

# MATH 650 Foundations of Optimization

## Section 0101 Fall 2019

- Instructor: Dr. Jinglai Shen
- E-mail: shenj@umbc.edu
- 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: real analysis, linear algebra, multi-variable calculus
- Recommended textbook (but not required): *Foundations of Optimization* by Osman Güler, Springer, 2010
- Other references:
  - D.P. Bertsekas. *Nonlinear Programming*. Athena Scientific, Belmont, MA, 2nd edition, 1999
  - J.M. Borwein and A.S. Lewis. *Convex Analysis and Nonlinear Optimization*. CMS Books in Mathematics, Springer-Verlag, New York, 2000
  - A.P. Ruszczyński. *Nonlinear Optimization*. Princeton University Press, 2006
- Important dates:
  - No class on Sept. 2nd (Labor Day) and Nov. 27th (Thanksgiving)
  - Last class: December 9th, Monday

**Course Description** Optimization techniques are widely used in diverse areas, including engineering, operations research, economics and finance, statistics, and social science. They have also stimulated a deep and elegant mathematical theory which becomes the foundation of various efficient numerical optimization algorithms. This course treats the basic theory of continuous optimization in finite dimensional vector spaces. Fundamental techniques from multivariable calculus (e.g., differentiability, and the implicit function theorem) and convex analysis (e.g., convex sets/functions, and polyhedra theory) will be covered in this course. By exploring these techniques, unconstrained and constrained optimization problems will be discussed. Focused topics include the Lagrange multiplier approach, Fritz John and Karush-Kuhn-Tucker conditions, local and global optimality conditions, and duality theory.

Specific topics are:

- Solution Existence Theory of Finite-dimensional Continuous Optimization
- Unconstrained Optimization
  - Review of multi-variable calculus
  - Optimality conditions: first-order and second-order optimality conditions
- Equality Constrained Optimization
  - Implicit function theorem
  - Optimality conditions: first-order and second-order optimality conditions
- Fundamentals of Convex Analysis and Convex Optimization
  - Convex sets and convex functions
  - Basics of convex optimization: optimality conditions and sub-differential
  - Separation of convex sets: Euclidean projection and separation theorems
  - Convex polyhedra and polyhedral cones
  - Farkas' lemma and transposition theorems
- Inequality Constrained Optimization
  - Fritz John and KKT optimality conditions, constrained qualification
  - Second-order optimality conditions
- Duality Theory
  - Saddle point, and weak duality
  - Strong duality

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

**Homework** Biweekly homework will be assigned; each homework assignment contains both theoretical questions (i.e., proofs) and hand-computation 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 two mid-term exams and one final exam. Each mid-term exam mainly focuses on topics covered in that month, and the final exam is comprehensive with more focus on the last part of the class. Please note that calculators and other computing devices are *not* allowed in any exam.

**Grading Policy** The grading scheme is as follows:

- Homework: 30%
- Mid-term exams: 40% (20% for each)
- Final exam: 30% (the final is comprehensive)

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 wish to contest a graded exam, you must make an appeal within *one week* of the return date to the class. 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 unforeseen but valid reason (e.g. illness), you must submit a written excuse. Failing to do so may result in loss of substantial points off the top in your make-up.