Stevens Institute of Technology
School of Business
Syllabus
BIA 650
Process Optimization and Analytics

Spring 2023	Lecture Time: Thursdays 3:30 PM - 6:00 PM
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	Course Room/Web Address: TBD and http://www.stevens.edu/canvas

Overview

This course covers basic concepts in optimization, analytics, and heuristic search. It provides an introduction to process analytics and optimization for various decision making problems in management and data analysis. Process analytics integrates real-time data and optimization models and methods to analyze and improve future process performance. The emphasis is on problem formulation and optimization modeling using Excel spreadsheet and Excel Solver. However, FICO Xpress Mosel optimization modeling and programming language is also practiced and recommended.

While the skills developed in this course can be applied to a very broad range of business problems, the practice examples and student exercises will focus on the following areas: marketing, logistics and supply chain optimization, capital budgeting, asset management, portfolio analysis, and data analysis.

Prerequisites: Admission requirements for the BI&A program.

Course Objectives

This course develops students' ability to analyze real-world decision-making problems and develop mathematical formulations that are amenable to solution techniques of operations research such as linear, nonlinear, integer optimization, combinatorial optimization, multi-stage optimization and simulation. The ability to translate practical problems into representations that are amenable to analysis requires critical thinking and imagination and is an essential skill for analysts wishing to develop creative solutions in practice. While the emphasis is on modeling rather than mathematical algorithms, the analytical techniques learned in this course are essential building blocks for various management problems and machine learning. This course is therefore an essential foundation for the study of other subject areas in the BI&A curriculum. Additional learning objectives include the development of:

Written and Oral Communications Skills: the individual project proposal will be used to assess written skills and the final presentations will be video-taped and used to assess presentation skills.

Ethical Understanding: all students will take part in an ethics quiz and ethical issues and business dilemmas will be discussed.

Team Skills: The final project for the course will involve student teams; an online survey instrument will be used to measure individual contributions to team performance.

Course Outcomes

After taking this course, students will be able to:

- Develop and solve optimization models in a number of domains such as supply chain modeling, marketing, production, asset management, capital budgeting and financial portfolio analysis.
- Develop simulation models and design simulation experiments.
- Perform process mining on workflow logs.
- Understand the optimization and search techniques underlying machine learning techniques such as neural networks and social network analysis.

Pedagogy

The course will employ lectures, class discussion, in-class individual assignments, individual homeworks and a team project. In the team project, students will analyze a real industrial problem, formulate a model, collect data, solve the problem using one or more of the techniques discussed in class, and interpret the solution for management.

Readings

Required Textbook

Wayne L. Winston and S. Christian Albright, **Practical Management Science**, Cengage Learning; 6th edition (2018)

Supplementary Textbooks

- D. Bertsimas, J. Dunn, **Machine Learning Under a Modern Optimization Lens**, Dynamic Ideas LLC; 1st edition (2019)
- D. Bertsimas, A. O'Hair, W. Pulleyblank, **The Analytics Edge**, Dynamic Ideas LLC; 1st edition (2016)
- S. Bradley, A. Hax, T. Magnanti, **Applied Mathematical Programming**, Addison-Wesley (1977)
- S. Wright, B. Recht, **Optimization for Data Analysis**, Cambridge University Press (2022)
- D. Berseimas, J. Tsitsiklis, **Introduction to Linear Optimization**, Athena Scientific (1997)
- J. C. Hull, **Machine Learning in Business: An Introduction to the World of Data Science**, Independently published; 2nd edition (2020)
- M. Weske, **Business Process Management: Concepts Languages and Architectures**, Springer; 3rd edition (2020)

Recommended Free Online Review Resources:

- **Linear Algebra:** Linkedin Learning: Machine Learning Foundations: Linear Algebra
- **Calculus:** Coursera: https://www.coursera.org/learn/introduction-to-calculus
  Coursera: https://www.coursera.org/specializations/mathematics-machine-learning

Grading and Homework Assignments

INDIVIDUAL HOMEWORKS and WEEKLY QUIZZES (45%):
To help reinforce the material covered in the lectures, a homework exercise will be assigned every few lectures, which will involve formulating and solving small but practically-relevant homework problems.

