ENGR 5010G – Advanced Optimization

Ontario Tech University
Faculty of Engineering and Applied Science

Instructor: Md Asif Khan, PhD

Term: Summer 2025

Dates: June 23 – August 5, 2025

Schedule: Tuesdays and Thursdays, 1:10 PM – 4:00 PM

Delivery Mode: In-person

Course Description

This graduate-level course provides an in-depth understanding of advanced optimization techniques and their application to engineering problems. The course begins with classical methods (e.g., Newton, quasi-Newton, and simplex) and progresses toward modern optimization methods such as genetic algorithms, swarm intelligence, and differential evolution. Topics also include constrained optimization, convex programming, semidefinite programming, and optimization software tools.

Learning Outcomes

By the end of the course, students will be able to:

- Formulate and classify engineering optimization problems.
- Analyze and apply classical and modern optimization methods.
- Evaluate algorithm performance on benchmark and real-world problems.
- Explore optimization software packages (e.g., MATLAB, SciPy, CVXPY).
- Present and critique optimization techniques or case studies.
- Apply optimization techniques in a final research project or technical application.

Weekly Schedule & Tentative Topics

Week 1 (June 24, 26)
Introduction to optimization and unconstrained methods (gradient descent, Newton, line search)

Week 2 (July 1, 3)
Constrained optimization, simplex, and interior-point methods
In-class Presentations: Journal/Conference Papers & Tools

Week 3 (July 8, 10)
Convex, quadratic, and semidefinite programming.
In-class Presentations: Journal/Conference Papers & Tools

Week 4 (July 15, 17)
Genetic algorithms and constraint handling in evolutionary methods.
Assignment 1 Due
In-class Presentations: Journal/Conference Papers & Tools

Week 5 (July 22, 24)
Differential evolution, PSO, simulated annealing, and benchmarking.
In-class Presentations: Journal/Conference Papers & Tools

Week 6 (July 29, 31)
Algorithm performance comparison and final review of heuristic approaches.
Assignment 2 Due
In-class Presentations: Journal/Conference Papers & Tools

Week 7 (August 5)
Final Project Presentations, Course Wrap-Up, Q&A
Final Project Report Due, Take-home Final Exam Distributed

Assessments

Component	Description	Weight
Assignment 1		20%
Assignment 2		20%
In-Class Presentation (Group of 4)	10 min presentation on a research paper, tool, or application	10%
Take-home Final Exam	Analytical/conceptual exam, due post-final class	20%
Final Project	Optimization of a real/complex problem with report and presentation	30%

Tools and Resources

Languages: Python (SciPy, DEAP, PyGAD), MATLAB

Text/References:

- **Kalyanmoy Deb**
  Multi-Objective Optimization Using Evolutionary Algorithms
  Volume 16, John Wiley & Sons, 2001.

- **El-Ghazali Talbi**
  Metaheuristics: From Design to Implementation
  John Wiley & Sons, 2009.
  ISBN: 978-0-470-27858-1

- Selected IEEE/Elsevier conference/journal articles

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