

Math 6366 Optimization Theory

Fall 2023, MoWe 4:00 pm–5:30 pm

Course Math 6366: Optimization Theory (Section 11572)

Instructor Dr. Andreas Mang

✉ andreas@math.uh.edu

☎ 713.743.7409

🌐 <https://www.math.uh.edu/~andreas>

Office PGH 614

Office Hours MoWe 3:00 pm–4:00 pm or by appointment (andreas@math.uh.edu)

Class Time and Place MoWe 4:00 pm–5:30 pm in S132

Course Website <https://www.math.uh.edu/~andreas/teaching/math6366-FA23>

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1 Prerequisites

Credit for or concurrent enrollment in MATH 4331 and MATH 4377, or consent of instructor. Students are expected to have a good grounding in basic real analysis and linear algebra.

2 Textbooks

This course will be based on the following textbook:

- [Convex Optimization](#) by S. Boyd and L. Vandenberghe. Cambridge University Press 2004.

This book can be downloaded here: <http://stanford.edu/~boyd/cvxbook>. Additional reading materials are:

- [Lectures on Convex Optimization](#) by Yurii Nesterov. Springer 2018.
- [Introduction to Nonlinear Optimization](#) by A. Beck. SIAM 2014.
- [Numerical Optimization](#) by J. Nocedal and S. J. Wright. Springer 2006.
- [An Introduction to Optimization](#) by E. K. P. Chong and S. H. Zak, Wiley 2013.

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3 Course Description

This course will introduce the theoretical foundations of optimization and strategies to its numerical solution. Starting from first principles we will discuss how to design and analyze simple iterative methods for efficiently solving a broad class of optimization problems. While the field of optimization is vast, there exists a small set of methods that achieve optimal performance. We will assess the efficiency of these techniques on prototypical optimization problems. This class will walk through classic results and provide a gateway to cutting edge research in the field.

4 Course Content

Course material will be made available section by section on **canvas**. This is the first semester of a two-semester course. The focus in this semester will be on convex optimization. The tentative content of this course is as follows:

§1 Convex set.

- affine and convex sets
- examples for convex sets
- operations that preserve convexity
- generalized inequalities

§2 Convex functions.

- basic properties
- operations that preserve convexity
- quasiconvex functions

§3 Convex optimization problems.

- optimization problems
- convex optimization and linear optimization problems
- quadratic optimization problems & geometric programming

§4 Duality.

- the lagrange dual function
- saddle-point interpretation
- optimality conditions

§5 Unconstrained and Equality Constrained Minimizations.

- unconstrained minimization problems
- gradient descent
- newton's method
- equality constrained minimization
- newton's method with equality constraints
- infeasible start newton method

§6 Interior-Point Methods.

- inequality constrained minimization problems

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- barrier method
- primal-dual interior point methods

§7 Selected Topics (if time permits).

5 Course Delivery Format

This course will be delivered face-to-face (in person). In between class meetings, there may also be asynchronous activities to complete (e.g., homework assignments).

6 Syllabus Changes

Please note that the instructor may need to make modifications to the course syllabus and may do so at any time. Notice of such changes will be announced as quickly as possible either in class or through MS Teams or by email.

7 Attendance Policy

Attendance is not required, but strongly encouraged. Additional information can be found in §16. Coming to class late or leaving early is disruptive and thus discouraged.

8 Office Hours

Office hours will take place in my office or be online one-on-one meetings. Please send me an email to make an appointment for office hours (andreas@math.uh.edu). I will keep the stated schedule for office hours open (MoWe 3:00 pm–4:00 pm).

9 Dropping Policy

| | |
|------------|--|
| 08/28/2023 | Last day to add a class. |
| 09/06/2023 | Official reporting day (ORD); drop a course without receiving a grade. |
| 11/15/2023 | Last day to drop a course or withdraw with a 'W'. |

10 Evaluation Criteria

Students will be evaluated through homework assignments (see §11), two midterm exams, and one cumulative final (see §12). The grading criteria are described in §13. For any assignment or test, illegible answers will be assumed to be incorrect and will receive no credit.

