CS 556 Mathematical Foundations of Machine Learning
Spring 2025

Erisa Terolli
Email: eterolli@stevens.edu
Office Hours: Monday 2PM - 3PM
Office: Gateway South 244

Course Overview:
This course will give a rigorous introduction to the mathematical foundations of machine learning, including but not limited to frequently used tools in linear algebra, calculus, probability, and widely applied methods such as linear regression and logistic regression. In addition, this course provides hands-on training on implementing these algorithms via Python. Students will be trained to use popular python libraries such as numpy, scipy and matplotlib.

Course assistants:
We have a great team of TAs: Abhishek and Ganesh

Textbook(s)

- Gilbert Strang, "Introduction to Linear Algebra", 2016 (https://math.mit.edu/~gs/linearalgebra/ila5/indexila5.html).
- Probability and Statistics for Engineering and the Sciences, Jay Devore, 8th Edition (https://faculty.ksu.edu.sa/sites/default/files/probability_and_statistics_for_engineering_and_the_sciences.pdf)
- Calculus, (https://openstax.org/details/books/calculus-volume-1).

Other Readings

- Marc Peter Diesenroth, Aldo Faisal and Cheng Soon Ong, "Mathematics for Machine Learning", Online Version - https://mml-book.github.io/.
- Christopher Bishop, Pattern Recognition and Machine Learning, (1st Edition), Springer Press, 2006
- Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar, Foundations of Machine Learning, MIT Press
- Jerome H. Friedman, Robert Tibshirani, and Trevor Hastie, The Elements of Statistical Learning, Springer

Materials

- Andrew Ng Lecture Stanford Notes: https://cs229.stanford.edu/notes2022fall/main_notes.pdf

Software:
We are going to heavily use Jupiter Notebooks. You can find more info in here: https://jupyter.org/install.

Coursework and grading:
- Homework should be completed on your own time. The assignment, and your submission, are via Canvas.

The course score is a weighted average of the following categories.
- Homework - 40%
- Exam 1 - 25%
- Exam 2 - 25%
- Project - 10%

Letter grades, with plus and minus, are assigned using the scale, which can be found in Canvas for this course.

CS 556 Policies

- You, your instructor, and the teaching assistants are bound by the Stevens Honor System. Students are responsible for reading and understanding the course policies in these web pages and for announcements made in class and in the course email list.
- You will be permitted to use the textbooks and course notes for homework. During exams, you are not permitted to use notes, books, computing, or communication devices unless a different policy is specifically announced by the instructor.
- During lectures please refrain from impolite behavior. In the physical classroom this includes talking on the phone, excessive texting, or otherwise being impolite.
- After grades are posted, you will have 3 days to inform your grader of a problem. You should also CC your instructor on the email. Do not try to request a grade change after three days, as you should learn from your mistakes in a timely fashion.

No make-up exams or quizzes
- There are no make-ups for exams.

Individual work
Except when groups are explicitly allowed, work must be done individually. You are encouraged to discuss the problems with your classmates but you must not share the details of the solutions. Not by email, not by text message, not by Discord chat, not by shared Google doc, not by word of mouth, etc. If you are unsure whether you have shared too much, discuss the situation with the TA or instructor; it is your obligation to avoid even the appearance of cheating. We may use Moss (https://theory.stanford.edu/~aiken/moss/) or other systems to verify your code is not too similar to that of other students in the class. If the system indicates a high likelihood of cheating, we will treat it as a violation of the Stevens Honor System.

Late homework
From time to time, all of us have trouble meeting deadlines, you will be confronted with many difficult deadlines. But homework doesn't get easier to do if it's late, and falling behind can snowball. Hence, the following strict policy for homework will be put in place: **20% penalty for up to 3 days late, 0 points later than 3 days.**

Communication
- You are more than welcome to ask the instructor and assistants questions as often as you want, and we will always be happy to help.
- The amount of help provided will be directly proportional to the amount of time left before the deadline. Please don't wait until the day before an assignment is due to see us; it'll be too late for us to provide help and too late for you to truly learn the material.
- Please do not ask at the end of the semester to find creative ways to increase your grade. If you suspect that you are not doing well, talk with the instructor to rectify the situation as quickly as possible so that you will have a good grade at the end of the semester.

CS 556 Goals and Assessment

At a high level, the instructor's goals for this course are to give students a rigorous introduction to the foundations of machine learning, including but not limited to frequently used tools in linear algebra, calculus, probability, and widely applied methods such as linear regression and support vector machines. In addition, this course provides hands-on training on implementing these algorithms via python from scratch. Students will be trained to use popular python libraries such as numpy, scipy and matplotlib.

