Course Syllabus

ISYE 6669

Deterministic Optimization

Fall 2025

**Professors: Dr. Andy Sun, Dr. Shabbir Ahmed, and Dr. Santanu S. Dey**

Course Description

The course will teach basic concepts, models, and algorithms in linear optimization, integer optimization, and convex optimization. The first module of the course is a general overview of key concepts in optimization and associated mathematical background. The second module of the course is on linear optimization, covering modeling techniques, basic polyhedral theory, simplex method, and duality theory. The third module is on nonlinear optimization and convex conic optimization, which is a significant generalization of linear optimization. The fourth and final module is on integer optimization, which augments the previously covered optimization models with the flexibility of integer decision variables. The course blends optimization theory and computation with various applications to modern data analytics.

Prerequisite

o Linear algebra

o Multivariate Calculus

o Basic Probability

o Familiarity with programming in Python

Course Goals

Student who take this course can expect to achieve the following goals:

o Learn modeling skills for formulating various analytics problems as linear, convex nonlinear, and integer optimization problems

o Learn basic optimization theory including duality theory and convexity theory, which will give the students a deeper understanding of not only how to formulate an optimization model, but also why.

o Learn fundamental algorithmic schemes for solving linear, nonlinear, and integer optimization problems.

o Learn computational skills for implementing and solving an optimization problem using modern optimization modeling language and solvers.

Grading Policy

o There will be one midterm quiz and one final quiz that will be graded by faculty.

The midterm will be 40% and the final will be 40% of the overall grade.

o There will be homework assignments most weeks of the semester. Your two lowest homework grades will be dropped, and the remaining ones will add up to

20% of the course grade. Some of the assignments will be faculty graded, and others will be peer-graded (based on the median score assigned by your peer graders). You will also need to peer-grade others’ homework; you will not receive a final grade for your homework submission if you do not complete your peer assessments.

o For OMS Analytics degree students, quizzes will be scaled to letter grades based on their difficulty and combined with the homework to determine an overall letter grade scale at the end of the semester.

o Grade Breakdown

• Homework 20%

• Midterm 40%

• Final Exam 40%

Total 100%

Homework and Quizzes Due Dates

All homework and quizzes will be due at the times in the table at the end of this syllabus. These times are subject to change so please check back often. Please convert from EST to your local time zone using a [Time Zone Converter](https://www.timeanddate.com/worldclock/converter.html).

Timing Policy

o The Modules follow a logical sequence

o Assignments should be completed by their due dates.

o Quizzes must be completed during the time allotted on the schedule.

o You will have access to the course content for the scheduled duration of the course.

Quiz Policy

o No notes (apart from what is stated bellow), books, or calculator/computers are allowed in the midterm and final quizzes.

o For midterm and final quizzes, you are allowed two blank sheets of paper for scratch work (OMS Analytics degree students will be proctored; you will have to show the front and back of the blank sheet while you are being proctored). For midterm you are allowed to use one sheet of paper with notes. For final you are allowed two sheets of paper with notes. Each student must prepare their own notes.

Attendance Policy

o This is a fully online course.

o Login on a regular basis to complete your work, so that you do not have to spend

a lot of time reviewing and refreshing yourself regarding the content.

Plagiarism Policy

o Plagiarism is considered a serious offense. You are not allowed to copy and paste or submit materials created or published by others, as if you created the materials. All materials submitted and posted must be your own.

Student Honor Code

All OMS Analytics degree students should abide by the Georgia Tech Student Honor Code

o Review the Georgia Tech Student Honor Code: [www.honor.gatech.edu](http://www.honor.gatech.edu/).

o Any OMS Analytics degree student suspected of behavior in violation of the

Georgia Tech Honor Code will be referred to Georgia Tech’s Office of Student

Integrity.

Communication

o All learners should ask questions, and answer their fellow learners’ questions, on the course discussion forums. Often, discussions with fellow learners are the sources of key pieces of learning.

o OMS Analytics degree students can also ask questions of the instructor and

teaching assistants via Piazza.

Netiquette

o Netiquette refers to etiquette that is used when communicating on the Internet.

When you are communicating via email, discussion forums or synchronously (real-time), please use correct spelling, punctuation and grammar consistent with the academic environment and scholarship1.

o In Georgia Tech’s MS in Analytics program, we expect all participants (learners, faculty, teaching assistants, staff) to interact respectfully. Learners who do not adhere to this guideline may be removed from the course.

1Conner, P. (2006–2014). Ground Rules for Online Discussions, Retrieved 8/14/2020 from <https://tilt.colostate.edu/TipsAndGuides/Tip/128>

Course Topics and Sample Pacing Schedule

o The table below contains a course topic outline and homework due dates.

