Instructor: Dr. Lu Zhang, lz2784@columbia.edu

Lecture: MW, 1:10 pm – 2:25 pm

Classroom: TBA

Office Hours: MW (284A, Mudd), 3:00 pm – 4:00 pm or by appointment

TA: TBA

Course Description: Numerical optimization is a graduate-level course designed for graduate students from the various programs in SEAS. Senior and Junior students should consult with their advisors and with the instructor before taking this course. Here is the tentative schedule of this course, and necessary amendments will be made as it advances:

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week one (Sep. 9th – 10th) : No class

week two: Mathematical Preliminaries

(1) review some important notations and results from calculus, linear algebra

week three – week four : Unconstrained Optimization

(1) global and local optima (2) optimality conditions (3) Quadratic functions

week four – week five : Least Squares

(1) overdetermined systems (2) data fitting (3) denoising (4) nonlienar least squares

week six – week seven: Gradient Method

(1) Steepest-Descent method (2) Gradient method (3) Diagonal Scaling (4) Gauss-Newton Method (5) Convergence analysis (5) Newton's Method

week eight – week ten (No class on Nov. 1st) : Convexity

(1) Convex Sets (2) Algebraic Operations (3)Convex Hull (4) Convex Cones (5) Convex functions (6) Charaterizations of Convex Functions (7). Operations preserving Convexity

week eleven – week twelve (No class on Nov. 24th): Convex Optimization

(1) Definition (2) Orthogonal projection operator (3) Stationarity (4). Gradient Projection Method

week thirteen: Linearly constrained problems

(1) Seperation and Alternative Theorem (2) optimality conditions (3) KKT conditions

week fourteen: The KKT Conditions

(1) Inequality and Equality Constrained Problems (2) The Convex Case (3). Constrained least squares

week fifteen – week sixteen Dec. 12 – Dec. 23

Project Presentation

Textbooks: No textbook is required for this course, the lectures notes will be provided before lectures. However, students are encouraged to read the following

- Stephen Boyd, and Lieven Vandenberghe, *Convex Optimization*.
- Igor Griva, Stephen G. Nash, and Ariela Sofer, *Linear and Nonlinear Optimization*.

- Jorge Nocedal, and Stephen J. Wright, *Numerical Optimization*.
- Amir Beck, *Introduction to Nonlinear Optimization: Theory, Algorithms, and Applications with MATLAB*.

Prerequisites: calculus, including multivariate; linear algebra; introduction to numerical analysis (optional); elementary level of programming knowledge is required.

Important Dates: The following list does not replace the Columbia University Academic Calendar.

- Thursday, Sep. 9, First day of class
- week fifteen – sixteen, Dec 13 – 23, project presentation

Policy on out-of-sequence exams

We are only able to accommodate a limited number of out-of-sequence exams. We may approve out-of-sequence exams in the following cases:

1. A documented medical excuse.
2. A university-sponsored event such as an athletic tournament, a play, or a musical performance. Athletic practices and rehearsals do not fall into this category. Please have your coach, conductor, or other faculty advisor contact your instructor.
3. A religious holiday.
4. Extreme hardship such as a family emergency.

Scheduled out-of-sequence exams (those not arising from emergencies) must be taken before the actual exam. Makeups must occur within one week of the regularly scheduled exam, otherwise a zero score will be given.

Grading: The final grade will be computed with the following weights. for each category. Percentage will be converted to a letter according to the chart at right. These cutoffs may be adjusted downward—they will never be made more strict—but not significantly.

Category	Weight
Homework	60%
Final project	40%

Grade	Minimum %
A+	96
A	90
A-	85
B+	80
B	75
B-	70
C+	65
C	60
C-	50
D	40
F	0

A note on grades: Please refer the SEAS Bulletin for policy regarding the assignment of W, UW, and INC grades.

Canvas The chief means of communication for this course will be the course Canvas (aka Courseworks) site, accessed through https://courseworks2.columbia.edu/. Students are expected to check this for up-to-date assignments—including material separate from the text—and announcements.

Piazza Piazza is an online bulletin board reached through Canvas. This is the place to start with any questions about the course—content, logistics or otherwise—as it will likely produce the quickest reply.

Homework Homework will be given on a bi-weekly basis, depending on the advancement in the material. Please see future announcements regarding the mode of submission. **No late submission will be allowed.** If a certain homework set could not be submitted due to exceptional reasons (same categories as for out-of-sequence exams, see above), the student will be excused from submitting it all together.

Technology Technology can play an important role in the learning of mathematics, and as such, graphing, scientific calculators, and computer algebra systems (CAS) are permitted for class and homework, though they will not be required.

MATLAB Coding problems in homework will require you to use MATLAB. You can get MATLAB here https://cuit.columbia.edu/content/matlab (other programming languages are also allowed for your homework)

Academic Honesty Guidelines regarding cheating and plagiarism are laid out in the SEAS Bulletin and will be adhered to strictly. Collaboration is permitted, in fact encouraged, for home and class assignments; however, all submitted assignments must be written up independently and represent the student's own words and understanding.