ASEN 5519-003 / 6519-004
Design Optimization
Spring 2023

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Office Hours: TBD

Lectures: T/Th: 4:00- 5:25 pm, AERO 232.

Class Web Site: log on to https://canvas.colorado.edu/ to find
ASEN5519-003/6519-004 – Design Optimization

Class e-mail list: This is automatically done through CANVAS.

Textbooks:

General textbooks on design optimization (mostly in the context of solid mechanics):

1. *Introduction to Optimum Design* by J.S. Arora

2. *Structural Optimization: Fundamentals and Applications* by U. Kirsch

3. *Elements of Structural Optimization* by R.T. Haftka, Z. Gurdal

4. *Foundations of Structural Optimization: A Unified Approach* by A. J. Morris (*)

5. *Introduction to Optimization of Structures* by N.V. Banichuk

6. *Numerical Optimization Techniques for Engineering Design* G.N. Vanderplaats (*)

Useful textbooks on special topics

1. *Parameter Sensitivity in Nonlinear Mechanics* by M. Kleiber, et al. (*)

2. *Design Sensitivity Analysis of Structural Systems* by E.J. Haug, et al.

3. *Optimization of structural topology, shape, and material* by Martin P. Bendsøe and O. Sigmund

(*) Only physical copy available.

Course Objectives: Introduce the fundamentals of design optimization of problems in solid and fluid mechanics, and heat transfer with a focus on problems in aerospace engineering. Topics include PDE constrained optimization, nonlinear programming, sensitivity analysis, shape and topology optimization.

Major Course Topics:

1. Introduction into design optimization
   - Overview and terminology
   - Formulation of optimization problems
   - Lagrange function and KKT conditions

2. Gradient-based methods (for unconstrained problems)
   - Simplex, steepest decent, line search methods
   - Interval search, interpolation methods and Armijo's rule
   - Conjugate gradient method
   - Projected conjugate gradient method

3. Optimization algorithms for nonlinear programs
   - Overview of primal, penalty, dual and Lagrange Methods
   - Sequential convex approximation
   - Method of moving asymptotes

4. PDE-constrained optimization problems
   - Overview of PDEs models in solid, fluid mechanics and heat transfer
   - Sensitivity analysis approaches
   - Adjoint method and self-adjoint problems
   - Sensitivity analysis for transient, path-dependent problems

5. Shape optimization
   - Challenges and approaches
   - Shape sensitivity analysis
   - Applications to Multi-objective and min/max and bound methods

6. Topology optimization
   - Topology vs geometry / historical perspective (Maxwell and Michell theories)
   - Global search methods (generic algorithms, particle swarm methods)
   - Relaxation, optimality criteria and homogenization methods
   - Density methods
   - Level set methods

7. Selected Problems (if time permits)
   - Density methods: regularization and geometry control
   - Parametric level-set methods: Hamilton-Jacobi approach
   - Multi-disciplinary optimization problems
   - Coupled multi-physics optimization problems

Grading Guideline:

Group/Individual work:	Homework	65%
Individual:	Midterm Exam (03/21/2023)	15%
	Final Project	20%
		_____
		100%

Note: We reserve the right to make minor changes to this distribution of weights based on variations in assignments.

Course Policies and Procedures:

1. The instructor reserves the right to reply to email questions only in business hours, i.e., Monday through Friday, 8:00 am – 5:00 pm. Emails received 24 hours or less before the exams are not guaranteed to be responded to.

2. The instructor reserves the right to make changes to the weekly course schedule based on occurring events that require different dispositions. The instructors will give sufficient advanced notice through announcements in class and posting on CANVAS. Changes to this syllabus and assignments may be announced at any time during class periods. The instructors will post the current syllabus and assignments on CANVAS. Both are dated in the footnote.

3. This course exclusively uses CANVAS to send out announcements, to provide comments to students daily on class activities, and to provide general information about course assignments. It is strongly recommended that all students setup their CANVAS account such that they receive automatically a notification about new postings and updates to the CANVAS course page.

4. Acceptable excuses, such as medical certification of an emergency, are required to make up any exam. Any other medical or academic-related absences need to be communicated ahead of the expected absence.

5. Classroom Behavior: Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

6. Requirements for COVID-19: As a matter of public health and safety, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements and all public health orders in place to reduce the risk of spreading infectious disease. CU Boulder currently requires COVID-19

vaccination and boosters for all faculty, staff and students. Students, faculty and staff must upload proof of vaccination and boosters or file for an exemption based on medical, ethical or moral grounds through the MyCUHealth portal.

The CU Boulder campus is currently mask-optional. However, if public health conditions change and masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct and Conflict Resolution. For more information, see the policy on classroom behavior and the Student Code of Conduct. If you require accommodation because a disability prevents you from fulfilling these safety measures, please follow the steps in the "Accommodation for Disabilities" statement on this syllabus.

If you feel ill and think you might have COVID-19, if you have tested positive for COVID-19, or if you are unvaccinated or partially vaccinated and have been in close contact with someone who has COVID-19, you should stay home and follow the further guidance of the Public Health Office (contacttracing@colorado.edu). If you are fully vaccinated and have been in close contact with someone who has COVID-19, you do not need to stay home; rather, you should self-monitor for symptoms and follow the further guidance of the Public Health Office (contacttracing@colorado.edu). Please, contact your instructor if you cannot attend class, turn in an assignment, or miss the midterm.

8. Accommodation for Disabilities: If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

9. Preferred Student Names and Pronouns: CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

10. Honor Code: All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the Honor Code may include, but are not limited to: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution (honor@colorado.edu); 303-492-5550). Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found on the Honor Code website.

11. Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation: CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, protected-class discrimination and harassment, and related retaliation by or against members of our community on- and off-campus. These behaviors harm individuals and our community. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who believe they have been subjected to misconduct can contact OIEC at 303-492-2127 or email cureport@colorado.edu. Information about university policies, reporting options, and support resources can be found on the OIEC website.

    Please know that faculty and graduate instructors have a responsibility to inform OIEC when they are made aware of any issues related to these policies regardless of when or where they occurred to ensure that individuals impacted receive information about their rights, support resources, and resolution options. To learn more about reporting and support options for a variety of concerns, visit Don't Ignore It.

12. Religious Holidays: Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, please, let your instructor know about any issues created by the assignment schedule due to religious holidays.

See the campus policy regarding religious observances for full details.