

EGM 4344 Introduction to Numerical Methods of Engineering Analysis

Catalog 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. 3 credit hours.

1. Pre-requisites:

MAC 2311 Analytic Geometry and Calculus 1
MAC 2312 Analytic Geometry and Calculus 2
MAC 2313 Analytic Geometry and Calculus 3-

Co-requisites:

MAP 2302 Elementary Differential Equations

2. **Course Objectives:** The goal of EGM 4344 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 basic 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 do the following:

- *Structured programming.* Understand basic structured programming concepts involving decision making, loops, functions, and parameter passing implemented within the MATLAB programming environment.
- *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.

3. Contribution of course to meeting the professional component:

4A. EGM 4344 supports several program outcomes enumerated in the Mission Statement of

the Department of Mechanical and Aerospace Engineering. Specific ME and AE program outcomes supported by this course include: (1) Apply knowledge of chemistry and calculus based physics with depth in at least one of them (ME Program Outcome M1 and AE Program Outcome A1); (2) Apply knowledge of advanced mathematics through multivariate calculus and differential equations (ME Program Outcome M2 and AE Program Outcome A2); (2) Apply statistics and linear algebra (ME Program Outcome M3 and AE Program Outcome A3).

4B. Mathematical Sciences (75%), Physical Sciences (10%), Engineering Sciences (15%)

- 4. Relationship of course to program outcomes:** This course achieves the following ABET outcomes [note that the outcome number corresponds to the respective ABET outcomes (a) through (k). Also, note that superscripts represent related ME and AE program outcomes]:
- (a) Apply knowledge of mathematics, science, and engineering^{M2,A2,M3,A3} [outcome (a), high coverage, 35% of the course grade; method of assessment is homework and three exams]
 - (e) Identify, formulate, and solve engineering problems^{M1,A1,M2,A2,M3,A3} [outcome (e), high coverage, 30% of the course grade; method of assessment is homework and four exams]
 - (k) Use the techniques, skills, and modern engineering tools necessary for engineering practice^{M2,A2,M3,A3} [outcome (k), high coverage, 35% of course grade; method of assessment is homework and four exams]

5. Instructor: B.J. Fregly

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- b. Telephone: 392-8157
- c. E-mail address: fregly@ufl.edu
- d. Web site: www.mae.ufl.edu/~fregly/Egm4344.htm

6. Teaching Assistants

Yoshifumi Nozaki

- a. Office location: 237 MAE-B
- b. Telephone: 392-7903
- c. E-mail address: yoshin@ufl.edu

Manoj Parmar

- a. Office location: 237 MAE-B
- b. Telephone: 392-7903
- c. E-mail address: mparmar@ufl.edu

7. Meeting Times:

Lectures:

MWF Period 6 – 12:50-1:40 pm

Office hours:

MWF Period 7 – 1:55-2:45 pm (Fregly)

MWF Period 9 – 4:05-4:55 pm (Nozaki)

T Period 6-7, Th Period 6 – 12:50-2:45 pm (Parmar)

8. Class/laboratory schedule: During assigned meeting times.

9. Meeting Location:

Lectures: 303 MAE-A

Office hours – Fregly: 208 MAE-A

Office hours – Nozaki: 237 MAE-B

Office hours – Parmar: 237 MAE-B

10. Material and Supply Fees: None

11. Required Textbooks and Software

- a. Title: *Applied Numerical Methods with MATLAB for Engineers and Scientists*
- b. Authors: Steven C. Chapra
- c. Publication date and edition: 2008, Second Edition
- d. ISBN number: 978-0-07-313290-7
- e. Software: Matlab 7 Student Version (Release 2007a)

- a. Title: *Introduction to MATLAB 7 for Engineers*
- b. Authors: William J. Palm III
- c. Publication date and edition: 2005, First Edition
- d. ISBN number: 978-0-07-254818-1

Both books can be purchased on-line as Ebooks at a substantial discount over hard copy prices. Instructions for purchasing the Ebook version of the textbooks are provided on the course web site.

