MECH 577 Optimum Design
Fall 2010

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Office Hours: Tue &Wed 3:00–4:00

On-line Tutoring: Send your queries to `angeles@cim.mcgill.ca`. Computation code and updates on the course are available at

`http://www.cim.mcgill.ca/~rmsl/Index/index.htm`

Course Outline

Objective: To lay the foundations for the development of a methodology that allows the formulation and the solution of engineering design tasks as optimization problems.

Topics

1. The role of optimization within the design process. Design methodology and design philosophy. Design variables and design space.

2. Single-variable optimization: Unimodality assumption. Solution methods: Dichotomous search; Fibonacci search; and golden-section search.

3. Background on multivariable optimization. The numerical solution of *determined* systems of linear and nonlinear equations: LU-decomposition, a.k.a. Gaussian elimination; the Cholesky decomposition of positive-semidefinite matrices; the Newton-Raphson method. The numerical solution of *overdetermined* systems of linear and nonlinear equations: orthogonalization methods for linear systems; the Newton-Gauss method for nonlinear systems. Numerical conditioning.

First Class Test

4. Unconstrained multivariable optimization. First- and second-order normality conditions. Direct methods: Hooke and Jeeves; Powell's conjugate directions; Nelder-Mead's simplex method. Gradient methods: Cauchy's steepest descent; Fletcher-Reeves' conjugate gradient; and quasi-Newton methods. Newton methods: the Newton-Raphson and the Levenberg-Marquardt methods.

5. Equality-constrained optimization: The first- and second-order normality conditions. Primal and dual forms. Linear quadratic problems: minimum-norm problems under linear constraints; least-square problems subject to linear constraints. Linear least-square problems under quadratic constraints.

Second Class Test—Only Material Not Covered in CT1

6. The orthogonal-decomposition algorithm (ODA). Application to equality constrained linear and nonlinear least-square problems. Application to arbitrary objective functions: Hessian-stabilization methods.
7. Inequality-constrained problems: The Karush-Kuhn-Tucker conditions. Direct and indirect methods. Indirect methods: penalty functions and slack variables.
8. Advanced topics: multiobjective optimization and stochastic methods.

Third Class Test—Only Material Not Covered in CT1 & CT2

Marking Scheme: The final mark is computed as the average of three projects (total of 67%) and three open-book quizzes (33%), the third one scheduled for the final day of lectures, Friday December 3rd. Individual project marks are based on (a) technical content (2/3 of total mark) and (b) presentation (1/3 of total mark).

Guidelines for Project Reports: Read `rprt-gdlns0100827.pdf`, which is posted on the course website, and handed out together with the Course Outline.

Bibliography:

Angeles, J., 2010, *MECH 577 Optimum Design Lecture Notes*, Department of Mechanical Engineering, McGill University, Montreal.
Boyd, S. and Vandenberghe, L., 2004, *Convex Optimization*, Cambridge University Press, Cambridge.
Luenberger, D., 1984, *Linear and Nonlinear Programming*, Second Edition, Addison-Wesley Publishing Company, Reading, MA.
Rao, S.S., 1996, *Engineering Optimization*, John Wiley & Sons, Inc., New York.

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3. Every student has the right to write term papers, examinations and theses in English or in French, except in courses where knowledge of a language is one of the objectives of the course.
4. To protect trees, please submit your assignments on double-sided sheets.