OPERATIONS RESEARCH & INFORMATION ENGINEERING (ORIE)

ORIE 1380 - Data Science for All (4 Credits)
Crosslisted with STSCI 1380, CS 1380, INFO 1380
This course provides an introduction to data science using the statistical programming language R. We focus on building skills in inferential thinking and computational thinking, guided by the practical questions we seek to answer from data sets arising in medicine, economics and other social sciences. The course starts with essential R programming principles, and how to use R for data manipulation, visualization, and sampling. These techniques are then used to summarize and visualize real data sets, draw meaningful conclusions from those data, and assess the uncertainty surrounding those conclusions. Throughout the process, students will learn to develop hypotheses about their data, and use simulations and statistical techniques to test these hypotheses. The course also covers how to use the Tidyverse open-source R packages to clean and organize complex data sets, and create high quality graphics for data visualization.
Distribution Requirements: (DLG-AG, OPHLS-AG), (SDS-AS), (STA-IL)
Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2022, Winter 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 3120 - Practical Tools for Operations Research, Machine Learning and Data Science (4 Credits)
The practical use of software tools and mathematical methods from operations research, machine learning, statistics and data science. Software tools include structured query language (SQL), geographical information systems (GIS), Excel and Visual Basic programming (VBA), and programming in a scripting language (either R or Python). Operations research methods include inventory management, discrete event simulation, and an introduction to the analysis of queuing systems. Machine learning and statistical methods include multiple linear regression, classification, logistic regression, clustering, time-series forecasting, and the design and analysis of A/B tests. These topics will be presented in the context of business applications from transportation, manufacturing, retail, and e-commerce.
Prerequisites: Prerequisite or corequisite: ENGRD 2700.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 3150 - Financial and Managerial Accounting (4 Credits)
Covers principles of accounting, financial reports, financial-transactions analysis, financial-statement analysis, budgeting, job order and process-cost systems, standard costing and variance analysis, and economic analysis of short-term decisions.
Last Four Terms Offered: Winter 2025, Fall 2024, Fall 2023, Winter 2023
Schedule of Classes (https://classes.cornell.edu/)

ORIE 3300 - Optimization I (4 Credits)
Formulation of linear programming problems and solutions by the simplex method. Related topics such as sensitivity analysis, duality, and network programming. Applications include such models as resource allocation and production planning. Introduction to interior-point methods for linear programming.
Prerequisites: MATH 2210 or MATH 2940.
Last Four Terms Offered: Fall 2024, Summer 2024, Fall 2023, Summer 2023
Schedule of Classes (https://classes.cornell.edu/)

ORIE 3310 - Optimization II (4 Credits)
A variety of optimization methods stressing extensions of linear programming and its applications but also including topics drawn from integer programming, dynamic programming, and network optimization. Formulation and modeling are stressed as well as numerous applications.
Prerequisites: ORIE 3300 or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 3500 - Eng Probability and Statistics: Modeling and Data Science II (4 Credits)
A rigorous foundation in theory combined with the methods for modeling, analyzing, and controlling randomness in engineering problems. Probabilistic ideas are used to construct models for engineering problems, and statistical methods are used to test and estimate parameters for these models. Specific topics include: random variables, probability distributions, density functions, expectation and variance, multidimensional random variables, and important distributions including normal, Poisson, exponential, hypothesis testing, confidence intervals, and point estimation using maximum likelihood and the method of moments.
Prerequisites: ENGRD 2700 or equivalent.
Last Four Terms Offered: Summer 2025, Fall 2024, Summer 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

ORIE 3510 - Stochastic Processes for Decision-Making (4 Credits)
Crosslisted with STSCI 3510
Uses basic concepts and techniques of random processes to construct models for a variety of problems of practical interest. Topics include: the Poisson process, Markov chains, renewal theory, models for queuing, and reliability.
Prerequisites: ORIE 3500 or equivalent.
Distribution Requirements: (OPHLS-AG)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 3741 - Learning with Big Messy Data (4 Credits)
Modern data sets, whether collected by scientists, engineers, medical researchers, government, financial firms, social networks, or software companies, are often big, messy, and extremely useful. This course addresses scalable robust methods for learning from big messy data. We'll cover techniques for learning with data that is messy - consisting of real numbers, integers, booleans, categoricals, ordinals, graphs, text, sets, and more, with missing entries and with outliers - and that is big - which means we can only use algorithms whose complexity scales linearly in the size of the data. We will cover techniques for cleaning data, supervised and unsupervised learning, finding similar items, model validation, and feature engineering.
Prerequisites: MATH 2940, ENGRD 2700, ENGRD 2110/CS 2110, CS 2800 or equivalents.
Forbidden Overlaps: CS 3780, CS 5780, ECE 3200, ECE 5420, ORIE 3741, ORIE 5741, STSCI 3740, STSCI 5740.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4100 - Manufacturing Systems Design: A Consulting Boot Camp (4 Credits)
This project-based course puts students in the roles of analysts and advisors to an industrial firm facing broad challenges in customer service, product quality, market share, and profitability. Students, working in teams, design a manufacturing logistics system and conduct capacity, material flow, and cost analyses of their design. By taking a view that integrates marketing, distribution, manufacturing, and engineering, students help the company transform into a world-class competitor.
Enrollment Information: Enrollment limited to: seniors.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4120 - Inventory, Operations, and Supply Chain Management: Models and Optimization (3 Credits)
Crosslisted with SYSEN 4200
This course will provide a rigorous coverage of the (stochastic and deterministic) models commonly used in the study of inventory, operations, and supply chain management. This includes the multi-period newsvendor model and its many variants, as well as more sophisticated models which arise in supply chain management, logistics, and the study of operations more broadly. We will study tools for analyzing and optimizing such systems, as well as operational insights which can be extracted from such models. The course will in general have a fairly mathematical orientation, focusing on using tools from stochastic modeling, optimization, and dynamic programming/algorithms to formulate and analyze these models.
Prerequisites: introductory courses in probability and optimization (including linear programming and dynamic programming.) An introductory course in algorithms is helpful, but not strictly necessary.
Last Four Terms Offered: Spring 2022, Fall 2018
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4126 - Principles of Supply Chain Management (4 Credits)
Supply chain management focuses on the flow of products, information, and money through organizations that constitute the supply chain. The course provides an overview of the key principles on which an effective supply chain should be constructed. These principles are presented and illustrated through a collection of cases. These cases are taught using an experiential learning model. Additionally, applications of analytic and simulation tools to the design and operation of supply chains are given.
Prerequisites: ORIE 3300/ 5300 and ORIE 3510/ 5510 or equivalents, or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4130 - Service System Modeling and Design (4 Credits)
Service systems arise primarily from the service sector of the economy. Examples are contact centers (also known as call centers), airlines, insurance and healthcare. This course describes techniques that are useful in the analysis and design of such systems. The class is structured around a number of cases. The emphasis is on modeling, solving the models, and interpreting the results. Both operational and strategic decisions are covered through appropriate examples.
Prerequisites: ORIE 3500, ORIE 3510.
Last Four Terms Offered: Spring 2025, Fall 2023, Fall 2021, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4152 - Entrepreneurship for Engineers (3 Credits)
Crosslisted with MAE 4610, ENGRG 4610
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4154 - Revenue Optimization and Marketplace Design (3 Credits)
Application of modeling and optimization techniques in designing a company's interface with the market. We will cover a variety of topics (product pricing and capacity control; designing product assortments and customer segmentation; the use of customer data in modeling and optimization; the design of online platforms and markets), with examples from transportation, retail, hospitality and the sharing exconomy.
Prerequisites: ORIE 3300 and ORIE 3500, or permission of instructor.
Last Four Terms Offered: Spring 2023, Spring 2017, Spring 2015, Spring 2014
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4160 - Topics in Data Science and OR (3 Credits)
Each year, the course will cover a different advanced topic at the intersection of data science and operations research, with the specific topic to be chosen by the instructor that year. The class will entail advanced reading, homework, and course project. Example semester-long topics include: Multi-arm bandit models in ML and OR, Statistical recovery in data science and OR, Graphical models in data science and OR, Causal inference in data science and OR, and Reinforcement learning in data science and OR.
Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2023, Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4330 - Discrete Models (4 Credits)
Covers basic concepts of graphs, networks, and discrete optimization. Fundamental models and applications, and algorithmic techniques for their analysis. Specific optimization models studied include flows in networks, the traveling salesman problem, and network design.
Prerequisites: ORIE 3300 and CS 2110, or permission of instructor.
Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4340 - Applications of Optimization: Modeling and Computation (4 Credits)
This course will cover the use of optimization models in several industries. Covered industries will include manufacturing, process, distribution, retail, and transportation. We will not cover models used exclusively in the financial industry. In each covered industry we will start with simple text-book models, and then extend these models to reflect the realities of the industry, the existing business decisions processes and the available data. We expect to have lectures from experts in some of these industries, each of whom will also discuss Operations Research roles and careers.
Last Four Terms Offered: Fall 2024, Spring 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4350 - Introduction to Game Theory (4 Credits)
Broad survey of the mathematical theory of games, including such topics as two-person matrix and bimatrix games; cooperative and noncooperative n-person games; and games in extensive, normal, and characteristic function form. Economic market games. Applications to weighted voting and cost allocation.
Prerequisites: ORIE 3300.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4390 - Optimization Models for Logistics, Networks, and Markets (1.5 Credits)
Hands-on experience with integer linear programming and dynamic programming: creating ILPs and DPs, implementing them, critiquing them, understanding solver output, and improving ILPs using better variables, constraints, symmetry breaking, etc. Examples of problems that we will study in this course are logistical problems like sequencing in production, scheduling problems with conflicts (vertex coloring), matching problems for markets and clustering problems in networks, but are not limited to these domains. In addition, a variety of general linear programming techniques such as Fourier-Motzkin elimination, Dantzig-Wolfe decomposition, Benders decomposition and extended formulations may be covered, as well as rounding techniques of LP solutions.
Prerequisites: ORIE 3300 and ORIE 3310, or permission of instructor.
Last Four Terms Offered: Fall 2022
Learning Outcomes:

- Demonstrate ability to formulate strong ILPs.
- Recognize, identify and improve problematic formulations.
- Understand information from solver, and use this to improve formulations.
- Ability to use Dynamic Programming in a variety of settings.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 4570 - Reinforcement Learning with Operations Research Applications (3 Credits)
The ongoing information revolution and the advent of the big data era make quantitative methods in the business context indispensable. This course introduces reinforcement learning, decision-making under uncertainty, and related algorithms through the lens of OR applications. Examples will be drawn from real-world problems in operations, revenue management, queuing, finance, transportation, healthcare, and other areas of interest. The course will cover modeling and applications, basic theory, and algorithms.
Prerequisites: ORIE 3150, ORIE 3300, and ORIE 3500.
Last Four Terms Offered: Fall 2024
Learning Outcomes:

- Be able to formalize dynamic decision problems under uncertainty as Markov decision processes.
- Learn about finite-horizon and infinite-horizon MDPs.
- Know how to solve MDPs exactly via dynamic programming as well as know how to solve MDPs approximately via reinforcement learning.
- Learn to read the technical literature in operations research, machine learning, and control literature.
- Gain hands-on experience in implementing and applying various exact and approximate algorithms.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 4580 - Simulation Modeling and Analysis (4 Credits)
Introduction to Monte Carlo simulation and discrete-event simulation. Topics include: random variate and process generation; data-driven distribution modeling; input and output analysis; modeling, analysis and optimization of complex systems. Emphasizes tools and techniques needed in practice; in particular, modeling in simulation in Python, as well as commercial discrete-event simulation languages.
Prerequisites: CS 2110/ENGRD 2110. Corequisite: ORIE 3500 with the permission of instructor.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4600 - Introduction to Financial Engineering (3 Credits)
This is an introduction to the most important notions and ideas in modern financial engineering, such as arbitrage, pricing, derivatives, options, interest rate models, risk measures, equivalent martingale measures, complete and incomplete markets, etc. Most of the time the course deals with discrete time models. This course can serve as a preparation for a course on continuous time financial models such as ORIE 5600.
Prerequisites: ORIE 3500, ORIE 3510.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4630 - Operations Research Tools for Financial Engineering (4 Credits)
Crosslisted with STSCI 4630
Introduction to the applications of OR techniques, e.g., probability, statistics, and optimization, to finance and financial engineering. The course reviews probability and statistics and surveys assets returns, ARIMA time series models, portfolio selection using quadratic programming, regression, CAPM and factor models, option pricing, GARCH models, fixed-income securities, and resampling techniques. Covers the use of R for statistical calculations, simulation, and optimization.
Prerequisites: engineering math through MATH 2940, ENGRD 2700 and ORIE 3500, and knowledge of R and multiple linear regression equivalent to ORIE 3120. No previous knowledge of finance required.
Distribution Requirements: (DLS-AG, OPHLS-AG), (SDS-AS)
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4656 - Extreme Values in Finance (3 Credits)
In order to be able to assess the risk associated with future extreme values in financial returns, a practitioner must have an idea how heavy the tails of the returns are and how they cluster. The practitioner must also be able to understand the extremal risks associated with a portfolio of financial instruments, potentially of a large size. In this course the students will learn to work with extreme values, to understand the difference between light tails and heavy tails, and learn how the largest return and the total return grow for different types of tails. They will also learn statistical techniques (mostly through R packages) used to work with extreme values.
Prerequisites: ORIE 3500.
Last Four Terms Offered: Spring 2024
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4740 - Statistical Data Mining I (4 Credits)
Examines the statistical aspects of data mining, the effective analysis of large datasets. Covers the process of building and interpreting various statistical models appropriate to such problems arising in scientific and business applications. Topics include naive Bayes, graphical models, multiple regression, logistic regression, clustering methods and principal component analysis. Assignments are done using one or more statistical computing packages.
Prerequisites: ORIE 3500, MATH 2940 or equivalent, programming experience. Highly recommended prerequisite: exposure to multiple linear regression and logistic regression
Last Four Terms Offered: Spring 2024, Spring 2022, Spring 2021, Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4742 - Info Theory, Probabilistic Modeling, and Deep Learning with Scientific and Financial Apps (3 Credits)
This course is about building and understanding machine learning models for scientific and financial applications. It will cover foundational aspects of information theory and probabilistic inference as they relate to model construction and deep learning. Topics include hamming codes, repetition codes, entropy, mutual information, Shannon information, channel capacity, likelihood functions, Bayesian inference, graphical models, and deep neural networks. The section on deep neural networks will consider fully connected, convolutional, recurrent, and LSTM networks, generative adversarial training, and variational autoencoders.
Prerequisites: ORIE 3500, MATH 2940 or equivalent, CS 2110 or equivalent, exposure to statistical machine learning at the level of ORIE 4740, ORIE 3741 or equivalent or permission of the instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2021, Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4820 - Data-Driven Decision Modeling and Analysis (3 Credits)
This course equips students with essential data-driven decision-making skills, integrating structured and unstructured data. It bridges classical modeling techniques with modern computational tools, emphasizing critical thinking, automation, and problem-solving. The curriculum prepares students for operations research, supply chain analytics, finance, and engineering management careers.
Prerequisites: ENGRD 2700, ORIE 3300 or equivalent.
Last Four Terms Offered: Spring 2023, Spring 2022, Spring 2021, Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4900 - Undergraduate Research in ORIE (1-4 Credits)
Students engage in a mentored investigation or inquiry that aims to make a scholarly contribution to the field of operations research and information engineering. All students are mentored by Cornell faculty in ORIE and may also have additional mentors from the field.
Learning Outcomes:
- Identify possible research problems.
- Analyze relevance and feasibility of a research problem.
- Demonstrate the ability to utilize the knowledge learned in ORIE and other courses to solve a research problem.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 4990 - Teaching in ORIE (1-3 Credits)
Involves working as a TA in an ORIE course. The instructor assigns credits (the guideline is 1 credit per four hours per week of work with a limit of 3 credits).
Exploratory Studies: (CU-UG)

Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

ORIE 4999 - ORIE Project (1-4 Credits)
Project-type work, under faculty supervision, on a real problem existing in some firm or institution. Opportunities in the course may be discussed with the associate director.
Exploratory Studies: (CU-UG)

Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5100 - Manufacturing Systems Design: A Consulting Boot Camp (4 Credits)
This project-based course puts students in the roles of analysts and advisors to an industrial firm facing broad challenges in customer service, product quality, market share, and profitability. Students, working in teams, design a manufacturing logistics system and conduct capacity, material flow, and cost analyses of their design. By taking a view that integrates marketing, distribution, manufacturing, and engineering, students help the company transform into a world-class competitor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5110 - Engineering Economics and Strategic Decision-Making (1 Credit)
Students learn to make sound financial decisions in engineering contexts using tools such as time value of money, discounted cash flow, and capital budgeting. The course covers tax implications and financial statement analysis. Emphasis is placed on evaluating real-world projects, sustainability, and developing persuasive business cases using Excel and Python.
Enrollment Information: Enrollment limited to: M.Eng. students in ORIE.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5126 - Principles of Supply Chain Management (4 Credits)
Supply chain management focuses on the flow of products, information, and money through organizations that constitute the supply chain. The course provides an overview of the key principles on which an effective supply chain should be constructed. These principles are presented and illustrated through a collection of cases. These cases are taught using an experiential learning model. Additionally, applications of analytic and simulation tools to the design and operation of supply chains are given.
Prerequisites: ORIE 3300/5300 and ORIE 3510/5510 or equivalents, or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5129 - Data Science for e-Retail and the Sharing Economy (3 Credits)
Many online and tech businesses face logistics challenges that require optimal management of physical resources. These challenges may take the form of opening fulfillment centers at the right locations, stocking the right amount of inventory, running optimal number of servers to satisfy computing needs, repositioning bikes in urban bike-sharing systems, and dispatching and repositioning vehicles in online ride-sharing systems. Addressing these challenges often requires building and deploying large-scale optimization models that can make decisions on the fly. We will cover logistics models that allow firms to optimally use its physical resources. From an application perspective, our models will cover the inventory and supply chain theory, network design and transportation logistics. From a methodology perspective, we will use linear and integer programming, stochastic programming, and Markov decision processes. The course will include a number of large case studies that focus on practical implementations.
Prerequisites: ORIE 5380 and ORIE 5530, or by permission of the instructor.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Spring 2023, Spring 2022, Spring 2021, Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5130 - Service System Modeling and Design (4 Credits)
Crosslisted with SYSEN 5130
Service systems arise primarily from the service sector of the economy. Examples are contact centers (also known as call centers), airlines, insurance and healthcare. This course describes techniques that are useful in the analysis and design of such systems. The class is structured around a number of cases. The emphasis is on modeling, solving the models, and interpreting the results. Both operational and strategic decisions are covered through appropriate examples.
Corequisites: ORIE 3310, ORIE 3510.
Last Four Terms Offered: Spring 2025, Fall 2023, Fall 2021, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5132 - Pricing Analytics and Revenue Management (3 Credits)
The field of Revenue Management (RM) deals with selling a product at the right price, at the right time to the right person. Many industries use revenue management tools to maximize the return on their limited supply of products including e-retail, manufacturing, transportation, entertainment, advertising, etc. For example, e-retailers use RM to decide what assortment of products to show to the customers. Airlines use RM to decide what fare classes should remain open and what fare classes should be closed. Hotels use Revenue management to choose the room rates and to decide how much to overbook. The course will cover different quantitative models in pricing analytics and revenue management including newsvendor models, demand forecasting, network revenue management, choice modeling, assortment optimization, service operations and auctions. We will present ideas and models in the context of different application settings.
Prerequisites: ORIE 5380 and ORIE 5530, or by permission of the instructor.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5135 - Computational Integer Programming (3 Credits)
Crosslisted with CS 5135
This course in Discrete Optimization is focused on Nondeterministic Polynomial-hard problems but with a very strong focus on the use of Mixed-Integer Linear Programming, general-purpose solvers to attack them.
Prerequisites: ORIE 5380/CS 5727 or some knowledge of linear programming.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Spring 2022
Learning Outcomes:

- Ability to express combinatorial optimization problems by models with linear constraints and integer variables.
- Discriminate among various types of models depending on their solvability with modern mixed-integer programming solvers.
- Analyze the complexity of the most important combinatorial optimization problems.
- Understand, design and implement mixed-integer programming algorithms to solve the developed models.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 5138 - Networks and Markets (3 Credits)
Crosslisted with CS 5854
The course examines how the computing, economic and sociological worlds are connected and how these connections affects these worlds. Tools from computer science, game theory and mathematics are introduced and then used to analyze network structures present in everyday life. Topics covered include social networks, web search, auctions, markets, voting, and crypto-currencies (e.g. bitcoin).
Prerequisites: basic probability.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Fall 2024, Spring 2024, Spring 2021, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5140 - Model Based Systems Engineering (4 Credits)
Crosslisted with SYSEN 5100, CEE 5240, ECE 5120, MAE 5910
Fundamental ideas of systems engineering, and their application to design and development of various types of engineered systems. Defining system requirements, creating effective project teams, mathematical tools for system analysis and control, testing and evaluation, economic considerations, and the system life cycle.Content utilizes model-based systems engineering, which is the integration of systems modeling tools, such as SysML, with tools for systems analysis, such as Matlab and Modelica. The vision for this integration is the ability to create and analyze complete parametric representations of complex products and systems. These systems make it possible to investigate the impact of changing one aspect of a design on all other aspects of design and performance. This course will familiarize students with these modeling languages. Off-campus students must provide their own Windows 7, internet-connected, computer with administrator access in order to install the commercial software used in this course.
Prerequisites: Prerequisite or corequisite: enrollment in group-based project with strong system design component approved by course instructor.
Enrollment Information: Enrollment limited to: seniors or graduate students in an engineering field.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5142 - Systems Analysis Behavior and Optimization (3 Credits)
Crosslisted with SYSEN 5200, CEE 5252, MAE 5920, ECE 5130
This is an advanced course in the application of analytical methodologies and tools to the analysis and optimization of complex systems. On completion of this course, students should be able to use probability and statistics as a modeling and analysis tool for systems exhibiting uncertainty; be able to use algorithms and dynamic programming to model and optimize systems with a recursive structure; be able to use optimization tools to optimize complex systems and tune parameters.
Prerequisites: ENGRD 2700, calculus skills, and familiarity with basic programming in a language such as python, C++, java, matlab, etc.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5154 - Revenue Optimization and Marketplace Design (3 Credits)
Application of modeling and optimization techniques in designing a company's interface with the market. We will cover a variety of topics (product pricing and capacity control; designing product assortments and customer segmentation; the use of customer data in modeling and optimization; the design of online platforms and markets), with examples from transportation, retail, hospitality, and the sharing economy.
Prerequisites: ORIE 5300, ORIE 5500.
Last Four Terms Offered: Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5160 - Topics in Data Science and OR (3 Credits)
Each year, the course will cover a different advanced topic at the intersection of data science and operations research, with the specific topic to be chosen by the instructor that year. The class will entail advanced reading, homework, and course project. Example semester-long topics include: Multi-arm bandit models in ML and OR, Statistical recovery in data science and OR, Graphical models in data science and OR, Causal inference in data science and OR, and Reinforcement learning in data science and OR.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5190 - Selected Topics in Applied ORIE (3 Credits)
Current topics dealing with applications of operations research.
Last Four Terms Offered: Fall 2020, Fall 2019, Fall 2018, Fall 2017
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5191 - Selected Topics in Applied ORIE (1-9 Credits)
Last Four Terms Offered: Spring 2022, Spring 2021, Spring 2020, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5210 - Financial Engineering Colloquium (1-2 Credits)
A weekly guest speaker series designed to broaden students' understanding and knowledge of the financial markets, challenges that industry is facing and learn about a variety of career paths within the field of quantitative finance. Every week the students will hear from a different seasoned finance professional.
Enrollment Information: Enrollment limited to: Financial Engineering M.Eng. students in NYC.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5213 - Discrete Optimization for Urban Planning and Mobility (3 Credits)
Crosslisted with INFO 5213
The course is organized around five major case studies on the use of discrete optimization and data (AI at large) for smart cities. Namely, 1) bike sharing, 2) bus transportation planning, 3) fairness in ambulance allocation (and police patrol), 4) downed tree reporting (NYC Department of Parks and Recreation), and 5) parcel delivery.The teaching is structured to provide three levels of understanding: a first level in which the problem is presented with its importance, impact, and characteristics. The need of a tech-based quantitative approach is claimed and justified. A second level in which, a high-level version of the algorithmic approach used to solve the problem is presented. A third level, dependent on students' interest and knowledge, in which the algorithmic approach is detailed.
Prerequisites: basic knowledge of linear algebra and data management.
Last Four Terms Offered: Spring 2025, Spring 2023
Learning Outcomes:

- Students will learn real case studies on modern city development, planning, and management. The three-level teaching structure should allow (i) the technically-oriented students to see how to use their competences on real-world problems, and (ii) the more domain-oriented students to be alerted at looking for technical solutions and recognize their need.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 5215 - Financial Engineering Career Practicum (1 Credit)
A professional development course designed specifically for MEng students in ORIE concentrating in Financial Engineering. Through a series of panels and hands-on workshops, students will develop effective job search materials and participate in active exercises covering topics such as networking, interviewing for specific career paths, and other communication skills for today's professional environments.
Enrollment Information: Enrollment limited to: ORIE M.Eng students.
Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5217 - Digital N-of-1 Trials and their Application (3 Credits)
Traditionally, treatment guidelines and health recommendations are based on large cohort studies or randomized controlled trials (RCTs), which provide only average effect estimates. This limits their ability to predict whether an intervention will benefit an individual. With the rise of digital solutions, personalized approaches like N-of-1 trials are gaining traction. These modern designs allow for individual treatment effects and improve population-level effect estimates. This seminar covers N-of-1 trials and other modern study designs such as micro-randomized trials. First, we will get an overview of different study types and their characteristics, then we will give an introduction of the practical aspects for performing N-of-1 trials, and then the main focus of the class will be on methodological approaches for planning and analyzing N-of-1 trials.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Spring 2025
Learning Outcomes:

