

ASEN 5519
Design Optimization of Aerospace Structures
Spring 2020

Instructors: Jorge Luis Barrera Cruz, Kurt Maute
Office: 350-N
Phone: (303) 735-2103
e-mail: jorge.barreracruz@colorado.edu, maute@colorado.edu
Office Hours: Fr 2:00 -3:00 pm

Lectures: T/Th: 11:30- 12:45 pm, AERO 232.

Class Web Site: log on to <https://canvas.colorado.edu/> to find
ASEN5519 – Design Optimization of Aerospace Structures.

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 (and quizzes)	65%
Individual:	1 Midterm Exam	15%
	Final Project	20%
		<hr/> 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 and approved ahead of the expected absence.
5. 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 or injury, see Temporary Medical Conditions under the Students tab on the Disability Services website.
6. 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, students must let the instructors know of any such conflicts within the first two weeks of the semester so that reasonable arrangements can be worked out. See [campus policy regarding religious observances](#) for full details.

7. Students and faculty each have responsibility for maintaining an appropriate learning environment. 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 policies on [classroom behavior](#) and the [Student Code of Conduct](#).
8. 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.
9. The University of Colorado Boulder (CU Boulder) is committed to fostering a positive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct, intimate partner abuse (including dating or domestic violence), stalking, or protected-class discrimination or harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or cureport@colorado.edu. Information about the OIEC, university policies, anonymous reporting, and the campus resources can be found on the OIEC website. Please know that faculty and instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.
10. All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the policy may include: 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 the Honor Code (honor@colorado.edu); 303-492-5550). Students found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the Honor Code Office website.