Homework Submission: All home works must be submitted through the course website at Canvas. Submissions via email will not be considered. Each homework submission should include two files (an Excel File and an Explanation File in pdf or doc). The explanation file should clearly specify the ingredients of the optimization model, the type of the optimization model, the solving method that you used to obtain the optimal solution, the computed optimal solution, and the management explanation of the solution.

Homework Presentation: The Excel assignment submissions will be graded on their clarity as well as numerical accuracy. In particular, the excel spreadsheet (not the solver dialog box) should clearly show the constraints in the model.

Late Submission: All assignments are due on the deadlines specified on canvas. In fairness to others, submissions only one week after the deadline can be accepted but will be penalized 15% for the week overdue.

COURSE EXAMINATION (25%):
This examination (Canvas Quiz) will take place shortly after the mid-point of the course. Its purpose is to consolidate the learning on optimization techniques. It will involve the formulation and solution of a number of typical problems from business practice.

INDIVIDUAL PROJECT PROPOSAL (10%):
An individual project involving the framing of a data analysis problem and optimization model, the development of appropriate research questions and the identification of relevant data sources will be due in the latter half of the semester.

TEAM PROJECT REPORT & PRESENTATION (20%):
The team project will involve solving a real industry problem presented in the form of a case study. Alternatively, the team can take a real industry problem, collect data, and develop an optimization model and recommend a solution. One of the deliverables for this exercise is a team oral presentation in the last lecture and will be worth **5%** of the **20%** team project grade.
Online tutorials on oral presentations are available at:
Part 1 - http://vimeo.com/54537755 Part 2 - http://vimeo.com/54537939

Ethical Conduct

The following statement is printed in the Stevens Graduate Catalog and applies to all students taking Stevens courses, on and off campus. "Cheating during in-class tests or take-home examinations or homework is, of course, illegal and immoral. A Graduate Academic Evaluation Board exists to investigate academic improprieties, conduct hearings, and determine any necessary actions. The term 'academic impropriety' is meant to include, but is not limited to, cheating on homework, during in-class or take home examinations and plagiarism."

Consequences of academic impropriety are severe, ranging from receiving an "F" in a course, to a

warning from the Dean of the Graduate School, which becomes a part of the permanent student record, to expulsion. *Reference:* *The Graduate Student Handbook*

Please note that assignments in this class may be submitted to www.turnitin.com, a web-based anti-plagiarism system, for an evaluation of their originality.

COURSE SCHEDULE

1. Introduction to Optimization
Readings: W&A Textbook: Chapters 1 and 2
2. Linear Optimization
Readings: W&A Textbook: Chapter 3
3. Optimization with Excel Solver and Examples
Readings: W&A Textbook: Chapter 4
4. Network Optimization
The classic transportation model. Supply chain modeling. Graph theory – the shortest path model. *Readings:* W&A Textbook: Chapter 5
5. Integer Optimization
Approaches to optimization with integer variables. The branch and bound approach. Either-or constraints. Examples: capital budgeting, spatial analysis: location models *Readings:* W&A Textbook: Chapter 6.
6. Nonlinear Optimization and Convex Optimization
Convex and concave functions; assumptions for nonlinear optimization in Solver. Sales force assignment. Balancing risk and return - portfolio optimization. *Readings:* W&A Textbook: Chapter 7
7. Heuristic Algorithms
Conditions under which standard optimization techniques fail. The evolutionary approach. *Readings:* W&A Text: Chapter 8
8. Multi-objective Optimization
Goal programming; pareto optimality and trade-off curves; the Analytic Hierarchy Process (AHP) *Readings:* W&A Textbook: Chapter 16
9. Midterm (at Canvas)
Readings: lecture materials of weeks 1-8
10. Optimization under Uncertainty
Readings: W&A Textbook: Chapter 9
11. Optimization via Simulation
Readings: W&A Textbook: Chapters 10 and 11, Lecture Slides
12. Optimization in Data Analysis
Readings: Lecture Slides
13. Ethics in Business **Case Studies in Optimization and Data Analytics**
Readings: Lecture Slides
14. Student Presentations on Final Projects
Each team presents their term project: written report plus oral presentation