ENME 610 – DESIGN OPTIMIZATION WITH ENGINEERING APPLICATIONS

Fall 2015, Mechanical Engineering, UMBC

COURSE DESCRIPTION: This graduate-level course presents analytical and numerical methods utilized in the solution of design optimization problems encountered across different disciplines in engineering. The content of the course includes mathematical analysis of one- and multi-dimensional problems, gradient-based (e.g., GRG, SQP), and gradient-free (e.g., GA, SA) methods. Students will have the opportunity to develop their programming skills and use commercially available computational tools.

REFERENCES*:

- Belegundu, A.D. & Chandrupatla T.R., *Optimization Concepts and Applications in Engineering*, 2nd Edition, Cambridge University Press, 2011.
- Arora, J.S., *Introduction to Optimum Design*, 3rd Edition, Academic Press, 2011.
- Bendsoe M. P., and Sigmund O., Topology Optimization, 2nd edition, Springer; 2003.
- Rao, S.S., *Engineering Optimization: Theory and Practice*, 4th Edition, John Wiley & Sons, 2009.

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Office hours: Wed from 11:15 to 12:15 PM / by appointment

TEACHING ASSISTANT: TBD

CLASS SCHEDULE: Tue and Thu 10:00-11:15 a.m. (ENG #112)

GRADING:

Midterm Exam (Open book/note)	25%
Final Exam (Open book/note)	35%
Term Project	20%
Homework	20%

The grading will follow the usual weighted scoring: A (weighted sum 90.0%~); B (80.0~89.9%); C (70.0~79.9%); D (60.0~69.9%); and F (~59.9%).

COURSE POLICIES:

1. Neatness and clarity count in homework problems. Do not hand in pages ripped out of spiral notebooks. Make sure all computer printouts are no larger than standard sized paper (8-1/2 x 11in.)
2. All homework must represent your own work. Consultation with other members of the class is allowed, but all work must represent an individual effort. For example the design of a computer program may be done in consultation with someone else, however the

* Lecture note will be provided.

actual coding of the program must be an individual effort. The exception this policy is in the case of take home tests. All aspects of the test must be done individually.

3. Homework and reports turned in late will receive a 25% per day penalty starting immediately after the time that the assignment is due.

SCHEDULE:

I. Fundamentals

Date	Module	Lecture Topic
8/27	1-2	History. Optimization problem: types and formulation. Vector algebra. Linear dependence. Linear systems. Eigenvalue problem. Quadratic forms. Positive definiteness.
9/3	3-4	Sets. Functions. Gradient, Jacobian, and Hessian. Numeric evaluation of gradient and Hessian. Matrix calculus. Taylor's theorem. **HW01**

II. Single-variable optimization

Date	Module	Lecture Topic
9/10	5-6	Functions of single variable Problem formulation. Classes of optimal points. Optimality conditions. Convexity. Unimodality. Methods Powell's, Newton's, and secant method. Order of convergence

III. Unconstrained multivariate optimization

Date	Module	Lecture Topic
9/17 No lecture on 22th	7-8	Principles of gradient-based optimization Numerical methods Steepest descent method. Conjugate gradient method. Newton's method. Quasi-Newton methods. **HW02**
9/29	9-10	Trust regions methods. Minimum quadratic error. Order of Convergence

IV. Constrained multivariate optimization

Date	Module	Lecture Topic
10/6	11-12	Analytical elements Problem formulation. First order necessary conditions (equality/inequality constr.). Second order sufficient conditions. Convexity. **HW03**

10/13		**Midterm Exam**
10/15	13-14	Linear Programming (LP) Standard form. Basic solutions. Simplex method.
10/22	15-16	Quadratic Programming (QP) Non-linear programming (NLP) Zoutendijk's method of feasible directions. Generalized Reduced Gradient (GRG). **HW04**
10/29	17-18	Sequential linear programming (SLP). Sequential quadratic programming (SQP).

V. Global optimization

Date	Module	Lecture Topic
11/5	19-20	Global search algorithms Genetic Algorithms. Simulated Annealing. **HW05**

VI. Applications

Date	Module	Lecture Topic
11/12	-	**Presentation - Project planning**
11/17	20	Technical programming with Matlab
11/24 No lecture on 26th	21-23	Topology optimization Problem definition. Sensitivity analysis. Matlab code. **HW06**

VII. Multiobjective problems

Date	Module	Lecture Topic
12/1	24	Multi-objective problems Pareto Optimality.
12/8	-	**Project final presentation**
12/10-16		**Final Exam**

Prepared by Dr. Soobum Lee, April 6, 2015.