Matlab 7 Student Version can be purchased either from the UF Bookstore or directly from the Mathworks web site (http://www.mathworks.com/academia/student_version/index.html). Either way, I suggest purchasing it TODAY so that you will have the software in time for your first homework assignment.

If you already have it, Matlab 6 Student Version will also work fine except that it does not have the Optimization Toolbox, which will be required for one of your homework assignments. If you have Matlab 6 Student Version, you will need to work with someone who has Matlab 7 Student Version when you do the Optimization homework assignment.

12. Recommended Reading

Recommendation 1

- a. Title: *Applied Numerical Analysis Using MATLAB*
- b. Author: Laurene V. Fausett
- c. Publication date and edition: 2008
- d. ISBN number: 0-13-239728-5

Recommendation 2

- a. Title: *Numerical Methods with Matlab: Implementation and Application*

- b. Author: Gerald Recktenwald
- c. Publication date and edition: 2001, First Edition
- d. ISBN number: 0201308606

Recommendation 3

- a. Title: *Numerical Methods Using Matlab*
- b. Author: George Lindfield and John Penny
- c. Publication date and edition: 1999, Second Edition
- d. ISBN number: 0130126411

Recommendation 4

- a. Title: *MATLAB Primer*
- b. Author: Timothy A. Davis and Kermit Sigmon
- c. Publication date and edition: 2004, Seventh Edition
- d. ISBN number: 978-1584885238

13. Course Outline: See attached outline for a day by day lecture schedule. The course will cover the following general topics:

- Part 1 Modeling, Computers, and Error Analysis
 - Mathematical Modeling Numerical Methods & Problem Solving
 - MATLAB Fundamentals
 - Programming with MATLAB
 - Roundoff and Truncation
- Part 2 Roots and Optimization
 - Roots: Bracketing Methods
 - Roots: Open Methods
 - Optimization
- Part 3 Linear Algebraic Equations and Matrices
 - Linear Algebraic Equations and Matrices
 - Gauss Elimination
 - LU Factorization
 - Matrix Inverse and Condition
 - Iterative Methods
- Part 4 Curve Fitting
 - Linear Regression
 - General Linear Least-Squares and non-linear Regression
 - Polynomial Interpolation
 - Splines and Piecewise Interpolation
- Part 5 Numerical Differentiation and Integration
 - Numerical Integration Formulas
 - Numerical Integration Functions
 - Numerical Differentiation
- Part 6 Ordinary Differential Equations
 - Initial Value Problems
 - Adaptive Methods and Stiff Systems

Boundary-Value Problems

14. Attendance and Expectations:

Attendance: Attendance is not required except for exams. However, it will be extremely difficult for you to pass the course unless you attend lectures regularly.

Homework: Homework assignments will involve the completion of selected problems at the end of each chapter in the textbook. To receive full credit, you will be required to complete all assigned problems AND to follow the homework formatting instructions provided with this syllabus. No partial credit will be given for incorrect or incomplete solutions.

You are encouraged to work together to figure out the solution process for homework problems. Consequently, you are encouraged to become part of a study group early on in the course, as this will greatly facilitate your ability to learn from one another as well as to complete the homework assignments. However, each student must write out his or her own final solution, and direct copying of another student's solution will be considered a violation of the University honor code.

Late homework assignments will not be accepted. However, since difficult weeks will arise during the semester, each student will be permitted one late homework assignment turned in not more than one week after the original due date. Homework assignments and due dates will be given in class, and homework will generally be due one week after the last material in the assignment was covered in class. Hardship cases will be considered on an individual basis and only if the instructor has been contacted *before* the due date of the assignment.

Exams: Exams will be in-class and will be closed-book, closed notes, but you will be allowed to bring one sheet of paper (front and back) with as much material written on it as you want.

Exam problems may be taken directly from the homework problems 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 in the textbook as possible. Since it would be difficult to complete every homework assignment given the large amount of material to be covered, a study group would be an excellent place to discuss the solution process to each problem in preparation for exams.

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 explanation of why you think the grade should be higher. However, the final decision will remain the instructor's.

