EGMN 321 – Numerical Methods

Course Description

A study of numerical algorithms used in error analysis, computing roots of equations, solving linear algebraic equations, curve fitting, numerical differentiation and integration, numerical methods for ordinary differential equations and a brief introduction to numerical methods for partial differential equations. The course content is tailored for mechanical and nuclear engineering applications.

Course Objectives

In this course students will acquire the following skills:

- to understand the role of computers in engineering as a complement to analytical and experimental approaches
- to gain a basic understanding of computer arithmetic and round-off errors and how to avoid loss of significance in numerical computations
- to investigate the robustness and the accuracy of the algorithms and/or how fast the numerical results from the algorithms converge to the true solutions
- to learn how the numerical techniques and simple algorithms implemented
- to be able to communicate the results of numerical computation, with adequate explanations, in written and graphical form

Some Details:

Prerequisite: MATH-301 and EGMN-215, with a minimum grade of C in each, or permission of instructor. Understanding of Calculus and Linear Algebra (MATH-301), knowledge and experience with programming in MATLAB (EGMN-215) are strongly required. Students will use MATLAB software on their own as a tool in this course to solve the problems.

Textbook: Steven C. Chapra and Raymond P. Canale, *Numerical Methods for Engineers*, 7th/8th Edition, McGraw-Hill, 2015/2021. ISBN 978-0073397924/978-1260232073

Reference: Steven C. Chapra, *Applied Numerical Methods with MATLAB for Engineers and Scientists*, 4th Edition, McGraw Hill, 2018. ISBN 978-0073397962

Instructor: Dr. Zeyun Wu (email: zwu@vcu.edu)

Schedule: 2:00 – 3:15 PM, or 3:30 – 4:45 PM, Tuesday & Thursday

Classroom: Room E1232, East Engineering Hall

Office hours: 10:00 – 11:00 AM, Friday; or upon email appointment

Office: Room E2236, East Engineering Hall

Attendance: Since class discussion is a major course ingredient, regular attendance is mandatory.

Software: There is no strict requirement to use a specific software package for solving the assigned problems. Students can use MATLAB, EXCEL, Mathcad, or high-level C/C++ programing. The solutions obtained using different software packages will be graded. However, it is assumed that students have the knowledge and experienced with programming in MATLAB (prerequisite EGMN-215), since MATLAB will be used as a main tool in this course. Short review of MATLAB will be given in this course in several lectures. EXCEL and other software packages will be only briefly introduced. Students may refer to Appendix B and C in textbook for getting started with MATLAB and Mathcad and learn these software packages on their own.

Lecture: The lecture slides augmenting the main textbook and other materials will be posted by the instructor on Canvas before the class starts. The students are not permitted to distribute these notes to other parties during or after the semester.

Homework: Homeworks will be assigned during the semester according to the course timetable and posted electronically on Canvas. Homework and other assignment solutions should be uploaded by students in Canvas in the end of day they are due (normally before midnight), unless otherwise rescheduled in the class. *Late submission of homeworks will not be accepted.* Solutions will be graded and electronically turned in to students. The solution steps and the approach followed must be made clear to the grader. MATLAB, EXCEL, Mathcad or C/C++ software can be used for solving the assigned problems. Unless indicated otherwise, each student is expected to work on the homework assignments independently. Copying solutions of others is considered plagiarism. Students may type their solutions in Word or solve the problems by hand on a paper, take picture, and insert an image into Word file. However, all solutions should be submitted electronically in Canvas as a *SINGLE PDF* file.

Project: Projects will be assigned during the semester. The project assignments will be given one week before the due date for submission of projects at midnight they are due. Late submission of projects will not be accepted. Project solution should be submitted electronically in Canvas as a *SINGLE PDF* file.

Exam: Midterm and final exams will be given according to the course timetable. The manner of assignment and submission of exams is the same as that of the homeworks. The due date for submission of exams will be at midnight they are due. You cannot discuss with anybody else for the exam and have to work on the problems independently.

Grade:

Homeworks	30%,
Projects	20%,
Midterm Exams (take home)	30%,
Final Exam (take home)	20%.

Final grade: **A**=90-100: **B**=80-89; **C**=65-79; **D**=55-64: **F**<55

Others: This syllabus is subject to change. Please visit **Canvas** to get the latest updates to the syllabus and other class information. Materials provided in class and in **Canvas** are for your personal use only. So please do not distribute them to others or any public domain.

Important note: students should visit http://go.vcu.edu/syllabus and review all syllabus statement information. The full university syllabus statement includes information on safety, registration, the VCU Honor Code, student conduct, withdrawal and more.

