

## **ENG EC 524/SE 524 Optimization Theory and Methods**

### **2007-2008 Catalog Data:**

**ENG EC 524/SE 524 Optimization Theory and Methods** Preq: Consent of instructor.

Introduction to optimization problems and algorithms emphasizing problem formulation, basic methodologies, and underlying mathematical structures. Classical optimization theory as well as recent advances in the field. Topics include modeling issues and formulations, simplex method, duality theory, sensitivity analysis, large-scale optimization, integer programming, interior-point methods, non-linear programming optimality conditions, gradient methods, and conjugate direction methods. Applications are considered; case studies included. Extensive paradigms from production planning and scheduling in manufacturing systems, fleet management, air traffic flow management, optimal routing in communication networks, and optimal portfolio selection. Meets with ENG SE 524. Students may not receive credit for both.

**Status in the Curriculum: Elective**

**Class/Lab Schedule:** Lecture: 4 hours/week

**Textbook and other required materials:** D. Bertsimas and J.N. Tsitsiklis, *Introduction to Linear Optimization*, Athena Scientific, 1997.

**References:** D.P. Bertsekas, *Nonlinear Programming*, Athena Scientific, 1999 (2<sup>nd</sup> Edition).  
C.H. Papadimitriou and K. Steiglitz, *Combinatorial Optimization: Algorithms and Complexity*, Prentice-Hall, 1982.

D.G. Luenberger, *Introduction to Linear and Nonlinear Programming*, (2nd Ed.), Addison-Wesley, 1984.

**Coordinator:** Ioannis Paschalidis, Associate Professor of Electrical & Computer Engineering and of Systems Engineering.

### **Prerequisites by topic:**

1. A certain degree of mathematical maturity, acquired, for example, in a series of mathematics courses including MA 123, MA 124, MA 225, and MA 226.
2. A working knowledge of linear algebra, as taught in MA 142 or EK 102.

### **Goals:**

The objective of the course is to develop a strong background in linear optimization and introduce key concepts in nonlinear optimization. Optimization is introduced as a fundamental methodology with many applications in signals and systems, networks, communications, and other fields (operations research, finance).

### **Computer Usage:**

Some assignments use CPLEX, a state-of-the-art commercial optimization package by ILOG. The Department has a departmental license for CPLEX, which allows multiple users to simultaneously use the package. CPLEX is installed in a Linux workstation, which acts as a license server and is maintained by Prof. Paschalidis' group.

**Course Learning Outcomes:**

As an outcome of completing this course, students will:

1. Understand the importance of optimization and its uses in a variety of areas related to Electrical and Computer Engineering and Systems Engineering.
2. Be able to formulate practical problems (e.g., routing/scheduling in communication and sensor networks, resource allocation in communication systems, problems in control systems) as optimization problems and apply various techniques to solve them.
3. Be able to develop custom-made algorithms that exploit the special structure in a problem of interest, and thus, lead to more computationally efficient solutions than standard methods.
4. Gain familiarity with a state-of-the-art optimization software package that is widely used in research and practice.
5. Improve their ability to clearly organize mathematically sophisticated technical arguments and write effective technical reports.
6. Obtain strong background in a fundamental area, which can facilitate lifelong learning and adaptation to emerging areas of practice and research. An optimization background is also helpful for students who plan to attend an information sciences and systems research graduate program.
7. Improve their ability to work in teams (teamwork for assignments is encouraged).

**Course Learning Outcomes mapped to Program Outcomes:**

Program Outcomes	a	b	c	d	e	f	g	h	i	j	k
Course Outcomes	1-3, 5-6	1-2 4	1-4	7	1-4	-	5	-	6	-	1-4
Emphasis (1-5)	5	4	5	3	5	2	3	1	4	1	5

1 = not at all; 5 = a great deal

**Topics:**

1. Linear programming (LP) formulations (2 lectures).
2. Geometry of LP (2 lectures).
3. Simplex method (3 lectures).
4. LP Duality (3 lectures).
5. Sensitivity analysis and parametric LP (1 lecture).
6. A case study (1 lecture).
7. Linear large-scale Optimization (2 lectures).
8. Nonlinear Programming (NLP) formulations, properties, and algorithms (2 lectures).
9. Interior-point methods for LP (3 lectures).
10. Network problems. (3 lectures)
11. Integer Programming (IP) formulations and solution methods (2 lecture).
12. Case Studies (2 lectures).

**Contribution of Course to Meeting the Professional Component:**

Engineering topics: 80%

Math & Basic Science: 20%