SYLLABUS / SEMESTER PLAN

Instructor
Dr. Scott Ferguson
3244 EBIII (919-515-5231)
scott_ferguson@ncsu.edu

Office Hours
Tuesdays and Thursdays
2:30 – 3:30 pm
or by appointment

Course time / location
Schedule: Mondays and Wednesdays from 8:05 am – 9:20 am
Room: 1230 EBII

Office hours
While I can be reached by phone in my office (919-515-5231), office hours will also be held virtually using Collaborate (https://collaborate.wolfware.ncsu.edu/). This will allow multiple students to be accommodated at the same time and allow for increased interaction.

Course description
Optimization involves finding the “best” solution according to specified criteria. In the context of engineering design, the “best” solution may refer to a minimum cost or weight, maximum quality or efficiency, or some other performance index pertaining to a disciplinary objective. However, determining the optimal design involves more than just the minimization or maximization of an objective function. Designers must also identify the design variables that represent the physical form of the system and the constraints that represent limitations on the design space. Typically, the problems of interest in engineering are of a nonlinear nature, in that the objective functions and constraints considered are nonlinear.

This course introduces traditional nonlinear optimization methods that can be used to solve a wide variety of engineering design problems across all engineering disciplines. Additionally, students will study the tradeoffs associated with the design of complex engineering systems. By the end of the semester, students will have gained the ability to create a formal optimization problem, have basic knowledge of numerical optimization algorithms, and will have sufficient understanding of the strengths and weaknesses of these approaches.

Note: Programming will be required, though codes are usually simple (choice of language / software is yours)

Text (not required, but useful)

Course website
Moodle: http://wolfware.ncsu.edu
• Course Syllabus
• Announcements: e.g., important class information, homework hints
• Class Notes: specific class note postings, extra example problems
• Homework: e.g., all homework assignments

Updated: August 14, 2014
Course topics

- Introduction to optimization – design variables, constraints, objective functions, penalty functions, development of formalized optimization problem statements
- Techniques for solving single variable optimization problems
- Techniques for solving constrained and unconstrained multi-variable problems
- Using graphical techniques to identify an optimal problem
- Computer implementation of optimization schemes
- Examination of heuristic-based optimality criteria methods
- Modeling engineering design problems for optimization
- Mathematical foundations of multidisciplinary and multiobjective design optimization

Skills/understanding

At the end of this class, you will have the foundation needed to:

- Model and formulate optimization problems in standard form and assess the optimality of a solution
- Construct computer programs to determine the optimal solution for unconstrained and constrained nonlinear optimization problems of multiple variables
- Determine the advantages and disadvantages of applying different optimization techniques for a specific problem
- Model and analyze multiobjective and multidisciplinary optimization problems

Grading

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Homework</td>
<td>30%</td>
</tr>
<tr>
<td>Exams (2)</td>
<td>45% (22.5% each)</td>
</tr>
<tr>
<td>Project</td>
<td>25%</td>
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Late assignments will not be accepted unless there is a compelling reason as to why the assignment is late. Assignments should be uploaded using the course Moodle page.

Exams

There will be two (2) “in-class” exams. These exams will be closed-book. If you receive an exam back and you feel it was graded incorrectly, this is the process to request a re-grade:

1) Attach a separate sheet of paper to the front of the exam explaining what you think is wrong;
2) Mark, in a different color, the place on the exam where you think the error occurred;
3) Resubmit the exam. Make your explanation on the front page clear and to the point. Do not expect to be able to explain your explanation – your written explanation should be adequate and complete by itself.

Course project

The course project is due Wednesday, December 10th. I will assign your project (which will be longer than a traditional homework assignment). No late submissions will be accepted. Further details regarding the project will be given as the semester progresses.

Miscellaneous

Cheating of any kind (copying, plagiarism, etc.) however, will not be tolerated and will result in an F for the course. Please review the following website (http://www.ncsu.edu/stud_affairs/osc/Alpage/acaintegrity.html) for further information on academic integrity at NCSU. In addition, reasonable accommodations will be made for students with verifiable disabilities. Students must register with the Disability Services Office.
**Teaching philosophy**

“The lasting measure of good teaching is what the individual student learns and carries away. “

Barbara Harrell Carson, 1996, *Thirty Years of Stories*

I will always be available during office hours and by appointment (unless otherwise specified). I will also try my best to answer all email questions in a timely manner. If you experience problems with the material, please contact me for help. Finally, constructive course feedback is always encouraged.

**Course outline (dates, topics, and assignments all subject to change)**

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Assignment</th>
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</table>
| 1-2  | Introduction to optimization  
Terminology; Optimization problem statement; Iterative optimization  
Existence and uniqueness of solutions; Necessary and sufficient conditions | |
| 2    | Using graphical approaches to find the optimum | HW 1 |
| 3    | Functions of a single variable  
Interpolation methods  
Elimination methods | HW 2 |
| 4-5  | Unconstrained functions of multiple variables  
Iterative solution technique  
Zero-order methods  
Gradient-based methods  
Second order methods  
Design variable scaling | HW 3 |
| 6 or 7 | Exam 1 |
| 6-7  | Sequentially unconstrained minimization techniques (SUMT)  
Interior penalty function  
Exterior penalty function  
Augmented Lagrange Multiplier (ALM) | HW 4 |
| 8-9  | Constrained minimization techniques  
Linear programming  
Non-linear methods (Feasible directions, GRG, SQP) | HW 5 |
| 10-11| Heuristic optimization techniques  
Genetic algorithms  
Ant colony optimization  
Particle swarm optimization | HW 6 |
| 12   | Multiobjective optimization  
Pareto sets and tradeoffs  
Basic multiobjective formulations (weighted sum, compromise programming) | HW 7 |
| 13-14| Advanced concepts  
Metamodelling  
Optimization with discrete variables | HW 8 |
| 15   | Exam 2 |
| 16   | Multidisciplinary design optimization (MDO)  
Overview of problem formulations | |

**Final project due – Wednesday, December 10th**