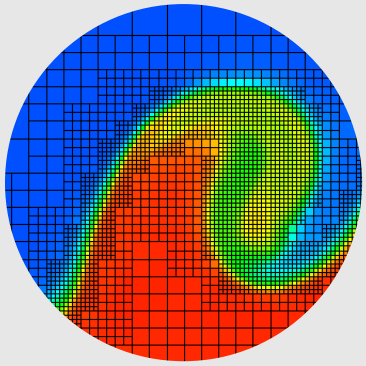

Advanced Mathematical Methods for Engineers

MAE 384

Instructor Info

Alberto Scotti

Office Hrs: Tues & Thurs 12:00-13:30

ERC 283

Zoom link

adscotti@asu.edu

Course Info

Prereq: MAE 215; MAT 274 or 275; MAT 242 or 343. Pre/co-requisite MAT 267 or 272.

Tues & Thurs

9:00-10:15

Recitation

Tuesday or Wednesday

16:30-17:45T, 18:00-19:15W

SCOB201(T),ECG G237(W)

TA Info

Ethan Hadimani

Office Hrs: TTh 11:00-13:30

Zoom link

ehadiman@asu.edu

Overview

Broadly speaking this course can be divided in two parts. In the first part we will look at Partial Differential Equations (PDEs) that arise in many engineering contexts. We will learn how to use analytic methods (aka paper-and-pencil methods) to solve special cases. In general, analytic methods cannot be used to solve most problems that arise in practice (even though they are described by the same general equations). Taking the Heat equation as a special template, we will then look at how a PDE can be approximated as a set of Ordinary Differential Equations (ODEs), and how the latter can be in turn approximated as a set of algebraic equations that can be solved with the aid of a numerical computer. Thus, in the second part, we will cover the numerical techniques that have been developed to estimate derivatives, integrals and other operators of calculus, solve linear and nonlinear system of equations, solve system of ODEs with the aid of a computer.

Material

Required Texts

Numerical Methods/MATLAB: Arizona State University, Whiley Custom Learning Solutions, ISBN: 978-1-119-17552-0. Mind that this is a custom made book, which contains chapters from three different textbooks.

Grading Scheme

5%	Attendance/Participation
15%	Homework, weekly
50%	Midterm Exams, 25% each
30%	Final Exam

Grades will follow the standard scale: A+ = 97-100; A = 94-96.9; A- = 90-93.9; B+ = 87-89.9; B- = 80-86.9; C+ = 76-79.9; C = 70-75.9; E $<$70.

Course Outcomes

- Comprehension
  - Identify and estimate errors in numerical solutions.
  - Solve linear partial differential equations using numerical methods.
  - Solve a partial differential equation analytically.
- Application
  - Solve linear systems of equations using direct methods.
  - Solve nonlinear single variables equations and multivariate systems of equations using basic root finding techniques.
  - Perform curve fitting and interpolation using given or generated data sets.
  - Calculate derivatives of given functions or generated datasets in one or more variables using finite difference methods.
  - Calculate integrals of given functions or generated datasets using numerical integration techniques.
  - Analyze periodic data using discrete Fourier transform.
  - Solve ordinary differential equations (single equations and systems of equations) using numerical methods.
  - Present numerical results in appropriate fashion.
- Analysis
  - Solve engineering problems using a combination of appropriate numerical methods.

FAQs

Do I really need to know how to program in MATLAB?

Yes, if you are planning to get a passing grade.

Do I really need to attend lectures and recitation sessions?

Yes, if you are planning to get a decent passing grade.

Do we really need advanced mathematics?

Hard to believe, but advanced mathematics is actually pretty useful for doing actual engineering (advanced or otherwise).

Unfortunately, I cannot make it to office hours. What can I do?

Just let me know, and we can find a time that works for both of us. You can also try to stop by my office.

Covered topics

These are the topics that we will cover. They are not ordered chronologically.

- Representation of numbers
  - Round-off and truncation errors
- Curve Fitting
  - Distance of curves: least-square interpolation.
- Fourier analysis
  - Review of complex numbers.
  - Fourier expansion over finite and infinite domains.
  - Discrete Fourier Transform.
  - Power spectra and Parseval's theorem.
- Roots of equations.
  - One unknown: bracketing and open methods.
  - System of nonlinear equations: Newton's method.
- Solutions to systems of linear equations
  - Basic concepts from linear algebra: eigenvalues and eigenvectors.
  - Direct and iterative methods.
  - Operation count.
- Numerical integration and derivatives
  - Forward, backward and centered differences.
  - Newton-Cotes formulas.
  - Accuracy.
- Numerical solution to ordinary differential equations
  - Explicit and implicit methods.
  - Euler and Runge-Kutta.
  - Accuracy and stability.
  - Boundary-value problems.
- Analytical solutions to partial differential equations
  - Classifications of PDEs.
  - Separation of variables solutions for linear, homogeneous equations.
  - Inhomogeneous boundary conditions.
- Numerical solutions of PDEs
  - Finite difference solution to the heat equation.
  - Finite difference solution to the Laplace equation.