- Understand the main concepts of planning & conducting N-of-1 trials and selected other study designs.
- Perform individual-level and aggregated analysis of N-of-1 trials using state-of-the-art methods.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 5220 - Applied Financial Engineering (in NYC) (5 Credits)
Project course in Manhattan satisfying the engineering design project requirement for the M.Eng degree.
Enrollment Information: Enrollment limited to: Financial Engineering M.Eng. students in NYC.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5230 - Quantitative Trading Strategies (2 Credits)
This course covers numerical techniques for quantitative trading in Finance. The main computational tool is Python. The computational techniques draw from interpolation, linear algebra, optimization, stochastic control, Monte Carlo simulation, queuing theory, finite difference methods, binomial trees, as well as statistical techniques such as regression, co-integration and principal components analysis. The applications include pricing, market microstructure, hedging and asset allocation for bonds, futures, equities and options. The focus is on theories that can be implemented in trading situations and the Interactive Brokers platform is used extensively for trading assignments.
Enrollment Information: Enrollment limited to: Financial Engineering M.Eng. students in NYC.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5235 - Sustainable Urban and Energy Delivery Systems (3 Credits)
Crosslisted with ECE 5235, INFO 5235
The course focuses on how to transition from legacy energy delivery infrastructures dependent on fossil fuel to a sustainable decarbonized grid that harnesses distributed renewable energy resources and responsive demand from buildings, electrified transportation systems, and industrial loads. The content includes models and abstractions for the architecture of the cyber-physical energy system, its economics, and future evolution, and numerical optimization and learning methods in support of the infrastructure's safety critical operations in the legacy system and in the future architecture. At the MSc level the students will focus on learning how to use tools and data while at the graduate level the students will be asked to also solve problems, formulate novel solutions, interpret results. Similarly, to differentiate the MSc from PhD level and course outcomes, the final project will require the MSc students to pick one out of a set of predefined problems while the PhD students will have to define an original problem and solution.
Prerequisites: coursework in ML, data science, law and policy or ethics, calculus and algebra, algorithms, and python programming. Recommended prerequisite: coursework in theory and optimization.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2024, Spring 2023
Learning Outcomes:

- Students will be able to identify technical and operational models for energy delivery systems and appreciate why energy consumption in urban environments is bound to continue to be the most significant source of emissions under the status quo.
- Students will learn about and analyze emerging technological solutions in wide area sensing and IoT networks, machine learning and decision models that support the coordination the distributed renewable resources on the supply side with the flexible demand of electricity in urban environments.
- Students will identify security challenges that are unique of cyber-physical infrastructures and need to be addressed to advance to rip the benefits of digital technology in the field.
- Through assignments and projects, the students will gain hands-on experience in demonstrating on how to apply novel data models, network technology and software tools that encompass the various topics covered in the class.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 5240 - Bond Mathematics and Mortgage-Backed Securities (2 Credits)
A transaction-oriented course covering U.S. Bond markets. The course covers valuation, trading strategies, and risk profiles of bonds, with a special emphasis on mortgage-backed securities.
Enrollment Information: Enrollment limited to: Financial Engineering M.Eng. students in NYC.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5250 - Business Applications of Optimization (3 Credits)
Optimization models and methods are used to make businesses more efficient and cost effective. In this class, we will learn how to build and solve optimization models to make both strategic and operational decisions, and how to use data effectively to implement these models. We will cover business applications and problems such as pricing (how to price a product for retail?), choice modeling (how to estimate customers preferences in an online retail platform?), facility location (where to open warehouses and fulfillment centers?) and matching problems (how to match drivers to riders for example in the ride-sharing business?). The class will discuss both discrete optimization models that are used for instance in matching problems, and continuous optimization models that used for instance in pricing.
Prerequisites: ORIE 5380/CS 5727, basic background on probabilities and stochastic modeling, knowledge of a programming language, such as Python or R or Java, are expected.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Summer 2021
Learning Outcomes:

- Learn to develop and apply mathematical and analytical models to solve a wide range of optimization problems that arise in business applications.
- Identify opportunities in which optimization and business analytics can be used.
- Identify and solve a business problem using data by working on a project related to topics in operations, pricing and revenue management.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 5252 - Special Topics in Financial Engineering (2 Credits)
This course is taught by a seasoned finance professional and focuses on the tools and techniques used by quantitative traders. The topics covered include risk measurement and management, alpha forecasting methods, and the development and application of trade execution cost models. The emphasis of the course is to enable students to apply quantitative financial models within a real-life trading environment.
Enrollment Information: Enrollment limited to: Financial Engineering M.Eng. students in NYC.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5253 - Special Topics in Financial Engineering II (2 Credits)
This course is taught by a seasoned finance professional and provides an overview of the current challenges in the asset management industry and proposes practical solutions to overcome these challenges.
Enrollment Information: Enrollment limited to: Financial Engineering M.Eng. students in NYC.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5254 - Special Topics in Financial Engineering III (2 Credits)
This course is taught by a seasoned finance professional and is designed to familiarize students with the most recent developments in the equity derivatives marketplace. The emphasis will be on practical side of trading and analyzing attractive strategies in the equity derivatives markets.
Enrollment Information: Enrollment limited to: Financial Engineering M.Eng. students in NYC.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5255 - Special Topics in Financial Engineering IV (2 Credits)
This course is taught by a seasoned finance professional and will introduce students to the subject of market microstructure and the hottest areas of study within the field. Specifically, the course will focus on the recent electronification of the financial markets, and the resulting effects.
Enrollment Information: Enrollment limited to: Financial Engineering M.Eng. students in NYC.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5256 - Special Topics in Financial Engineering V (2 Credits)
This course is taught by a seasoned finance professional. Machine learning (ML) is changing virtually every aspect of our lives. As it relates to finance, this is the most exciting time to adopt a disruptive technology that will transform how everyone invests for generations. Students will learn scientifically sound ML tools used in the financial industry.
Enrollment Information: Enrollment limited to: ORIE M.Eng. financial engineering students in NYC.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5257 - Special Topics in Financial Engineering VI (2 Credits)
Algorithmic trading and ML-powered tools have impacted all asset classes: beyond the most liquid (and well-studied) equity markets, we have observed a growing number of assets (such as bonds, foreign exchange, crypto, on-line adverts, etc.) that are now primarily traded electronically, yet not necessarily via a classical exchange. In this course, we will cover the tools required to compete in FX, Rates and Crypto markets, covering the main protocols (price-streams, second-price auctions, etc.) with particular emphasis on how to apply the latest ML techniques to gain a competitive edge.
Enrollment Information: Enrollment limited to: ORIE M.Eng. financial engineering students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5258 - Python for Finance (1.5 Credits)
Python is rapidly becoming a golden standard for quantitative finance. In this course students will be exposed to the powerful and fast open-source data science libraries and specific applications of analyzing financial data sets.
Prerequisites: ENGRD 2700 and familiarity with Python.
Enrollment Information: Enrollment limited to: first semester ORIE FE MEng students.
Last Four Terms Offered: Spring 2025, Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Students will enhance their knowledge of Python and Python libraries as they pertain to financial applications.
- Students will apply their data analysis and statistical knowledge for financial modeling and will work with financial data sets.
- Students will learn how to draw insights from data science algorithms with the help of Python packages.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 5259 - Market Microstructure and Algorithmic Trading: Theory and Practice (1.5 Credits)
Modern financial markets have evolved to offer a variety of methods to trade and interact withother participants. Seemingly simple, the different microstructures can create opportunities for improved execution. Alongside the rise of complex market structures, algorithmic trading has become more sophisticated and increasingly reliant on AI & ML models: we introduce the core concepts of algorithmic execution, spanning the full spectrum of trading horizons, from High Frequency market-making to strategies that aim to efficiently execute large orders.
Enrollment Information: Enrollment limited to: ORIE MEng students, with priority given to students enrolled in the Financial Engineering Concentration.
Last Four Terms Offered: Spring 2025
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5260 - Special Topics in Quantitative Finance (2 Credits)
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5270 - Big Data Technologies (2 Credits)
This course offers a broad overview of computational techniques and mathematical skills useful for data scientists. Topics include: unix shell, regular expressions, version control: (git), data structures and algorithms, working with databases, data analysis using Python and related libraries (Pandas, NumPy/Scipy, scikit-learn), parallel computing (Map-Reduce, Spark, Hadoop), basic finite-precision arithmetic, an overview of standard machine learning and optimization algorithms, and time-permitting, a guided tour of functional programming. Students are expected to be comfortable in at least one programming language; Python will be used for most of the course
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5300 - Optimization I (4 Credits)
Formulation of linear programming problems and solutions by the simplex method. Related topics such as sensitivity analysis, duality, and network programming. Applications include such models as resource allocation and production planning. Introduction to interior-point methods for linear programming.
Prerequisites: MATH 2940.
Last Four Terms Offered: Fall 2024, Summer 2024, Fall 2023, Summer 2023
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5310 - Optimization II (4 Credits)
A variety of optimization methods stressing extensions of linear programming and its applications but also including topics drawn from integer programming, dynamic programming, and network optimization. Formulation and modeling are stressed as well as numerous applications.
Prerequisites: ORIE 5300.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5330 - Discrete Models (4 Credits)
Covers basic concepts of graphs, networks, and discrete optimization. Fundamental models and applications, and algorithmic techniques for their analysis. Specific optimization models studied include flows in networks, the traveling salesman problem, and network design.
Prerequisites: ORIE 3300 and CS 2110, or permission of instructor.
Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5340 - Applications of Optimization: Modeling and Computation (4 Credits)
This course will cover the use of optimization models in several industries. Covered industries will include manufacturing, process, distribution, retail, and transportation. We will not cover models used exclusively in the financial industry. In each covered industry we will start with simple text-book models, and then extend these models to reflect the realities of the industry, the existing business decisions processes and the available data. We expect to have lectures from experts in some of these industries, each of whom will also discuss Operations Research roles and careers.
Last Four Terms Offered: Fall 2024, Spring 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5350 - Introduction to Game Theory (4 Credits)
Broad survey of the mathematical theory of games, including such topics as two-person matrix and bimatrix games; cooperative and noncooperative n-person games; and games in extensive, normal, and characteristic function form. Economic market games. Applications to weighted voting and cost allocation.
Prerequisites: ORIE 3300.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5355 - Applied Data Science: Decision-Making Beyond Prediction (3 Credits)
Crosslisted with INFO 5370
This course considers the data science challenges beyond training an accurate predictive model, especially for systems about people (data of behavior), and for people (deployed models to influence behavior). Whether for online marketplaces, transportation, governmental, or urban systems, effective data science in such settings requires dealing with user incentives and strategic behavior, networked and decentralized decision-making, and privacy and ethics concerns. Primary evaluation will be through programming based assignments (in Python) and conceptual questions.
Prerequisites: Recommended prerequisite: ENGRD 2700, CS 1380, or equivalent, and experience programming in Python. Recommended corequisite: INFO 5430 or CS 5785.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Articulate common challenges in data science about and for people.
- Design, develop, and deploy data science models that effectively deal with such challenges.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 5370 - Optimization Modeling in Finance (3 Credits)
Explores optimization in the context of finance, including methodologies beyond linear programming, such as second-order cone programming and semidefinite programming. Topics include Markowitz portfolio theory and modeling; factor models for portfolio selection and risk control; the Black-Litterman model (and related Bayesian topics); utility functions; coherent risk measures; stochastic programming; and optimal execution of portfolio transactions. Emphasis is on concepts that are directly implementable.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5380 - Optimization Methods (3 Credits)
Crosslisted with CS 5727
This course covers algorithmic and computational tools for solving optimization problems with the goal of providing decision-support for business intelligence. We will cover the fundamentals of linear, integer and nonlinear optimization. We will emphasize optimization as a large-scale computational tool, and show how to link programming languages with optimization software to develop industrial-strength decision-support systems. We will demonstrate how to incorporate uncertainty into optimization problems. Throughout the course, we will cover a variety of modern applications, including pricing and marketing for e-commerce, ad auctions on the web, and on-line ride-sharing.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5390 - Optimization Models for Logistics, Networks, and Markets (1.5 Credits)
Hands-on experience with integer linear programming and dynamic programming: creating ILPs and DPs, implementing them, critiquing them, understanding solver output, and improving ILPs using better variables, constraints, symmetry breaking, etc. Examples of problems that we will study in this course are logistical problems like sequencing in production, scheduling problems with conflicts (vertex coloring), matching problems for markets and clustering problems in networks, but are not limited to these domains. In addition, a variety of general linear programming techniques such as Fourier-Motzkin elimination, Dantzig-Wolfe decomposition, Benders decomposition and extended formulations may be covered, as well as rounding techniques of LP solutions.
Prerequisites: ORIE 3300 and ORIE 3310 or permission of instructor.
Last Four Terms Offered: Fall 2022
Learning Outcomes:

- Demonstrate ability to formulate strong ILPs.
- Recognize, identify and improve problematic formulations.
- Understand information from solver, and use this to improve formulations.
- Ability to use Dynamic Programming in a variety of settings.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 5500 - Eng Probability and Statistics: Modeling and Data Science II (4 Credits)
A rigorous foundation in theory combined with the methods for modeling, analyzing, and controlling randomness in engineering problems. Probabilistic ideas are used to construct models for engineering problems, and statistical methods are used to test and estimate parameters for these models. Specific topics include: random variables, probability distributions, density functions, expectation and variance, multidimensional random variables, and important distributions including normal, Poisson, exponential, hypothesis testing, confidence intervals, and point estimation using maximum likelihood and the method of moments.
Prerequisites: ENGRD 2700.
Last Four Terms Offered: Summer 2025, Fall 2024, Summer 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5510 - Introduction to Engineering Stochastic Processes I (4 Credits)
Uses basic concepts and techniques of random processes to construct models for a variety of problems of practical interest. Topics include: the Poisson process, Markov chains, renewal theory, models for queuing, and reliability.
Prerequisites: ORIE 5500.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5530 - Modeling Under Uncertainty (3 Credits)
We will learn how to model randomness, analyze its impact, and make optimal decisions when it is present. We will cover stochastic modeling techniques, statistical principles, simulation, and decision-making under uncertainty. Using applications, we will demonstrate how we can use statistical principles to gain insight from data generated by systems with randomness. We will use simulation models to assess the performance of such systems and gauge how it changes in response to our decisions. We will introduce and use stochastic modeling techniques, such as Markov chains and Poisson processes, to build models of random phenomena and use these to gain understanding and guide decisions. As well as covering theoretical concepts, the course will put substantial emphasis in computational implementation of both simulation and decision-making problems.
Prerequisites: ENGRD 2700.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5550 - Applied Time Series Analysis (4 Credits)
Crosslisted with STSCI 5550
Introduces statistical tools for the analysis of time-dependent data. Data analysis and application will be an integral part of this course. Topics include linear, nonlinear, seasonal, multivariate modeling, and financial time series.
Prerequisites: BTRY 3080 or equivalent, STSCI 4030 or ECON 3140, or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5570 - Reinforcement Learning with Operations Research Applications (3 Credits)
The ongoing information revolution and the advent of the big data era make quantitative methods in the business context indispensable. This course introduces reinforcement learning, decision-making under uncertainty, and related algorithms through the lens of OR applications. Examples will be drawn from real-world problems in operations, revenue management, queuing, finance, transportation, healthcare, and other areas of interest. The course will cover modeling and applications, basic theory, and algorithms.
Prerequisites: ORIE 3150, ORIE 3300, and ORIE 3500, or equivalents.
Last Four Terms Offered: Fall 2024
Learning Outcomes:

- Be able to formalize dynamic decision problems under uncertainty as Markov decision processes.
- Learn about finite-horizon and infinite-horizon MDPs.
- Know how to solve MDPs exactly via dynamic programming as well as know how to solve MDPs approximately via reinforcement learning.
- Learn to read the technical literature in operations research, machine learning, and control literature.
- Gain hands-on experience in implementing and applying various exact and approximate algorithms.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 5580 - Simulation Modeling and Analysis (4 Credits)
Introduction to Monte Carlo simulation and discrete-event simulation. Topics include: random variate and process generation; data-driven distribution modeling; input and output analysis; modeling, analysis and optimization of complex systems. Emphasizes tools and techniques needed in practice; in particular, modeling and simulation in Python, as well as commercial discrete-event simulation languages.
Prerequisites: ORIE 3500 or equivalent, CS 2110/ENGRD 2110. For students with insufficient background in probability, ORIE 3500 must be taken in parallel.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5581 - Monte Carlo Simulation (2 Credits)
Introduction to Monte Carlo simulation. Topics include: random variate and process generation; data-driven distribution modeling; input and output analysis. Emphasizes modeling and simulation in Python.
Prerequisites: ORIE 3500 or equivalent, CS 2110/ENGRD 2110. For students with insufficient background in probability, ORIE 3500 must be taken in parallel.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5582 - Monte Carlo Methods in Financial Engineering (2 Credits)
An overview of Monte Carlo methods as they apply in financial engineering. Generating sample paths. Variance reduction (including quasi random number), discretization, and sensitivities. Applications to derivative pricing and risk management.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5600 - Financial Engineering with Stochastic Calculus I (4 Credits)
Introduction to continuous-time models of financial engineering and the mathematical tools required to use them, starting with the Black-Scholes model. Driven by the problem of derivative security pricing and hedging in this model, the course develops a practical knowledge of stochastic calculus from an elementary standpoint, covering topics including Brownian motion, martingales, the Ito formula, the Feynman-Kac formula, and Girsanov transformations.
Prerequisites: ORIE 3510.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5610 - Financial Engineering with Stochastic Calculus II (4 Credits)
Building upon the foundation established in ORIE 5600, this course presents advanced models for pricing and hedging financial derivatives, along with essential computational methods. The curriculum focuses on models for equities, foreign exchange, and fixed-income securities, utilizing local and stochastic volatility frameworks, the Heston model, partial differential equation (PDE) methods, change of numeraire techniques, stopping times, and the Heath-Jarrow-Morton (HJM) model.
Prerequisites: ORIE 5600.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5630 - Operations Research Tools for Financial Engineering (4 Credits)
Crosslisted with STSCI 5630
Introduction to the applications of OR techniques, e.g., probability, statistics, and optimization, to finance and financial engineering. The course reviews probability and statistics and surveys assets returns, ARIMA time series models, portfolio selection using quadratic programming, regression, CAPM and factor models, option pricing, GARCH models, fixed-income securities, and resampling techniques. Covers the use of R for statistical calculations, simulation, and optimization.
Prerequisites: MATH 2940, ENGRD 2700, ORIE 3500, ORIE 3120.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5640 - Statistics for Financial Engineering (4 Credits)
Crosslisted with STSCI 5640
Regression, ARIMA, GARCH, stochastic volatility, and factor models. Calibration of financial engineering models, estimation of diffusion models, estimation of risk measures, multivariate models and copulas, bayesian statistics. Students are instructed in the use of R software.
Prerequisites: ORIE 3500/ORIE 5500, ORIE 4600 or ORIE 4630 or ORIE 5600 (highly recommended).
Enrollment Information: Primarily for: M.Eng students in financial engineering.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5650 - Quantitative Methods of Financial Risk Management (3 Credits)
A historical perspective of market risk measurement including the Markowitz, CAPM and APT models and of insurance risk management, a description of the Value-at-Risk approach and an overview of VaR variants and extensions such as delta-VaR, CVaR and more generally distorsion risk measures, and a description of the qualitative approach of risk management by different companies. The course surveys methods for evaluating risk and consider multivariate methods for evaluating portfolios requiring copula tools which have become popular. Topics in credit risk: methods for determining default probabilities and company ratings based on financial ratios, and approaches to measuring credit risk which can be roughly divided into structural models and reduced-form models; first to default products and impact of correlation. Topics in insurance: pensions and life insurance, property and casualty insurance. Topics in finance: correlation of extremes, Herd index and systemic risk. Topics for environmental risks: flood risk, hurricane risk, weather derivatives and cat-bonds. Topics in energy: extremes and nuclear risk, energy supply issues, river network dam management. Regulations aspects (Basel II-III for banks and Solvency II for the insurance industry) and internal risk models for banks and insurance companies. Issues about concrete implementation of extreme value theory for regulation. Introduction to economic capital and economic capital allocation, and to competition issues in insurance and between old and new energies. Case studies and concrete examples of quantitative risk management issues and applications to financial, insurance, energy and environmental sectors. Participation of Chief Risk Officers of some companies to one or two sessions.
Prerequisites: ORIE 3500.
Last Four Terms Offered: Spring 2025, Fall 2023, Fall 2022, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5656 - Extreme Values in Finance (3 Credits)
In order to be able to assess the risk associated with future extreme values in financial returns, a practitioner must have an idea how heavy the tails of the returns are and how they cluster. The practitioner must also be able to understand the extremal risks associated with a portfolio of financial instruments, potentially of a large size. In this course the students will learn to work with extreme values, to understand the difference between light tails and heavy tails, and learn how the largest return and the total return grow for different types of tails. They will also learn statistical techniques (mostly through R packages) used to work with extreme values.
Prerequisites: ORIE 3500.
Last Four Terms Offered: Spring 2024
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5735 - Graph-Based Data Science for Networked Systems (3 Credits)
Crosslisted with ECE 5260
The goal of this course is to introduce data structural and computational models that are indexed by the irregular support of a graph. The graph represents the network that couples the dynamics of many agents, or it can be a more abstract Bayesian graphical model that explains how observations are conditionally dependent. The course will start from introducing basic concepts in graph theory followed by an introduction to random graphs models. This part will be followed by network dynamical models that model the observations from these processes. Bayesian graphical models will be briefly covered as a more general statistical abstraction and computational framework to perform inferences. The course will then introduce the students to the emerging field of graph signal processing, a theory that generalizes digital and image processing to graph signals.
Prerequisites: linear algebra, probability theory, basic python or MATLAB programming skills.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2022, Spring 2022
Learning Outcomes:

- Students will be able to identify the type of data that are amenable to be the outcome of network dynamical models or Bayesian graphical network models exemplified in the course or a generalization of the ones covered.
- Students will be able to understand the difference between these kinds of multivariate data compared to time-series or images.
- Students will be able to analyze the data to predict and infer data trends, for a given model.
- Students will be able to analyze the data to learn the latent network structure and system parameters.
- Students will be able to demonstrate and document the data analysis performance on synthetic and on real data.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 5740 - Statistical Data Mining I (4 Credits)
Examines the statistical aspects of data mining, the effective analysis of large datasets. Covers the process of building and interpreting various statistical models appropriate to such problems arising in scientific and business applications. Topics include naive Bayes, graphical models, multiple regression, logistic regression, clustering methods and principal component analysis. Assignments are done using one or more statistical computing packages.
Prerequisites: ORIE 3500, MATH 2940 or equivalent, programming experience. Exposure to multiple linear regression and logistic regression strongly recommended.
Last Four Terms Offered: Spring 2024, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5741 - Learning with Big Messy Data (4 Credits)
Modern data sets, whether collected by scientists, engineers, medical researchers, government, financial firms, social networks, or software companies, are often big, messy, and extremely useful. This course addresses scalable robust methods for learning from big messy data. We'll cover techniques for learning with data that is messy --- consisting of real numbers, integers, booleans, categoricals, ordinals, graphs, text, sets, and more, with missing entries and with outliers --- and that is big --- which means we can only use algorithms whose complexity scales linearly in the size of the data. We will cover techniques for cleaning data, supervised and unsupervised learning, finding similar items, model validation, and feature engineering.
Prerequisites: MATH 2940, ENGRD 2700, ENGRD 2110/CS 2110, CS 2800 or equivalents.
Forbidden Overlaps: CS 3780, CS 5780, ECE 3200, ECE 5420, ORIE 3741, ORIE 5741, STSCI 3740, STSCI 5740
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5742 - Info Theory, Probabilistic Modeling, and Deep Learning with Scientific and Financial Apps (3 Credits)
This course is about building and understanding machine learning models for scientific and financial applications. It will cover foundational aspects of information theory and probabilistic inference as they relate to model construction and deep learning. Topics include hamming codes, repetition codes, entropy, mutual information, Shannon information, channel capacity, likelihood functions, Bayesian inference, graphical models, and deep neural networks. The section on deep neural networks will consider fully connected, convolutional, recurrent, and LSTM networks, generative adversarial training, and variational autoencoders.
Prerequisites: ORIE 3500, MATH 2940 or equivalent, CS 2110 or equivalent, exposure to statistical machine learning at the level of ORIE 4740, ORIE 3741 or equivalent or permission of the instructor.
Last Four Terms Offered: Spring 2025, Spring 2024
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5750 - Applied Machine Learning (3 Credits)
Crosslisted with CS 5785, ECE 5414
Learn and apply key concepts of modeling, analysis and validation from machine learning, data mining and signal processing to analyze and extract meaning from data. Implement algorithms and perform experiments on images, text, audio and mobile sensor measurements. Gain working knowledge of supervised and unsupervised techniques including classification, regression, clustering, feature selection, and dimensionality reduction.
Prerequisites: CS 2800 or equivalent and basic familiarity with Matlab or Python, or permission of instructor.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5751 - Applied Causal Inference using Machine Learning (3 Credits)
Crosslisted with CS 5726
Provides an applied treatment of modern causal inference using machine learning to handle high-dimensionality and nonparametric estimation. Formulates key causal questions in the languages of structural equation modeling and potential outcomes. Presents methods for estimating and constructing confidence intervals on causal and structural parameters using machine learning, including de-biased machine learning, and for learning how to predict heterogeneous treatment effects. Introduces tools from machine learning and deep learning developed for prediction purposes and discusses how to adapt them to causal inference. Emphasizes the applied and practical perspectives with real-world-data examples and assignments. Requires basic knowledge of statistics and machine learning and programming experience in R or Python.
Prerequisites: ORIE 5750 or CS 5785 and working knowledge of calculus, probability, and linear algebra as well as a modern scripting language such as Python.
Enrollment Information: Enrollment limited to: Cornell Tech students.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2022, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5820 - Data-Driven Decision Modeling and Analysis (3 Credits)
This course equips students with essential data-driven decision-making skills, integrating structured and unstructured data. It bridges classical modeling techniques with modern computational tools, emphasizing critical thinking, automation, and problem-solving. The curriculum prepares students for operations research, supply chain analytics, finance, and engineering management careers.
Prerequisites: ENGRD 2700, ORIE 3300 or equivalent.
Last Four Terms Offered: Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5915 - MEng Career Practicum (1 Credit)
A professional development course designed specifically for MEng students in ORIE. Through a series of panels and hands-on workshops, you will develop effective job search materials and participate in active exercises covering topics such as networking, interviewing for specific career paths, and other communication skills for today's professional environments.
Enrollment Information: Enrollment limited to: ORIE M.Eng students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5920 - Enterprise Engineering Colloquium (1 Credit)
Crosslisted with MAE 5949
Weekly meeting for master of engineering students. Discussion with industry speakers and faculty members on the uses of engineering in the effective and efficient design, manufacturing, marketing, distribution, sustainment, and retirement of goods and services.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5925 - M.Eng. Professional Review (1-2 Credits)
An interactive course in which students present findings and share lessons from their summer internship experiences.
Enrollment Information: Enrollment limited to: ORIE M.Eng. students in their second or third semester.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5940 - Systems Engineering Project (3 Credits)
Substantial, group-based design project that has a strong systems design component. The project must be approved by an ASE 1 instructor before the student enrolls in the course. (The following projects are preapproved: FSAE, HEV, Robocup, Brain.) A formal report is required.
Enrollment Information: Enrollment limited to: M.Eng. students enrolled in systems engineering option.
Last Four Terms Offered: Spring 2022, Fall 2021, Spring 2021, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5980 - ORIE Master of Engineering Project (1 Credit)
Initial segment of the Master of Engineering project experience, culminating in a project charter that details the problem statement, the data and resources to be used, and a work plan for the spring semester.
Enrollment Information: Enrollment limited to: ORIE M.Eng students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5981 - ORIE Master of Engineering Project (4-5 Credits)
Principal segment of the Master of Engineering project experience, culminating in a formal final report and oral presentation to project stakeholders.
Enrollment Information: Enrollment limited to: ORIE M.Eng. students.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 5999 - Special Projects in ORIE (1-9 Credits)
Faculty-supervised project work that may involve independent readings, scholarly research, or an applied project in collaboration with a Cornell entity or an external partner organization. Students must submit a proposal detailing the project goals, statement of work, deliverables, and learning outcomes. The proposal must be approved by the supervising faculty member and the student's program director.
Enrollment Information: Enrollment limited to: graduate students and/or MEng early admit students and/or permission of instructor.
Last Four Terms Offered: Spring 2025, Fall 2024, Fall 2023, Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6125 - Computational Methods in Operations Research (3 Credits)
A suite of tools and techniques that enable computation in operations research. Structured and efficient programming, code optimization, code review, version management systems, building a user interface, exploring and manipulating large-scale datasets.
Prerequisites: course in probability and statistics, as well as in programming.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6150 - Collective Decision Making (3 Credits)
Students will learn about theoretical approaches from across computer science, economics, and operations research to group decision settings, in particular in voting and the fair allocation of resources. This course will mainly focus on theoretical approaches to these topics. We will study key solution concepts from computational social choice theory, cooperative and non-cooperative game theory, and fair division: approaching them with tools from optimization, algorithms, and probability. The course will cover the foundations of these concepts, as well as cutting-edge research results based on these concepts. As part of the course, students will read, present, and discuss research papers, and perform a research project.
Learning Outcomes:

- Given a group decision setting, identify appropriate solution concepts and apply them.
- Design decision algorithms and prove structural properties using optimization, algorithm, and probability theory.
- Read and evaluate recent research papers on group decision making.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 6170 - Engineering Societal Systems (3 Credits)
This class will explore topics in the intersection of computer science, economics, and operations - on the application of algorithms, data science/machine learning, and mechanism design to the study of democracy, markets, and societal systems at large.
Enrollment Information: Enrollment limited to: PhD students or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2022
Learning Outcomes:

- Students will be competent in using modeling and methodological tools in the study of societal systems.
- Students will be knowledgeable in the state-of-the-art research in application domains.
- Students will be able to understand and critique research papers and presentations and conduct original research.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 6180 - The Design of Online Marketplaces (3 Credits)
Last Four Terms Offered: Fall 2021, Spring 2019, Spring 2016
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6217 - Applied Bayesian Analysis for Computational Research (3 Credits)
Crosslisted with CS 6384
Bayesian modeling and data analysis is a powerful tool for computational research. It consists of writing a probability model and then fitting it with observed data, while handling uncertainty. The model can be flexible, encompassing hierarchy, spatio-temporal dynamics, graphs, and high-dimensionality. This course is a graduate, hands-on introduction to Bayesian analysis in Stan and/or Pyro. The focus will be on writing and fitting models in practice for computational research, including the applied Bayesian statistics workflow: model building, checking, and evaluation. The course will also discuss research papers that use such methods.
Prerequisites: Recommended prerequisite: some coursework in mathematical maturity as well as probability statistics.
Enrollment Information: Enrollment limited to: Cornell Tech students and Ithaca PhD Students.
Last Four Terms Offered: Spring 2023
Learning Outcomes:

- Students will start with a research question and construct a data generating process for the setting then construct a Bayesian model reflecting that process.
- Students will record the model in a Bayesian programming language such as Stan and/or Pyro.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 6300 - Mathematical Programming I (4 Credits)
Rigorous treatment of the theory and computational techniques of linear programming and its extensions, including formulation, duality theory, algorithms; sensitivity analysis; network flow problems and algorithms; theory of polyhedral convex sets, systems of linear equations and inequalities, Farkas' Lemma; and exploiting special structure in the simplex method and computational implementation.
Prerequisites: advanced calculus and elementary linear algebra.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6328 - Convex Analysis (3 Credits)
Last Four Terms Offered: Spring 2025, Spring 2022, Spring 2018, Spring 2015
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6334 - Combinatorial Optimization (3 Credits)
Topics in combinatorics, graphs, and networks, including matching, matroids, polyhedral combinatorics, and optimization algorithms.
Last Four Terms Offered: Spring 2022, Fall 2019, Fall 2016, Spring 2014
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6336 - Integer Programming (3 Credits)
Continuation of ORIE 6300. Introduces optimization problems over mixed-integer sets and studies the mathematical foundations of such problems. The algebraic and geometric properties of polyhedral formulations of mixed-integer programming problems are studied. Key topics include: formulations, relaxations, polyhedral theory, cutting planes, column generation, decomposition and enumeration. Some homework assignments would include computational tasks that require using optimization software.
Prerequisites: ORIE 6300.
Last Four Terms Offered: Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6338 - Heuristic Mixed-Integer Programming (3 Credits)
Discrete Optimization problems are generally formulated through Mixed-Integer Linear and Nonlinear Programming (MIP) and solved, to a large extent, by both commercial and noncommercial MIP solvers. Solving the formulated models to proven optimality is generally not necessary on the application side and often out of reach. However, computing high quality feasible solutions is a strong requirement in applications. The course covers the methodology behind the development of effective heuristic methods within MIP solvers and presents recent hybridization mechanisms based on data and Machine Learning.
Enrollment Information: Primarily for: PhD students.
Last Four Terms Offered: Fall 2022
Learning Outcomes:

- Understand MIP technology and its implementation in modern MIP solvers to produce fast and reliable high-quality solutions for Discrete Optimization problems.
- Master the use of MIP solvers to solve problems in the applied context.
- Hybridize Discrete Optimization techniques through Machine Learning.
- Pinpoint important research directions in the field.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 6340 - Mathematics of Data Science (3 Credits)
Last Four Terms Offered: Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6360 - Optimization Under Uncertainty: Robust and Online Models (3 Credits)
In most sequential decision problems, uncertainty evolves over time and we need to make decisions in the face of uncertainty. This is a fundamental problem arising in almost every business application where real-time decisions are based on the information revealed thus far. The uncertainty in the problem can be modeled in a number of ways (e.g., a probability distribution over some parameters or an uncertainty set for some variables) and the selection of an appropriate framework is purely a choice of the decision-maker. Such a selection depends on various considerations ranging from the availability of historical data to the tractability of the resulting optimization problem and the robustness of resulting solutions. In the first part of the class, we primarily focus on robust optimization which is a widely used paradigm to handle adversarial models of uncertainty. We also contrast robust optimization with various other paradigms such as stochastic optimization and distributionally robust optimization. In the second part of the class, we focus on discrete optimization problems under uncertainty such as two-stage facility location and sequential matching problems. We will discuss these classes of discrete problems under both the paradigm of robust optimization (worst-case scenario analysis) as well as online optimization (competitive ratio analysis).
Prerequisites: familiarity with basic concepts of probability and linear programming.
Last Four Terms Offered: Spring 2024, Spring 2022
Learning Outcomes:

- Students will be able to introduce various paradigms for Optimization under uncertainty.
- Students will be able to introduce tools to solve such problems, including ones to develop optimal or near-optimal algorithms in both static and dynamic robust settings and discuss the various tradeoffs that arise such as tractability vs. performance.
- Students will be able to discuss recent research papers and applications in the area.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 6500 - Applied Stochastic Processes (4 Credits)
Introduction to stochastic processes that presents the basic theory together with a variety of applications. Topics include Markov processes, renewal theory, random walks, branching processes, Brownian motion, stationary processes, martingales, and point processes.
Prerequisites: one-semester calculus-based probability course.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6510 - Probability (4 Credits)
Covers sample spaces, events, sigma fields, probability measures, set induction, independence, random variables, expectation, review of important distributions and transformation techniques, convergence concepts, laws of large numbers and asymptotic normality, and conditioning. In the last part of the course, we will cover applications to epidemic modeling.
Prerequisites: real analysis at level of MATH 4130, one-semester calculus-based probability course.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6580 - Simulation (3 Credits)
Introduction to Monte Carlo and discrete-event simulation. Emphasizes underlying theory. Random variate generation, input and output analysis, variance reduction, selection of current research topics.
Prerequisites: computing experience and ORIE 6500 or equivalent, or permission of instructor.
Last Four Terms Offered: Spring 2022, Spring 2016, Fall 2014, Spring 2013
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6590 - Approximate Dynamic Programming and Reinforcement Learning (3 Credits)
This course develops theories and algorithms for optimal sequential decision making under uncertainty. The emphasis will be on approximate algorithms to deal with large-scale decision models that can be highly uncertain. Various bounding techniques in recent literature will be covered. The course will intersect with traditional topics such as Markov decision processes, reinforcement learning, and bandit problems.
Prerequisites: ORIE 6500 or equivalent.
Last Four Terms Offered: Spring 2021, Spring 2019, Fall 2017
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6640 - Martingale Theory and Applications in Finance (3 Credits)
This course introduces Martingale Theory with a view towards applications to pricing and hedging of financial derivatives. We discuss both complete and incomplete markets as well as risk measure-based pricing and hedging approaches. Further topics include market models for financial derivatives and recent machine-learning developments in finance such as deep hedging.
Prerequisites: ORIE 6500 or ORIE 6510, or equivalent.
Last Four Terms Offered: Fall 2023, Fall 2022
Learning Outcomes:

- Understand key relations between martingale theory and asset pricing.
- Identify a toolkit of martingale methods to solve valuation problems in both complete and incomplete market models for financial derivatives.
- Demonstrate how these methods are applied in various practical pricing and hedging.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 6700 - Statistical Principles (4 Credits)
Topics include review of distribution theory of special interest in statistics: normal, chi-square, binomial, Poisson, t, and F; introduction to statistical decision theory; sufficient statistics; theory of minimum variance unbiased point estimation; maximum likelihood and Bayes estimation; basic principles of hypothesis testing, including Neyman-Pearson Lemma and likelihood ratio principle; confidence interval construction; and introduction to linear models.
Prerequisites: undergraduate probability/statistics course.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6730 - Mathematics of Deep Learning (3 Credits)
Empirical observation of deep neural networks shows surprising phenomena that classical statistical theory fails to fully describe. For example, bounds on generalization error from classical statistics grow with the flexibility of the model class but neural networks often exhibit low generalization error despite being extremely flexible. Also, training deep neural networks with stochastic gradient descent produces accurate models despite non-convexity of the loss landscape. A recently emerged literature is developing new theory to explain these and other mysteries. After presenting relevant theoretical results from classical statistics and a brief refresher on deep learning, the course will present theoretical results from recent research articles, complementing them with empirical evidence, emphasizing what is unknown along with what is known.
Prerequisites: CS 4782 or CS 5787, and ORIE 6500.
Last Four Terms Offered: Fall 2024
Learning Outcomes:

- Identify the main ideas in classical statistical theory and what phenomena they fail to explain in deep learning.
- Identify the main hypotheses in the recent literature for the emergence of these phenomena and the evidence for and against these hypotheses.
- Demonstrate an understanding of the main ideas in recent theoretical results explaining why deep learning works so well.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 6731 - LLMs for Better Decision-Making (3 Credits)
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6746 - Theory of Causal Inference and Decision-Making (1-3 Credits)
Last Four Terms Offered: Fall 2022, Spring 2020, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

ORIE 6751 - Data-Driven Optimization Under Uncertainty: Theory, Methods, and Current Trends (3 Credits)
Optimization with random costs and constraints underlies many important decision-making problems in operations, healthcare, policymaking, and beyond. Models for these problems include stochastic, chance-constrained, robust, and distributionally robust optimization. Recent years have seen intense interest in using data to inform such decision-making models - both data on the uncertain variables themselves and on auxiliary observations. The aim of this course is to understand the landscape of recent developments and prepare students to both use these tools and contribute to them in their own research. The course will combine lectures on the relevant fundamental theoretical constructs and tools with presentations of selected recent papers, clustered into themes, including contextual stochastic optimization, data-driven robust and distributionally robust optimization, optimization of counterfactuals from observational data, and sequential decision making.
Prerequisites: familiarity with basic statistics, probability, and optimization, or permission of the instructor.
Enrollment Information: Enrollment limited to: Ph.D. students.
Last Four Terms Offered: Spring 2021
Learning Outcomes:

- Be able to formulate a decision making problem with uncertain variables as an optimization model.
- Learn the theoretical tools that underlie data-driven optimization and be able to apply them to study both finite-sample and asymptotic properties of data-driven optimization methods.
- Understand the landscape of the current literature and be able to draw upon it in one's research.
- Become prepared to contribute to the modern literature on data-driven optimization.

Schedule of Classes (https://classes.cornell.edu/)

ORIE 6780 - Bayesian Statistics and Data Analysis (3 Credits)
Crosslisted with STSCI 6780
Priors, posteriors, Bayes estimators, decision theory, asymptotic theory, Bayes factors, credible regions, hierarchical models, nonparametric Bayes, computational methods, Bayesian robustness, and applications. This is a theory-oriented course intended for PhD students. For a more applied introduction to Bayesian statistics, students should take STSCI 4780, Bayesian Data Analysis: Principles and Practice, which is offered in the spring.
Prerequisites: ORIE 6700 or an equivalent course in mathematical statistics. A basic knowledge of R is assumed.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 7170 - Theory of Linear Models (3 Credits)
Crosslisted with STSCI 7170, ILRST 7170
Properties of the multivariate normal distribution. Distribution theory for quadratic forms. Properties of least squares and maximum likelihood estimates. Methods for fixed-effect models of less than full rank. Analysis of balanced and unbalanced mixed-effects models. Restricted maximum likelihood estimation. Some use of software packages and illustrative examples.
Prerequisites: BTRY 4090 or MATH 4720, BTRY 6020, or equivalents.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 7190 - Selected Topics in Applied Operations Research (1-3 Credits)
Current research topics dealing with applications of operations research.
Last Four Terms Offered: Spring 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 7191 - Selected Topics in Applied Operations Research (1-3 Credits)
Current research topics dealing with applications of operations research.
Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2020, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

ORIE 7390 - Selected Topics in Mathematical Programming (1-3 Credits)
Last Four Terms Offered: Spring 2020, Fall 2019, Fall 2018, Fall 2017
Schedule of Classes (https://classes.cornell.edu/)

ORIE 7391 - Selected Topics in Mathematical Programming (3 Credits)
Current research topics in mathematical programming.
Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 7590 - Selected Topics in Applied Probability (1-3 Credits)
Topics are chosen from current literature and research areas of the staff.
Last Four Terms Offered: Spring 2025, Fall 2024, Fall 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

ORIE 7790 - Selected Topics in Applied Statistics (3 Credits)
Last Four Terms Offered: Spring 2024, Spring 2020, Fall 2010, Fall 2009
Schedule of Classes (https://classes.cornell.edu/)

ORIE 7900 - Special Investigations (1-6 Credits)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

ORIE 7999 - PhD Independent Research (1-12 Credits)
Independent research for ORIE Ph.D. students.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

ORIE 9000 - ORIE Graduate Colloquium (1 Credit)
Weekly one and one-half hour meeting devoted to presentations by distinguished visitors, by faculty members, and by advanced graduate students on topics of current research in the field of operations research.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)