ECE 3251: Optimization in Information System Fall 2026 Syllabus

August 13, 2026

Summary

ECE 3251 is an introduction to the fundamentals of optimization with a focus on algorithms and applications in signal processing, control systems, machine learning, and robotics. The central theme of the course is the use of linear algebra and optimization in posing and solving practical information processing problems. Upon successful completion of this course you should be able to:

- pose real-world engineering tasks as optimization problems and recognize common kinds of optimization problems when you encounter them,
- efficiently compute the solutions to large-scale optimization problems, and
- understand how to combine data with mathematical models to solve practical engineering problems.

Prerequisites

The main prerequisite for this course is an introductory class in linear algebra and multivariable calculus (MATH 2551 or equivalent), with a recommended minimum grade of B. Much of the course will involve the use of matrices and vectors, so students should be comfortable using matrices to represent systems of equations and taking gradients of functions with multiple variables. Familiarity with eigenvalues, eigenvectors, and eigenvalue decompositions will be extremely beneficial. Additionally, students should have basic Python programming skills (CS 1301 or equivalent).

Instructor and the Office Hours

Pan Li
panli@gatech.edu
Office hours: TBD Location: TBD

Teaching Assistant and the Office Hours

TBD

Grading

- **Homeworks (40%):** There will be ≈ 8 homework assignments. See further details below.
- **Two Midterm quizzes (30%):** This is tentatively scheduled for xxx and xxx in class.
- **Final exam (30%):** This is tentatively scheduled for xxx.

Homework

Homework will be assigned either weekly or biweekly, with solutions submitted online through Canvas. Homework is typically due on Fridays at 11:59 PM. Late submissions are accepted until the following Monday at 11:59 PM, but will only receive 80% of the earned credit.

It is recommended that homework be typed and compiled into a PDF format. A LaTeX template is available on Canvas for your convenience. Alternatively, we also accept photos of handwritten homework. However, please ensure that handwritten work is clear and legible, as the TA/grader reserves the right to withhold credit for unreadable submissions, even if the solutions are correct.

The homework assignments will be hard; many of them will require significant amounts of time and effort to complete. But this is really where most of the learning takes place. You will get out of the assignments what you put into them. Students who complete all of the assignments in full will be rewarded with a deep understanding of the role that linear algebra and optimization play in data science, machine learning, robotics, and controls (among other things). Effectively, homework is worth much more than 40% of your grade. In teaching many courses over the years, the instructors **have never seen a case where a student does not put effort into the homework assignments but does well on the exams**.

Students are *strongly* encouraged to discuss homework problems with one another. However, **each student must prepare and turn in their own solutions written in their own words**. **Cases where solutions appear to be identical or nearly identical will be immediately referred to the Office of Student Integrity.**

Unauthorized use of any previous semester course materials, such as tests, quizzes, and homework, is prohibited in this course. Furthermore, redistributing materials from this semester is also prohibited. For any questions involving these or any other Academic Honor Code issues, please consult me or www.honor.gatech.edu.

Textbook

There is no required text. Extensive course notes will be provided that cover all of the required material in full. These will be posted as they become available at the course website. Textbooks

that you might find useful (and from which a large portion of the notes were sourced) include:

- Boyd and Vanderberghe: *Convex Optimization*
  Available at http://amzn.to/2RBbH30,
  also available as a free pdf at http://web.stanford.edu/~boyd/cvxbook/
- Bertsekas, Nedic, and Ozdaglar: *Convex Analysis and Optimization*
  http://amzn.to/2C6cxek
- Nocedal and Wright: *Numerical Optimization*
  http://amzn.to/2VEpmp0
- Ben-Tal and Nemirovski: *Lectures on Modern Convex Optimization*
  http://amzn.to/2RDoKRx
- Luenberger: *Optimization by Vector Space Methods*
  http://amzn.to/2GZs0Cx

Course Objectives

Upon successful completion of this course, students should:

1. Be able to recognize and differentiate between common classes of optimization problems.
2. Have an understanding of how duality can be exploited to develop alternative approaches to solving an optimization problem.
3. Be able to implement and analyze the convergence properties of common iterative optimization algorithms.
4. Be able to translate practical engineering problems into optimization problems (modeling).

Course Expectations and Guidelines

Academic integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit www.catalog.gatech.edu/policies/honor-code. Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Redistributing materials from this course and/or using external sites for assistance (e.g., contributing to test banks, CourseHero, Chegg, or similar sites) is prohibited.

Collaboration and group work

Students are *strongly* encouraged to discuss homework problems with one another. However, **each student must write up and turn in their own solutions written in their own words**. **Cases where solutions appear to be identical or nearly identical will be immediately referred to the Office of Student Integrity.**

Exams will be completed during specified time frames. If you expect to miss an exam, please contact me as soon as you realize this so we can make alternative arrangements.

Accommodations for students with disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or disabilityservices.gatech.edu, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail us as soon as possible in order to set up a time to discuss your learning needs.

Student-Faculty expectations agreement

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, we encourage you to remain committed to the ideals of Georgia Tech while in this class. See www.catalog.gatech.edu/rules/22 for an articulation of some basic expectation that you can have of us and that we have of you.

Outline

The outline below should be treated as an approximation; it is subject to (hopefully small) changes.

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1. The method of least squares
   (a) Applications and formulation: Regression and interpolation
   (b) Solving least squares problems (Review of multivariable calculus)
   (c) Understanding least squares problems (Review of linear algebra)
   (d) Computing least squares solutions
2. Unconstrained optimization
   (a) Convexity
   (b) Gradient descent
   (c) Acceleration: Conjugate gradients, the heavy ball method, Nesterov's optimal method
   (d) Newton's method and quasi-Newton methods

(e) Non-smooth optimization

(f) Stochastic gradient descent

(g) Applications: Approximation, filter design, tracking, logistic regression, neural networks

3. Constrained optimization

   (a) Lagrange duality

   (b) The KKT conditions

   (c) Algorithms for constrained optimization

   (d) Linear programs

   (e) Quadratic programs

   (f) Second order cone programs

   (g) Semidefinite programs

   (h) Applications: Support vector machines, portfolio optimization, feature selection, optimal power flow, recommendation systems

4. Beyond convex optimization

   (a) Integer programming

   (b) Dynamic programming

   (c) Optimization on graphs

   (d) Optimization in game theory

   (e) Applications: Error correction, optimal control, reinforcement learning, generative adversarial networks

Throughout the course, we will be using different applications to motivate the theory. These will cover some well-known (and not so well-known) problems in signal and image processing, communications, control, machine learning, and statistical estimation (among other things).