ME 2004: Engineering Analysis Using Numerical Methods

Course Description

This course is intended for engineering students with the *desire to learn* about fundamentals of computer programming and numerical methods. The major objectives of the course are to develop logical computer programming skills and to introduce the students to numerical methods required to perform engineering computations. Breaking complex engineering problems into a logical set of simpler problems is emphasized.

Course Staff

Instructor: T. Jaisohn Kim (jais0hn@vt.edu)
Office hours are posted on the Canvas homepage.

Course Learning Statements

Having successfully completed this course, the student will be able to:

- Write original programs for numerical solution of systems of linear equations modeling engineering systems.
- Write original programs for numerical solution of nonlinear equations arising in engineering analysis.
- Write original programs for numerical integration.
- Write original programs for numerical solution of first-order ordinary differential equations.
- Apply programming and numerical analysis tools for the solution of engineering problems.

Modality

ME 2004 is a hybrid course. All lectures, except for the first lecture, are delivered asynchronously. You are expected to gradually work through the content throughout each week. The only live synchronous lecture will occur over Zoom on Monday, August 22 from 10:10-11am (first day of class). (See Canvas for the Zoom link)

The course registration also includes a face-to-face Recitation on Fridays from 2:30-3:45pm or 4-5:15pm. Recitation attendance is mandatory.

Textbooks and Software

This course uses three textbooks:

- *Applied Engineering Mathematics* (Brian Vick, CRC Press, 1st edition, 2020). This can be purchased from the VT Bookstore or through CRC Press.
- *MATLAB: A Practical Introduction to Programming and Problem Solving* (Stormy Attaway, Elsevier, 5th edition, 2019). This is a freely available textbook; you can download it from the link here or use the PDFs posted to the Canvas site.
- *Numerical Methods in Engineering with MATLAB* (Jaan Kiusalaas, Cambridge University Press, 2nd edition, 2012) This is a freely available textbook; you can download it from the link here or use the PDFs posted to the Canvas site.
- Additional lecture notes will be posted to Canvas.

This is a MATLAB-intensive class. Assignment and lectures will utilize MATLAB. We will not program in any other language. Assignments submitted in other programming languages will not be accepted. Please download:

- MATLAB R2020a or later
- All toolboxes preferred, but these 5 at the bare minimum:
  - Control System Toolbox
  - Curve Fitting Toolbox
  - Image Processing Toolbox
  - Signal Processing Toolbox
  - Symbolic Math Toolbox

Some built-in functions we will use were introduced in R2020a, so you cannot use an older version. If you have an older version, please uninstall that version and install the latest version. We will use some built-in functions specific to certain toolboxes, so please ensure you have downloaded all of the toolboxes, or at least the five listed above if you have limited hard drive space. MATLAB and the constituent toolboxes can be freely installed as part of the VT Engineering Software Bundle. Please contact VT's 4Help for installation troubleshooting.

You also need:

- A way to digitize handwritten work. Two commonly used apps are:
  - CamScanner
  - Adobe Scan
- A PDF merger. Two common apps are:
  - PDF Annotator (included in the VT Engineering Software Bundle)
  - CombinePDF (there are many free PDF mergers on the Internet)
- Microsoft Office, including OneNote (included in the VT Engineering Software Bundle)

Class Structure

Each week, you will have a series of textbook readings, pre-recorded lectures, and quizzes to complete before coming to Friday's Recitation. During Recitation, you will work in a small group to solve some simple problems related to the lectures/readings. The readings, lectures, quizzes, and recitation problems are meant to prepare you for the Workshop and Homework sets. The readings and lectures may not always overlap: some material in the readings is not explicitly covered in the lectures, and vice versa. However, you are responsible for *all* content covered across both mediums. You also have one Midterm Exam and one Final Exam.

It is your responsibility to keep up with deadlines. We suggest being proactive and scheduling daily blocks dedicated to this course. Programming requires extensive out-of-class practice; it is extremely difficult to catch up in this class once you're behind.

Quizzes

Quizzes ask simple questions which draw directly from the course textbook and/or the lectures. Although quiz questions are mostly conceptual, some may require basic calculations. There may be multiple quizzes per week. The 2 lowest Quiz grades are dropped.