11 Homework Assignments

Homework assignments will be given on a bi-weekly basis. There will be a total of six to eight theoretical homework assignments. In fairness to fellow students, late homework will **not** be accepted. However, your lowest homework score throughout the term will be dropped to allow for missed assignments. Digital

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copies of your homework assignments have to be uploaded on Canvas as a PDF at the designated due date. This is a sharp deadline; no late submission will be possible. If you do not submit your homework on time you will receive a score of zero. If you cannot hand in your homework on the designated due date, contact me by email at least one day **before** the assigned due date. Homework scores cannot be changed after one week after they have been returned.

In addition to the theoretical part, there will be **optional** computational assignments. These assignments can be done in Matlab (<https://www.mathworks.com/products/matlab.html>), Julia (<https://julialang.org>), or Python (<https://www.python.org>).

It is expected that you express your ideas clearly, legibly, and completely, which often requires complete English sentences (i.e., a justification) rather than a long string of equations or unconnected mathematical expressions. Homework can and should be worked on and discussed with others. Collaboration is a big part of learning and of scholarship in general. I strongly encourage you to participate in study groups with fellow students attending this course. However, the write-up of the homework has to be independent, and in your own words. Your homework needs to be complete, neatly written, and stapled. If you use any external source (e.g., books or internet) you must acknowledge the source in your submission. Penalty for not reporting your sources will be a score of zero for the homework. Your coding solutions have to be submitted by email as instructed in the homework assignments. I reserve the right to deduct points if these rules are not followed.

If you are considering to take the prelim, I strongly encourage you to work on all **theoretical** homework assignments. It is your responsibility to be well prepared for the exams and the prelim.

12 Exams

During the semester there will be two in class midterm exams and one *cumulative* final exam. The exams will contain a mixture of computational and conceptual problems. Some of them will resemble problems you have seen in your homework, while some may be brand new to you. Exams shall be worked on independently and without the use of your textbook, homework, and class notes. There will be **no makeup exams** (see §13 and §14 for details). Exam grades can be disputed until one week after they have been returned. After that your grade cannot be changed. The exam period for the final exam is in December (specific dates are not yet announced). The last day of class is December 2, 2023. The tentative schedule for the exams is:

| | date and time | duration | place |
|-----------|-----------------------------|------------|-----------------|
| Midterm 1 | 10/09/23, 4:00 PM – 5:30 PM | 90 minutes | in class (S132) |
| Midterm 2 | 11/06/23, 4:00 PM – 5:30 PM | 90 minutes | in class (S132) |
| Final | 11/29/23, 4:00 PM – 5:30 PM | 90 minutes | in class (S132) |

The intention of the exams is to develop a theoretical foundation and prepare math majors for the prelim. There might be the possibility to work on computational and theoretical projects, too.

13 Grading

The final grade for the class will be determined as follows:

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| category | percentages | score |
|------------|-------------|-------------|
| homework | 30% | $y_3 = 150$ |
| midterm 1 | 20% | $y_1 = 100$ |
| midterm 2 | 20% | $y_2 = 100$ |
| final exam | 30% | $y_4 = 150$ |
| total | 100% | 500 |

These weights are approximate; I reserve the right to change them later. The letter grade of the course will be assigned based on the percentage $x = 100\% \left(\frac{1}{500} \sum_{i=1}^4 y_i \right)$ of all points (semester score) earned.

| letter grade | percentage | letter grade | percentage |
|--------------|--------------------------|--------------|----------------------|
| A | $93\% \leq x \leq 100\%$ | C | $73\% \leq x < 77\%$ |
| A– | $90\% \leq x < 93\%$ | C– | $70\% \leq x < 73\%$ |
| B+ | $87\% \leq x < 90\%$ | D+ | $67\% \leq x < 70\%$ |
| B | $83\% \leq x < 87\%$ | D | $63\% \leq x < 67\%$ |
| B– | $80\% \leq x < 83\%$ | D– | $60\% \leq x < 63\%$ |
| C+ | $77\% \leq x < 80\%$ | F | $x < 60\%$ |

14 Makeup Policy

Not turning in homework by the assigned due date or not being present for an exam results in a **score of zero**. There will be **no makeup assignments**. Technology failures will not be accepted as reason for missed assignment due dates. Therefore, do not leave anything to the last minute. It is the student's responsibility to identify alternative ways to complete or submit an assignment.