Course web site: Students will be expected to check it on a regular basis for up-to-date course information. This may include changes to the syllabus, homework assignment due dates, and exam schedules. The course web site is accessible from the Teaching link on my faculty home page <http://www.mae.ufl.edu/~fregly>.

Class E-mail Alias: To facilitate communication with the class, an e-mail alias will be created by the University. In order to be included in the distribution list, you will need to have a xxx@ufl.edu e-mail address. You can check this by going to the University of Florida home page, clicking on Phonebook at the top of the page, and then searching for your name. If your e-mail address is not listed as xxx@ufl.edu, then you will need to contact the UF Computing Help Desk (<http://helpdesk.circa.ufl.edu>) to have this corrected during the first week of classes. If you do not have your e-mail address corrected, then you will not receive potentially important e-mail distributions from the instructor to the class. Note that you can always forward your xxx@ufl.edu e-mail to some other e-mail address if desired.

Personal responsibility: You are personally responsible for all information disseminated during the lectures. This policy means that you are responsible to know all homework due dates, knowing when exams will be given, where they will be given, what material they will cover, and knowing all material, handouts, and announcements made in the lectures, whether or not you were present. Thus, if you miss a lecture, it is your responsibility to obtain all information presented during that lecture. "I missed that information" or "I was unaware of that information" will not be accepted as valid excuses.

Workload: Numerical Methods requires an extensive amount of programming, and completing the assignments is the only way to solidify your understanding of the material. My goal is to give you the quality of education that you would get at any top university in the nation, so be prepared to invest a lot of time in this course. The payoff will be not only a deeper understanding of numerical methods but also an improved ability to think critically and independently.

15. Grading: The final course grade will be calculated based on the following percentages:

Exam 1	20%
Exam 2	20%
Exam 3	20%
Exam 4	20%
Homework	20%

For individuals in the gray area between two grades, performance on the homework will be used to make the final decision.

Exam grades will not be curved. Thus, it is theoretically possible for every student in the class to receive an A (or an E). Your grade will depend only on your performance and not on that of others in the class. It is therefore in your best interest to work with others on the homework assignments to improve your understanding of the material. Please note, however, that all work on the exams must be completed individually, and that no communication whatsoever is permitted with others during the exams. Also, no make-up exams will be given, so if you miss an exam without prior permission from the instructor, you will receive a zero grade.

Every student in the course will earn his or her own final course grade based on the percentages noted above. The instructor is simply the individual who does the calculations. Consequently, if you receive an E as a final course grade, there will be nothing that I can do about it. If, during the semester, you are afraid that you are not performing well enough to pass the course, come see me so that we can try to get you back on track.

16. Grading Scale:

A	90-100%
B+	85-89%
B	80-84%
C+	75-79%
C	70-74%
D+	65-69%
D	60-64%
E	0-59%

17. Make-up Exam Policy: No make up exams will be given. If you miss an exam without prior consent of the course instructor, you will receive a grade of zero.

18. Honesty Policy: All students admitted to the University of Florida have signed a statement of academic honesty committing themselves to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action. This statement is a reminder to uphold your obligation as a UF student and to be honest in all work submitted and exams taken in this course and all others.

Any student caught cheating on an exam or homework assignment will receive a failing grade in the course. ALL incidents of possible cheating will be reported to the Office of Student Judicial Affairs. A formal review of the incident will be performed, and if found guilty, the student will receive a permanent mark on his or her transcript indicating an academic honesty violation in EGM 4344. This situation would be extremely detrimental for future employment or graduate school applications.

19. Accommodation for Students with Disabilities: Students Requesting classroom accommodation must first register with the Dean of Students Office. That office will provide the student with documentation that he/she must provide to the course instructor when requesting accommodation.

20. UF Counseling Services: Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:

- University Counseling Center, 301 Peabody Hall, 392-1575, Personal and Career Counseling.
- SHCC mental Health, Student Health Care Center, 392-1171, Personal and Counseling.
- Center for Sexual Assault/Abuse Recovery and Education (CARE), Student Health Care Center, 392-1161, sexual assault counseling.
- Career Resource Center, Reitz Union, 392-1601, career development assistance and counseling.

21. Software Use: All faculty, staff and student 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.