigned problems will be graded for each assignment. You are required to complete all assigned problems.
- Late HW will be accepted up to 24 hours after the due date with a maximum-grade penalty of 20 points. That is, your grade will be rounded down to an 80. If this sounds severe, turn in your homework on time. If you have an absolute doomsday of a week, this is your safety valve. Hardship cases will be considered on an individual basis and only if the instructor has been contacted before the due date of the assignment. Students with hardship cases (e.g., due to medical problems) will be referred to the Dean of Students office, which will perform a background investigation to determine if the hardship is legitimate.

- If you do not agree with the grading of a HW problem, you will have one week from the date the HW is returned to submit a written argument of why you think the grade should be higher. However, the final decision will remain the instructor's.

Exams

- Exams will be closed-book and closed notes. The instructor will announce, in class, any allowed formula sheets or resources at least one week before the exam.
- No cell phones or calculators (or anything that can store formulae) are allowed during exams. An abacus is allowed if desired.
- Exam problems may be taken directly from the homework problems or from lecture discussions with some modifications. Thus, in addition to the weight placed on homework in the final grade, it is to your advantage to understand as many of the homework problems as possible. The emphasis of the exams will be to test your understanding, not on formulaic repetition, so expect the exam problems to be challenging and to test your grasp of the methods taught in the class.
- Makeup exams are only allowed for students with extreme, documented circumstances. Students must contact the instructor as soon as possible to provide documentation and request a make-up exam. Excused absences must be consistent with university policies in the undergraduate catalog and require appropriate documentation.
- If you do not agree with the grading of a particular exam problem, you will have one week from the date the exam is returned to submit a written argument of why you think the grade should be higher. However, the final decision will remain the instructor's.

E-learning course web site (Canvas)

- Students are expected to check Canvas on a regular basis for up-to-date course information. This may include changes to the syllabus, homework assignment due dates, and exam schedules.

Workload

- Numerical Methods requires a great deal of programming, and completing the assignments is the only way to solidify your understanding of the material. The lectures will introduce the material, but **you should expect to spend a significant amount of time on the homework**; this is where the real learning takes place.

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies:
https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/

Evaluation of Grades

Assignment	Percentage of Final Grade
Homework	30%
Lowest Exam	20%
Middle Exam	25%
Highest Exam	25%
	100%

Tentative Exam Weeks

Last week of September/first week of October
Last week of October/first week of November
Monday, December 9th, 12:30pm-*2:30pm (not the day/time shown on one.uf)*

Grading Policy

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00

80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Students Requiring Accommodations
Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy
UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is

either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Cheating at the University of Florida is unacceptable and will not be tolerated. While learning together and collaboration in the interest of learning are welcome, cheating and plagiarism are not. You are welcome to work with others to learn, but your work must be your own. If you need help with a problem, do not search for someone else's solution online. Using solutions such as those on Chegg is an Honor Code violation in this class, as is posting class material such as notes, assignments, solutions, etc. Instead, **come to office hours to get help from the SAs or myself!** We are the most direct and Honor Code-approved method of getting help in the class. *Use us!*

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.ufl.edu.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall*,* 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*: https://distance.ufl.edu/state-authorization-status/#student-complaint*.