Faculty of Eng. & Natural Sci.

ENS511-202202

Engineering Optimization

Instructor(s)

Name	Email	Office	Phone	Web	Office Hours
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Course Content

This course will cover optimization methods for solving engineering problems. The methods will include linear and nonlinear programming, integer programming, dynamic programming, network models and an introduction to metaheuristic algorithms. Special emphasis will be given to practical aspects.

Objectives

This course will expose students to operations research modeling and basic tools for optimization. It is designed for engineering students who do not have an industrial engineering background but would like to learn about modeling and optimization concepts. This course will be particularly useful for those who are likely to use these methods in their research and projects.

Recommend or Required Reading

Textbook

Introduction to Operations Research 11th Edition by Frederick Hillier and Gerald Lieberman. (Publisher: McGraw-Hill)

Readings

- Operations Research: An Introduction, Global Edition, 10th Edition by Hamdy A. Taha (Publisher: Pearson)
- Optimization in Operations Research: Pearson New International Edition by Ronald L.Rardin (Publisher: Pearson)
- Engineering with Excel, 5th Edition by Ronald W Larsen (Publisher: Pearson)

- Algorithm Design: Pearson New International Edition, 1st Edition by Jon Kleinberg & Eva Tardos (Publisher: Pearson)

Assessment Methods and Criteria

	Percentage(%)	Number of assessment methods
Quiz	90	3
Participation	10	

Course Outline

Week 1: Introduction to optimization and its engineering and machine learning applications. Overview of optimization methods and problem formulations.

Week 2-3: Linear programming: Formulations, Simplex algorithm, Duality theory, and Sensitivity analysis.

Week 4-5: Graph theory: Network flows, matchings, and cuts.

Week 6-7: Dynamic programming: Bellman's principle and its applications in optimal control and decision-making.

Week 8: Midterm Exam 1

Week 9-10: Nonlinear programming: Unconstrained optimization, gradient, and Newton methods, and constrained optimization techniques such as Karush-Kuhn-Tucker conditions and penalty functions.

Week 11-12: Applications of optimization in machine learning, including linear and nonlinear regression, classification, and neural networks.

Week 13-14: Topics such as stochastic optimization, heuristics, metaheuristics, Multi-objective optimization, and optimization under uncertainty.

New this year: Optimization applications in machine learning include linear and nonlinear regression, classification, and neural networks. These applications involve finding the optimal parameters of a model that minimize the error between the predicted and actual values.

Linear regression models the relationship between a dependent variable and one or more independent variables. The goal is to find the best-fit line that minimizes the sum of the squared errors between predicted and actual values. Linear regression can be formulated as a linear programming problem and solved using optimization techniques such as the simplex algorithm.
Nonlinear regression models a relationship between a dependent variable and one or more independent variables when the relationship is nonlinear. Nonlinear regression problems are usually solved using optimization techniques such as gradient descent or Newton's method.
Classification is a problem of identifying to which of a set of categories a new observation belongs, based on a training set of data containing observations whose category membership is known. Optimization techniques such as gradient descent and Newton's method are often used to find the optimal parameters of a classification model.
Neural networks are machine learning algorithms inspired by the structure and function of the human brain. The goal is to find the optimal parameters of a neural network that minimize the error between the predicted and actual values. Optimization techniques such as gradient descent and backpropagation are often used to find the optimal parameters of a neural network.

Learning Outcomes

At the end of the course, the student is expected to have the ability to construct mathematical models of real life problems and to use appropriate methods/software to solve the constructed models.

Course Policies

We may need to make changes to our course plan based on a nationwide reassessment of higher education that is scheduled to take place at the beginning of April. The course content that will be delivered remains the same, but details such as the method of course delivery, the timing and number of exams, and other specifics may be subject to change. We will keep you informed as we receive more information and make any necessary adjustments to the course plan.

-- Attendance & Lecture Participation Grade
We want students to explain their thoughts and recommendations clearly and engage in constructive discussions with others.
This requires students to join the lecture hours fully prepared for the class session material.
Each student's class participation (i.e., comments, questions, answers, discussions with other students, etc.) will be graded.

GRADING IS BASED ON THREE QUIZZES ADMINISTERED IN PERSON.

FOR 2023 SPRING THE FOLLOWING HAS CHANGED.
%-- Quizzes
% We will have three quizzes during the semester. Quizzes are short exams administered at the beginning of a % lecture with a question(s) from the most recent topic discussed in the classroom. Quizzes may or may not
% be announced beforehand and will be in person. No cheat sheets are allowed. All quizzes will be given
% after the week of April 10.

%-- Exams
% There will be one midterm and one final exam. Both exams are comprehensive for the topics discussed in
% class up to and including the week of the exam. All exams will be in class, and the midterm exam will be
% during lecture hours. No cheat sheets are allowed. The date of the exam will be announced later but you
% can expect it to be after the week of April 10.

-- Assignments and Term Project:
The students need to develop their coding capabilities. Hence, there will be group project assignments. The students will use any programming language, such as Python, Visual Studio, or MATLAB, to model and solve optimization problems. The project will be assigned in the second half of the semester. However, due to the latest developments in OpenAI, assignments will no longer be evaluated. Thus, it is the student's responsibility to develop their coding capabilities if they wish to do so.

-- Make-up Exam Policy
There will be a single make-up exam that will be conducted after the final exam.
The student needs to inform the instructor and document the reason for missing the regular exam.
The make-up exam cannot be taken to replace an already-taken exam.