MAE 530 Introduction to Design Optimization
Syracuse University, Spring 2026

Welcome to MAE 530:
I'm excited to explore the world of design optimization with you this semester. This course will equip you with practical skills in numerical optimization, problem-solving, and engineering design. By the end, you'll be able to apply these methods to real-world problems, including projects where you can see your designs come to life. I encourage you to engage actively, ask questions, and collaborate—this is an applied and interactive course, and your curiosity is your greatest asset. [1]

Course Description:
Theory and use of numerical design optimization methods. Problem formulation, practical application, and result analysis. Unconstrained nonlinear problems constrained linear and nonlinear problems, and multiobjective optimization. Extensive use of MATLAB functions and programming.

Instructor:	Dr. Xiyuan Liu, xliu127@syr.edu 359 Link Hall, Ph: 315.443.1733
Course Website:	Blackboard.syr.edu
Class Location & Time:	Monday, Wednesday 3:45 – 5:05 PM, Science & Tech Ctr 3-212.
Office Hours:	Tuesday 2 – 3 PM (359 Link) Wednesday 2 – 3 PM (359 Link) Other office hours can be scheduled by emailing me.
Textbook:	Jasbir Singh Arora, Introduction to Optimum Design (4th Edition), Elsevier, 2017. ISBN 978-0-12-800806-5. The required textbook is available in the SU Bookstore (Schine Student Center)
Prerequisites:	MAT 485 Also, you are expected to possess basic ability to use MATLAB (ECS 104) [2]
Course Communication:	I will communicate with the class via email for all important notices and messages. Please check your Syracuse email account regularly! Documents and grades will be posted on Blackboard.

Course Learning Objectives: [3]

After taking this course, you will be able to:
- formulate an optimization problem in terms of design variables, objective function, and constraints for engineering applications.
- select and apply appropriate techniques for solving constrained and unconstrained, linear and nonlinear optimization problems.
- demonstrate the use of optimization techniques, including topology optimization, on a variety of engineering problems.

- integrate optimization methods into an engineering design project, including problem formulation, numerical solution, and evaluation of results.
- understand the principles and practical considerations involved in implementing optimization in real-world engineering design, including manufacturing constraints and performance evaluation.

Grading:

Class participation [4]	10 %
Lab module [4]	30 %
Exam	20 %
Design Project	40 %

Grade	A	A-	B+	B	B-	C+	C	C-	D	F
Range	$\geqslant 93$	92.99-90	89.99-87	86.99-83	82.99-80	79.99-77	76.99-73	72.99-70	69.99-60	<60

Note: Your grade in this class does not depend on how well other students are doing, which means, there will be no curving.

* Actual cutoff scores might be adjusted to reflect instructor's opinion, above scale will guarantee you get the corresponding grades.
* Grades of D may not be assigned to graduate student.

Grading Error:

Please come to my office hours in person for correction. Corrections will not be made without the original document handed to me in person. All errors need to be corrected within one week of the return date.

Class Participation:

The University policy on classroom attendance states that *"Attendance is expected in all courses at Syracuse University."* It is important that you attend all classes and labs, as your presence and engagement contribute to both your learning and the overall class experience.

While participation and attendance will not be directly graded, attendance will be monitored through in-class activities. Your questions, insights, and contributions enrich the learning environment for everyone, and active participation is encouraged and appreciated.

If you miss class due to illness or personal reasons, please contact the ECS Dean's Office for an official excuse. For planned absences related to athletic events, field trips, or similar commitments, you must submit a signed absence request from your coach, advisor, or other relevant authority **before** the absence.

Homework: [6]

You are encouraged to work together on homework assignments, however each person must individually turn in their own work and it must represent your level of understanding of the material. I recommend working with other students to figure out how to do the problem, but do not write anything down while looking at their work (no pencil in your hand). Then go to your own paper and try to work the problem yourself.

Due Dates: All assignments are due at the stated date and time on the course schedule or LMS.

Grace Period: A 24-hour grace period is allowed with a 10% deduction from the earned grade.

Late Submission: 24 - 72 hours late will = 30% deduction from the earned grade; > 72 hours = zero unless prior approval

Exceptions: Extensions will only be granted for documented emergencies or university-approved reasons and must be requested before the due date whenever possible.

Academic Integrity:

While discussion of class-related assignments is encouraged, whatever is turned in should be the reflection of individual work. Copying assignments is not a way to learn. No collaboration will be allowed during tests; accessing outside information (crib sheets, electronic transfer of any kind) is strictly forbidden. Identical errors are easy to spot: don't do it, it is not worth it. If you are caught violating the academic integrity policy, you will be reported.

- The instructor and TA will have access to your work. If you are caught cheating on any one of the homework/quizzes, you will receive a zero grade for all the homework/quizzes for the semester.

- Cheating during the tests/final will result in a zero grade for that test/final.