Policies and procedures

- Attendance:
  - This class is offered as an in-person class only and will follow all ASU policies concerning in-person classes. Do not attend class if you feel sick, may be infected with Covid-19, or have been exposed to someone infected with Covid-19! Simply follow the guidelines set by the CDC for isolation/quarantine and notify the instructor as soon as possible. On an individual basis, a plan will be worked out to let you make up for any missed class participation credit.
  - Attendance to lectures and recitation sessions is *strongly* recommended.
  - Missing exams: All tests must be taken in person. Exceptions are granted for documented medical and personal emergencies as stipulated by the Dean's office.
- Assignments, tests and exams:
  - Poorly reasoned and/or written solutions will receive no credits, even if the answer appears to be correct.
  - All material (answers, procedures, plots (computer generated, code,...)) must be converted to PDF and submitted via Gradescope. Pages must be numbered, and your name must appear on the first page.
  - All material must be submitted in a manner that shows respect for the person who will grade it. This is called professionalism. If you have great penmanship by all means you can submit handwritten answers (when appropriate). Otherwise, typeset your answers.
- Procedures specific to MATLAB codes:
  - In addition to a PDF copy submitted to Gradescope, Matlab code must be submitted via Matlab grader. Needless to say, the code must run. If the code does not run, it will receive no credits.
  - Matlab code must contain enough comment lines so that the internal logic can be followed.
  - *Save all of our codes/files on your local machine.*

Incomplete grade

An "incomplete" may be awarded only in cases when a student, who is otherwise performing satisfactorily, cannot complete final course requirements, such as the final exam or final assignment, due to circumstances beyond the student's control (such as illness or a family emergency). Such circumstances must be documented. Incompletes will be approved only within the last one or two weeks of the semester. Incompletes cannot be requested after the time of the scheduled final exam for the course. To request a grade of incomplete, the student must formally apply to the instructor using the university's "Incomplete Grade Request" form. Requests must be submitted to the student's advisor prior to the final grade due date and are subject to final approval by the program.

Academic Integrity

Students in this class must adhere to ASU's academic integrity policy, which can be found here. Students are responsible for reviewing this policy and understanding each of the areas in which academic dishonesty can occur. In addition, all engineering students are expected to adhere to both the ASU Academic Integrity Honor Code and the Fulton Schools of Engineering Honor Code. All academic integrity violations will be reported to the Fulton Schools of Engineering Academic Integrity Office (AIO). The AIO maintains record of all violations and has access to academic integrity violations committed in all other ASU college/schools. All work submitted for the course cannot have been submitted for any other course or any previous section of this same course. Student a cademic integrity violations are reported to the Fulton Schools of Engineering Academic Integrity Office (AIO). Withdrawing from this course will not absolve you of responsibility for an academic integrity violation and any sanctions that are applied.

Unless explicitly allowed by your instructor, the use of generative AI tools on any course assignment or exam will be considered academic dishonesty and a violation of the ASU Academic Integrity Policy. Students confirmed to be engaging in non-allowable use of generative AI will be sanctioned according to the academic integrity policy and FSE sanctioning guidelines.

Discussions are encouraged for assignments. However, individual assignments must be your own work (i.e., not a copy of another student's work). Copying will not be tolerated. Cheating on assignments will result in a ZERO for that assignment and further consequences according to the school policy. Turning in a copy of another student's work under another name, copying from internet sources, allowing others to copy your work, copying resources from previous semesters, using tutors, using online resources such as Chegg/CourseHero etc., and/or using textbook solution manuals constitutes cheating and will result in a ZERO for that assignment and further consequences according to the school policy. Collaboration/discussions/cheating during quizzes/exams is NOT allowed and will result in a ZERO for that quiz/exam and possibly a failing grade for the course. The use of graphing calculators, cell phones, smart watches, or any electronic device capable of communicating or storing information during quizzes/exams constitutes cheating and will result in a ZERO for that quiz/exam and further consequences according to the school policy.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact SAILS as soon as possible to make an appointment to discuss your special needs and obtain an accommodation letter. Please e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Copyright

All course content and materials, including lectures (Zoom recorded lectures included), are copyrighted materials and students may not share outside the class, upload to online websites not approved by the instructor, sell, or distribute course content or notes taken during the conduct of the course (see ACD 304–06, "Commercial Note Taking Services" and ABOR Policy 5-308 F.14 for more information).

You must refrain from uploading to any course shell, discussion board, or website used by the course instructor or other course forum, material that is not the student's original work, unless the students first comply with all applicable copyright laws; faculty members reserve the right to delete materials on the grounds of suspected copyright infringement.

