# INEG 5683

**Nonlinear Programming**

**Instructor:** Dr. Ed Pohl **Office:** 4207 Bell Engineering

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**Required Textbook:** *Engineering Optimization: Theory and Practice*, 4th Edition, Singiresu S. Rao, Wiley, 2009, ISBN 978-0-470-18352-6.

# (Available as E-book in UARK library)

**Additional References:**

*Applied Optimization with MATLAB Programming*, 2nd Edition, P.Venkataraman, John Wiley, 2009.

*Introduction to Optimum Design,* 3rd Edition, J. Arora, Elsevier, Academic Press, 2012 *Nonlinear Programming: Theory and Algorithms*, 3rd Edition, Bazaraa, Shereli, and Shetti, Wiley, 2006.

*Linear and Nonlinear Optimization*, 2nd Edition, Griva, Nash and Sofer, SIAM, 2009.

**Prerequisites:** Calculus of Several Variables

Familiarity with Basic Concepts of Linear/Matrix Algebra Computer Programming Skills

Familiarity with MATLAB Familiarity with Excel - Solver

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| **Grading:** |  |  |  | **Final Grade** |
|  | **Homework** | 150 pts | 25% | A > 90% |
|  | **Exams** | 2 @ 150 pts | 50% | B 80 - 89% |
|  | **Course Project** | 1 @ 150 pts | 25% | C 70 – 79% |
|  |  |  |  | D 60 - 69% |
|  | **Total** | 600 pts | 100% | F < 59% |

All graded material will be returned to students during class. Once a graded item has been returned, you have **48 hours** to challenge the grade. **To challenge a grade, you must submit a typed description of the grading error (attached to the graded item) to me**. Your description must include your name and e-mail address. I will respond to your challenge within 48 hours of its receipt.

The grading scale above reflects the baseline for the course. Based on the general performance of the class as well as individual performance throughout the course I may lower the cut-off for some or all of the letter grades. Such changes will not occur until all graded events have been recorded.

**Course Description:** Nonlinear programming problems arise in a wide variety of applications, such as civil, mechanical, and electrical engineering design, military planning, supply chain modeling, and financial engineering. This course provides an introduction to the theory and methodology of nonlinear programming. The focus will be on engineering and management science applications of nonlinear optimization. Both single and multi-variable as well as unconstrained and constrained problems are addressed. Throughout the course, students will be asked to solve a number of applied nonlinear optimization problems using a variety of optimization software algorithms. We will utilize the MATLAB programming environment in this course. Many of the algorithms are available as preprogrammed functions in this environment. Students will be expected to compare the performance of different algorithms on a variety of problems during the semester.

**Course Objectives:** The objective of this course is for the student to be able to demonstrate a basic understanding of the various algorithms and techniques used in solving both constrained and unconstrained nonlinear optimization problems. Upon completion of this course, students should be able to:

1. Define and formulate a parameter optimization problem.
2. Articulate the Karush-Kuhn-Tucker Necessary and Sufficient Conditions for Optimality.
3. Distinguish between various classes of optimization problems: parameter vs. functional, univariate vs. multivariate, linear vs. nonlinear, constrained vs. unconstrained, primal vs. dual, scalar vs. vector, and local vs. global.
4. Comprehend the basic concepts of optimization, design variables, objective and constraint functions, direct and indirect methods of optimization, penalty functions, barrier functions, Lagrange multipliers, optimality criteria, convergence criteria, feasibility, convexity, duality, global optimization techniques, and multi-objective techniques.
5. Demonstrate proficiency in using the computational tools needed to solve numerical optimization problems.
6. Utilize the concepts presented in the course to formulate and solve a nonlinear constrained optimization problem of several variables.

# Course Policies:

**Communication -** Students should check their e-mail on a daily basis. A course web page is located on UA’s Blackboard site at <https://learn.uark.edu/>. This web page will be used for course-related email and discussion lists, dissemination of materials, recorded lectures and access to on-line grades.

**Homework – Homework problems will be assigned on a regular basis.** . The purpose of these assignments is to help you learn the course material. Homework assignments make up a significant part of your course grade. They are an essential part of the learning process. They provide you an opportunity to practice applying the concepts, and reinforce the material covered in lecture. There is usually a direct correlation between how well students do on exams and how seriously they take the homework assignments. You should use the homework as an early warning system about how well you understand the material. If you have trouble with the homework, it is far better to know about it early and use it as motivation for asking questions to aid your understanding. Students who do well are those that spend the time clarifying what they do not understand. Students who do poorly are those that let things slip (sometimes relying too much on help from others in doing their homework). *I encourage you to discuss homework problems with each other.* Solutions will be posted the following day after a homework assignment is collected in order to provide students feedback. ***A minimum of one problem from each assignment will be selected at random and graded.***

# Course Project:

Students will be responsible for going out into the literature and researching a topic related to nonlinear optimization. Students should collect several papers (2-4) from the recent literature (2007 to present) on a topic of interest to them. Students will then summarize the topic in a short report which outlines the topic area, discusses its importance, and demonstrates the concepts discussed in the papers, explain their relationship to concepts covered in class, and ***apply the concepts to a specific problem of interest defined by the students*.** Students will be required to give a 20-30 minute presentation of their material to the instructor during the last week of the semester. A project guideline is attached containing suggestions on formatting the project as well as the grading criteria that will be utilized by the instructor and your fellow students in evaluating your performance.

**Inclement Weather -** If the University is closed due to inclement weather on the day of a lecture, any assignment (homework or test) scheduled for that day will automatically be re-scheduled for the next lecture.

**Academic Honesty -** Each University of Arkansas student is required to be familiar with and abide by the University’s ‘Academic Integrity Policy’ which may be found at <http://provost.uark.edu/> Students with questions about how these policies apply to a particular course or assignment should immediately contact me.