COLLEGE OF ENGINEERING
Systems & Industrial Engineering

SIE 449/549: Optimization for Machine Learning
Spring 2026

Instructor Contact Information

Dr. Erfan Yazdandoost Hamedani (erfany@arizona.edu)
Office Hours: Monday 11am-12pm via Zoom (in-person by appointment)
Office: ENGR 321
Zoom Meeting ID for office hours: https://arizona.zoom.us/j/84806268054

The instructor will be available to answer questions and/or discuss course materials during the office hours or by appointment. Office hours for online students will be offered through Zoom, at the same time as on-campus students. Email communication is preferred when the instructor is on travel.

Time and Location

Tue, Thu 11:00 AM - 12:15 PM
Location: Richard A. Harvill Building, Room 102 (in-person class)

Class Recordings

The class will be recorded using Panopto and/or Zoom and will be uploaded on D2L website. If you have any questions or concerns about the recording, please contact the instructor. For lecture recordings, which are used at the discretion of the instructor, students must access content in D2L only. Students may not modify content or re-use content for any purpose other than personal educational reasons. All recordings are subject to government and university regulations. Therefore, students accessing unauthorized recordings or using them in a manner inconsistent with UArizona values and educational policies are subject to suspension or civil action.

Course Website: You need to check https://d2l.arizona.edu/ at least once per day for lecture notes, homework assignments, project instructions, supplemental readings, grades, etc.

Course Description

This course will provide senior undergraduate and graduate students an introduction to mathematical nonlinear optimization with applications in machine learning. This course will involve analysis of optimization algorithms, in particular, scalability of algorithms to large datasets will be discussed in theory and in implementation. The fundamental algorithms for nonlinear optimization are studied and applied to supervised learning models, including but not limited to nonlinear regression, logistic regression, and support vector machines. Students will write their own implementation of the algorithms in the MATLAB/Python programming language and explore their performance on realistic data sets.

Course Prerequisites

SIE 270 – Mathematical Foundations of Systems and Industrial Engineering, or equivalent knowledge of linear algebra (systems of linear equations, matrix methods for systems of linear equations).
SIE 340 – Deterministic Operations Research, or equivalent knowledge of linear programming.
SIE 305 – Introduction to Engineering Probability and Statistics is recommended but not required.

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Course Objectives and Learning Outcomes

This course aims to teach engineering students the application of optimization methods to solve machine learning problems. Students will:

- Understand and characterize optimal solutions for nonlinear optimization.
- Learn fundamental algorithms for unconstrained optimization.
- Specialize optimization methods for machine learning.
- Gain practical skills in implementing these algorithms in MATLAB/Python.
- Explore the trade-offs between time and accuracy in machine learning methods.

Graduate students will also:
- Delve deeper into theoretical foundations of optimization.
- Conduct comprehensive literature reviews for the course project.
- Implement advanced optimization methods in their course projects.
- Demonstrate proficiency in advanced optimization software tools.

Reading Materials

Lecture notes will be provided and can be downloaded from D2L course website.
Recommended reference books:

- Beck, Amir. *Introduction to nonlinear optimization: Theory, algorithms, and applications with Python and MATLAB, Second Edition*. Society for Industrial and Applied Mathematics, 2023.
- Beck, Amir. *First-order methods in optimization*. Society for Industrial and Applied Mathematics, 2017.
- Shapiro, Alexander, Darinka Dentcheva, and Andrzej Ruszczynski. *Lectures on stochastic programming: modeling and theory*. Society for Industrial and Applied Mathematics, 2021.

Grading Scale and Policies

Homework (25%): 4-6 sets

- The main purpose is to practice the skills needed to meet the learning outcomes for this course.
- Homework assignments and due time will be posted in the Assignments section on D2L.
- 50% of the grade will be reduced for up to 24-hour late submission.
- No grade will be given for more than 24 hours late submission.
- Please communicate and coordinate any extension request directly with your instructor before the due dates. Late requests will not be accommodated.
- Graduate students (SIE 549): Extra advanced problems in each homework for graduate students.