Exceptions are possible in the case of extreme circumstances, such as a documented, serious illness. In the event that a student cannot be present to turn in homework or take an exam on the day it is held the student needs to speak to me in advance, and make every attempt to do the work before (and not after) the rest of the class.

15 Academic Honesty/Honor Code

High ethical standards are critical to the integrity of any institution, and bear directly on the ultimate value of conferred degrees. All UH community members are expected to contribute to an atmosphere of the highest possible ethical standards. Maintaining such an atmosphere requires that any instances of academic dishonesty be recognized and addressed. The [UH Academic Honesty Policy](#) is designed to handle those instances with fairness to all parties involved: the students, the instructors, and the University itself. All students and faculty of the University of Houston are responsible for being familiar with this policy.

Posting answers for homework assignments online (at group chats or other online tools) is considered an academic honesty violation. Students are expected to know the difference between "getting and/or giving help on a problem" and "getting/giving answers to a problem." If a student is caught sharing answers (in person or online), they might be reported to the departmental hearing officer for an academic honesty violation. If a student becomes aware of cheating or any other violations; that student is responsible for informing the instructor.

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16 Excused Absence Policy

Regular class attendance, participation, and engagement in coursework are important contributors to student success. Absences may be excused as provided in the University of Houston [Undergraduate Excused Absence Policy](#) and [Graduate Excused Absence Policy](#) for reasons including: medical illness of student or close relative, death of a close family member, legal or government proceeding that a student is obligated to attend, recognized professional and educational activities where the student is presenting, and University-sponsored activity or athletic competition. Under these policies, students with excused absences will be provided with an opportunity to make up any quiz, exam or other work that contributes to the course grade or a satisfactory alternative. Please read the full policy for details regarding reasons for excused absences, the approval process, and extended absences. Additional policies address absences related to [military service](#), [religious holy days](#), [pregnancy and related conditions](#), and [disability](#).

17 Religious Holy Days

Students whose religious beliefs prohibit class attendance or the completion of specific assignments on designated dates may obtain an excused absence. To do so, please make a written request for an excused absence and submit it to your instructor as soon as possible, to allow the instructor to make arrangements. For more information, see the Student Handbook (<http://catalog.uh.edu/index.php>).

18 Late Registration

No special accommodations will be made for students who register late for this class, miss class, or are denied access to *Canvas* owing to late registration. It is the sole responsibility of the student to seek out and obtain course materials or announcements if they miss class or cannot access these items through *Canvas*. No make-up exams or extensions on assignments will be granted for late registration. If you do encounter problems accessing the course material, please contact the TA and instructors immediately for help, in person and via email. We are best able to help you the sooner you let us know.

19 Recording of Class

Students may not record all or part of class, livestream all or part of class, or make/distribute screen captures, without advanced written consent of the instructor. If you have or think you may have a disability such that you need to record class-related activities, please contact the [Justin Dart, Jr. Student Accessibility Center](#). If you have an accommodation to record class-related activities, those recordings may not be shared with any other student, whether in this course or not, or with any other person or on any other platform. Classes may be recorded by the instructor. Students may use instructor's recordings for their own studying and notetaking. Instructor's recordings are not authorized to be shared with anyone without the prior written approval of the instructor. Failure to comply with requirements regarding recordings will result in a disciplinary referral to the Dean of Students Office and may result in disciplinary action.

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20 Cell Phones and Electronic Devices

During class and exam periods, all cell phones and other electronic devices must be turned off and kept in a secure location away from the students immediate view. The use of laptop computers in class is only permitted if students are using the computers to take notes or for purposes related to the class.

21 Resources for Online Learning

The University of Houston is committed to student success, and provides information to optimize the online learning experience through our [Power-On](#) website. Please visit this website for a comprehensive set of resources, tools, and tips including: obtaining access to the internet, AccessUH, Blackboard, and Canvas; using your smartphone as a webcam; and downloading Microsoft Office 365 at no cost. For questions or assistance contact UHOnline@uh.edu.

22 UH Email

Please check and use your CougarNet email for communications related to this course. Faculty use the CougarNet email to respond to course-related inquiries such as grade queries or progress reports for reasons of FERPA. To access this email, [login](#) to your Microsoft 365 account with your CougarNet credentials.

