USC Viterbi School of Engineering

EE 588, Optimization for the information and data sciences

Units: 04

Term—Mon-Wed

Location: TBD

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Teaching Assistant:

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Course Description

This course will focus on optimization problems and algorithms that arise in many science and engineering applications. Fundamental topics include convex sets, convex functions, generalized inequalities, least-squares, linear and quadratic programs, semidefinite programming, optimality conditions and duality theory. The course also covers optimization methodology with a focus on first order methods. Sample topics include: efficient first-order algorithms for smooth and non-smooth optimization, accelerated

schemes, Newton and quasi-Newton methods, iterative algorithms and non-convex optimization. Some applications to signal processing, control, machine learning and statistics will be presented.

Learning Objectives

Students will learn to identify and solve convex optimization problems. They will learn to use optimality conditions and duality theory for optimization. They will be exposed to numerous applications of convex optimization in different fields and the basics of optimization algorithms.

Prerequisite(s): EE441 (Linear Algebra), recommended preparation EE 503 (Probability)
Co-Requisite (s):
Concurrent Enrollment: course(s) that must be taken simultaneously: N/A
Recommended Preparation: N/A

Course Notes

Grading Type: letter grade
The course is Web-Enhanced **(Blackboard)**.
Copies of lecture slides and other class information will be posted on Blackboard.

Technological Proficiency and Hardware/Software Required

Students will be assumed to have basic Matlab skills.

Required Readings and Supplementary Materials

Required textbook:
First half:
Convex Optimization by S. Boyd and L. Vandenberghe, Cambridge University Press.
Second half:
No text book, recommended readings:
Convex Optimization: Algorithms and Complexity by S. Bubeck.
Numerical Optimization. J. Nocedal and S. J. Wright, Springer Series in Operations Research, Springer-Verlag, New York, 2006 (2nd edition).
Introductory Lectures on Convex Optimization: A Basic Course. Y. Nesterov. Kluwer, 2004.

Description and Assessment of Assignments

Students will be assigned a homework every other week. Homework will consist of solving textbook problems and will sometimes include a “research-oriented” problem to stimulate and probe students’ creativity. Homeworks are to be submitted in class on the due date. Late homeworks will not be accepted unless prior approval for late submission has been obtained. There will be no midterm and one final exam. There will be no make up exams.

Grading Breakdown

Assignment	Points	% of Grade
participation		7%
homework		48%
final		45%
TOTAL	0	1
TOTAL		

Assignment Submission Policy

Homework to be submitted in class two weeks after assignment. Late homeworks will not be accepted unless prior approval for late submission has been obtained. The lowest grade among all homeworks will be dropped.

Additional Policies

Attendance of the lectures is expected.

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	Readings and Homework	Deliverable/ Due Dates
Week 1 Dates	Introduction to mathematical optimization, sample examples and applications, Mathematical background	Textbook Chapter 1, Textbook Appendix A	
Week 2 Dates	Affine and Convex sets, geometric of convex sets, operations preserving convexity	Textbook Chapter 2,	Homework #1 assigned
Week 3 Dates	Convex functions, basic properties and examples, operations preserving convexity, conjugate function, Quasi-convex functions, log-concave and log-convex functions	Textbook Chapter 3, Sections 3.1-3.5	
Week 4 Dates	Convex Optimization Problems, linear and quadratic optimization problems	Textbook Chapter 4, Sections 4.1-4.4	Homework #1 due, Homework#2 assigned.
Week 5 Dates	Geometric programming, Generalized inequality constraints, semidefinite programming, Pareto optimality	Textbook Chapter 4, Sections 4.5-4.7	
Week 6 Dates	Duality, Lagrange dual function, Dual problem, Weak and strong duality, optimality conditions, applications of duality, applications in information and game theory, Perturbation and sensitivity analysis, Examples, Theorems of alternatives, duality for generalized inequalities	Textbook Chapter 5, Sections 5.1-5.9	Homework #2 due, Homework#3 assigned.
Week 7 Dates	Norm approximation and least norm problems, Robust approximation, function fitting and interpolation, optimal input design	Textbook Chapter 6	

Week 8 **Dates**	Applications in machine learning: Maximum likelihood estimation, exponential families, regression and classification		Homework #3 due, Homework#4 assigned
Week 9 Dates	Applications in Statistics: Hypothesis testing, Chebyshev and Chernoff bounds	Textbook Chapter 7	
Week 10 Dates	Geometric problems, projection on a set, distance between sets, centering, placement and facility location	Textbook Chapter 8, Sections 8.1-8.6	Homework #4 due, Homework#5 assigned
Week 11 Dates	Descent algorithms and line search methods		.
Week 12 Dates	Acceleration, momentum, and conjugate gradients, Newton and Quasi-Newton methods		Homework #5 due, Homework#6 assigned.
Week 13 Dates	Coordinate descent, Stochastic and incremental gradient methods		
Week 14 Dates	Non smooth optimization, Subgradient methods, proximal algorithms, Projected gradient methods		Homework #6 due, Homework#7 assigned.
Week 15 Dates	Lagrangian decomposition, The Alternating Direction Method of Multipliers		Last homework # 7 due.
FINAL Date			Date: For the date and time of the final for this class, consult the USC *Schedule of Classes* at www.usc.edu/soc.

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Section 11, *Behavior Violating University Standards*https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct/.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the *Office of Equity and Diversity* http://equity.usc.edu/ or to the *Department of Public Safety* http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us. This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. *The Center for Women and Men* http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage sarc@usc.edu describes reporting options and other resources.

Support Systems

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.htmlprovides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information http://emergency.usc.edu/*will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.