AME 208 Mathematical Methods in Engineering

Units: 4.0
Fall 2024, T/Th 8-9:50am

Location: SSL 202

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Office Hours: TBD
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Catalog Description

Common tools for Aerospace and Mechanical Engineers: Vectors, Matrices, Fundamentals of Python, Data Manipulation and Analysis, Statistics, Data Presentation, Optimization, Large Data Sets

Course Description

The course covers mathematic and analytical tools for aerospace and mechanical engineers. Course content is presented in the context of real-world engineering problems and the presentation of data/results will follow "best-practices" for effective quantitative communication both numerically and graphically. Additionally, this course will provide an introduction to current topics in data analysis including optimization and machine learning.

The course is structured into four parts. The first unit offers a unified discussion of vectors and matrices, followed by elements of linear algebra routinely used in mechanics and aerospace engineering (solution of linear systems of equations, eigensystem decomposition, singular value decomposition, etc.). The second unit covers elements of statistics and regression as required for error analysis. The third unit offers an introduction to the computer language python, and its numerical and symbolic manipulation libraries. Python will be used for numerical solution of small (exact) and large (iterative) systems of equations, introduction of visualization and graphical output of results, numerical integration of ordinary differential equations, and elementary transform analysis using symbolic manipulation. Finally, the fourth unit will cover optimization (constrained and unconstrained) and elements of large data analysis and machine learning.

Learning Objectives.

AME 208 is intended to teach students baseline skills in data manipulation, analysis and presentation which are routinely used in both aerospace and mechanical engineering. Upon completion of this course, it is expected that students will be able to

1) Solve engineering problems using vectors and matrices
2) Solve linear systems of equations both manually and computationally
3) Perform standard analytical and graphical tasks using Python
4) Effectively construct professional quality graphs following best-practices for data presentation
5) Apply the fundamentals of statistical analysis to determine effective uncertainty in measurement and computational results
6) Optimize solutions for systems of equations
7) Manipulate large data sets and assembly data required for the training of machine learning algorithms

Prerequisite(s): PHYS 152
Co-Requisite(s): MATH 245
Concurrent Enrollment: N/A
Recommended Preparation: ITP-168 or equivalent

Course Notes

AME 208 will rely on Brighspace and Piazza for all course communications. This includes discussion forums for assignments, course materials, and grade reporting. Before the semester begins, students should verify they have access to all web content.

Technological Proficiency and Hardware/Software Required

Students will require python (freely accessible from https://www.python.org). Binaries for all commonly used platforms (Windows, Mac, and Linux) are available. The software is also installed in Viterbi instructional computers labs.

Optional Readings and Supplementary Materials

The main textbook for AME 208 is Computational Science and Engineering by G. Strang, but most necessary course material will be delivered in lecture and posted to Brightspace. The lecture content is derived from the textbooks below:

Computational Science and Engineering, Gilbert Strang (2007), Wellesley-Cambridge Press, (ISBN: 9780961408817)
Theory and Design for Mechanical Measurements, Figliola & Beasley (2019), Wiley (ISBN: 978-1118881279).

Other reading material:

Learning Scientific Programming with Python, Hill C (2020), Cambridge University Press (ISBN: 9781108745918)
Differential Equations and Linear Algebra, Gilbert Strang (2015), Wellesley-Cambridge Press (ISBN: 978-0980232790)
Linear Algebra and Optimization for Machine Learning**,** Charu C. Aggarwal (2020), Springer (ISBN: 978-030403430)
A Primer on Scientific Programming with Python, Hans Peter Langtangen (2016), Springer (ISBN: 9783662498866)
Learn to Code by Solving Problems, Daniel Zingaro (2021), No Starch Press (ISBN: 9781718501324)
Advanced Engineering Mathematics, Erwin Kreyszig (2011), John Wiley & Sons (ISBN: 9780470458365)
Learning Python, 5th Edition, Mark Lutz (2013), O'Reilley Media (ISBN: 978-1449355739)
Introduction to Machine Learning with Python: A Guide for Data Scientists, Muller A & Guido S (2016), O'Reilly Media (ISBN: 9781449369415)
Linear Algebra and Learning from Data, Gilbert Strang (2019), Wellesley-Cambridge Press, (ISBN: 9780692196380)

Description and Assessment of Assignments

This course consists of 6 homework assignments, 2 midterm exams and 1 final exam. Homeworks are written assignments and will stress best-practices of professional written communication. Assignments with a programing component will not stress optimization of code. However, code will be submitted to Brightspace to ensure academic integrity.

Midterm 1 covers course content through Week 5 and Midterm 2 covers content from Weeks 6-10. Midterms are in-class and are 60 minutes in duration. The Final Exam is cumulative covering all course content, please refer to the USC Schedule of Classes for the final exam schedule.

All assignments and assessments are given in the weekly breakdown.

Grading Breakdown

The total grade for the course is calculated from homeworks, two midterm exams and one final exam. All assignments and exams are counted towards the final grade and no assignments are "dropped" during the semester.

Assessment Tool (assignments)	% of Grade
Homeworks	30
Midterm 1	20

Midterm 2	20
Final	30
TOTAL	100

Assignment Submission Policy

Assignments are due ***before*** the first lecture on the week they are due. All assignments will be submitted digitally to Brighspace via Turn-It-In. All assignments must be submitted on time. Late assignments will be docked 50% and no assignments will be accepted more than 48 hours late. Instructors must be notified ASAP in the case of documented illness or emergency.

Classroom Norms

It is expected that students attend lecture sessions and are active participants in classroom discussion.

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	Deliverables
Week 1	Review of Vectors & Matrices	
Week 2	Linear systems of equations; solution by elimination and iteratively	HW 1 assigned
Week 3	Eigensystem and Singular value Decomposition	HW 1 due HW 2 assigned
Week 4	Introduction to Python	HW 2 due
Week 5	Using python to solve linear systems of equations	HW 3 assigned
Week 6	Visualization & Graphics	HW 3 due
Week 7	Statistics, regression & error analysis	**Midterm 1**
Week 8	Examples of error analysis in engineering	HW 4 assigned
Week 9	Scientific computing with Python: Spyder. Application to numerical solution of nonlinear equations (Newton method)	HW 4 due
Week 10	Numerical integration of ODEs	HW 5 assigned
Week 11	Scientific computing with Python: Jupyter. Application to symbolic transform analysis (Fourier & Laplace)	HW 5 due
Week 12	Optimization; Euler-Lagrange equations and method of Lagrange multipliers	**Midterm 2**
Week 13	Numerical solution of optimization problems by conjugate gradient	HW 6 assigned
Week 14	Large dataset manipulation and intro to machine learning	HW 6 due
Week 15	Use of neural networks in engineering context	
FINAL		Tuesday, December 17 from 4:30-6:30 p.m

Statement on Academic Conduct and Support Systems

Academic Integrity:
The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, comprises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

988 Suicide and Crisis Lifeline - 988 for both calls and text messages – 24/7 on call
The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new,

shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL) – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

The Office of Student Accessibility Services (OSAS) - (213)740-0776
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention - (213) 740-0411
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity, Equity and Inclusion - (213) 740-2101
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call
Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice - (323) 442-2850 or otfp@med.usc.edu
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.