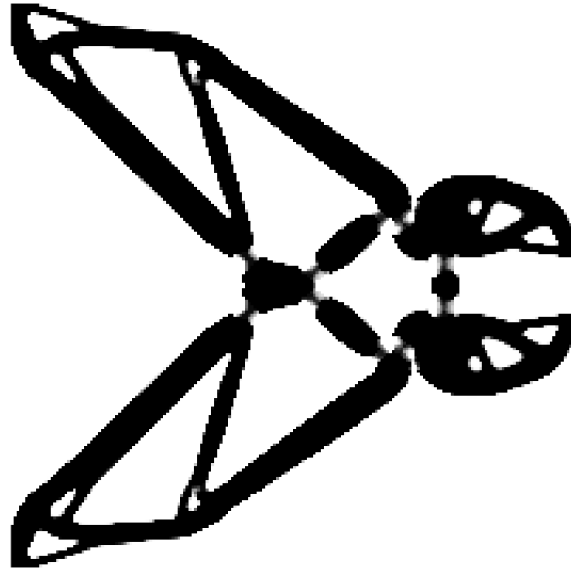




## **ME498 – Mechanical Design Optimization**

Fall 2026 Syllabus

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Last Revised: August 18, 2026

### **Course Overview**

This course is intended to introduce the basic concepts of design optimization with applications from multiple industries. The course will begin with a brief summary of numerical optimization and examples using parametric design and sizing optimization. Then, the finite element method is introduced for use in topology optimization. Examples of optimal structures and mechanisms will demonstrate a reduction in material usage, improved product performance and shorter design cycles compared to heuristic design. The course includes assignments in the form of design challenges and a final project in which students will optimize an original design.

### **Learning Objectives**

After this course, students will be able to:

- Develop an optimization framework for a design task
- Identify design parameters, objectives, and constraints
- Derive expressions for sensitivities of objective/constraint functions with respect to design variables

- Implement gradient-based numerical optimization for these design tasks using Python/Matlab
- Implement size/shape/topology optimization
- Communicate a design methodology in a clear, succinct and professional manner.

## Course Logistics

- **Term:** Fall 2026
- **Credits:** 3 for section TG3, 4 for sections TG4 or TGO
- **Duration:** Full Semester
- **Format:** In-person for sections TG3 and TG4, asynchronous remote for section TGO
- **Website:** <https://canvas.illinois.edu>
- **Communications:** <https://campuswire.com/p/G3C26B6C5> Code: 0503
- **Lecture:** Tues. & Thurs. 12:00–1:20 PM, 410B1 Engineering Hall.
- **TFG Office Hours:** TBD
- **TA:** Sarah Kzam (sbukzam2@illinois.edu)
- **SBK Office Hours:** TBD
- **Workload Expectation:** 2-4 hours outside of class for every hour of class time.

## Primary References

- Course Notes, to be distributed on Canvas.
- Lecture recordings will only be made available to students registered in TGO section.

## Supplemental References

- [Engineering Design Optimization](#), Martins & Ning [M&N]
- [Numerical Optimization](#), Nocedal & Wright [N&W]
- [An Introduction to Structural Optimization](#), Christensen & Klarbring [C&K]
- [A First Course In Finite Elements](#), Fish and Belytschko [F&B]
- [Introduction to Finite Element Methods](#), Felippa [Felippa]
- [Topology Optimization: Theory, Methods, and Applications](#), Bendsøe & Sigmund [B&S]

## Assessments

### Homework & Reflections, 30%

Weekly(ish) homework assignments submitted via Gradescope. While working with peers is encouraged, everyone must submit entirely original work. These submissions should aim for a standard of professionalism; that is, a submission should be a stand-alone document that fully documents the work. Submissions should be *traceable*, i.e., they can be followed, checked, and independently reproduced by another engineer. Every result can be traced back to its source assumptions, inputs, methods, equations, and references.

Weekly reflections submitted via Google form are intended help solidify what you learned and how you learned it each week, along with any struggles/confusion/difficulty etc.

## Midterm Exam, 35%

An in-class exam, tentatively scheduled for 10/29/26.

## Final Project, 35%

Students will develop original optimization code and apply it to a chosen design task. The project will be delivered in the style of a conference: OptiCon 2026! The initial submission proposing the project will allow for instructor feedback. The final submission will include a report and a prerecorded presentation.

## Course Outline

(Note: All times are estimates and subject to change.)

