IE 509: Nonlinear Programming
Fall 2022

Instructor: **Burak Kocuk** (burakkocuk@sabanciuniv.edu)

Lecture Hours: Tuesday 09:40–10:30 (FENS L065), Wednesday 15:40–17:30 (FENS L029).

Office Hours: Tuesday 08:40–09:30 (FENS 2095), Wednesday 14:40–15:30 (FENS 2095).

Pre-requisite: Either an undergraduate level optimization/operations research course, or strong background in real analysis and linear algebra.

Catalog Description: Review on linear algebra and analysis, convex sets and functions, quadratic programming, descent algorithm, line search, conjugate directions, Newton's method, optimization of nondifferentiable functions, necessary and sufficient conditions for constrained optimization problems, duality theory, penalty and barrier methods, Kuhn-Tucker methods, introduction to semi-infinite and semidefinite optimization, applications.

Course Topics: This course will cover five main topics:

1. `Background Material:` Applications of nonlinear programming, basic convex analysis (convex sets, convex functions), linear programming review.
2. `Nonlinear Programming Theory:` Lagrangian duality, saddle points, optimality conditions, quadratic programming.
3. `Nonlinear Programming Algorithms for Unconstrained Problems:` Algorithms for univariate and multivariate problems (line search, Newton's methods, steepest descent, conjugate gradient).
4. `Nonlinear Programming Algorithms for Constrained Problems:` Active Set/Penalty/Barriers methods, augmented Lagrangians, sequential quadratic programming.
5. `Advanced Topics:` Conic programming, nonconvex optimization (if time permits).

Software: Students will use Python programming language to implement some basic algorithms and utilize commercial solvers (e.g. Gurobi).

Reference Books: *Optimization III*, A. Nemirovski (Lecture Notes) `http://www.isye.gatech.edu/~nemirovs/`.
Lectures on Modern Convex Optimization, A. Ben-Tal and A. Nemirovski (SIAM).
Convex Optimization, S. Boyd and L. Vandenberghe (Cambridge University Press).
Numerical Optimization, J. Nocedal and S. Wright (Springer Press).

Grading:	Midterm (30%), Final (40%), Homework (30%), Lecture Scribing (bonus).
Exams:	There will be two exams. The midterm exam will be in late November and the final exam will be scheduled by SR. The final exam will have a small computer-based part.
Homework:	There will be five homework assignments, each featuring some theoretical as well as computer-based questions. Students are allowed to work together as long as they submit their own homework and acknowledge who they have worked with.
Lecture Scribing:	Each student can earn some bonus points by scribing/editing notes in LaTeX.