ME 8710 ENGINEERING OPTIMIZATION

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Description: Optimization in the context of engineering Design. Non-linear and linear, static and dynamic, constrained and unconstrained formulation and solution of practical problems. Structural optimization. Multi-objective optimization. Heuristic approaches: Genetic Algorithms, Simulated Annealing. Topology optimization.

Textbook: None required but it is strongly recommended to have some of the listed below for reference.

References:

- *Elements of Structural Optimization* – Haftka and Gurdal, Kluwer, 1996 (out of print)
- *Principles of Optimal Design* by Papalambros, Cambridge Press, 2017
- *Genetic Algorithms in Search, Optimization and Machine learning*. Goldberg, Addison Wesley, 1992.
- *Engineering Optimization*. Ragsdell, Reklaitis, Ravindran, Wiley, 1983.
- *Optimization concepts and applications in engineering* by Belegundu, Chandrupatla Prentice Hall, 1999
- *Optimization in Practice with MATLAB* by Messac, Cambridge Press, 2015

Recommended Web Resource: MIT OPENCOURSEWARE
Course: ESD77. Multidisciplinary System Design Optimization

Objectives: To provide engineering students interested in CAE/CAD an engineering view of optimization as a tool for design. The course will concentrate on the mathematical and numerical techniques of optimization as applied to engineering problems. It is designed to provide students with a strong background in optimization which can be complemented by more specialized courses.

Learning outcomes:

1. Students will know the various optimization approaches currently available
2. Students will program several methods to understand the trade-off between efficiency and programming complexity
3. Students will be able to set up optimization problems and solve them
4. Students will know which algorithm can be used for a specific problem type
5. Students will know how to use commercial optimization codes and couple them with analysis codes
6. Students will know when to use approximation methods to reduce the computational burden

Topical Outline:

1. Introduction to the formulation of optimization problems. Unconstrained optimization. Zero order search.
2. Powell's method. First order search.
3. Gradient, conjugate gradient methods.
4. Second order search. Newton-Raphson, Davidon-Fletcher-Powell.
5. Constrained optimization. Penalty methods. Direct methods of constrained optimization.
6. Linear programming.
7. Sensitivity analysis. Approximations, equality and cumulative constraints.
8. Generalized reduced gradients.
9. Law of diminishing returns and function approximation concepts.
10. Sensitivity of objective function and Lagrange Multipliers. Primal dual Methods.
11. Heuristic based optimization - genetic algorithms, simulated annealing, …
12. Multi-objective - Pareto-optimization, Goal programming.
13. Topology optimization
14. Multi-level optimization. Optimization of complex engineering problems.
15. Robust optimization

Grading:	Programming projects (4 or 5 hw projects)	45%
	1 Semester Project (in groups)	25%
	Quizzes (2)	10%
	Final	20%

You are required to complete **all assignments**. The assignments must be **performed on an individual basis** (unless otherwise specified), and must be turned in on time at the beginning of class.

- Should be professional quality (clear, concise, and correct). Do not turn in sloppy homework – if I cannot read it, it will not be graded. **State the problem, formulate the optimization correctly, identify variables, objective(s) and constraints, and discuss the results**.
- Care is important in presenting and communicating your thoughts, ideas, and conclusions, both to insure success in this course and to develop these communication tools.
- Brevity can be achieved without sacrificing content – be concise and state your conclusions and observations clearly. Long, verbose discussions are not required. Graphs and tables help.
- Assignments build on each other. DO NOT PROCRASTINATE, you will have a hard time finishing if you do. Turn in the assignments on time.
  All Assignments must be completed and turned in by the last day of class to receive a grade in the course.

A semester Project will be performed in two steps. You have to provide me with an abstract by mid-September explaining what you will analyze using some simulation code (FEA, CFD, Simulation tools) and providing me with the names of the group members. Your first report due Mid-October will state the problem, the design variables, and describe the results obtained from the simulation or analysis without optimization. You will then couple the analysis to an optimizer, each member of the group using a different optimizer, optimize your design and produce results. The group final report will be due at the last class date (December 5). Additional information will be provided.

Policies and ethics: My expectations of you are similar to those you have of me. I assume that you will review the material I post and take notes, that you will be on time and prepared with assignments, and that you will maintain a professional and courteous relationship. If an emergency prevents you from submitting an assignment, please let me know about it with as much notice as possible. For reasonable excuses, I will work with you on making up missed work. Special accommodations should be cleared by the last day to register. Students are expected to wait for up to 15 minutes if the instructor is late for class. I will not tolerate cheating, plagiarism, receiving unauthorized aid or any other violation of academic honesty. All work submitted to me for a grade is to be your own work. Any instance of academic dishonesty will be dealt with in the manner prescribed by the University http://www.registrar.clemson.edu/publicat/catalog/sections/aca_regs/. The Clemson University statement on academic integrity applies to all students in this class and will be rigorously enforced. Cheating includes giving or receiving assistance of any kind on an exam, homework, or final by any means. Cheating is grounds for failure in this course. This will be strictly enforced. Questions frequently arise concerning the acceptability of working together on design problems. In this course, you may consult other students only for the purpose of brainstorming on GENERAL solution strategies. You must do the actual assignment problem (or project) on your own. Copying another student's work (even from previous years), is strictly prohibited. A single instance of copying an assignment or project is grounds for failing this course and notifying the university administration.