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23 Communications and Announcements

Email communications related to this course will be sent to your [Exchange Email Account](#), which each University of Houston student receives (or whichever email address is linked to your student ID on ACCESS UH). Exchange email accounts can be accessed by logging into Office 365 with your CougarNet credentials or through Access UH. They can also be configured on IOS and Android mobile devices. Additional assistance can be found at the [Get Help](#) page.

24 Dissemination of Course Material

The materials provided by the instructor in this course are for the **use of the students enrolled in the course only**. Course materials and course recordings (if permission was warranted) may not be further disseminated without instructor permission. This includes sharing content to commercial course material suppliers or public domain platforms. Students are also prohibited from sharing materials derived from the instructor's content (e.g., a student's lecture notes).

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requesting a laptop through the Laptop Loaner Program; using your smartphone as a webcam; and downloading Microsoft Office 365 at no cost. For questions or assistance contact UHOnline@uh.edu.

26 Reasonable Academic Adjustments/Auxiliary Aids

The University of Houston is committed to providing an academic environment and educational programs that are accessible for its students. Any student with a disability who is experiencing barriers to learning, assessment or participation is encouraged to contact the Justin Dart, Jr. Student Accessibility Center (Dart Center) to learn more about academic accommodations and support that may be available to them. Students seeking academic accommodations will need to register with the Dart Center as soon as possible to ensure timely implementation of approved accommodations. Please contact the Dart Center by visiting the website: <https://uh.edu/accessibility> calling (713) 743-5400, or emailing jdcenter@Central.UH.EDU.

27 Mental Health and Wellness Resources

The University of Houston has a number of resources to support students' mental health and overall wellness, including [CoogsCARE](#) and the [UH Go App](#). [UH Counseling and Psychological Services \(CAPS\)](#) offers 24/7 mental health support for all students, addressing various concerns like stress, college adjustment and sadness. CAPS provides individual and couples counseling, group therapy, workshops and connections to other support services on and off-campus. For assistance visit <https://uh.edu/caps>, call 713-743-5454, or visit a [Let's Talk](#) location in-person or virtually. [Let's Talk](#) are daily, informal confidential consultations with CAPS therapists where no appointment or paperwork is needed.

The [Student Health Center](#) offers a Psychiatry Clinic for enrolled UH students. Call 713-743-5149 during clinic hours, Monday through Friday 8 a.m. - 4:30 p.m. to schedule an appointment.

The [A.D. Bruce Religion Center](#) offers spiritual support and a variety of programs centered on well-being.

Need Support Now? If you or someone you know is struggling or in crisis, help is available. Call CAPS crisis support 24/7 at 713-743-5454, or the National Suicide and Crisis Lifeline: call or text 988, or chat 988lifeline.org.

28 Title IX/Sexual Misconduct

Per the UHS Sexual Misconduct Policy, your instructor is a "responsible employee" for reporting purposes under Title IX regulations and state law and must report incidents of sexual misconduct (sexual harassment, non-consensual sexual contact, sexual assault, sexual exploitation, sexual intimidation, intimate partner violence, or stalking) about which they become aware to the Title IX office. Please know there are places on campus where you can make a report in confidence. You can find more information about resources on the Title IX website at <https://uh.edu/equal-opportunity/title-ix-sexual-misconduct/resources>.

29 Security Escorts and Cougar Ride

UHPD continually works with the University community to make the campus a safe place to learn, work, and live. Our Security escort service is designed for the community members who have safety concerns and would like to have a Security Officer walk with them, for their safety, as they make their

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way across campus. Based on availability either a UHPD Security Officer or Police Officer will escort students, faculty, and staff to locations beginning and ending on campus. If you feel that you need a Security Officer to walk with you for your safety please call 713-743-3333. Arrangements may be made for special needs.

Parking and Transportation Services also offers a late-night, on-demand shuttle service called Cougar Ride that provides rides to and from all on-campus shuttle stops, as well as the MD Anderson Library, Cougar Village/Moody Towers and the UH Technology Bridge. Rides can be requested through the UH Go app. Days and hours of operation can be found at <https://uh.edu/af-university-services/parking/cougar-ride>.

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