Recitation Problems

In Recitation, you will work with a small team to solve a few problems oriented at understanding the basic concepts from the week's video lectures, readings, and quizzes. Recitation problems are due by the end of the class and are graded on a Pass/Fail basis (Pass = 1 point; Fail = 0 points). The lowest Recitation grade is dropped.

Workshops

Workshop problems typically consist of short-ish problems meant to quickly check your coding ability. They are hosted on an external website, MATLAB Grader. Invitations will be sent at the beginning of the course. The lowest WS grade is dropped.

Homework

HWs emphasize practical problem solving over conceptual knowledge. They are typically more involved than Workshop problems. Each HW is worth 4 points. After each HW is due, you will self-grade your work for correctness (out of 2 points) using the provided solutions. Then, we will grade your work for style and readability (out of 2 points). No HW grades are dropped.

Midterm/Final Exam

The Midterm and Final Exams will be administered on the assigned dates and cover the requisite material. Exams are cumulative. They include conceptual and numerical programming questions.

MATLAB Onramp

Early in the semester, you will complete the official MathWorks MATLAB Onramp. You will earn a certificate upon completion, which you can post on your resume or LinkedIn profile!

Grading Policy

The final assignment of grades is left to the discretion of the instructor.

The assignment of an *A* will be for demonstrated excellence in the subject. Every assignment in the class will be challenging; they are intended to inspire deep thought and allow you to demonstrate mastery of the subject.

Item	***Weight***
Quizzes	2.5%
MATLAB Onramp	2.5%
Recitation Problems	5%
Workshops	20%
Homework	20%
Midterm Exam	25%
Final Exam	25%
Total	*100%*

Your *letter* grade is computed as follows:

Letter Grade	***Score***
A	[93+
A-	[90 – 93)
B+	[87 – 90)
B	[83 – 87)
B-	[80 – 83)
C+	[77 – 80)
C	[73 – 77)
C-	[70 – 73)
D+	[67 – 70)
D	[63 – 67)
D-	[60 – 63)
F	[0 – 60)

Assignments may be curved during the semester, but don't count on it. There may be some extra credit, but don't count it.

Hopefully this grading policy is clear. At any time during the course one can calculate his or her current grade and can also compute necessary scores on future assignments to reach possible higher grades.

Late Work

We recognize the difficulty of online learning. However, we also recognize the need to be timely out of respect for the instructors and your fellow classmates. Ample time is given for all assignments. No unexcused late work is allowed. Technology failures (including Canvas/Internet outages, computers crashing) do not constitute excused absences. Keep backups of all your work! Hardware failure or "lost" code is not a valid excuse. Assume that your computer will crash sometime during the course and plan for it. Note that all submissions are automatically timestamped. Do NOT wait until the last minute, or even the last day, to submit assignments. Servers can get overloaded near the deadline. Give yourself enough time to handle issues that may arise. We suggest submitting all assignments at least 24 hours in advance.

Any late work requests must be submitted through the *Request for Excused Absence* form on Canvas. Known absences (academic conferences, ROTC obligations, etc.) must be submitted at least 72 hours before the assignment's deadline. Circumstances out of the student's control, such as illness, a death in the family, etc. shall normally be considered an excused absence that justifies the request. Circumstances within the student's control are normally considered an unexcused absence for which a make-up request may be denied.

Academic Integrity

All ME 2004 students are required to have read over the Undergraduate Honor Code policies and adhere to them throughout the course. The Undergraduate Honor Code that each member of the university community agrees to abide by states:

"As a Hokie, I will conduct myself with honor and integrity at all times. I will not lie, cheat, or steal, nor will I accept the actions of those who do."

Students enrolled in this course are responsible for abiding by the Honor Code. A student who has doubts about how the Honor Code applies to any assignment is responsible for obtaining specific guidance from the course instructor before submitting the assignment for evaluation. Ignorance of the rules does not exclude any member of the University community from the requirements and expectations of the Honor Code.

