

The University of Iowa
The College of Liberal Arts and Sciences
Fall 2023

Optimization Techniques: MATH:4820 Sec 0001

Class location 205 MLH (MacLean Hall)
& times: 10:30–11:20am MWF

Course ICON site: To access the course site, log into Iowa Courses Online (ICON) <https://icon.uiowa.edu/index.shtml> using your Hawk ID and password.

Course Home:

The College of Liberal Arts and Sciences (CLAS) is the home of this course, and CLAS governs the add and drop deadlines, the “second-grade only” option (SGO), academic misconduct policies, and other undergraduate policies and procedures. Other UI colleges may have different policies.

Instructor Office location & Student drop-in hours:

Office hours: MW 11:30am–12:20pm
F 11:30am–12:30pm over Zoom (link on
ICON)

Office location: McLean Hall 325B

Students are invited to drop by during these hours to discuss questions about the course material or concerns. I am also available by appointment if you are unable to attend my drop-in hours.

Instructor: Prof. David Stewart
Phone: 335-3832
Email: david-e-stewart@uiowa.edu
URL: [http://www.math.uiowa.edu/~dstewart/
classes/](http://www.math.uiowa.edu/~dstewart/classes/)

Departmental Executive Office (DEO) / Department Head:

DEO: Ryan Kinser
email: ryan-kinser@uiowa.edu
room: MLH 14

Description

Catalog description: Basic theory of optimization, use of numerical algorithms in solution of optimization problems; linear and nonlinear programming, sensitivity analysis, convexity, optimal control theory, dynamic programming, calculus of variations.

Detail

- Maximizers and minimizers of a function $f: C \rightarrow \mathbb{R}$, C a subset of \mathbb{R}^n
- Existence of a minimizer (or maximizer)
- Convex functions and convex sets
- Necessary conditions for a minimizer, first order and 2nd order
- Sufficient conditions for local minimizer
- Gradient descent methods and variants
- Line searches for gradient descent
- Newton method and variants for optimization
- Stochastic gradient descent & variants
- Conjugate gradient method and quasi-Newton methods
- Constrained optimization (equality and inequality constrained optimization)
- Theory: Lagrange multipliers, and Karush–Kuhn–Tucker conditions via Farkas lemma

- Practice: algorithms for constrained optimization
- Stochastic methods for continuous optimization & stochastic differential equations
- Optimization with differential equations: optimal control

Learning Objectives and Goals of the Course:

At the completion of the course, the student will be able to:

- Be able to identify conditions under which global minimizers exist
- Be able to identify critical points and when a critical point is definitely a local minimizer
- Be able to implement and use basic optimization algorithms such as gradient descent
- Be able to analyze basic algorithms for optimization
- Be able to formulate constrained optimization problems
- Be able to identify Lagrange multiplier points and identify KKT points
- Understand what is needed to create an algorithm for constrained optimization problems

Textbook

Numerical Optimization 2nd edition by J. Nocedal and S.J. Wright. Published Springer (2006). ISBN: 978-0387303031. (At time of writing, it is available new on Amazon.com for \$55.60.)

Collaboration policy

Students are encouraged to discuss homework. However, *all homework submitted must be your own work (or your own group for group work) and in your own words.* This includes all programs, code, or other software. Where you do use some outside source for material, *cite your sources.* This includes any and all use of automated systems that generate text, code, or images. No material in an exam can be discussed with other students while the exam is in progress.

All students in CLAS courses are expected to abide by the CLAS Code of Academic Honesty. Undergraduate academic misconduct must be reported by instructors to CLAS according to these procedures. Graduate academic misconduct must be reported to the Graduate College according to Section F of the Graduate College Manual.

Student Complaints

I really want to make this course as useful to you as I reasonably can. So if you have a complaint, I would appreciate you coming to me about it first, so that we can create a way of overcoming the difficulty. If we are unable to resolve the problem, you can discuss the issue with the Director or Chair of the school, department, or program offering the course (DEO: Ryan Kinser).

Undergraduate students should contact CLAS Undergraduate Programs for support when the matter is not resolved at the previous level. Graduate students should contact the CLAS Associate Dean for Graduate Education and Outreach and Engagement when additional support is needed.

Drop Deadline for this Course

You may drop an individual course before the deadline; after this deadline you will need collegiate approval. You can look up the drop deadline for this course here. When you drop a course, a "W" will appear on your transcript. The mark of "W" is a neutral mark that does not affect your GPA. Directions for adding or dropping a course and other registration

changes can be found on the Registrar’s website. Undergraduate students can find policies on dropping and withdrawing here. Graduate students should adhere to the academic deadlines and policies set by the Graduate College.

