

ME875
Optimal Design of Mechanical Systems
Spring 2009

Instructor: Prof. A. Diaz

Classroom: 2320 EB

Meeting Time: Tu-Th 8:00-9:20

Office Hours: to be announced

Web site : www.egr.msu.edu/~diaz/ or through Engineering Courses web pages

GRADING

Based on homework (short and long) and projects. Extensive programming using MATLAB or Mathematica is required in this course.

Homework (about 7) 60%

Projects (2) 40%

TOPICS

Part I: Mathematical Preliminaries (5 weeks ^(*))

1. Linear Algebra

Vector spaces: vectors in n-Space, norms, dot products, subspaces, span, linear independence, bases, dimension. Matrices and determinants: matrices and matrix algebra, transpose, inverse. Eigenvalue Problems: symmetric matrices, quadratic forms, positive definiteness.

2. Functions on R^n

Continuity and differentiability of functions in R^n . Gradients and Hessians. Taylor expansions in n-dimensions. Convexity.

DG Zill and MR Cullen, Advanced Engineering Mathematics

J Arora, Introduction to Optimum Design, Appendix B.

MS. Bazara and CM Shetty Nonlinear Programming, Appendix A.

3. Optimization Problems in R^n . Mathematical Formulation

Unconstrained problems in several dimensions.

Constrained problems in several dimensions: simple bounds, linear inequality constraints, general nonlinear inequality constraints. Graphical interpretation.

Local and global solutions. Necessary and sufficient conditions for optimality: Kuhn-Tucker Conditions.

Ref: J. Arora Introduction To Optimum Design
Class notes

4. Numerical Solution by Mathematical Programming

One dimensional problems: line search

Unconstrained problems in R^n : conjugate gradient algorithm

Constrained problems in R^n : moving asymptotes or sequential quadratic programming.

A. L. Peressini , F.E. Sullivan and J.J. Uhl The Mathematics of Nonlinear Programming, Springer, 2000

G Vanderplaats Numerical Optimization Techniques for Engineering Design

Class notes

^(*) Approximate

Part II: Parametric (sizing) optimization (5 weeks ^(*))

5. Sensitivity Analysis

Discretization via the finite element method. Sensitivity of linear, static systems. Direct and adjoint variable methods. Sensitivity of eigenvalues. Optimization and finite element methods.

6. Optimal Design of Static, Linear Systems (Truss and Similar Mechanical Systems)

7. Optimal Design of Dynamical Systems, Eigenvalue Problems, Frequency Response, Transient Response

J. Arora, *Introduction to Optimum Design* 2nd Ed Elsevier 2004

Haug, E., Choi, K.K. and Komkov, V., *Design Sensitivity Analysis of Structural Systems*, Academic Press

Haug E. and Arora, J., *Applied Optimal Design*

Class notes

Part III: Shape and Topology Optimization (5 weeks ^(*))

8. The Shape Optimization Problem As A Material Distribution Problem

Problem statement. Regularization via homogenization. A homogenization method. Layered materials.

9. Structural Topology Optimization

Material models. Design variables in topology optimization. Optimal material orientation problem. Minimum compliance problems via optimality criteria algorithms.

10. Special Problems Related to the Topology Optimization Problem

Material design, compliant mechanism design, filters and other “tricks” in topology optimization.

Class notes

Bendsoe M. P. and Sigmund, O., [Optimization of Structural Topology, Shape and Material](#)

B. Hassani and E. Hinton [Homogenization and Structural Topology Optimization](#)

Various articles

READING ASSIGNMENTS

No required textbook.

Reading assignments will be posted in class web site

^(*) Approximate