Worcester Polytechnic Institute

MA 4235: Mathematical Optimization
Department of Mathematical Sciences
D Term 2022

Instructor	**Teaching Assistant**
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Class: Mon, Tues, Thurs, and Fri,   3pm-3:50pm,   Stratton Hall 203

Textbook:

- *The Mathematics of Nonlinear Programming*, by A.L. Peressini, F.E. Sullivan, & J.J. Uhl.

Course Delivery:

This course is offered in-person on the WPI campus. Asynchronous video materials may occasionally be used to supplement in-class meetings.

All in-person meetings will be video captured and will be posted on the course Canvas site.

- The video materials can be used by students who may need to transition to remote learning due to COVID-19 issues.

All resources & course assignments will be posted in the Modules section of the Canvas course webpage. The Modules section organizes the course content chronologically, with all assignments included. All deliverables for the course will appear in the Modules section.

Worcester Polytechnic Institute

Course Description:

This course will focus on continuous nonlinear optimization. We will cover selected chapters from the text dealing with both unconstrained and constrained optimization. Most of the optimization algorithms covered will be basic line search methods, including Newton's Method and the method of steepest descent. We will also cover least squares fits, Lagrange multipliers, convexity, convex optimization, and the Karush-Kuhn-Tucker (KKT) conditions. An applied course project will be assigned. If time permits, we may cover trust-region methods, conjugate gradient methods, or spline fitting.

Prerequisite Material:
Knowledge of multivariable calculus and introductory linear algebra are required. Knowledge of vector calculus and undergraduate real analysis is helpful but not necessary. Experience with programming will be helpful.

Additional References:
- *Numerical Optimization*, by Nocedal and Wright (available online through Gordon Library). This book gives a more advanced treatment of the material and is considered a classic text in the discipline.

Learning Outcomes:
By the completion of this course, learners will be able to:
- Identify and work with symmetric positive definite matrices
- Find and identify local extrema of functions of n variables
- Find and identify global extrema of convex functions
- Use line search methods to numerically find and identify extrema of functions
- Model real-world problems using tools of nonlinear optimization
- Find and identify extrema of constrained nonlinear optimization problems
- Model and solve nonlinear optimization problems using software

Communication:
The primary interface for communication with the instructor will be email, the Canvas course website, office hours, & Piazza. All information about the course will be maintained on the course web page in WPI's Canvas system.

Check your *WPI* email daily.

The use of Piazza in Canvas is *strongly* encouraged for discussion with the instructor and peer students. It provides a forum where students can post questions anonymously if preferred.

Students can expect a response to email questions within 24 hours on weekdays and within 48 hours on weekends.

Office Hours:
These are interactive sessions with the instructor or teaching assistant that will be managed in the Canvas course calendar & will be held either online using Zoom or in-person, depending on COVID-19 pandemic conditions. Students are *strongly* encouraged to attend office hours.

Course Approach:
This is a semester-long course.
- Each week begins on Monday at 6am US Eastern Time and ends on the following Sunday at 11:59pm US Eastern Time.
- The Canvas course webpage will be used to manage all aspects of the course. Content will be managed primarily in the announcements, modules, assignments, calendar, & Piazza sections of the Canvas page.
- Each week the course will consist of:
  o Four in-person meetings as per the course schedule
  o Office hours
  o One written homework assignment
  o One exam on weeks 4 and 7
- All written homework will be submitted in a *single-file* PDF upload to Canvas.
- There are two exams.
- There will be a course project. Students are **required to work in teams** on projects and to submit professional quality project reports, complete with formal references & citations.
  o Project teams will create a video presenting their project work.

Course Requirements:

1. **Assignments**
   There are two primary assignment categories for this course:

   o **Written Homework**
      These assignments involve handwritten solutions to problems. Solutions should be second draft and thoroughly demonstrate solutions, derivations, and proofs including justifications of steps. These assignments are to be submitted as scanned PDF files in Canvas. Each assignment should be submitted as *one* PDF file.

      Students are encouraged to discuss the homework problems with other students & in discussions on Piazza, but all homework assignments must be completed, written, and submitted independently.

      Some homework assignments will require the use of MATLAB programming.

