Fall 2023
Numerical Optimization MAD 5420

Details

- Time and Place : MW 16:50 - 18:05, LOV Room 105
- Instructor: K. A. Gallivan (421 Love Building, kgallivan@fsu.edu)
  - Homepage: www.math.fsu.edu/~gallivan
  - Office Hours: 14:30 – 16:50 Monday and Wednesday, and by appointment.
  - For remote contact during office hours or other arranged meetings, use the Zoom meeting room link on my homepage.
- Prerequisites: MAC2313 (Calculus 3), MAP3105 (Linear Algebra), MAD3703 (Numerical Analysis 1), programming proficiency.
- No textbook is required however there are recommended reference texts that are useful study resources.
- Reference Texts:
  1. Numerical Optimization, J. Nocedal and S. J. Wright, Springer, Second Edition
  2. Introduction to Nonlinear Optimization, A. Beck, SIAM
  3. Iterative Methods for Optimization, C. T. Kelley, SIAM
  4. Optimization by Vector Space Methods, D. G. Luenberger, Wiley
  5. Numerical Methods for Optimization and Nonlinear Equations, J. E. Dennis Jr. and R. B. Schnabel, SIAM.
  6. Nonlinear Programming, D. P. Bertsekas, Athena Scientific, Second Edition
  7. Numerical Methods for Least Squares Problems, A. Björck, SIAM
  8. Primal-Dual Interior-Point Methods, S. J. Wright, SIAM
  9. Combinatorial Optimization: Algorithms and Complexity, C. H. Papadimitriou and K. Stieglitz, Dover (Prentice Hall originally)
- Class Information: Class notes, homework, programming assignments and announcements will be posted on the class website (follow the teaching link from www.math.fsu.edu/~gallivan). You are expected to consult the website in a timely and regular manner. The user and password information for portions of the class website will be given during the first class meeting. Canvas will be used for class email announcements, submit homework, and post grades.
- Other books, papers, and software resources will be cited, posted or linked in the class notes, the homework, and on the class website. These are background material and suggested references. You will be expected to read a small subset identified in the lectures. The others are for your graduate academic development.
- Lectures will be given in person.

- Class Participation Policy: Participation in class by asking questions and responding to questions posed by the instructor is expected and strongly encouraged. The diverse background of the students implies several students will be unfamiliar with each topic and clarification by such questions and responses is vital to understanding. Students are expected to be prepared for class lectures and for any office visits.

- Meetings with the instructor are expected and encouraged especially for discussions that are too lengthy for class. It is particularly important to have such meetings early and often for material about which you are uncertain. Group meetings are encouraged.

- Grades: Homework (programming and written problems) 100%

- There are no exams.

- Electronic devices may be used to access class notes and related material during lectures.

- Homework: Homework will be assigned regularly consist and will comprise written exercises and programming assignments.

- Solutions to the programming assignments are preferred to be in a compiled and typed language such Fortran, C, C++, Java. Julia is also acceptable but variable types and data structures are expected to be defined and constructed explicitly. However, Julia, Python and environment-based programs in, e.g., MATLAB, are also acceptable.

- Homework solutions will be submitted using the class Canvas page.

- Plagiarism is a violation of the university honor code. With respect to the solutions of programming problems in the homework, it is not acceptable to engage in plagiarism. You may discuss the programming problems with each other **but any significant discussion must cited, i.e., it should be treated like the citation of any outside material used in your solutions. Such a citation must include names and a brief description of the substance of the discussion.** All students must design and implement their own code. All students must write individually the description of the code, its complexity, the experimental design, the empirical results and the interpretation of the results. **No student should provide any portion of their code to any other student in class.** If you find a library code (not written by a student in class) that performs a portion of the task **it must be cited – including the specific source of the code and its function.** You are still responsible for describing correctly its implementation and time/space complexity in your solutions. Credit for the program will be prorated based on the amount of functionality performed by a cited library code relative to the functionality required to solve the assigned problem. **Citations when writing solutions to the analytical problems included in a graded homework or programming assignment and applicable penalties for plagiarism are covered by these same policies.** The first offense of submitting a solution without the appropriate citation will result in 0 credit for the programming/experimental portion of the assignment or the particular solution to the analytical problem. Multiple offenses may result in referral to the university for discipline according to university regulations.

- University Attendance Policy: Excused absences include documented illness, deaths in the family and other documented crises, call to active military duty or jury duty, religious holy days, and official University activities. These absences will be accommodated in a way that does not arbitrarily penalize students who have a valid excuse. Consideration will also be given to students whose dependent children experience serious illness.

- Class Attendance Policy: With the exception of the first class meeting, attendance is not required but **it is strongly advised**. A student absent from class bears the full responsibility for all subject matter and procedural information discussed in class.

Content

This course is an introduction to the theory and algorithms to solve continuous optimization problem. The topics include, as time permits:

1. Hilbert space theory and basic algorithms for approximation problems.
    - Approximation, optimality, projection, and orthogonality.
    - Parameterization for an unconstrained optimization form.
    - The Normal Equations.
    - Transformation-based structure modification approach.
    - Incremental observation updates.
    - Relationship to unconstrained convex quadratic problems.
2. Unconstrained optimization on $\mathbb{R}^n$
    - Optimality conditions on $\mathbb{R}^n$.
    - Line search algorithms on $\mathbb{R}^n$.
    - Introduction to trust region algorithms on $\mathbb{R}^n$.
3. Linear Programming
    - Convexity and optimality conditions for linear programming on $\mathbb{R}^n$
    - Simplex algorithm
    - Interior point and penalty methods introduction
4. Constrained optimization on $\mathbb{R}^n$
    - Optimality conditions for optimization over a convex feasible set in $\mathbb{R}^n$.
    - Gradient projection for a convex feasible set on $\mathbb{R}^n$.
    - KKT Optimality conditions for nonlinear programming on $\mathbb{R}^n$.
    - Constraint qualifications.
    - Basic nonlinear programming algorithms on $\mathbb{R}^n$.
5. Proximal gradient methods.
6. Algorithms for large-scale problems.
7. Application examples.

Objectives

The material covered in the class covers tools that have been developed to solve problems numerically. Thus, you will be expected to be able to analyze, design, and implement some of the techniques and to solve problems with them. In addition, you will be expected to know how the methods were derived and when they are and are not appropriate to use.

Syllabus Changes

Except for changes that substantially affect implementation of the evaluation (grading) statement, this syllabus is a guide for the course and is subject to change with advance notice.

Honor Code

The Florida State University Academic Honor Policy outlines the University's expectations for the integrity of students' academic work, the procedures for resolving alleged violations of those expectations, and the rights and responsibilities of students and faculty members throughout the process. Students are responsible for reading the Academic Honor Policy and for living up to their pledge to " ... be honest and truthful and ... [to] strive for personal and institutional integrity at Florida State University." (Florida State University Academic Honor Policy, found at https://dof.fsu.edu/honorpolicy.htm.)

Americans with Disabilities Act

Students with disabilities needing academic accommodation should during the first week of class:

1. register with and provide documentation to the Student Disability Resource Center;
2. contact the instructor indicating the need for accommodation and what type.

This syllabus and other class materials are available in an alternative format upon request. For more information about services available to FSU students with disabilities, contact the :

Student Disability Resource Center
874 Traditions Way
108 Student Services Building
Tallahassee FL, 32306-4167
644-9566 (voice), 644-8504 (TDD), sdrc@admin.fsu.edu, http://www.disabilitycenter.fsu.edu.