MATH 453  Numerical Optimization

1. **Catalog Description**

   **MATH 453 Numerical Optimization**  
   4 units

   Prerequisite: MATH 306 and MATH 451.


2. **Required Background or Experience**

   Prerequisite: MATH 306 and MATH 451, or consent of instructor.

   In order to understand numerical optimization, students must have an understanding of linear algebra from MATH 306, and a working knowledge of the techniques of numerical analysis from MATH 451.

3. **Learning Objectives**

   Upon completion of this course students should:

   a. Be familiar with the mathematical foundations and practical aspects of numerical optimization.
   b. Have the modeling skills to formulate appropriate optimization problems.
   c. Be able to implement algorithms using existing optimization software.

4. **Text and References**

   Text to be chosen by the instructor. Suggested texts include:

   - Chang, Edwin & Stanislaw, Zak. *An Introduction to Optimization*.

5. **Minimum Student Materials**

   Access to computing equipment to allow implementation of numerical procedures.

6. **Minimum University Facilities**

   Classroom with ample chalkboard space for class use and appropriate computing facilities.
7. **Content**

**Topics**

a. Review of Calculus and linear algebra
   1. Eigenvalues and eigenvectors
   2. Positive semidefinite matrices and quadratic forms
   3. Gradient, Jacobian, Hessian
   4. Taylor’s formula for functions of several variables

b. Optimality conditions for optimization
   1. Constraint sets, feasible directions, first order necessary conditions
   2. Second order necessary and sufficient conditions

c. Algorithms for unconstrained optimization
   1. Golden section method
   2. Steepest gradient algorithm
   3. Conjugate gradient algorithm
   4. Newton and quasi-Newton algorithms

d. Linear programming
   1. geometric view (convex sets and extreme points)
   2. algebraic view (simplex method)
   3. duality
   4. saddle points, complementary slackness

e. Constrained optimization I (equality constraints)
   1. Lagrange multipliers: algebra and geometry of the Lagrangian
   2. Lagrange multipliers: as dual variables; sensitivity
   3. algorithms: Lagrangian method, projection gradient methods
      algebra and geometry of the Lagrangian

f. Constrained optimization II (inequality constraint)
   1. Kuhn-Tucker theory: algebra and geometry of Kuhn-Tucker vector
   2. Duality and sensitivity:
   3. algorithms: Interior point method, penalty methods

8. **Methods of Assessment**

   The primary methods of assessment are: essay examinations, computing projects, quizzes and homework. Typically, there will be one or more hour-long examinations during the quarter, and a required comprehensive final examination. Students are required to show their work and are graded not only on the correctness of their answers, but also on their understanding of the concepts and techniques.