Grading

A +/– grading scheme will be used. Although the College of Liberal Arts and Sciences has some guidelines for the percentages of A’s, B’s, C’s, etc., these are only guidelines, and the class may vary substantially from these values depending on the overall abilities of the members of the class. Note that A+ will be given *only for exceptional work of unusual quality*.

Letter grades at the end of the course will be determined by the final weighted score as computed using the above percentages. The cutoff scores for the different letter grades are expected to be

A	B	C	D	F
90 to 100	80 to 90	70 to 80	60 to 70	below 60

The instructor reserves the right to adjust these cutoffs if the instructor believes there are reasons to do so.

Assessment

Homework will be posted on ICON as appropriate. Make sure that you keep up to date with the course’s ICON page.

There will be one midsemester exam (25%), homework assignments (25% total), a project (25%), and a final exam (25%). There may also be ungraded homework assigned during the course. The midterm exams will cover the material covered up to that point in the class. The final exam will be comprehensive (that is, cover all material covered in the class).

The end-of-class project is intended to be a capstone project for the course. This will be a project provided by the instructor, and its content will go

beyond the classroom material. This project will involve both significant theory as well as programming to implement the ideas.

Do not plan your end of the semester travel plans until the final exam schedule is made public. It is your responsibility to know the date, time, and place of the final exam. According to Registrar's final exam policy, **students have a maximum of two weeks after the announced final exam schedule** to request a change if an exam conflict exists or if a student has more than two exams in one day (see the policy here).

Unexcused late homework will typically be penalized by reducing the score by 20%. If you are aware that you will be likely be late with homework, please contact the instructor as soon as possible so that accommodations can be made as appropriate. Missed exams due to unavoidable circumstances can be made up; please contact the instructor as soon as possible after becoming aware of this so that suitable accommodations can be made. Students with mandatory religious obligations or UI authorized activities must discuss their absences with the instructor as soon as possible. Religious obligations must be communicated within the first three weeks of classes.

Date and Time of the Final Exam

The final examination date and time will be announced by the Registrar generally by the fifth week of classes and it will be announced on the course ICON site once it is known. **Do not plan your end of the semester travel plans until the final exam schedule is made public. It is your responsibility to know the date, time, and place of the final exam.** According to Registrar's final exam policy, students **have a maximum of two weeks after the announced final exam schedule** to request a change if an exam conflict exists or if a student has more than two exams in one day (see the policy here).

Attendance policy

It is expected that all students will endeavor to attend all classes. Exceptions will be given for temporary illness, mandatory religious obligations,

or other special circumstances that make attendance unusually difficult. If you can not attend class for a length of time or expect to miss a significant fraction of the classes, please contact the instructor as soon as possible to explain and discuss alternative accommodations. Please see the instructor regarding make-up exams if you are unable to attend an exam because of any of the exceptions listed above.

Students have the right to a distraction-free learning environment. Students are also expected to help each other learn and to contribute overall to the learning environment of the course. Arriving prepared for class is part of this expectation. Attendance also means that you can ask questions if something needs more explanation.

Calendar of Course Assignments and Exams

Course assignments will be posted on ICON as they come available. I will aim to post assignments Monday of every week and they will be due either the Friday or Saturday of that week.

The midterm exams will be held on Wednesday Sept 27th 6:30–8pm at 1505 SC, and on Wednesday Nov 1st 6:30–8pm also at 1505 SC. The final exam will be during the final exam week, and its date and time will be announced around the 5th week of class.

Additional Notes

- **Course plan:** The course plan may be modified during the semester. Such modifications will be announced in advance during class periods; the student has responsibility for keeping up with such changes. You should also make a habit of reviewing the ICON web page for this course, which is accessible via: ICON <http://icon.uiowa.edu/> This page will have homework details and other information posted to it as the class progresses.

College of Liberal Arts and Sciences (CLAS) Course Policies

- **Attendance and Absences Policies:** University regulations require that students be allowed to make up examinations which have been missed due to illness or other unavoidable circumstances. Students with mandatory religious obligations or UI authorized activities must discuss their absences with me as soon as possible. Religious obligations must be communicated within the first three weeks of classes.
- **Exam Policies** (see link)
- **Communication: UI Email:** Students are responsible for all official correspondences sent to their UI email address (uiowa.edu) and must use this address for any communication with instructors or staff in the UI community.

University Policies

- Accommodations for Students with Disabilities
- Basic Needs and Support for Students
- Classroom Expectations
- Exam Make-up Owing to Absence
- Free Speech and Expression
- Mental Health
- Military Service Obligations
- Non-discrimination Religious Holy Days
- Sexual Harassment/Misconduct and Supportive Measures
- Sharing of Class Recordings