Written Homework Assignment Rubric:

Each homework problem is graded out of 10 points according to the criteria below:

Grade	
10	Completely correct, clear, & thorough write-up of problem solution, citing appropriate rules & theorems where appropriate. Quality is neat and easily readable.
9	Correct, clear, & thorough write-up of methodology & problem solution, citing appropriate rules & theorems where appropriate, with 1 minor mistake or omission. Quality is neat and easily readable.
6-8	Mostly correct write-up of methodology & problem solution with a few minor mistakes or omissions. Quality is neat and readable.
2-5	Incorrect solution. Partial credit is given according to key insights for the problem. Quality is readable.
0-1	Little to no work shown, giving only answers.

- o **Projects**
  Students will work in teams on course project work. Real data will be used to implement models covered in class in a real-world setting.

  Students are required to compose a professional quality project report. Each project report should

    - Include visual representations of the models and results, such as graphs, tables, histograms, or charts.
    - Include a formal references section with formal citations using MLA format to those references where appropriate. Note that **any** work that is not the students' own original work **must be properly cited**. WPI's policies on citations can be found here: https://libguides.wpi.edu/friendly.php?s=citingsources

3. **Exams**
   There are two exams in this course:

Midterm Exam	Friday, April 8	In-Class
Final Exam	Monday, May 2	In-Class

4. **Late Work Policy**
   Extensions for assignments may be granted on a case-by-case basis. If you feel like you need an extension on an assignment, I strongly encourage you to communicate with me about this as early as possible. Reasonable extension requests will be granted. Late assignments without approved extensions will receive a grade of zero.

Worcester Polytechnic Institute

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Grading Policy:

The numerical course grade will be determined scheme below:

Category	Weight
Midterm Exam	25%
Final Exam	25%
Homework Average	35%
Project	15%

Each homework grade will be converted to a percentage, and then those percentages are averaged to compute the homework average.

Final course letter grades are based on a student's performance as follows:

Letter Grade	Percentage
A	90 - 100
B	80 - 89
C	70 - 79
D	60 - 69
F	0 - 59

The instructor may adjust these grade cutoffs at the end of the course, but such an adjustment can only happen in the students' favor. For example, the minimum score for a grade of B could be decreased from 80 to 79, but it would never increase above 80.

Course incompletes may be granted if the major part of the course is completed. In addition, in the case of an incomplete, the student is responsible for handing in the final work within the WPI required timeframe of one (1) year. After this time, an incomplete grade changes to an NR grade.

Accessibility Services:

Students with approved academic accommodations should plan to submit their *accommodation* letters through the *Office of Accessibility Services Student Portal.* Should you have any questions about how accommodations can be implemented in this particular course, please contact me as soon as possible. Students who are not currently registered with the Office of Accessibility Services (OAS) but who would like to find out more information regarding requesting accommodations, documentation guidelines, and what that all entails should plan to contact them either via email *AccessibilityServices@wpi.edu* or via phone (508) *831-4908.*

Mental Health:

We are embarking on this course during a difficult time, one during which many are experiencing mental health issues. As your course instructor, I am invested in your success in this course and in your well-being, and I will support you to help you succeed.

Mental health challenges, including significant stress, anxiety, mood changes, excessive worry, or problems with eating and/or sleeping can interfere with learning. The source of issues like these might be related to your course work; if so, please meet with me to discuss these issues.

WPI provides mental health services to support the well-being and academic success of students. The Student Development & Counseling Center (*SDCC).* offers free, confidential services to help you manage personal challenges.

In the event I suspect you need additional support, I will express my concerns and the reasons for them and remind you of resources that might be helpful to you. It is not my intention to know the details of what might be bothering you, but simply to let you know I am concerned and that help, if needed, is available.

Getting help is a smart and courageous thing to do -- for yourself and for those who care about you.

Worcester Polytechnic Institute

Academic Integrity:

You are expected to be familiar with the *WPI Academic Integrity Policy,* which can be found [here](). Consequences for violating the Academic Honest Policy range from earning a zero on the assignment, failing the course, or being suspended or expelled from WPI.

Common examples of violations include:

- Copying and pasting text directly from a source without providing appropriately cited credit
- Paraphrasing, summarizing, or rephrasing from a source without providing appropriate citations
- Collaborating on individual assignments
- Turning in work where a good portion of the work is someone else's, even if properly cited

This syllabus is subject to change at the professor's discretion.