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| **Weeks** | **Course Topics** | **Release Dates** |
| Week 1 | Module 1: Introduction  • Lesson 1: Introduction to  Optimization Models  • Lesson 2: Mathematical ingredients  • Lesson 3: Classification of  optimization problems  Module 2: Illustration of the optimization process  o Lesson 1: A portfolio optimization problem  o Lesson 2: Formulating a portfolio optimization model  o Lesson 3: Solving the portfolio optimization model  o Lesson 4: Summary of the optimization process | Aug 18, 2025 at 8:00 a.m. Eastern |
| Week 1  Homework | Homework 1 | Aug 18 at 8: 00 a.m. Eastern –  Aug 28 at 11:59 p.m. |

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|  |  | Peer Assmt: Aug 28 at 11:59  Eastern – Sep 1 at 11:59  Eastern |
| Week 2 | Module 3: Review of Mathematical Concepts  • Lesson 1: Linear Algebra  • Lesson 2: Properties of Functions  • Lesson 3: Properties of Sets  Module 4: Convexity  • Lesson 1: Convex Functions  • Lesson 2: Convex Sets  • Lesson 3: Convex Optimization  Problems | Aug 25, 2025 at 8:00 a.m. Eastern |
| Week 2  Homework | Homework 2 | Aug 25 at 8: 00 a.m. Eastern –  Sep 4 at 11:59 p.m.  Peer Assmt: Sep 4 at 11:59  Eastern – Sep 8 at 11:59  Eastern |
| Week 3 | Module 5: Outcomes of Optimization  • Lesson 1: Possible Outcomes of  Optimization  • Lesson 2: Existence of Optimal  Solutions  • Lesson 3: Local and Global Optimal  Solutions  • Lesson 4: Idea of Improving Search  Module 6: Optimality Certificates  • Lesson 1: Optimality Certificates and  Relaxations  • Lesson 2: Lagrangian Relaxation and  Duality | Sep 1, 2025 at 8:00 a.m. Eastern |
| Week 3  Homework | Homework 3 | Sep 1 at 8: 00 a.m. Eastern –  Sep 11 at 11:59 p.m.  Peer Assmt: Sep 11 at 11:59  Eastern – Sep 15 at 11:59  Eastern |

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| Week 4 | Module 7: Unconstrained Optimization: Derivative Based  • Lesson 1: Optimality Conditions  • Lesson 2: Gradient Descent  • Lesson 3: Newton's Method  Module 8: Unconstrained Optimization: Derivative Free  • Lesson 1: Methods for Univariate  Functions  • Lesson 2: Methods for Multivariate  Function | Sep 8, 2025 at 8:00 a.m. Eastern |
| Week 4  Homework | Homework 4 | Sep 8 at 8: 00 a.m. Eastern –  Sep 18 at 11:59 p.m.  Peer Assmt: Sep 18 at 11:59  Eastern – Sep 22 at 11:59  Eastern |
| Week 5 | Module 9: Linear Optimization Modeling - Network Flow Problems  • Lesson 1: Introduction to LP Modeling  • Lesson 2: Optimal Transportation  Problem  • Lesson 3: Maximum Flow Problem  • Lesson 4: Shortest Path Problem  Module 10: Linear Optimization Modeling  - Electricity Market  • Lesson 1: How Electricity Markets  Work  • Lesson 2: Modeling Power plant  Scheduling Using LP  • Lesson 3: Market Clearing  Mechanism  • Lesson 4: A Real-World Example | Sep 15, 2025 at 8:00 a.m. Eastern |
| Week 5  Homework | Homework 5 | Sep 15 at 8: 00 a.m. Eastern –  Sep 25 at 11:59 p.m. |

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|  |  | Peer Assmt: Sep 25 at 11:59  Eastern – Sep 29 at 11:59  Eastern |
| Week 6 | Module 11: Linear Optimization Modeling - Decision-Making Under Uncertainty  • Lesson 1: the Need to Make  Decisions Under Uncertainty  • Lesson 2: Two-Stage Stochastic  Linear Programming  • Lesson 3: An Example Using  Stochastic LP  • Lesson 4: How to Solve Stochastic  Programs  Module 12: Linear Optimization Modeling - Handling Nonlinearity  • Lesson 1: The Power of Piecewise  Linear Functions  • Lesson 2: Robust Regression Using LP  • Lesson 3: Radiation Therapy  • Lesson 4: LP Models for Radiation  Therapy | Sep 22, 2025 at 8:00 a.m. Eastern |
| Week  6 Homework | Homework 6 | Sep 22 at 8: 00 a.m. Eastern –  Oct 2, at 11:59 p.m.  Peer Assmt: Oct 2 at 11:59  Eastern – Oct 6 at 11:59  Eastern |
| Week 7 | Module 13: Geometric Aspects of Linear  Optimization  • Lesson 1: Basic Geometric Objects in  LP  • Lesson 2: Extreme Points and Convex  Hull  • Lesson 3: Extreme Rays and  Unbounded Polyhedron  • Lesson 4: Representation of  Polyhedrons | Sep 29, 2025 at 8:00 a.m. Eastern |

