

MATP6610/4820 • Computational Optimization • Spring 2020

Time: 2:00-3:50pm TF Location: SAGE4101

Instructor: Yangyang Xu
Email: xuy21@rpi.edu
Phone: 518-276-6902
Office: Amos Eaton 310
Office hours: TF 4:00pm – 5:00pm or By Appointment
Course page: <https://xu-yangyang.github.io/MATP6610.html>

Teaching Assistant: Chang Liu
Email: liuc10@rpi.edu
Office: Amos Eaton 424
Office hours: W 11:00am – 12:00pm or By Appointment

Course Objective and Topics

This course is to introduce optimization methods and applications. An emphasis will be placed on understanding and implementing optimization algorithms, including gradient-type methods, Newton-type methods, derivative free methods, primal-dual type methods. The following topics will be covered.

1. Concepts of numerical algorithm and convergence
2. Fundamentals of unconstrained optimization
3. Gradient type methods: steepest gradient descent, projected gradient, conjugate gradient, proximal gradient, and Nesterov's accelerated proximal gradient methods
4. Newton type methods: Newton's method, quasi-Newton method, and Gauss-Newton method
5. Derivative free methods: coordinate descent method
6. Theory of functional constrained optimization: Karush-Kuhn-Tucker (KKT) conditions and Lagrangian duality
7. Simplex method and Interior-point methods for linear programming
8. Ellipsoid method and cutting-plane methods
9. Penalty methods, barrier function methods, and augmented Lagrangian method
10. Alternating direction method of multipliers and application in imaging and statistics
11. Trust-region method (**if time permits**)

Learning outcomes

After taking the course, **undergraduate students are expected to know:**

1. how to estimate the per-iteration complexity, namely, counting the number of arithmetic operations
2. how to find stationary points of a function by formulating the first-order optimality condition
3. how to analytically check local and/global optimality of a given point for an unconstrained problem
4. how to numerically implement each optimization method that is taught and verify if a computed point is approximately a local/global optimal solution
5. how to apply optimization methods to applications such as in imaging, finance, and machine learning

In addition to the above, **graduate students are expected to also know:**

1. how to analyze the convergence and/or convergence rate of certain iterative methods
2. how to formulate the KKT systems of a functional constrained problem
3. how to choose appropriate optimization methods depending on the structure of applications

Prerequisites

Multi-variable calculus, linear algebra, and some experience of Matlab.

Textbooks

- *Numerical Optimization* by Jorge Nocedal and Stephen Wright, 2006
- *Lectures on Convex Optimization* by Yurii Nesterov, 2018
- *Constrained Optimization and Lagrange Multiplier Methods* by Dimitri P. Bertsekas, 1996.
- *Introduction to Mathematical Programming* by Michael Kupferschmid
- *An Introduction to Optimization* by Edwin K. P. Chong and Stanislaw H. Zak, 4th Edition, 2013

Homework and exams

- **Homework:** roughly once every 1.5 weeks and will be due in class. The homework will be posted on the course page <https://xu-yangyang.github.io/MATP6610.html>
- **Exam:** one mid-term exam (tentative time: 2:00-3:50pm on Feb. 28, 2020)
- **Project:** one final project (to be assigned after mid-term)

Evaluation and Grading Policy

All students will be evaluated and graded by the following policy.

1. **Evaluation:** homework 40%, mid-term exam 30%, and the final project 30%.
2. **Grading of homework:**
 - For each homework, a random portion of assigned problems will be graded;
 - The score composes of two parts: completeness (50%, check if all problems are finished), and correctness (50%, check if graded problems are done correctly)
3. **Late homework:**
 - Homework that is late up to one day will be penalized by 30%;
 - Homework that is late between one day and two days will be penalized by 50%;
 - No homework will be accepted if it is late more than two days;
 - Late homework needs be directly handed to the instructor or slide under the instructor's office door and notify the instructor by email.
4. **Exam:**
 - No early exam will be taken.
 - A make-up exam will be administered only at the discretion of the instructor in the event of a verifiable emergency. In the event of a verifiable emergency, the student must contact the instructor as soon as possible, and in any case, prior to the next regularly scheduled class.
5. **Project:** Each student is required to write the report and program individually. The project will be graded based on both the report and program code. **No late project will be accepted.**

Attendance

Attendance and participation in class is a vital part of the learning process. Regular class attendance is strongly encouraged. It is the students' responsibility to keep informed of any announcement, or policy changes made during scheduled classes.

Academic Integrity

Intellectual integrity and credibility are the foundation of all academic work. A violation of Academic Integrity policy is, by definition, considered a flagrant offense to the educational process. It is taken seriously by students, faculty, and Rensselaer and will be addressed in an effective manner.

If found responsible for committing academic dishonesty, a student may be subject to one or both types of penalties: an academic (grade) penalty administered by the professor and/or disciplinary action through the Rensselaer judicial process described in the Student Rights and Responsibilities Handbook.

Academic dishonesty is a violation of the Grounds for Disciplinary Action as described in the handbook. A student may be subject to any of the following types of disciplinary action should disciplinary action be pursued by the instructor: disciplinary warning; disciplinary probation; disciplinary suspension, expulsion and/or alternative actions as agreed on by the student and hearing officer. It should be noted that no student who allegedly commits academic dishonesty will be able to drop or change the grade option for the course in question and is not eligible to request an F examination for the course.

The academic integrity policy applies to all students, undergraduate and graduate, and to scholarly pursuits and research. Additionally, attempts to commit academic dishonesty or to assist in the commission or attempt of such an act are also violations of this policy.