

Course Outline for MATH 2621, Introduction to Mathematical Optimization

MATH 2621 Introduction to Mathematical Optimization (3 units)

Prerequisite: One of the following: MATH 241, DATA/[MATH 1265](#), or [MATH 2263](#); and one of the following: MATH 206, MATH 244, [MATH 1151](#), or [MATH 2341](#).

Algorithms and mathematical analysis for solving optimization problems. One-dimensional search methods; Newton's method extended to multi-dimensional optimization problems and gradient methods. The basic mathematics of neural networks and examples of their application.

Optimization problems with equality and inequality constraints. 3 lectures. Cross-listed as DATA/[MATH 2621](#).

Course Learning Objectives	
1	Distinguish between set-constrained and unconstrained optimization and, for a given problem, identify which type of optimization is relevant.
2	State necessary and sufficient conditions for minimizers and maximizers.
3	Use the gradient of a real-valued function for optimization.
4	Compare and contrast gradient-based iterative methods to those based on higher-order derivatives.
5	Analyze optimization methods for convergence.
6	Describe the components and structure of an artificial neural network.
7	Apply optimization techniques to the training of a feedforward neural network.
8	Apply the method of Lagrange multipliers to optimization problems with equality or inequality constraints.

Expanded Course Content

Textbooks, materials, and/or other resources
An Introduction to Optimization by Chong and Zak (CZ), 4th edition; Deep Learning by Goodfellow, Bengio, and Courville (GBC).

Week	Readings	Topics of Discussion
1	Chapter 1 of GBC	Introduction to optimization, the need of optimization algorithms in computer science
2	Chapters 2, 3 of CZ	Vector spaces, matrices, and linear transformations
3	Chapters 4, 5 of CZ	Concepts from geometry and calculus
4	Chapter 7 of CZ	One-dimensional search methods: Golden Section, Newton's and Secant methods, and their convergence analysis
5	Chapter 9 of CZ	Newton's method in higher-dimensional problems: algorithm, analysis, and applications
6	Chapter 8 of CZ	The method of steepest descent
7	Chapter 8 of CZ	Analysis of gradient methods
8	Chapter 13 of CZ	Introduction to neural networks
9	Chapter 13 of CZ	Single-neuron training and the back-propagation algorithm
10	Chapter 9 of GBC	Application of basic neural networks in computer science
11	Chapter 20 of CZ	Optimization problems with equality constraints and the use of Lagrange multipliers
12	Chapter 21 of CZ	Optimization problems with inequality constraints
13	Chapter 21 of CZ	The Karush-Kuhn-Tucker condition
14	Chapter 12 of GBC	Additional applications of optimization algorithms in computer science
15	Chapter 12 of GBC	Additional applications of optimization algorithms in computer science

Method of Assessment

The possible methods of assessment are written individual examinations, quizzes, in-class worksheets or presentations, projects, and homework. All exams are to be proctored in-person, and one or more midterms and a cumulative final exam are required.

Instructional Mode

The instructional mode for this class is face-to-face. This designation means that the essential academic standards of the course require in-class student engagement, and thus remote instruction is not appropriate.