Suggestions and Recommendations

- ***don't miss class:*** new material and example problems are covered in each lecture; if you missed class, you are responsible for learning the missed material on your own
- ***read textbook in advance:*** the reading topics for each lecture are provided above in the course timetable
- ***start all assignments early:*** take some time to consider the problems and determine whether or not you need instructor's or TA's assistance; last-minute questions and solutions are not a good idea; start-to-finish time demands for assignments could vary from an hour to several hours
- ***carefully read and follow all instructions:*** electronic assignments and solutions will be the norm in this course; demonstrate the effort to solve the problems in order to get a grade, do not leave an empty page below the problem statement (zero grade); don't lose credit for failure to pay attention to simple things!
- ***ask questions:*** during class and during office hours

Course Evaluation

Each student in the course is expected to fill out an online course evaluation; directions will be emailed to you towards the end of the semester.

Withdrawal from Classes

Before withdrawing from classes, students should consult their instructor as well as other appropriate university offices. Withdrawing from classes may negatively impact a student's financial aid award and his or her semester charges. To discuss financial aid and the student bill, visit the Student Services Center at 1015 Floyd Avenue (Harris Hall) and/or contact your financial aid counselor regarding the impact on your financial aid.

202x Fall Events and Holidays

- August 22: First day lecture
- September 4: Labor Day, no class
- November 7: Election Day, no class
- November 20 - 26: Fall and Thanksgiving breaks, no classes
- December 11: Last day of classes
- December 12 - 19: Final examinations

Tentative Course Content

This content is subject to changes, but tentatively, we will cover the following topics:

- Brief review of MATLAB software
- Introduction to the numerical methods for solving the engineering problems
- Numerical errors: computer representation of real numbers, accuracy, precision, and round-off errors, Taylor series and truncation errors
- Methods for root finding of equations and convergence
- Methods for curve fitting
- Numerical integration and differentiation
- Ordinary differential equations
- Partial differential equations: initial and boundary value problems
- Topics at the discretion of the instructor, such as: advanced topics in root finding, curve fitting, or numerical integration, systems of linear equations, optimization, etc.

Course Timetable (subject to change)

Class	Lec	Day	Date	Topics	HW & Project Due Date
1	1	Tuesday	8/22/202x	Course Introduction and Overview	
2	2	Thursday	8/24/202x	Software Review – MATLAB	
3	3	Tuesday	8/29/202x	Software Review – Programming	
4	4	Thursday	8/31/202x	Numerical and Engineering Problem Solving	HW #1, 09/07/202x
5	5	Tuesday	9/05/202x	Approximations and Round-Off Errors	
6	6	Thursday	9/07/202x	Truncation Errors and Taylor Series	HW #2, 09/21/202x
7	7	Tuesday	9/12/202x	Roots of Equations: Bracketing Methods	
8		**Thursday**	**9/14/202x**	**Midterm Exam 1**	
9	8	Tuesday	9/19/202x	Roots of Equations: Open Methods	
10	9	Thursday	9/21/202x	Roots of Equations: Roots of Polynomials	Project #1, 10/05/202x
11	10	Tuesday	9/26/202x	Roots of Equations: Case Studies	
12	11	Thursday	9/28/202x	Linear Equations: Gauss Elimination	
13	12	Tuesday	10/03/202x	Linear Equations: LU Decomposition	
14	13	Thursday	10/05/202x	Linear Equations: Special Matrices and Gauss-Seidel Iterations	HW #3, 10/19/202x
15	14	Tuesday	10/10/202x	Linear Algebraic Eqns: Application	
16		**Thursday**	**10/12/202x**	**Midterm Exam 2**	
17	15	Tuesday	10/17/202x	Curve Fitting: Least-Squares Regression	
18	16	Thursday	10/19/202x	Curve Fitting: Interpolation	HW #4, 10/26/202x
19	17	Tuesday	10/24/202x	Curve Fitting: Fourier Approximation	
20	18	Thursday	10/26/202x	Curve Fitting: Case Studies	Project #2, 11/09/202x
21	19	Tuesday	10/31/202x	Numerical Integration: Integration Formulas	
22		**Thursday**	**11/02/202x**	**Midterm Exam 3**	
		Tuesday	11/07/202x	No class (Election Day)	
23	20	Thursday	11/09/202x	Numerical Integration: Integration of Analytical Equations	HW #5, 11/16/202x
24	21	Tuesday	11/14/202x	Numerical Differentiation	
25	22	Thursday	11/16/202x	Numerical Differentiation and Integration: Case Studies	HW #6, 11/30/202x
		Tuesday	11/21/202x	No class (Fall Break)	
		Thursday	11/23/202x	No class (Thanksgiving Day)	
26	23	Tuesday	11/28/202x	ODEs: Euler's Method	
27	24	Thursday	11/30/202x	ODEs: Runge-Kutta Methods	HW #7, 12/07/202x
28	25	Tuesday	12/05/202x	ODEs: Boundary and Eigenvalue Problems	
29	26	Thursday	12/07/202x	ODEs: Case Studies	Last class
			TBD	**Final Exam**	