In-class Assignments (5%): To ensure an engaged and interactive learning environment, in-class assignments will occur at random class sessions. To account for unforeseen circumstances or challenging times, one lowest grade will be dropped. There will be no make-up for missed in-class assignments.

- If you attempt to solve the in-class assignment, regardless of whether the answer is correct or not, you will receive 100%, otherwise you will receive 50% as a participation score.
- Distance and online students are required to watch the recorded lecture videos and have until the next day (before midnight) to upload their solutions to D2L.

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Midterm exam (30%): Tentative time: Thursday, March 5, during the class.

- The exam will be based on the material covered during lectures, homework, and the materials on D2L. More details will be given in class.
- Online students will take the exam via Zoom, and their camera must remain on throughout the exam. Preferably, they take the exam at the scheduled class time, but they can arrange an alternative time if necessary.

Class project (40%): Presentation (20%); Final report (20%)

- Students will work in groups of 2 to 3 with the prior consent of the instructor. All team members should be enrolled in SIE 449, or all enrolled in SIE 549. Online and Distance-learning students may join a group or complete the project individually.

- **Objective**: Each group should implement three optimization algorithms for training a classification task and deploy on a tinyML device to test.

- Students will submit a report and present their final demonstration in class at the time specified in the lecture schedule table. Distance-learning students may submit and present to the instructor and/or class via Zoom before the last day of class for the final project presentation.

- Final project report is expected to be a PDF file in a journal format (template will be provided), describing 4 What (i.e., what is the problem, what has been done, what needs to be done, what are the results/conclusions), and 1 Why (i.e., why it is important).

- Graduate students (SIE 549): Implement three or more optimization methods for training a neural network for an image classification task, deploy on a tinyML device, and compare the methods empirically and theoretically.

- **Handling Inactive Team Members**: If a team member is not fulfilling their responsibilities or is unresponsive, the team should address the issue early on. If they cannot resolve it internally, they must inform the instructor promptly. The instructor may, if necessary, provide alternative arrangements or assignments to ensure the affected team can continue its progress. If the problem persists and is not rectified, the instructor reserves the right to assess individual contributions separately. End-of-semester complaints will not be considered, and the entire team will be penalized for the team member's lack of contribution.

Regrading: If you feel that an error has been made in the grading, you may request a regrade in a written form outlining the potential error and submitted to the instructor via email within one week of it being returned (please attach the scanned copy of homework/exam). This timetable will be strictly adhered to.

Final grade: The final letter grade will be distributed as follows: A: 90-100; B: 80-89.9; C: 70-79.9; D: 60-69.9; E: ≤59.9. Requests for incompletes (I) and withdrawal (W) must be made in accordance with university policies which are available at http://catalog.arizona.edu/policy-type/grade-policies.

Guide to Success:

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1. Spend 5 minutes before each class to preview what we are about to learn.

2. Come to class and take notes by hand.

3. Use the textbook to read more examples and details about each topic.

4. Do homework without using solved examples as a guide.

5. Teach material to a real or imagined audience. In trying to explain concepts in a way that others can understand, you become aware of the details that are not entirely clear.

6. Go to office hours. Office hours are for any students who want to talk to the professor about Homework, Classwork, Learning Strategies, Research Opportunities and Career Goals.

Scheduled Topics

1. Review mathematical preliminaries

2. Optimality conditions

3. Convex optimization

4. Data fitting and denoising

5. Gradient and accelerated gradient methods

6. Stochastic optimization

7. Variance reduction methods

8. Subgradient Method

9. Projected/proximal gradient method

Classroom Attendance

- If you must miss the equivalent of more than one week of class, you should contact the Dean of Students Office DOS-deanofstudents@email.arizona.edu to share documentation about the challenges you are facing.
- Non-attendance for any reason does **not** guarantee an automatic extension of due date or rescheduling of examinations/assessments. Please communicate and coordinate any request directly with your instructor before the due dates or exam days. Late requests will not be considered. Note that there will be no make up for in-class assignments if you not attend the class.