### 1. Introduction (Week 1)

- Topics: Motivation, Design Process, Background/Review of prerequisites
- Suggested Reading:
  - M&N App. A

### 2. Optimization Basics (Weeks 2-3)

- Topics: Terminology, Optimization Statements, Optimality Conditions, Graphical Methods
- Suggested Reading:
  - M&N Ch. 1
  - C&K Ch. 1

### 3. Numerical Methods (Weeks 4-5)

- Topics: 1D (Line Search) & nD (Linear Programming, Steepest Descent, Newton's Method) Unconstrained Methods, nD Constrained Methods
- Suggested Reading:
  - M&N Ch. 4-5

### 4. Finite Element Analysis (Weeks 6-8)

- Topics: Truss Elements in 1D & 2D, Elasticity, Plane Stress Elements
- Suggested Reading:
  - F&B

### 5. Sensitivity (Weeks 9-10)

- Topics: Finite Difference, Adjoint & Direct Methods
- Suggested Reading:
  - M&N Ch. 6
  - C&K Ch. 6

### 6. Topology Optimization (Weeks 11-13)

- Topics: Size & Topology Optimization, Penalty (Material Interpolation), Filtering, Sensitivity, Model Updating, Numerical Implementation

- Suggested Reading:
  - C&K Ch. 9
  - B&S Ch. 1
- 7. Special Topics (time permitting, Weeks 15-16)
  - Potential Topics: Compliant Mechanisms, Heat transfer, Dynamics, Uncertainty...
  - Suggested Reading: TBD

## Course Policies

- **Attendance:**

- I do not take attendance in lecture. My commitment is to make classes worth attending. Please arrive on time and bring a computer, as we will be doing some active learning activities. Please resist the distractions of having a computer in front of you for anything not related to class; it diminishes your experience and that of those around you.

- **Late Policy:**

- All assignments submitted electronically shall be due at the close of business (COB) on the assigned day, which is 5 pm CT. There will be no deduction for assignments submitted within 7 hrs of this time. Assignments submitted more than 7 hrs late will receive zero credit.

- **Regrade Requests:**

- Requests for re-grading assignments need to be submitted within one week of receiving the grade, along with a written explanation justifying the request.

- **Acceptable sources for assistance**

- We will have office hours with the professor and TA(s). You are free to make use of this time for assistance on assignments.
- You are also free to work in partnership with other students, as long as the work you submit is your own and represents your understanding of the course material.

- **Generative AI:**

- The developments around generative AI are in flux, and the rules that are expressed in this syllabus may need to change on short notice. This may affect the contents of assignments, as well as their evaluation. In principle, you may submit work that is based on or derived from AI-generated content, as long as this use is properly documented. You need to include the full prompt(s) and the response(s) as an attachment to any submission that makes use of generative AI. You are solely responsible for the correctness of all submissions. The intended use of AI in this course is to aid in your work, not as a substitute for your own understanding. Admittedly, this is a subjective determination which will be discussed/clarified as needed.
- Written assignments, such as the end-of-semester project, should be your own writing. The intent of written assignments is to demonstrate your understanding the technical work as well as your ability to clearly communicate this work.

- **Copyright:**

- All materials that the instructor(s) provide during the course are copyrighted (even if not explicitly stated on the materials). This copyright will apply to all course notes, homework problem sets, exams, Matlab code, solutions of any kind, etc.
- You are not permitted to share the materials outside of the course (e.g. homework sharing websites). That is a copyright violation and may be prosecuted under the “facilitating infractions” clause of the academic integrity code.

- o Please remember that the course materials are the intellectual property of the instructor(s) and TA(s). We hope that you will act respectfully in this regard.

## **Campus Policies:**

- **Academic Integrity:**

- o 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. <http://studentcode.illinois.edu/> Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: <https://studentcode.illinois.edu/article1/part4/1-401/>. 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.

- **Family Educational Rights and Privacy Act (FERPA):**

- o Please visit <http://registrar.illinois.edu/ferpa> for information about the Family Educational Rights and Privacy Act (FERPA).

- **Mental Health:**

- o 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 well-being. 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, 610 East John Street Champaign, IL 61820
- \* McKinley Health Center: 217-333-2700, 1109 South Lincoln Avenue, Urbana, Illinois 61801
- \* 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.

\*This statement is approved by the University of Illinois Counseling Center

- **Community of Care:**

- o 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.
- **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, call 333-1970, email: [disability@illinois.edu](mailto:disability@illinois.edu), or go to the [DRES website](#).
- **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 (<https://conflictresolution.illinois.edu>; [conflictresolution@illinois.edu](mailto:conflictresolution@illinois.edu); 333-3680) for disciplinary action
- **Emergency Response Recommendations:**
  - Emergency response recommendations and campus building floor plans can be found at the following website: <https://police.illinois.edu/em/run-hide-fight/>. 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 on its [website](#) 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: <https://wecare.illinois.edu/resources/students/#confidential>.
- Other information about resources and reporting is available here: [wecare.illinois.edu](https://wecare.illinois.edu).