Course Outcomes:
This course will develop students' ability to understand the foundations of machine learning and the practical implementations. Students will also receive hands on training on trending topics such as large-scale optimization and recommender systems.

- apply basic concepts in linear algebra to problems in machine learning
- apply principal component analysis to analyze high-dimensional data
- apply gradient descent to solve general optimization problems
- apply linear regression to solve real-world problems
- use numpy to solve machine learning problems

Approximate Weekly Schedule (subject to revision):

Week	Topics	Date
0	Introduction and Course Overview	01/27/2025
1	Vectors and Matrices	01/27/2025
2	System of Linear Equations	02/03/2025
3	Vector Spaces and Subspaces	02/10/2025
4	Orthogonality and Projections	02/18/2025
5	Matrix Decomposition	02/24/2025
6	Principle Component Analysis	03/03/2025
7	Exam 1	03/10/2025
8	Derivatives + Optimization	03/24/2025
9	Gradient Descent	03/31/2025
10	Probability Theory	04/07/2025
11	Probability Distributions	04/14/2025
12	Exam 2	04/21/2025
13	Linear Regression	04/28/2025
14	Logistic Regression	05/05/2025

ACADEMIC INTEGRITY

Graduate Honor System

Enrollment into the graduate class of Stevens Institute of Technology signifies a student's commitment to the Honor System. Accordingly, the provisions of the Stevens Honor System apply to all graduate students in coursework and Honor Board proceedings. It is the responsibility of each student to become acquainted with and to uphold the ideals set forth in the Honor System Constitution. More information about the Honor System including the constitution, bylaws, investigative procedures, and the penalty matrix can be found online at https://web.stevens.edu/honor/.

The following pledge shall be written in full and signed by every student on all submitted work (including, but not limited to, homework, projects, lab reports, code, quizzes and exams) that is assigned by the course instructor. No work shall be graded unless the pledge is written in full and signed.

"*I pledge my honor that I have abided by the Stevens Honor System*."

Reporting Honor System Violations

Students who believe a violation of the Honor System has been committed should report it within ten business days of the suspected violation. Students have the option to remain anonymous and can report violations online at https://www.stevens.edu/honor.

LEARNING ACCOMMODATIONS

Stevens Institute of Technology is dedicated to providing appropriate accommodations to students with documented disabilities. The Office of Disability Services (ODS) works with graduate and graduate students with learning disabilities, attention deficit-hyperactivity disorders, physical disabilities, sensory impairments, psychiatric disorders, and other such disabilities in order to help students achieve their academic and personal potential. They facilitate equal access to the educational programs and opportunities offered at Stevens and coordinate reasonable accommodations for eligible students. These services are designed to encourage independence and self-advocacy with support from the ODS staff. The ODS staff will facilitate the provision of accommodations on a case-by-case basis.

Disability Services Confidentiality Policy

Student Disability Files are kept separate from academic files and are stored in a secure location within the Office of Disability Services. The Family Educational Rights Privacy Act (FERPA, 20 U.S.C. 1232g; 34CFR, Part 99) regulates disclosure of disability documentation and records maintained by Stevens Disability Services. According to this act, prior written consent by the student is required before our Disability Services office may release disability documentation or records to anyone. An exception is made in unusual circumstances, such as the case of health and safety emergencies.

For more information about Disability Services and the process to receive accommodations, visit https://www.stevens.edu/office-disability-services. If you have any questions please contact: Phillip Gehman, the Director of Disability Services Coordinator at Stevens Institute of Technology at pgehman@stevens.edu or by phone 201-216-3748.

INCLUSIVITY

Name and Pronoun Usage

As this course includes group work and in-class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect. This includes the ability for all students to have their chosen gender pronoun(s) and chosen name affirmed. If the class roster does not align with your name and/or pronouns, please inform the instructor of the necessary changes.

Inclusion Statement

Stevens Institute of Technology believes that diversity and inclusiveness are essential to excellence in academic discourse and innovation. In this class, the perspective of people of all races, ethnicities, gender expressions and gender identities, religions, sexual orientations, disabilities, socioeconomic backgrounds, and nationalities will be respected and viewed as a resource and benefit throughout the semester. Suggestions to further diversify class materials and assignments are encouraged. If any course meetings conflict with your religious events, please do not hesitate to reach out to your instructor to make alternative arrangements.

You are expected to treat your instructor and all other participants in the course with courtesy and respect. Disrespectful conduct and harassing statements will not be tolerated and may result in disciplinary actions.