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Generative AI use

In this course, you may use generative AI tools, like ChatGPT, to assist with homework, provided they are properly cited, but you must not copy and paste directly from them. Be aware that AI-generated mathematical solutions may contain errors, so always verify your work. Consult with the instructor if you're unsure about appropriate use. AI cannot be used for quizzes, project, or exams.

Academic advising

If you have questions about your academic progress this semester, please reach out to your academic advisor (https://advising.arizona.edu/advisors/major). Contact the Advising Resource Center (https://advising.arizona.edu/) for all general advising questions and referral assistance. Call 520-626-8667 or email to advising@.arizona.edu

Life challenges

If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office can be reached at 520-621-2057 or DOS-deanofstudents@email.arizona.edu.

Physical and mental-health challenges

If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520-621-9202. For After Hours care, call (520) 570-7898. For the Counseling & Psych Services (CAPS) 24/7 hotline, call (520) 621-3334.

Absence and Class Participation Policy

Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures and discussion section meetings. Absences may affect a student's final course grade. If you anticipate being absent, are unexpectedly absent, or are unable to participate in class online activities, please contact me as soon as possible. To request a disability-related accommodation to this attendance policy, please contact the Disability Resource Center at (520) 621-3268 or drc-info@email.arizona.edu. If you are experiencing unexpected barriers to your success in your courses, the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office is located in the Robert L. Nugent Building, room 100, or call 520-621-7057.

The UA's policy concerning Class Attendance, Participation, and Administrative Drops is available at: http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop. The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, http://policy.arizona.edu/human-resources/religious-accommodation-policy. Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: https://deanofstudents.arizona.edu/absences

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Classroom Behavior Policy

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (i.e. texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

Safety on Campus and in The Classroom

For a list of emergency procedures for all types of incidents, please visit the website of the Critical Incident Response Team (CIRT): https://cirt.arizona.edu/case-emergency/overview

Also watch the video available at
https://arizona.sabacloud.com/Saba/Web_spf/NA7P1PRD161/common/learningeventdetail/crtfy00000000000003560

Threatening Behavior Policy

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to one's self. See: http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students.

Accessibility and Accommodations

Our goal in this classroom is that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please let me know immediately so that we can discuss options. You are also welcomed to contact Disability Resources (520-621-3268) to establish reasonable accommodations. For additional information on Disability Resources and reasonable accommodations, please visit http://drc.arizona.edu/. If you have reasonable accommodations, please plan to meet with me by appointment or during office hours to discuss accommodations and how my course requirements and activities may impact your ability to fully participate.

Code of Academic Integrity

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See:

http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity.

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The University Libraries have some excellent tips for avoiding plagiarism available at:

http://new.library.arizona.edu/research/citing/plagiarism

Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA email to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student email addresses. This conduct may also constitute copyright infringement.

UA Nondiscrimination and Anti-harassment Policy

The University is committed to creating and maintaining an environment free of discrimination, http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

Name and pronoun usage statement. This course supports elective gender pronoun use and self-identification; rosters indicating such choices will be updated throughout the semester, upon student request. As the course includes group work and in-class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect.

Inclusive Excellence is a fundamental part of the University of Arizona's strategic plan and culture. As part of this initiative, the institution embraces and practices diversity and inclusiveness. These values are expected, respected and welcomed in this course.

Additional Resources for Students

UA Academic policies and procedures: http://catalog.arizona.edu/2015-16/policies/aaindex.html
Student Assistance and Advocacy information: http://deanofstudents.arizona.edu/student-assistance/students/student-assistance
Office of Diversity: : http://diversity.arizona.edu
Campus Health: http://www.health.arizona.edu/counseling-and-psych-services

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Subject to Change Statement

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.