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|  | Module 14: Algebraic Aspects of Linear  Optimization  • Lesson 1: Basic Feasible Solution  • Lesson 2: Polyhedron in Standard  Form  • Lesson 3: Basic Feasible Solution in  Standard Form LP  • Lesson 4: Why We Care So Much  About BFS |  |
| Week  7 Homework | Homework 7 | Sep 29 at 8: 00 a.m. Eastern –  Oct 9 at 11:59 p.m.  Peer Assmt: Oct 9 at 11:59  Eastern – Oct 13 at 11:59  Eastern |
| Week 8 | Module 15: Simplex Method in a Nutshell  • Lesson 1: Local Search - The General  Idea  • Lesson 2: Local Search - Specialized to LP  • Lesson 3: How to Walk on the Edge  • Lesson 4: When to Stop and Declare  Victory  Module 16: Further Development of Simplex  Method  • Lesson 1: Summarize Simplex  Method  • Lesson 2: Handling Degeneracy  • Lesson 3: Phase I/Phase II Simplex  Method  • Lesson 4: An Example | Oct 6, 2025 at 8:00 a.m. Eastern |
| Week  8 Homework | Homework 8 | Oct 6 at 8: 00 a.m. Eastern –  Oct 16 at 11:59 p.m.  Peer Assmt: Oct 16 at 11:59  Eastern – Oct 20 at 11:59  Eastern |

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| Midterm | Midterm Exam | Oct 13, 2025 at 8: 00 a.m. Eastern – Oct 20 at 11:59 p.m. Eastern |
| Week 9 | Module 17: Linear Programming Duality  • Lesson 1: Introduction to Duality  Theory  • Lesson 2: Lagrangian Relaxation and  LP Duality  • Lesson 3: Weak Duality and Strong Duality  • Lesson 4: Table of Possibles and  Impossibles  • Lesson 5: Complementary Slackness  Module 18: Robust Optimization  • Lesson 1: Concept of Robustness  • Lesson 2: Concept of Robustness in  Example  • Lesson 3: Robust Linear Program  • Lesson 4: More Examples of Robust  Linear Optimization | Oct 13, 2025 at 8: 00 a.m. Eastern |
| Week  9 Homework | Homework 9 | Oct 13 at 8: 00 a.m. Eastern –  Oct 23 at 11:59 p.m.  Peer Assmt: Oct 23 at 11:59  Eastern – Oct 27 at 11:59  Eastern |
| Week 10 | Module 19: Large-Scale Optimization Cutting Stock Problem  • Lesson 1: Cutting Stock Problem  • Lesson 2: Gilmore-Gomory  Formulation  • Lesson 3: Column Generation  • Lesson 4: Column Generation for  Cutting Stock Problem  Module 20: Large-Scale Optimization  • Lesson 1: Example for Column  Generation | Oct 20, 2025 at 8: 00 a.m. Eastern |

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|  | • Lesson 2: Primal-Dual Relationship:  Constraint Generation  • Lesson 3: Primal-Dual Relationship:  Pricing Problem and Separation Problem |  |
| Week  10 Homework | Homework 10 | Oct 20 at 8: 00 a.m. Eastern –  Oct 30 at 11:59 p.m.  Peer Assmt: Oct 30 at 11:59  Eastern – Nov 3 at 11:59 |
| Eastern |
| Week 11 | Module 21: Large-Scale Optimization Dantzig-Wolfe Decomposition  • Lesson 1: Exploiting Special Structures  of Large-Scale Optimization  • Lesson 2: Dantzig-Wolfe  Decomposition 1  • Lesson 3: Dantzig-Wolfe  Decomposition 2  • Lesson 4: Dantzig-Wolfe  Decomposition 3  • Lesson 5: Example  Module 22: Nonlinear Optimization Modeling - Approximation and Fitting  • Lesson 1: Linear Equations, Norm, and  Least Square  • Lesson 2: Function Fitting  • Lesson 3: Normal Equation and  Singular Value Decomposition  • Lesson 4: Image Compression,  Constrained Least Squares, and SVD• Lesson 3: Support Vector Machine  • Lesson 4: Nonlinear Discrimination | Oct 27, 2025 at 8: 00 a.m. Eastern |
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| Week 11  Homework | Homework 11 | Oct 27 at 8: 00 a.m. Eastern –  Nov 6 at 11:59 p.m.  Peer Assmt: Nov 6 at 11:59  Eastern – Nov 10 at 11:59  Eastern |
| Week 12 | Module 23: Convex Conic  Programming Introduction | Nov 3, 2025 at 8: 00 a.m. Eastern |

