Mathematics 661: Optimization
Fall 2020

**Catalog Description:** Linear and nonlinear programming, simplex method, duality and dual simplex method, post-optimal analysis, constrained and unconstrained nonlinear programming, Kuhn-Tucker conditions. Applications to management, physical and life sciences. Computational work with the computer.

**Instructor:** John Rhodes, j.rhodes@alaska.edu, 208B Chapman, 474-5445

**Instructor Office Hours:** M,W 10:30-11:30, F 8:00-9:00, and by appointment; via Zoom (e-mail to start)

**Electronic Access:** Lectures will be delivered via Zoom, and recorded. Access to recordings will only be to class members. All course materials and assignments will be posted on the public course website:

`https://jarhodesuaf.github.io/M661.html`

You will need to be able to produce pdfs of homework and exams, which will be turned in using Dropbox.

**Prerequisites:** Knowledge of calculus, linear algebra and computer programming. (This means a solid undergraduate background in the first two, and comfort with programming in a high-level language like MATLAB.)

**Credit Hours:** 3.0

**Required Text:** Griva, Nash, and Sofer, Linear and Nonlinear Optimization, 2nd ed., SIAM Press 2009

**Class Meetings:** MWF 11:45-12:45, via Zoom

**Programming:** Homework and a project will involve some computer programming. I strongly recommend using MATLAB, but you can opt for a similarly capable language if you choose. MATLAB is already on many UAF computers, but you may be able to download it to a personal one. See https://www.alaska.- edu/oit/software/authenticate/files/employee/matlab/

**Midterm Exams:** Monday, Oct. 12 (Format TBD, based on COVID-19 considerations)

**Final Exam:** 11:15 a.m. - 2:15 p.m., Monday, Dec. 7 (Format TBD, based on pandemic considerations)

**Course overview and learning outcomes:** Optimization problems are ubiquitous in applied mathematics, arising in almost every science and engineering field, as well as some social sciences and business. Many of these have to do with optimal fitting of models to data, such as in the common statistical framework of maximum likelihood estimation of parameters. Others have to do with finding the 'best' way to do something, such as design an airline schedule to maximize passenger load or minimize costs. Rather than the simple functions of a single variable you dealt with in Calculus I, the functions to be optimized may have hundreds of variables. Moreover, there are often constraints on the variable values, making the framework more similar to the simple Lagrange Multiplier problems you saw in Calculus III.

Most real-world optimization problems can only be solved approximately, using numerical calculations on a computer. The techniques vary, depending on the form of the function to be optimized (that is, the *objective function*) and the constraints. Are they linear?, quadratic?, convex? The importance of these problems for applications has resulted in a large and rich field, in which both theoretical and practical computational issues blend to determine approaches.

This course will introduce you to the field of optimization, highlighting some of the main threads and ways of thinking. It cannot be comprehensive, but it should position you well both to implement basic approaches yourself and to understand and use more narrowly focused professional software produced by others.

**Mechanics of the course:** Due to the COVID-19 pandemic, this course is being taught via Zoom instead of in-person. However, it will preserve the flow and interaction of an in-person class as much as possible. This includes regular lecture meetings 3 days a week, which students are encouraged to interrupt with questions. While attendance at the live Zoom lectures is not required (and you can watch recordings if you miss an occasional one), it is assumed.

**Homework:** Homework from the text will be assigned regularly, along with occasional additional problems on handouts. All will be posted with due dates (typically the following Monday) on the course web page.

You are encouraged to work with others on the homework. Discussions with your peers are an effective way to learn. However, you must *write up solutions independently.*

**Project:** You will do an independent project, in the form of a written paper, on some optimization topic of your choice. This may focus on an application of particular interest to you, a type of optimization problem, or a technique of solution. It must include a mix of theory and actual computation, though the relative emphasis between these is up to you. The project is due **Friday Nov. 25**, but you will also have to have your topic approved by early October.

**Examinations:** There will be a midterm exam and a final. If possible these will be in-person, but may be timed exams you take on your own. What materials you can consult during them (if any) will be made clear. As students in a graduate course, preparing for your professional life, your honesty is expected.

**Missed examinations or assignments** that are not approved in advance will result in a zero grade on that exam or assignment. No make-ups will be allowed except in unforseeable circumstances (e.g., documented illness, quarantine, family emergencies, etc.). Notifying me by email or a note that you will miss an exam or due date is not sufficient for advance approval; you must speak with me via Zoom if you believe you have a valid excuse.

**Auditing** of this course will only be allowed for those who agree to participate fully, as evidenced by completion of homework, midterm exam, and class participation.

**Grades:** Your course performance will be evaluated based on 45% Homework, 15% Project, 20% midterm exam, 20% final exam. Course grades will be determined according to the following cutoffs:

A: $\geq$ 90%, B: $\geq$ 80%, C: $\geq$ 70%, D: $\geq$ 60%.

The extreme 3 points of each grade range will receive a '+' or '–'. Cutoff points may be moved downward if particular assignments or exams turn out to be unexpectedly difficult. Note that you are not in competition with your peers; everyone in the class may get an A, or everyone may get an F.

**University and Department Policies:** Your work in this course is governed by the UAF Honor Code. The Department of Mathematics and Statistics has specific policies on incompletes, late withdrawals, and early final exams:

`http://www.dms.uaf.edu/dms/Policies.html`.

**Student disabilities statement:** Your instructor will work with the Office of Disability Services to provide reasonable accommodation to students with disabilities.

**Student protections statement:** UAF embraces and grows a culture of respect, diversity, inclusion, and caring. Students at this university are protected against sexual harassment and discrimination (Title IX). Faculty members are designated as responsible employees which means they are required to report sexual misconduct. Graduate teaching assistants do not share the same reporting obligations. For more information on your rights as a student and the resources available to you to resolve problems, please go to the following site:

`https://catalog.uaf.edu/academics-regulations/students-rights-responsibilities/`.

**COVID-19 statement:** Students should keep up-to-date on the universitys policies, practices, and mandates related to COVID-19 by regularly checking this website:

`https://sites.google.com/alaska.edu/coronavirus/uaf/uaf-students?authuser=0`

Further, students are expected to adhere to the universitys policies, practices, and mandates and are subject to disciplinary actions if they do not comply.

# Tentative Schedule

| Week | Chapters | Area |
|---|---|---|
| 8/24 | 1 | Fundamentals of Optimization |
| 8/31 | 1 | |
| 9/7 | (Labor Day M), 2 | |
| 9/14 | 2 | |
| 9/21 | 11 | Non-linear Unconstrained Optimization |
| 9/28 | 11 | |
| 10/5 | 12 | |
| 10/12 | Midterm Exam, 14 | Non-linear Constrained Optimization |
| 10/19 | 14 | |
| 10/26 | 4 | Linear Programming |
| 11/2 | 5 | |
| 11/9 | 5 | |
| 11/16 | 6 | |
| 11/23 | 6, Project due (Thanksgiving W,F) | |
| 11/30 | 6, catch-up | |