Math 591 Syllabus, Spring 2017

Mark Steinberger

MAT 591 Optimization methods and nonlinear programming
Class number 10698
Class location ES146
Class time MWF 1:40–2:35
Prerequisites Basic linear algebra and calculus of several variables
Instructor Mark Steinberger
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Course home page http://math.albany.edu/~mark/classes/591/

The book is available online for free via http://stanford.edu/~boyd/cvxbook/. (An additional book you might find useful is Dimitri Bertsekas, Nonlinear Programming, Athena Scientific, but it is neither required nor necessary.)

We will cover material from Chapters 2-5 and 9-11 from Boyd and Vandenberghe. The topics of interest include the basics of convex sets and convex functions, followed by specific techniques to optimize convex functions, e.g., Newton’s method, gradient descent, linear programming, quadratic optimization, and semidefinite programming.

The basic context is as follows. We are given a real-valued function \( f(x_1, \ldots, x_n) \) of several variables, and we wish to find a point \( x = (x_1, \ldots, x_n) \) at which \( f \) attains its minimum value. In practice, the points \( x \) which are feasible for practical problems are often subject to constraints. Conceptually, this says that we should regard \( f \) as having a fixed domain \( C \subset \mathbb{R}^n \), i.e., \( f \) is a function

\[
    f : C \to \mathbb{R}.
\]

We wish to find the points at which \( f \) attains its minimum value, and what that value is.

In practice, this is an impossible problem, so we need to place additional conditions on \( C \) and on \( f \). In most of the cases we consider here, we shall insist that both \( C \) and \( f \) be convex.
The convexity of $C$ means that for any pair of points $x, y \in C$, the line segment between them lies in $C$, i.e.,

\[(1) \quad (1 - t)x + ty \in C \quad \text{whenever } x, y \in C \text{ and } t \in [0, 1].\]

The convexity of $f$ means that

\[(2) \quad f((1-t)x+ty) \leq (1-t)f(x)+tf(y) \quad \text{whenever } x, y \in C \text{ and } t \in [0, 1].\]

When working with only one variable, i.e., when $n = 1$, this can be seen in terms of familiar ideas from calculus. (1) means that $C$ is an interval, and (2) means $f$ is “concave up”. If $f$ is twice differentiable, then one method of solution is a second derivative test.

We will examine a variety of issues in the $n$-dimensional case, including methods of finding approximate solutions, and contexts in which convex optimization can be used to solve important applied problems.

There will be three in-class exams for this course, along with group work done either in-class or as homework. The point count for the final grade is determined as follows:

- Group work 13%
- Each in-class exam 29%

Class attendance is absolutely essential. If for some reason you need to miss class, it is imperative that you get notes from someone. And finding someone who takes good notes isn’t always easy. :-) Also, it is usually easier to digest the material if you see and hear it presented. In any case, you are expected to attend class. The university’s medical excuse policy is available at [http://www.albany.edu/health_center/medicalexcuse.shtml](http://www.albany.edu/health_center/medicalexcuse.shtml).

You are strongly encouraged to discuss this material with each other and with me, both in office hours and in class. Verbalizing mathematical questions is a very useful step toward understanding them. Classroom discussion is strongly encouraged. Please ask questions! If there is something you don’t understand or can’t follow, there will be a number of other people in the class in the same boat. So a number of people will benefit if you ask.

It is very important to stay current with the material. If you fall behind, it will be hard to catch up. And if you are having trouble, please do come to office hours early on. If you leave it until the last minute, you probably won’t be able to learn it in time.

But office hours are not only for those who have fallen behind. Office hours are extremely helpful for learning and I seriously enjoy discussing the material with students and helping them learn. It is especially useful to work with a group of students. The synergy really helps everyone learn.

Other than during exams, you are strongly encouraged to work with other students and with me. The in-class work will be mainly in groups. During exams, you may ask me questions but should not communicate with anyone else. Use of phones during exams is prohibited. The university’s academic
integrity policy is available via http://www.albany.edu/undergraduate_bULLETIN/regulations.html.