Policy against threatening behavior

Per the Student Services Manual, SSM 104–02, students, faculty, staff, and other individuals do not have an unqualified right of access to university grounds, property, or services. Interfering with the peaceful conduct of university-related business or activities or remaining on campus grounds after a request to leave may be considered a crime. All incidents and allegations of violent or threatening conduct by an ASU student (whether on- or off- campus) must be reported to the ASU Police Department (ASU PD) and the Office of the Dean of Students.

Disability Accommodations

Suitable accommodations will be made for students having disabilities. Students needing accommodations must register with the ASU Disabilities Resource Center and provide documentation of that registration to the instructor. Students should communicate the need for an accommodation in sufficient time for it to be properly arranged. See ACD 304-08 Classroom and Testing Accommodations for Students with Disabilities.

Harassment and Sexual Discrimination

Arizona State University is committed to providing an environment free of discrimination, harassment, or retaliation for the entire university community, including all students, faculty members, staff employees, and guests. ASU expressly prohibits discrimination, harassment, and retaliation by employees, students, contractors, or agents of the university based on any protected status: race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, and genetic information. Title IX is a federal law that provides that no person be excluded on the basis of sex from participation in, be denied benefits of, or be subjected to discrimination under any education program or activity. Both Title IX and university policy make clear that sexual violence and harassment based on sex is prohibited. An individual who believes they have been subjected to sexual violence or harassed on the basis of sex can seek support, including counseling and academic support, from the university. If you or someone you know has been harassed on the basis of sex or sexually assaulted, here you can find information and resources.

Mandated sexual harassment reporter

As a mandated reporter, I am obligated to report any information I become aware of regarding alleged acts of sexual discrimination, including sexual violence and dating violence. Counseling is available if you wish discuss any concerns confidentially and privately.

Additional information

- Syllabus changes: Any information in this syllabus (other than grading and absence policies) may be subject to change with reasonable advance notice.
- How Long Students Should Wait for an Absent Instructor: In the event the instructor fails to indicate a time obligation, the time obligation will be 15 minutes for class sessions lasting 90 minutes or less, and 30 minutes for class sessions lasting more than 90 minutes. Students may be directed to wait longer by someone from the academic unit if they know the instructor will arrive shortly.
- Notes, assignments, etc. will be posted on Canvas.
- You may struggle at times in this class. Seek help, and seek it early. You can come to my office hours, to the TA office hours, or use the Tutoring Center which provides a valuable resource for students struggling with the concepts covered in class and may be used to help with homework.
- Students may collaborate on solving homework problems. However, each student is responsible for submitting his/her own work separately.

Class Schedule

Date	Module	Topic	Reading (from textbook)
1/9	0	Review of syllabus; how to be successful in this class. PDEs: Introduction	
1/11	1	PDEs: Classification.	628–630, 694–699.
1/16	1	Analytic solutions to PDEs: separation of variables.	646–649
1/18	1	Analytic solutions to PDEs: Fourier methods.	656–658
1/23	1	Analytic solutions to PDEs: Operatorial view. Eigenvalues and Eigenvectors.	586–591,699-702,
1/25	1	PDEs in higher dimensions; Laplace equation.	
1/30	1	PDEs: Examples	
2/1	2	Complex numbers.	
2/6	2	Fourier Series.	251–268
2/8	2	Fourier Integrals	284–289
2/13	2	Discrete Fourier Transform	271–275
2/15	3	Curve fitting and interpolation.	193–224
2/20	1–2	Review	
2/22	-	Midterm I (1-2)	
2/27	3	Curve fitting and interpolation.	364–366
2/29	4	Numerical Integration	341–360
3/5	-	Spring Break	
3/7	-	Spring break	
3/12	4	Newton-Cotes	364–366
3/14	5	Numerical derivation: finite differences.	303-320, 325–326
3/19	5	Numerical derivation: Partial Derivatives.	327–329
3/19	5	Numerical derivatives: Fourier Analysis	
3/21	5	Numerical derivatives	
3/26	6	ODE: Initial Value and Boundary Value problems.	385–430

3/28	6	ODE: Implicit and explicit methods.	
4/2	6	ODE: Stability vs. accuracy, stiff systems	452-457
4/9	6	ODE: BVP	XXX-XXX
4/9	-	Second midterm DURING RECITATION	
4/11	7	Systems of linear equations: Direct methods: Gauss-Jordan elimination.	99–118
4/16	7	Solution of nonlinear equations: Operation count	XXX-XXX
4/18	7	Iterative methods: convergence and condition number.	132–136
4/23	8	Number representation, round-off errors.	First chapter XXX
4/25	-	Number representation, final review.	
5/02		Final	SCOB 252 7:30a-9:20a