MATH 651 Optimization Algorithms
Section 0101 Spring 2019

- Instructor: Dr. Jinglai Shen
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- Office: Math/Psyc 417
- Phone: (410) 455-2402
- Lectures: Mon and Wed, 5:30–6:45 pm, at Math/Psyc 105
- Office hours: Mon and Wed, 4:30–5:30 pm or by appointment
- Course web-page: http://www.math.umbc.edu/~shenj
- Prerequisites: linear algebra, multi-variable calculus, real analysis, and basic knowledge of optimization theory (Math 650) is recommended. MATLAB programming or other numerical software programming is needed.
- Recommended textbook: *Numerical Optimization* by Jorge Nocedal and Stephen J. Wright, 2nd Ed., Springer, 2006
- Other references:
  - D.P. Bertsekas. *Nonlinear Programming*, Athena Scientific, 2nd edition, 1999;
  - S. Boyd and L. Vandenberghe. *Convex Optimization*, Cambridge University Press, 2004;
  - O. Güler. *Foundations of Optimization*, Springer, 2010.
- Important dates:
  - No class on March 18–22 (spring break)
  - Last class: May 13, Monday

Course Description Optimization techniques are widely used in diverse areas, ranging from science and engineering to economics, finance, and social science. Most optimization problems arising from applications are large-scale and do not attain closed-form solutions, and thus they require numerical solvers. This course is an introduction to analysis and development of iterative numerical algorithms for continuous optimization problems, including both unconstrained and constrained optimization problems. Specific topics include line search methods (e.g., steepest descent and Newton's methods), trust region methods, conjugate gradient methods, gradient projection methods for convex optimization problems, as well as algorithms for certain representative optimization problems, such as linear programming (e.g., simplex and interior-point methods), quadratic programming, and least-squares problems. This course will also help you gain computational experience for solving optimization problems by writing and testing your numerical programs.

Detailed topics are:

- Introduction
- Unconstrained Optimization
  - Review of multi-variable calculus and optimality conditions (Chapter 2)
  - General line search methods: Wolfe conditions, and convergence properties (§3.1)
  - Steepest descent method, and convergence rate (§3.2)
  - Newton's method, and nonlinear equations (§3.4, Chapter 11)
  - Conjugate gradient methods (Chapter 5)
  - Quasi-Newton methods (Chapter 6)
  - Trust region methods (Chapter 4)
- Constrained Optimization
  - Optimality conditions: first-order and second-order conditions (Chapter 12)
  - Convex optimization (Chapter 12)
  - Gradient projection methods
- Linear Programming
  - Primal and dual formulations, and duality theory (Chapter 13)
  - Simplex and interior-point methods (Chapters 13-14)
- Quadratic Programming (Chapter 16)
- Least-Squares Problems (Chapter 10)

Please note that these topics are subject to change, depending on class progress.

Homework Biweekly homework will be assigned; each homework assignment contains theoretical questions (i.e., proofs) and numerical questions. Familiarity with numerical softwares, e.g., MATLAB, is required for solving numerical problems. Homework must be turned in by a specified date; *no late due will be accepted*. Please present your answers neatly and show all your work; answers without supporting work may not receive full credit.

Exams There will be one mid-term exam, and one final exam; both exams are take-home. More detailed policies will be announced later.

Grading Policy The grading scheme is as follows:

- Homework: 45%
- Mid-term exam: 25%
- Final exam: 30%

The letter grade will be computed based upon the numerical grade:

$$A : \geq 85; \quad B : 84 - 73; \quad C : 72 - 60; \quad D : 59 - 50; \quad F :< 50$$

Academic Integrity

- The UMBC Academic Integrity Statement:

  "*By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty, and they are wrong. Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal. To read the full Student Academic Conduct Policy, consult the UMBC Student Handbook, the Faculty Handbook, or the UMBC Policies section of the UMBC Directory [or for graduate courses, the Graduate School website]* ".

- All work in homework or an exam must be your own; collaborating on an exam is *not* permitted. Discussions with other students on homework problems are allowed and encouraged, but you should present your own work in the final turn-in; simply copying other people's work is a violation of UMBC's academic integrity code.

- If you must miss an exam due to a prior obligation, you must speak to the instructor *in advance* of the exam. If you must miss an exam due to an unforseen but valid reason, you must submit a written excuse. Failing to do so will result in loss of substantial points off the top in your make-up.