Spring 2026: EE 5720X - Introduction to Nonconvex Optimization

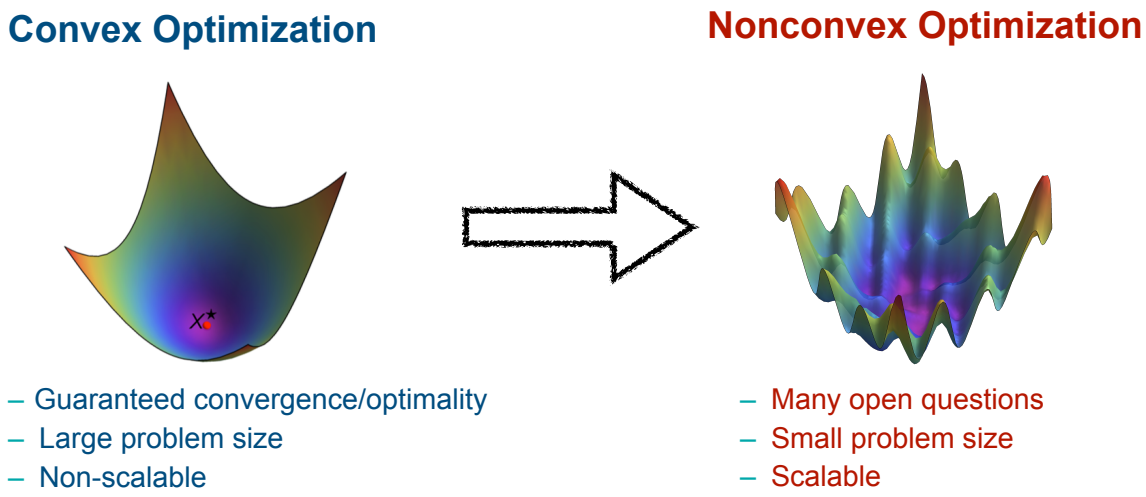
Instructor

Shuang Li, lishuang@iastate.edu. Meeting times: MWF 2:15-3:05 pm.

Course Description

This course provides an introduction to the theory and algorithms for solving nonconvex optimization problems arising in Signal Processing and Machine Learning. It begins with a review of key concepts from multivariable calculus (e.g., gradient, Hessian, Jacobian, Taylor series) and linear algebra, followed by a brief overview of convexity. The course then covers topics such as optimization landscape analysis, trust-region methods, cubic regularization, gradient-based and distributed algorithms, and Riemannian optimization. Applications include sparse recovery, matrix and tensor analysis, and neural network training, etc. Students will gain hands-on experience implementing algorithms in MATLAB or Python. The course covers not only the theoretical aspects but also practical applications in engineering and Machine Learning.

Prior completion of EE 5710 (Convex Optimization) is preferred but not required.



Why Take This Course?

- Develop both theoretical understanding and hands-on experience in modern nonconvex optimization.
- Gain intuition into the geometry and convergence of complex optimization problems.
- Build algorithms applicable to signal processing, machine Learning, and other engineering domains.

Grading Scale

Homework (50%); course project (30%); one final take-home exam (20%).

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Meeting times: MWF 2:15-3:05pm. Location: Coover 1011 Office hours: TBD

Course Materials

The course will primarily be based on the lecture notes and slides provided. However, the following reference books and articles are recommended for further reading and a deeper understanding of the topics covered.

- Boyd and Vandenberghe, Convex optimization
- Chong and Zak, An introduction to optimization: with applications to machine learning
- Nocedal and Wright, Numerical optimization
- Wright and Yi, High-dimensional data analysis with low-dimensional models: Principles, computation, and applications
- Chi, Lu, and Chen, Nonconvex optimization meets low-rank matrix factorization: An overview

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Schedule (tentative)

- Lecture 1 - Introduction (0.5 week)
- Lecture 2 - Foundations – Linear Algebra & Multivariable Calculus (1.5 weeks)
- Lecture 3 - Brief Review on Convexity (1 week)
- Lecture 4 - Introduction on Nonconvex Optimization in SP & ML (3 weeks)
- Lecture 5 - Gradient Descent & Hybrid Methods, interior-point method (2 weeks)
- Lecture 6 - Trust-Region Method (1 week)
- Lecture 7 - Cubic Regularization Method (1 week)
- Lecture 8 - Distributed Optimization (2 weeks)

- Lecture 9 - Riemannian Optimization (1 week)
- Lecture 10 - Course Review (1 week)

Absenteeism

Attendance in class is required unless the student has an official excused absence.

Homework

The homework assignments will be announced on Canvas and must be submitted on Canvas. Late homework will receive only 70% of the full credits. Homework submitted more than **two days** late will **not** be accepted. Reasonable exceptions will be made for emergency situations. I encourage working in groups on the homework, but the final work turned in must be your own.

Grading scale

Homework (50%); Course project (30%); one final take-home exam (20%). The following grading scale will be used to assign final letter grades.

A (93+)	A^- (90 to 93)		- All grading errors
B^+ (87 to 90)	B (83 to 87)	B^- (80 to 83)	need to be corrected
C^+ (77 to 80)	C (73 to 77)	C^- (70 to 73)	before the final grade
D^+ (67 to 70)	D (63 to 67)	D^- (60 to 63)	is posted.
F (below 60)			

Free Expression

Iowa State University supports and upholds the First Amendment protection of freedom of speech and the principle of academic freedom in order to foster a learning environment where open inquiry and the vigorous debate of a diversity of ideas are encouraged. Students will not be penalized for the content or viewpoints of their speech as long as student expression in a class context is germane to the subject matter of the class and conveyed in an appropriate manner.

Academic Dishonesty

- The class will follow Iowa State University's policy on academic dishonesty. Anyone suspected of academic dishonesty will be reported to the Office of Student Conduct in the Dean of Students Office (studentconduct.dso.iastate.edu/).
- Students are encouraged to work together on homework problems to develop an understanding of the material. However, each student must: (1) generate & turn in his/her own individual solutions that reflect his/her own individual level of understanding, and (2) cite any external resources used to answer a homework question (outside of the textbook, lecture notes, and other students in the course).
- In addition, students may not copy homework solutions from another student or from any other source, or consult homework or exam solutions from previous offerings of this course.

Mental Health and Well-Being Resources

We're committed to your success and well-being at Iowa State. As a Cyclone, you can access 24/7 resources, services, and people dedicated to helping you achieve your goals and be your best in and out of the classroom. Whether you need academic support or just someone to talk to, we're here for you at Cyclone Support (cyclonesupport.iastate.edu).