The Honor Code expressly forbids the following academic violations:

1. *Cheating*. Cheating includes the actual giving or receiving of any unauthorized aid or assistance or the actual giving or receiving of any unfair advantage on any form of academic work, or attempts thereof.
2. *Plagiarism*. Plagiarism includes the copying of the language, structure, programming, computer code, ideas, and/or thoughts of another and passing off the same as one's own original work, or attempts thereof.
3. *Falsification*. Falsification includes the statement of any untruth, either verbally or in writing, with respect to any circumstances relevant to one's academic work, or attempts thereof. Such acts include, but are not limited to, the forgery of official signatures; tampering with official records; fraudulently adding, deleting, or manipulating information on academic work, or fraudulently changing an examination or other academic work after the testing period or due date of the assignment.
4. *Fabrication.* Fabrication includes making up data and results, and recording or reporting them, or submitting fabricated documents, or attempts thereof.
5. *Multiple submission.* Multiple submission involves the submission for credit (without authorization from the instructor receiving the work) of substantial portions of any work (including oral reports) previously submitted for credit at any academic institution of attempts thereof.
6. *Complicity.* Complicity includes intentionally helping another to engage in an act of academic misconduct, or attempts thereof.
7. *Violation of University, College, Departmental, Program, Course, or Faculty Rules.* The violation of any University, College, Departmental, Program, Course, or Faculty Rules relating to academic matters that may lead to an unfair academic advantage by the student violating the rule(s).

The Virginia Tech honor code pledge for assignments is as follows:

"I have neither given nor received unauthorized assistance on this assignment."

The pledge is to be written out on all graded assignments at the university and signed by the student. The honor pledge represents both an expression of the student's support of the honor code and an unambiguous acknowledgment that the student has, on the assignment in question, abided by the obligation that the Honor Code entails. In the absence of a written honor pledge, the Honor Code still applies to an assignment.

Academic integrity expectations are the same for online classes as they are for in person classes. All university policies and procedures apply in any Virginia Tech academic environment, and all students are expected to follow them. **Jointly developing a solution to an individual assignment is considered a violation, as is sharing or reusing a file (computer file or handwritten document) in full or in part. You may discuss with your classmates what your program is required to accomplish but not how to achieve that goal. In no way should the individual statements of a program or the steps leading to the solution of the problem be discussed with or shown to anyone except the course's instructional staff. Furthermore, using sites such as (but not limited to) Chegg, CourseHero, GroupMe, etc. is a violation of the Virginia Tech Honor Code. Students who submit codes similar to the ones found on these websites will be referred to the Honor System. Recitation and Workshop Problems are the only exception to this policy.** Changing variable names from copied code is not only incredibly obvious to detect but also an Honor Code violation. All submitted work is fed through a plagiarism detection software. Do not make any assumptions as to who can provide help on an assignment.

You and your classmates are here to learn, and that happens best in an atmosphere of mutual respect with freedom from distractions and disturbances. **It is much easier to explain a poor grade to parents or a potential employer than to explain an Honor Court conviction.** Don't mortgage your future for a good grade on an assignment which is ultimately inconsequential in the grand scheme of life.

For additional information about the Honor Code, please visit: https://www.honorsystem.vt.edu/

Honor Code Pledge for Assignments: The Virginia Tech honor code pledge for assignments is as follows:

"I have neither given nor received unauthorized assistance on this assignment."

The pledge is to be written out on all graded assignments at the university and signed by the student. The honor pledge represents both an expression of the student's support of the honor code and a commitment to uphold the academic standards at Virginia Tech. If the pledge is not expressly written, submission of the assignment implicitly and automatically declares your support of the honor code.

Academic Misconduct Sanctions: If you have questions or are unclear about what constitutes academic misconduct on an assignment, please speak with me. We take the honor code very seriously in the course. The normal sanction I will recommend for a violation of the Honor Code is an F* sanction as your final course grade. The F represents failure in the course. The "*" is intended to identify a student who has failed to uphold the values of academic integrity at Virginia Tech. A student who receives a sanction of F* as their final course grade shall have it documented on their transcript with the notation "FAILURE DUE TO ACADEMIC HONOR CODE VIOLATION." You would be required to complete an education program administered by the Honor System in order to have the "*" and notation "FAILURE DUE TO ACADEMIC HONOR CODE VIOLATION" removed from your transcript. The "F", however, would be permanently on your transcript.

