

# Math 6366 Optimization Theory

Fall 2020, MWF 10:00 am–11:00 am

**Course** Math 6366: Optimization Theory (Section 13177)

**Instructor** Andreas Mang

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**Office** PGH 614

**Office Hours** MW 03:00 pm–04:00 pm or by appointment ([andreas@math.uh.edu](mailto:andreas@math.uh.edu))

**Class Time and Place** MWF 10:00 am–11:00 am on MS Teams (synchronous)

**Course Website** <https://www.math.uh.edu/~andreas/teaching/math6366-FA20>

**Information contained in this syllabus is subject to change without notice. This syllabus provides a general guideline for the course; deviations may be necessary. Students are expected to be aware of any additional course policies presented by the instructor during the course.**

## 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.

## 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 **blackboard**. 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
- barrier method
- primal-dual interior point methods

### §7 Selected Topics (if time permits).

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## 5 Syllabus Changes

Due to the changing nature of the COVID-19 pandemic, 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 through (specify how students will be notified of changes).

## 6 Attendance Policy

Attendance is not required, but strongly encouraged. Additional information can be found in §21.

## 7 Dropping Policy

**09/09/2020** Official reporting day (ORD); drop a course without receiving a grade.

**11/03/2020** Last day to drop a course or withdraw with a 'W'.

## 8 Homework Assignments

If not noted differently, homework assignments will be made available two weeks before the designated due date on **blackboard**. The homework has to be submitted on the designated due date. The deadline for handing in your homework will be 10:50 am sharp (i.e., before I leave the classroom). Late homework will **not** be accepted. The homework will be a combination of practical (computing) exercises and analysis. Computing will be done in Matlab (<https://www.mathworks.com/products/matlab.html>). If desired, solutions in Julia (<https://julialang.org>) or Python (<https://www.python.org>) are also acceptable. There will be a total of six to seven homework assignments. Homework scores cannot be changed after one week after they have been returned.

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 homework assignments. It is your responsibility to be well prepared for the exams and the prelim.

## 9 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 §10 and §11 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, 5, 2020. The tentative schedule for the exams is:

	date and time	duration	place
Midterm 1	10/09/20, 9:00 AM – 10/10/20, 9:00 PM	36 hours	online (take home)
Midterm 2	11/13/20, 9:00 AM – 11/14/20, 9:00 PM	36 hours	online (take home)
Final	12/04/20, 9:00 AM – 12/05/20, 9:00 PM	36 hours	online (take home)

The intention of the exams is to develop a theoretical foundation and prepare math majors for the prelim. Notice that the exams are not designed to take the full 36 hours. This is just to provide you with enough flexibility to schedule your own time to take the exam. There might be the possibility to work on computational and theoretical projects, too.

## 10 Grading

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

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	$x < 60\%$

## 11 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.

## 12 Academic Honesty/Honor Code

In online assignments and tests you will sometimes be asked to make an Academic Honesty Statement. University of Houston students are expected to adhere to the Academic Honesty Policy as described in the UH Undergraduate Catalog. "Academic dishonesty" means employing a method or technique or engaging in conduct in an academic endeavor that contravenes the standards of ethical integrity expected at the University of

Houston or by a course instructor to fulfill any and all academic requirements. Academic dishonesty includes, but is not limited to, the following: Plagiarism; Cheating and Unauthorized Group Work; Fabrication, Falsification, and Misrepresentation; Stealing and Abuse of Academic Materials; Complicity in Academic Dishonesty; Academic Misconduct.

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.

Refer to UH Academic Honesty website (<http://www.uh.edu/provost/policies/honesty>) and the UH Student Catalog for the definition of these terms and university's policy on Academic Dishonesty. Anyone caught cheating will be reported to the department for further disciplinary actions, receive sanctions as explained on these documents, and will have an academic dishonesty record at the Provosts office. The sanctions for confirmed violations of this policy shall be commensurate with the nature of the offense and with the record of the student regarding any previous infractions. Sanctions may include, but are not limited to: a lowered grade, failure on the examination or assignment in question, failure in the course, probation, suspension, or expulsion from the University of Houston, or a combination of these. Students may not receive a W for courses in which they have been found in violation of the Academic Honesty Policy. If a W is received prior to a finding of policy violation, the student will become liable for the Academic Honesty penalty, including F grades.

## 13 Office Hours

Office hours will take place online in one-on-one meetings. Please send me an email to make an appointment for online office hours ([andreas@math.uh.edu](mailto:andreas@math.uh.edu)). I will keep the former schedule for office hours (MW 03:00 pm–04:00 pm) open.

## 14 Course Delivery Format and Final Exam

This course is being offered in the synchronous online format. Synchronous online class meetings will take place according to the class schedule. There is no face-to-face component to this course. In between synchronous class meetings, there may also be asynchronous activities to complete (e.g., discussion forums and assignments). This course will have exams as announced in the tentative schedule provided in §9. Prior to the exam, descriptive information, such as the number and types of exam questions, resources and collaborations that are allowed and disallowed in the process of completing the exam, and procedures to follow if connectivity or other resource obstacles are encountered during the exam period, may be provided.

## 15 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 Center for Students with DisABILITIES (<http://www.uh.edu/csd>). 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.

## 16 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).

## 17 Resources for Online Learning

The University of Houston is committed to student success, and provides information to optimize the on-line learning experience through our Power-On website (<https://uh.edu/power-on/learning>). Please visit this website for a comprehensive set of resources, tools, and tips including: obtaining access to the internet, AccessUH, and Blackboard; 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](mailto:UHOnline@uh.edu).

## 18 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. Additional course communications will be announced on TEAMS during synchronous lectures and/or posted on the "Discussion Board."

## 19 Late Registration

No special accommodations will be made for students who register late for this class, miss class, or are denied access to Blackboard 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 Blackboard. 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.

## 20 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>).

## 21 Excused Absence Policy

Regular class attendance, participation, and engagement in coursework are important contributors to student success. Generally speaking, attendance is not required for this class. This is in accordance with general university wide policies: 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. Additional policies address absences related to [military service](#), [religious holy days](#), [pregnancy and related conditions](#), and [disability](#).

## 22 Students Disability Services/Special Needs

If a student has a disability and would like to request classroom accommodations, please see me after class or during office hours to discuss arrangements as soon as possible (see contact information above).

**Academic Adjustments/Auxiliary Aids:** The University of Houston System complies with Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990, pertaining to the provision of reasonable academic adjustments/auxiliary aids for students who have a disability. In accordance with Section 504 and ADA guidelines, University of Houston strives to provide reasonable academic adjustments/auxiliary aids to students who request and require them. If you believe that you have a disability requiring an academic adjustments/auxiliary aid, please visit The Center for Students with DisABILITIES (CSD) website at <http://www.uh.edu/csd> for more information.

**Accommodation Forms:** Students seeking academic adjustments/auxiliary aids must, in a timely manner (usually at the beginning of the semester), provide their instructor with a current Student Accommodation Form (SAF) (paper copy or online version, as appropriate) from the CSD office before an approved accommodation can be implemented.

Details of this policy, and the corresponding responsibilities of the student are outlined in The Student Academic Adjustments/Auxiliary Aids Policy (01.D.09) document under [STEP 4: Student Submission (5.4.1 & 5.4.2), Page 6]. For more information please visit the Center for Students with Disabilities Student Resources page.

Additionally, if a student is requesting a (CSD approved) testing accommodation, then the student will also complete a Request for Individualized Testing Accommodations (RITA) paper form to arrange for tests to be administered at the CSD office. CSD suggests that the student meet with their instructor during office hours and/or make an appointment to complete the RITA form to ensure confidentiality. RITA forms must be completed at least 48 hours in advance of the original test date. Please consult your counselor ahead of time to ensure that your tests are scheduled in a timely manner. Please keep in mind that if you run over the agreed upon time limit for your exam, you will be penalized in proportion to the amount of extra time taken.

## 23 Mental Health/CAPS Statement

Counseling and Psychological Services (CAPS) can help students who are having difficulties managing stress, adjusting to college, or feeling sad and hopeless. You can reach CAPS ([www.uh.edu/caps](http://www.uh.edu/caps)) by calling 713-743-5454 during and after business hours for routine appointments or if you or someone you know is in crisis. Also, there is no appointment necessary for the "Let's Talk" program (<https://www.uh.edu/caps/outreach/lets-talk>), which is a drop-in consultation service at convenient locations and hours around campus.

## 24 Help

The instructor is available for help during office hours. All the information about this course will be posted regularly on the course website. Material and homework assignments will be posted on blackboard. *Please check these sites often.*