

SE/EC/ME 724 Advanced Optimization Theory and Methods Course Information

Lecturer: Yannis Paschalidis, 8 St. Mary's St., Room 429, tel: x0434, yannisp@bu.edu, <http://sites.bu.edu/paschalidis/>. Office hours: Wed. 2-3 or by appointment arranged through email.

Time and place: MW 12:20-2:05, CAS 424.

Topics: This course focuses on nonlinear optimization and introduces some recent developments in the field. It complements SE/EC 524/674. The major topics we will cover are:

1. Theory and algorithms for nonlinear programming.
2. Large scale methods such as incremental gradient methods.
3. Modern Convex Optimization (e.g., Semidefinite programming, Conic Quadratic Programming, Robust Linear Programming).
4. Stochastic approximation algorithms.

These techniques have many applications in science and engineering. As various systems become more complex, controlling and optimizing their performance becomes increasingly important, hence, optimization is positioned as an indispensable and fundamental tool. In addition, optimization is becoming a critical tool in dealing with biological systems. Some representative applications include:

- Optimal routing in communication networks.
- Neural network training and applications in approximate dynamic programming techniques.
- Pattern recognition and classification.
- Optimal resource allocation in manufacturing and communication systems.
- Applications of semidefinite programming in combinatorial optimization, control theory, design of chips, and the derivation of performance bounds in controlled flexible manufacturing systems.
- Optimal portfolio selection in the finance industry.
- Estimation and system identification.
- Optimal control problems (e.g., rocket launching).
- Convex duality and its applications in large deviations theory.

- Applications of duality in microeconomic theory (e.g., pricing, equilibrium models, inverse equilibrium models).
- Traffic assignment and equilibrium in transportation networks.
- Drug design and molecular docking.
- Protein folding.

Prerequisites: The “official” prerequisite is SE/EC 524/674. What I view as very important is a working knowledge of Linear Algebra, Real Analysis, and some degree of mathematical maturity. The course will not depend heavily on material covered in SE/EC 524/674 but clearly it helps having taken that first.

Textbook: The required textbook for the course is:

[Ber] D.P. Bertsekas, *Nonlinear Programming*, Athena Scientific, 3rd Edition, 2016.

It covers most of the material on nonlinear programming we will cover and is available at the BU bookstore, Amazon, or other vendors.

We will also heavily depend on notes you should be taking in class and other material I will be distributing. Problem sets and some slides will be posted at <http://sites.bu.edu/paschalidis/> (under Courses).

Other books on these topics are:

On nonlinear programming:

[BSS] M.S. Bazaraa, H.D. Sherali, and C.M. Shetty, *Nonlinear Programming: Theory and Algorithms (2nd Ed.)*, Wiley, 1993.

[BTN01] A. Ben-Tal and A. Nemirovski, *Lectures on Modern Convex Optimization*, SIAM, 2001.

[Lue84] D.G. Luenberger, *Introduction to Linear and Nonlinear Programming, (2nd Ed.)*, Addison-Wesley, 1984.

[Lue69] D.G. Luenberger, *Optimization by vector space methods*, Wiley, 1969.

On linear programming and combinatorial optimization:

[BT] D. Bertsimas and J.N. Tsitsiklis, *Introduction to Linear Optimization*, Athena Scientific, 1997.

[Mur] K.G. Murty, *Linear Programming*, Wiley, 1983.

[PS] C.H. Papadimitriou and K. Steiglitz, *Combinatorial Optimization: Algorithms and Complexity*, Prentice-Hall, 1982.

On stochastic approximation and approximate dynamic programming:

[BerT] D.P. Bertsekas and J.N. Tsitsiklis, *Neuro-dynamic programming*, Athena Scientific, 1996.

On real analysis and linear algebra:

[Rud] W. Rudin, *Principles of mathematical analysis (Third edition)*, McGraw Hill, 1976.

[Str] G. Strang, *Linear algebra and its applications (Third edition)*, Harcourt Brace Jovanovich, 1988.

Grading:

1. 20% Homework.

2. 40% Mid-term.
3. 40% Final or Project (will be decided).

Rules of Conduct: You *may* collaborate in study groups on the solution of homeworks. You *must*, however, write up solutions on your own. If you do collaborate you *should* acknowledge your collaborators in the write-up for each problem (I view this as essential !) Also, if you used other material in obtaining a solution (e.g., other books and papers) you *should* reference your source. The due day on homeworks is *strict*.