Please refer to the "Avoiding Honor Code Violations" Canvas page for more detailed information.

Copyrights

Notes, assignments, quizzes, tests, exams, solutions, and other materials distributed to or generated in this class are intended for use only by students enrolled in this course this semester. Without the expressed written consent of the instructor, no one may show, give, or otherwise make such class materials available to anyone not enrolled in this course this semester. Prohibited activities include, but are not limited to, uploading a test, uploading solutions to problems, and submitting such class materials for online posting. The prohibition on sharing solutions applies to all solutions, regardless of who wrote the solutions.

The exception to this copyright policy are all materials directly originating from the videos on Jaisohn Kim's YouTube channel, as they are part of the public domain and filed under YouTube's copyright policy. You are free to distribute the videos and materials linked in the video descriptions as you wish.

Special Needs/SSD Accommodations

Students who have any special needs, circumstances, and/or SSD accommodations should feel free contact Jaisohn ASAP to discuss what can be done to help them fulfill the requirements of the class.

Course Changes

Any aspect of the course may be changed for any reason at any time. Changes will be communicated in writing to students. It is the student's responsibility to continually check email, Canvas, etc. for changes in assignment requirements, deadlines, structure, etc.

Although the spread of COVID-19 has been dramatically reduced, it is still possible to catch and transmit. While the University no longer mandates masks in classrooms, you are free to wear one (and other PPE) if you wish.

If you and/or a close contact test positive for COVID-19, isolate yourself for at least 5 days; do not come to Recitation. If you and/or a close contact exhibit symptoms, get tested and do not come to Recitation. In either case, notify Jaisohn and seek an Absence Verification from the Dean of Students. Students should prepare for the possibility of the in-person Recitations being moved to synchronous online Zoom meetings in the event of an outbreak.

Syllabus last updated: 8/18/22

Tentative Course Schedule (Weeks colored by major topic)

MATLAB Basics	Advanced MATLAB	Linear Algebra	Root Finding	Calculus	ODEs

Week	Dates	Topics
1	Aug 22-26	First day of class: Mon, 8/22, 10:10-11:00am. Zoom link on Canvas. Introduction, course mechanics, scalars/vectors/matrices MATLAB overview + review, MATLAB Grader
2	Aug 29-Sep 2	More MATLAB review Practical examples
3	Sep 5-9	Relational/logical operators Decision/repetition structures Function files Anonymous functions
4	Sep 12-16	Unit Step Function Practical examples
5	Sep 19-23	Debugging Physical processes and mathematical modeling Software development process Numerical errors **No Recitation this week**
6	Sep 26-30	Linear algebra theory "\" command Practical examples
7	Oct 3-7	Matrix inverse Vector/matrix norms Practical examples **No Recitation this week**
8	Oct 10-14	Linear least-squares regression Nonlinear regression, linear interpolation Practical examples

9	Oct 17-21	Root finding basics Graphical, Bisection and Newton-Raphson Method Practical examples fzero() Practical examples
10	Oct 24-28	More fzero() examples Midterm Exam Review **Midterm Exam: Friday, October 28 during Recitation**
11	Oct 31-Nov 4	Numerical differentiation basics Forward, backward, and central differences Practical examples Numerical integration basics Unit Step, Unit Pulse, and Delta/Impulse functions
12	Nov 7-11	Trapezoidal Rule, built-in functions Practical examples
13	Nov 14-18	ODEs introduction, 1st order ODEs overview Sketching phase portraits and anticipated solutions ode45() 1st order ODEs practical examples
14	Nov 21-25	Thanksgiving Break. Enjoy the holiday and eat lots of turkey!!
15	Nov 28-Dec 2	State-space Systems of 1st order ODEs Practical examples
16	Dec 5-7	More practical examples Final Exam review Last day of class: Wed, 12/7
Final Exam: Monday, December 12 3:25-5:25pm, Location TBD		

For all you plot lovers like me, here's a breakdown of the lecture video topic distribution: