EGM 3344  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 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 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 3344 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:** Renwei Mei
   a. Office location: 307 Nuclear Science Building
   b. Telephone: 392-0888
   c. E-mail address: rwmei@ufl.edu
   d. Web site: e-learning Sakai

6. **Teaching Assistants**
   Subramanian Annamalai, Like Li, Nima Rahmatian, Weian Sheng

7. **Meeting Times:**
   Lectures for Section **5403**:
   MWF 12:50—1:40 pm (CSE A101)

   Office hours:
   - MEI: MW 10:30 - 12:00 307 NSC
   - TAs: Subramanian Annamalai subbu.ase@ufl.edu 4-5 Tuesday MAE-B 237
   - Like Li likeli1985@gmail.com 3:30-4:30 Monday NSC 313
   - Nima Rahmatian nrah@ufl.edu 2-3 Thursday NSC 305
   - Weian Sheng wsheng@ufl.edu 3-4 Friday NEB 231

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

9. **Meeting Location:**
   Lectures: CSE A101
   Office hours – Mei: 307 NSC; MW 10:30-12:00
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
   d. ISBN number: 978-0-07-313290-7
   e. Software: Matlab Student Version (R2010a)

   a. Title: *A Concise Introduction to MATLAB*
   b. Authors: William J. Palm III
   d. ISBN number: 978-0-07-338583-9

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 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](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.

Note that earlier versions of Matlab may not contain the Optimization Toolbox.

12. Recommended Reading

13. Course Outline: 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 Errors
   Part 2  Roots Finding
           Roots: Bracketing Methods
           Roots: Open Methods
   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
14. Attendance and Expectations:

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

**Homework**: Homework will be assigned regularly. The assignments will involve the completion of selected problems at the regular intervals. 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.

Book chapters and due dates for homework assignments are provided on the assignment files.

Homework assignments will cover the following topics:
* Basic MATLAB Programming
* Advanced MATLAB Programming
* Rootfinding
* Linear Algebra
* Regression and Interpolation
* Numerical Integration of Functions
* Numerical Integration of ODEs

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. 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.
Exams: Exams will be in-class and will be closed-book and closed notes, but you will be allowed to bring ONE sheet of paper (one side only on 8.5”x11”) for midterm and ONE sheet for final exams.

- NO CELL PHONE (or anything that can store formulae) is allowed during the exams.
- NO programmable calculator is allowed during exams.
- Only scientific calculators are allowed during exams.

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.

E-learning 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.

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 a lot of programming, and completing the assignments is the only way to solidify your understanding of the material.

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

- Homework 10%
- Exam 1 45% (October 25, 12:50-1:40, CSE A101)

Exam 2 45% (December 14, 12:30-2:30, CSE A101)

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

16. Grading Scale:

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<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>A</td>
<td>90-100</td>
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<tr>
<td>A-</td>
<td>87-89</td>
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<tr>
<td>B+</td>
<td>84-86</td>
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<tr>
<td>B</td>
<td>80-83</td>
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<tr>
<td>B-</td>
<td>77-79</td>
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<tr>
<td>C+</td>
<td>74-76</td>
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<tr>
<td>C</td>
<td>70-73</td>
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<tr>
<td>C-</td>
<td>67-69</td>
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<td>D+</td>
<td>64-66</td>
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<td>D</td>
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<td>D-</td>
<td>57-59</td>
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<td>E</td>
<td>0-56</td>
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17. Make-up Exam Policy: No make-up exams will be given. You should plan your traveling schedule based on the information given here. 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, homework assignment, or project 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 significant grade penalty (possibly a failing grade) as well as a permanent mark on his or her transcript indicating an academic honesty violation in EGM 3344. 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, 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.