Syracuse University's Academic Integrity Policy holds students accountable for the integrity of the work they submit. Students should be familiar with the policy and know that it is their responsibility to learn about course-specific expectations, as well as about University policy. The University policy governs appropriate citation and use of sources, the integrity of work submitted in exams and assignments, and the veracity of signatures on attendance sheets and other verification of participation in class activities. The policy also prohibits students from submitting the same written work in more than one class without receiving written authorization in advance from both instructors. The presumptive penalty for a first offense by an undergraduate student is course failure, accompanied by a transcript notation indicating that the failure resulted from a violation of Academic Integrity Policy. For more information and the complete policy see http://academicintegrity.syr.edu

Disability Services:

I will accommodate the needs of student with disabilities in accordance with SU policy; in particular, for students who have been diagnosed with learning disability and require extra time for tests and exams, I ask that you remind me of your needs when a test is being scheduled so I can make arrangements (time and location of your exam). Students who are in need of disability-related academic accommodations must register with the Office of Disability Services (ODS), 804 University Ave, Room 309, 315-443-4498. Students with authorized disability-related accommodations should provide a current Accommodation Authorization Letter from ODS to the instructor and review these accommodations with the instructor. Accommodations, such as exam administration, are not provided retroactively; therefore, planning for accommodations as early as possible is necessary. For further information, see the ODS website http://disabilityservices.syr.edu

If you believe that you need accommodations for a disability, please contact the Office of Disability Services(ODS), http://disabilityservices.syr.edu, located in Room 309 of 804 University Avenue, or call (315) 443-4498 for an appointment to discuss your needs and the process for requesting accommodations. ODS is responsible for coordinating disability-related accommodations and will issue students with documented Disabilities Accommodation Authorization Letters, as appropriate. Since accommodations may require early planning and generally are not provided retroactively, please contact ODS as soon as possible. Syracuse University and I are committed to your success and to

supporting Section 504 of the Rehabilitation Act of 1973. This means that in general no individual who is otherwise qualified shall be excluded from participation in, be denied benefits of, or be subjected to discrimination under any program or activity, solely by reason of having a disability.

Religious Observances:

Syracuse University recognizes the diversity of faiths represented among the campus community and protects the rights of students, faculty, and staff to observe religious holidays according to their tradition. Under this policy, students are provided an opportunity to make up any examination, study, or work requirements that may be missed due to a religious observance provided they **notify their instructors before the end of the second week of classes.** Students have access to an online notification form through MySlice (MySlice/StudentServices/Enrollment/MyReligiousObservances) that they can use to notify their instructors. https://myslice.syr.edu. **Work must be made up within one week of returning from an absence.**

Tentative Schedule:

Week	Monday (Lecture)	Wednesday (Lab)	Project Milestone
1	Intro to optimization & course project	MATLAB Warm-up, using an Optimizer	Project overview given; baseline project brief distributed
2	Modeling real-world systems	Modeling in MATLAB & CAD	Students choosing self-proposed projects submit a **one-paragraph idea**
3	Graphical method	Graphical method in MATLAB	Self-proposed students refine concept based on feedback
4	Unconstrained optimization	Line search methods	**Proposal due** for self-proposed projects (problem statement, variables, constraints, test plan)
5	Search directions	Apply line search & gradient descent	Instructor approves/adjusts self-proposed projects
6	Gradient-based constrained optimization + KKT	KKT in MATLAB	All teams formulate numerical optimization problem
7	Penalty function methods	Apply penalty function	Numerical model implemented in MATLAB
8	**Spring Break**	—	—
9	SQP methods	Project Work: Apply SQP, penalty and KKT	**Numerical optimization results due** (parameters + predicted performance)
10	Heuristic optimization	Apply Heuristic optimization	Heuristic optimization results due
11	Topology optimization fundamentals	Apply topology optimization	Initial topology optimization run completed
12	Advanced topology optimization	Apply manufacturing constraints in topology optimization	Final topology-optimized geometry completed
13	Project work session	Testing prep session	Final CAD ready for print; testing plan finalized
14	Project presentations	Testing day	3D printed part tested; results compared to predictions

[1] This welcoming message is newly added to make the syllabus feel more personal and inviting. It also provides a concise summary of the course so that students have a clear understanding of what to expect.

[2] Revised all syllabus language from "the students" to "you" to create a more direct and engaging tone.

[3] Applied backward design to introduce a project in which students apply all concepts learned in class to optimize their design, then prototype and test it. Accordingly, modified Course Learning Outcome (LO) 3 to include topology optimization and added LOs 4 and 5 to reflect this change. I also ensured that all LOs are written clearly, specifically, and in measurable terms.

[4] Plan to adopt several interactive techniques during lecture sessions to increase student engagement and assess students' understanding of the topics.

[5] Added lab modules as part of the course redesign. Some lecture content will be converted into lab activities, with materials prepared in the form of documents, video demonstrations, and student-led exercises.

[6] Homework policy is modified to provide some level of flexibility.