

TKU213101
Optimization Methods
Teknik Optimisasi

BASIC INFORMATION

Course Credit	3 / 150 minutes per Week
Course Type	Required
Course Classification	Engineering Topics
Prerequisites	Single- and Multi-Variable Calculus; Linear Algebra

STUDENT AND LEARNING OUTCOMES

Covered Student Outcomes

Development of Engineering Solution (KP.2) Engineering Design (KP.3)

Learning Outcomes

- LO1** Students are able to understand and solve unconstrained optimization problems.
- LO2** Students are able to understand and solve linear programming problems.
- LO3** Students are able to understand and solve nonlinear constrained optimization problems.

COURSE DESCRIPTION

This course deals with analytical methods to solve optimization problems which very often appear in engineering. It studies the unconstrained optimization, linear programming, and nonlinear constrained optimization problems.

TOPICS

PART I : MATHEMATICAL REVIEW

1. Methods of Proof and Some Notation

- 1.1 Methods of Proof
- 1.2 Notation

2. Vector Spaces and Matrices

- 2.1 Vector and Matrix

- 2.2 Rank of a Matrix
- 2.3 Linear Equations
- 2.4 Inner Products and Norms

3. Transformations

- 3.1 Linear Transformations
- 3.2 Eigenvalues and Eigenvectors
- 3.3 Orthogonal Projections
- 3.4 Quadratic Forms
- 3.5 Matrix Norms

4. Concepts from Geometry

- 4.1 Line Segments
- 4.2 Hyperplanes and Linear Varieties
- 4.3 Convex Sets
- 4.4 Neighbourhoods
- 4.5 Polytopes and Polyhedra

5. Elements of Calculus

- 5.1 Sequences and Limits
- 5.2 Differentiability
- 5.3 The Derivative Matrix
- 5.4 Differentiation Rules
- 5.5 Level Sets and Gradients
- 5.6 Taylor Series

PART II : UNCONSTRAINED OPTIMIZATION

6. Basics of Set-Constrained and Unconstrained Optimization

- 6.1 Introduction
- 6.2 Conditions for Local Minimizers

7. One-Dimensional Search Methods

- 7.1 Introduction
- 7.2 Golden Section Search
- 7.3 Fibonacci Method
- 7.4 Bisection Method
- 7.5 Newton's Method
- 7.6 Secant Method
- 7.7 Bracketing

7.8 Line Search in Multidimensional Optimization

8. Gradient Methods

8.1 Introduction

8.2 The Method of Steepest Descent

8.3 Analysis of Gradient Methods

9. Newton's Method

9.1 Introduction

9.2 Analysis of Newton's Method

9.3 Levenberg-Marquardt Modification

9.4 Newton's Method for Nonlinear Least Squares

10. Conjugate Direction Methods

10.1 Introduction

10.2 The Conjugate Direction Algorithm

10.3 The Conjugate Gradient Algorithm

10.4 The Conjugate Gradient Algorithm for Non-quadratic Problems

11. Quasi-Newton Methods

11.1 Introduction

11.2 Approximating the Inverse Hessian

11.3 The Rank One Correction Formula

11.4 The DFP Algorithm

11.5 The BFGS Algorithm

PART III : LINEAR PROGRAMMING

12. Introduction to Linear Programming

12.1 Brief History of Linear Programming

12.2 Simple Examples of Linear Programs

12.3 Two-Dimensional Linear Programs

12.4 Convex Polyhedra and Linear Programming

12.5 Standard Form Linear Programs

12.6 Basic Solutions

12.7 Properties of Basic Solutions

12.8 Geometric View of Linear Programs

13. Simplex Method

13.1 Solving Linear Equations Using Row Operations

- 13.2 The Canonical Augmented Matrix
- 13.3 Updating the Augmented Matrix
- 13.4 The Simplex Algorithm
- 13.5 Matrix Form of the Simplex Method
- 13.6 Two-Phase Simplex Method
- 13.7 Revised Simplex Method

14. Duality

- 14.1 Dual Linear Programs
- 14.2 Properties of Dual Problems

PART IV : NONLINEAR CONSTRAINED OPTIMIZATION

15. Problems with Equality Constraints

- 15.1 Introduction
- 15.2 Problem Formulation
- 15.3 Tangent and Normal Spaces
- 15.4 Lagrange Condition
- 15.5 Second-Order Conditions
- 15.6 Minimizing Quadratics Subject to Linear Constraints

16. Problems with Inequality Constraints

- 16.1 Karush-Kuhn-Tucker Condition
- 16.2 Second-Order Conditions

17. Convex Optimization Problems

- 17.1 Introduction
- 17.2 Convex Functions
- 17.3 Convex Optimization Problems
- 17.4 Semi-definite Programming

18. Algorithms for Constrained Optimization

- 18.1 Introduction
- 18.2 Projections
- 18.3 Projected Gradient Methods with Linear Constraints
- 18.4 Lagrangian Algorithms
- 18.5 Penalty Methods

REFERENCES

[1] Edwin K. P. Chong, Stanislaw H. Zak., 2013., An Introduction to Optimization, 4th Edition