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|  | • Lesson 1: Convex Cones, Order, and  Linear Conic Programming  • Lesson 2: Second-Order Cone and  SOCP  • Lesson 3: PSD Cone and SDP  Module 24: SOCP, SDP Examples  • Lesson 1: Statistical Classification  Problem  • Lesson 2: Experimental Design  • Lesson 3: Extremal Ellipsoid Problem |  |
| Week 12  Homework | Homework 12 | Nov 3 at 8: 00 a.m. Eastern –  Nov 13 at 11:59 p.m.  Peer Assmt: Nov 13 at 11:59  Eastern – Nov 17 at 11:59  Eastern |
| Week 13 | Module 25: Discrete Optimization - Introduction  • Lesson 1: Why Discrete Variables  • Lesson 2: Discrete Optimization  Challenges  • Lesson 3: Computational Complexity  Module 26: Discrete Optimization - Modeling With  Binary Variables 1  • Lesson 1: Nonconvex Functions  • Lesson 2: Nonconvex Sets and Logical  Relations  • Lesson 3: Logical Relations | Nov 10, 2025 at 8: 00 a.m. Eastern |
| Week 13  Homework | Homework 13 | Nov 10 at 8: 00 a.m. Eastern –  Nov 20 at 11:59 p.m.  Peer Assmt: Nov 20 at 11:59  Eastern – Nov 24 at 11:59  Eastern |

Module 27: Discrete Optimization - Modeling With

Binary Variables 2

Week 14

• Lesson 1: Set Packing, Covering, Partitioning

• Lesson 2: Graph and Network

Problems

Module 28: Discrete Optimization - Modeling Exercises

• Lesson 1: Modeling Exercises - 1

• Lesson 2: Modeling Exercises - 2

• Lesson 3: Modeling Exercises - 3

Nov 17, 2025 at 8: 00 a.m. Eastern

Week 14

Homework

Week 15

Homework 14

Module 29: Discrete Optimization - Linear

Programming Relaxation

• Lesson 1: Linear Programming

Relaxation

• Lesson 2: Ideal Formulations

Module 30: Discrete Optimization - Solution

Methods

• Lesson 1: Enumeration

• Lesson 2: Cutting Plane Methods

• Lesson 3: Branch-and-Bound

Algorithm

• Lesson 4: Heuristics

Nov 17 at 8: 00 a.m. Eastern –

Nov 27 at 11:59 p.m.

Peer Assmt: Nov 27 at 11:59

Eastern – Dec 1 at 11:59

Eastern

Nov 24, 2025 at 8:00 a.m. Eastern

Week 15

Homework

Homework 15

Nov 24 at 8: 00 a.m. Eastern –

**Dec 2 at 11:59 p.m.**

Peer Assmt: Dec 2 at 11:59

Eastern – Dec 6 at 11:59

Eastern

Dec 4, 2025 at 8:00 a.m.

Final Final Exam

Eastern – Dec 11, 2025 at 11:59 p.m. Eastern

Course Materials

o All content and course materials can be accessed online

o There is no textbook for this course

o Reference books:

▪ R. Rardin. “Optimization in Operations Research”, Prentice Hall, 1998.

▪ S. Boyd and L. Vandenberghe, “Convex Optimization,” Cambridge University Press, 2004. Online: https://web.stanford.edu/~boyd/cvxbook/

▪ A. Ben-Tal and A. Nemirovski, “Lectures on Modern Convex

Optimization,” SIAM, 2001.

Technology/Software Requirements

o Internet connection (DSL, LAN, or cable connection desirable)

o PuLP optimization software (free download; see <http://www.coin-or.org/PuLP/>-- Windows version and (for Mac users) a Linux version)

o CVX in Python: CVXOPT, CVXPY software (available at [http://cvxopt.org](http://cvxopt.org/)

and <https://www.cvxpy.org/>)

o CVX in MATLAB: CVX software (available at <http://cvxr.com/cvx/>)

o Python programming language (free download; see [http://www.python.org](http://www.python.org/) ).

Preferably use the Anaconda distribution ([http://www.anaconda.com](http://www.anaconda.com/))

o Adobe Acrobat PDF reader (free download; see <https://get.adobe.com/reader/>)