ILLINOIS

# SE 413: Engineering Design Optimization
# Spring 2025

## Course Information

- Tuesday/Thursday 3:30-4:50 pm, 106B1 Engineering Hall (full semester)
- Sections: R (3 credits, in-person), S (4 credits, in-person), ONL (4 credits, online asynchronous)

### Instructor Information


- James T. Allison, Associate Professor, Industrial and Enterprise Systems Engineering
- jtalliso@illinois.edu, systemdesign.illinois.edu, youtube.com/@designimpact2178
- Office Hours: In-person: Tu 9-10 am W 3-4 pm, TB 313 | Virtual, by appointment,

- Teaching Assistant (TA): Chad Peterson
- Teaching Assistant contact information: cp44@illinois.edu
- Teaching Assistant office hours: In-person: W 12:00-12:50 pm, Fri 11:00-11:50 am, and by appointment. Location: TB 406.


### Course Description

Application of optimization techniques to engineering design problems. Emphasis on problem formulation, including applications in structural, mechanical, and other design domains. Important theoretical results and numerical optimization methods. Matlab programming assignments to develop software for solving nonlinear mathematical programming problems. 3 or 4 undergraduate hours. 3 or 4 graduate hours. **Prerequisites: MATH 241 and MATH 257/415.**

## Learning Outcomes

The primary objective of this course is for students to gain the knowledge and creative skill required to translate practical engineering design problems into mathematical optimization problems that can be solved using numerical methods for optimization, and to be effective in solving and analyzing these problems. In supporting this primary objective, the following objectives should be met by students:

- Demonstrate an understanding of how design optimization fits into the overall engineering design process.
- Learn how to formulate practical engineering design problems as well-posed optimization problems.
- Understand continuous optimization theory and its implications for algorithm development, problem formulation, and system modeling.
- Develop a detailed understanding of numerical methods for optimization through both theoretical development and implementation in MATLAB.

The final course grade for each student is based on how well these learning objectives have been met as assessed through quizzes, homework, exams, the semester project, and other class assignments and activities.

## Prerequisites

MATH 241 and MATH 257/415

# Course Materials

## Learning Management System

Canvas: https://canvas.illinois.edu/courses/55120

## Required and Recommended Course Readings

- **Required:** Engineering Design Optimization (SE 413 Course Notes, pdf available to SE 413 students)
- **Optional Additional Reference:** Engineering Design Optimization [free pdf download] (Martins and Ning, 2021)
- **Optional Additional Reference:** Principles of Optimal Design: Modeling and Computation (Third Edition, Papalambros and Wilde, 2017)
- **Optional Additional Reference:** Numerical Methods for Unconstrained Optimization and Nonlinear Equations. (Dennis and Schnabel, 1996)

- **Optional Additional Reference:** Nonlinear Programming. (Bertsekas, 1999)

### Required Software

Homework and project assignments will require the use of MATLAB, which is available to all University of Illinois students at no cost:

https://www.mathworks.com/academia/tah-portal/university-of-illinois-urbana-champaign-31483508.html

## Course Requirements and Policies

### Grading Breakdown

| Instructional Activity | Number of Assessments | Weight |
|---|---|---|
| Homework | 8 | 30% |
| Asynchronous Quizzes | 12 | 5% |
| Midterm Exams | 2 | 30% |
| Semester Project | 8 | 25% |
| Class Participation | TBD | 10% |

### Course Components

#### Assignments

- Homework 1: MATLAB Programming (Jan 31)
- Homework 2: Mathematical Preliminaries (Feb 7)
- Homework 3: Numerical Optimization Foundations (Feb 21)
- Homework 4: EDO Problem Formulation and Analysis (Feb 28)
- Homework 5: Unconstrained Optimization 1 (March 28)
- Homework 6: Unconstrained Optimization 2 (April 11)
- Homework 7: Constrained Optimization 1 (April 25)
- Homework 8: Constrained Optimization 2 (May 2)

#### Asynchronous Quizzes

Twelve asynchronous quizzes are to be taken during the semester. Each quiz includes multiple choice questions that test your knowledge of topics recently covered in lectures. These quizzes are due weekly, except for weeks impacted by exams.

## Semester Project Deliverables

The final project report is the primary assessment for the semester project. It is the course integrative assessment that takes the place of a final exam. The report is due during finals week. Several intermediate project deliverables are due during the semester to aid students in making progress toward a successful semester project. Students enrolled for four credits have additional semester project requirements compared to students enrolled for three credits.

## Exams

Two take-home midterm exams are given. The primary goal of these exams is to assess student conceptual understanding of course topics.

- Exam 1: March 6
- Exam 2: May 6

# Class Attendance and Participation

The Student Code states ”Regular class attendance is expected of all students at the university.” Attendance will not be formally recorded. Class participation is 10% of the overall grade, which will be assessed via student a self-assessment, an instructor assessment, and a small number of class activities. Class participation scores are higher for students who can point to evidence of class engagement in their self-assessments, such as attendance and vocal participation in class, attending office hours, and other types of engagement

# Final Letter Grades/ Grading Scale

| Percentage | Letter Grade |
|---|---|
| ‘A’ grade and exceptional mastery | A+ |
| 94.00% - 100% | A |
| 90.00% - 93.99% | A- |
| 87.00% - 89.99% | B+ |
| 83.00% - 86.99% | B |
| 80.00% - 82.99% | B- |
| 77.00% - 79.99% | C+ |
| 73.00% - 76.99% | C |
| 70.00% - 72.99% | C- |
| 67.00% - 69.99% | D+ |
| 63.00% - 66.99% | D |
| 60.00% - 62.99% | D- |

| | |
|---|---|
| 59.99% and below | F |

# Additional Course and Campus Policies

## Academic Integrity

The University of Illinois Urbana-Champaign *Student Code* should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity.

Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy. Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

## Students with Disabilities

The University of Illinois is committed to ensuring that all students, including those with disabilities, do not experience barriers to learning and participating fully in class. If you have a letter of accommodation from DRES and have not already given it to me, please do so as soon as possible to ensure your accommodation needs are met.

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may:

- Visit: 1207 S. Oak St., Champaign
- Contact: 217-333-1970
- Email: disability@illinois.edu
- Visit: DRES website

## Family Educational Rights and Privacy Act (FERPA)

The federal Family Educational Rights and Privacy Act (FERPA) affords students certain rights with respect to their education records

## Mental Health

Significant stress, mood changes, excessive worry, substance/alcohol misuse or interferences in eating or sleep can have an impact on academic performance, social development, and emotional wellbeing. The University of Illinois offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings which are covered through the Student Health Fee. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources

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

- Counseling Center 217-333-3704
- McKinley Health Center 217-333-2700
- National Suicide Prevention Lifeline 800-273-8255
- Rosecrance Crisis Line 217-359-4141 (available 24/7, 365 days a year)

If you are in immediate danger, call 911.

## Community of Care

As members of the Illinois community, we each have a responsibility to express care and concern for one another. If you come across a classmate whose behavior concerns you, whether in regard to their well-being or yours, we encourage you to refer this behavior to the Connie Frank CARE Center (formerly the Student Assistance Center) in the Office of the Dean of Students. You may do so by calling 217-333-0050 or by submitting an online referral. Based on your report, staff in the Student Assistance Center will reach out to offer support and assistance.

Further, as a Community of Care, we want to support you in your overall wellness. We know that students sometimes face challenges that can impact academic performance (examples include mental health concerns, food insecurity, homelessness, personal emergencies). Should you find that you are managing such a challenge and that it is interfering with your coursework, you are encouraged to contact the Connie Frank CARE Center (formerly the Student Assistance Center) in the Office of the Dean of Students for support and referrals to campus and/or community resources.

## Disruptive Behavior

Behavior that persistently or grossly interferes with classroom activities is considered disruptive behavior and may be subject to disciplinary action. Such behavior inhibits other students' ability to learn and an instructor's ability to teach. A student responsible for disruptive behavior may be required to leave class pending discussion and resolution of the problem and may be reported to the Office for Student Conflict Resolution. For Disciplinary action visit:

- Email: conflictresolution@illinois.edu
- Contact: 217-333-3680

## Emergency Response Recommendations

Emergency response recommendations and campus building floor plans can be found on the Division of Public Safety website. I encourage you to review this website within the first 10 days of class.

## Religious Observances

It is the policy of the University of Illinois Urbana-Champaign to reasonably accommodate its students' religious beliefs, observances, and practices that conflict with a student's class attendance or participation in a scheduled examination or work requirement, consistent with state and federal law. Students should make requests for accommodation in advance of the conflict to allow time for both consideration of the request and alternate procedures to be prepared. Requests should be directed to the instructor. The Office of the Dean of Students provides an optional resource to assist students in making such requests.

## Sexual Misconduct Reporting Obligation

The University of Illinois is committed to combating sex-based misconduct. Faculty and staff members are required to report any instances of sex-based misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: wecare.illinois.edu.

## Veterans and Military Students

As a military-friendly institution, and per federal regulations and Illinois statutes, the University of Illinois Urbana-Champaign has established policies and procedures to accommodate military-connected students. In addition to the support available at the Chez Veterans Center, members of the National Guard or Reserves and active-duty military personnel with military obligations (e.g., deployments, training, drills) are encouraged to communicate these, in advance whenever possible, to the instructor. The policy for Excused Absences and Departure from the University for U.S. Military or other U.S. National Defense Services can be found at Student Code website.

# Course Schedule/Outline

| Week | Topics |
|---|---|
| 1 (L1) | • Introduction to EDO<br>• Design Automation<br>• Algorithmic Thinking |

| Week | Topics |
|---|---|
| 2 (L2) | • Optimization Solver Introduction<br>• Mathematical Preliminaries |
| 3 (L3) | • Numerical Foundations for Optimization |
| 4 (L4) | • EDO Problem Formulation and Analysis |
| 5 (L5) | • EDO Problem Formulation and Analysis |
| 6 (L6) | • EDO in Practice |
| 7 | • Exam Review<br>• Exam 1 |
| 8 (L7) | • Unconstrained Optimization Part A |
| 9 | • Spring Break |
| 10 (L8) | • Unconstrained Optimization Part B |
| 11 (L9) | • Unconstrained Optimization Part C |
| 12 (L10) | • Constrained Optimization Part A |
| 13 (L11) | • Constrained Optimization Part B |
| 14 (L12) | • Constrained Optimization Part C |
| 15 | • Exam Review |
| 16 | • Exam 2 |