ORI - Operations Research and Industrial Engineering

Operations Research and Industrial Engineering: ORI

Lower-Division Courses

Upper-Division Courses

ORI 366. Operations Research Models.

Same as Mechanical Engineering 366L. Formulation and solution-interpretation for operations research models requiring, for example, optimization, simulation, or analysis of Markov chains or queues. Applications include manufacturing design and control, routing and scheduling, plant location, inventory analysis, and management of queueing systems. Three lecture hours a week for one semester. Mechanical Engineering 366L and Operations Research and Industrial Engineering 366 may not both be counted. Prerequisite: For engineering majors, Mathematics 408D or 408M and Mechanical Engineering 318M with a grade of at least C- in each; for non-engineering majors, upper-division standing and written consent of instructor.

ORI 367. Simulation Modeling.

Same as Mechanical Engineering 367S. Basic concepts of discrete-event simulation. Statistical input and output analysis. Application of simulation software. Modeling of systems under uncertainty. Three lecture hours a week for one semester. Mechanical Engineering 367S and Operations Research and Industrial Engineering 367 may not both be counted. Prerequisite: For engineering majors, Mechanical Engineering 318M with a grade of at least C-, Mechanical Engineering 335 or the equivalent; for non-engineering majors, upper-division standing and written consent of instructor.

ORI 369. Decision Analysis.

Principles and application of techniques for the logical illumination of complex decision problems within any context. Subjects may include utility theory, probability as a statement of belief, risk preference, value of information and control, probability assessment, influence diagrams, risk sharing and scaling, and life-and-death decision making. Three lecture hours a week for one semester. Prerequisite: Mechanical Engineering 353 or equivalent with a grade of at least C-.

ORI 370. Statistical Methods in Manufacturing.

Contemporary concepts and methods for statistical quality design and control will be presented. These include: descriptive statistics, behavior of process over time, design and interpretation of control charts, process capability studies, measurement system analysis, correlation and regression analysis, design and analysis of two level factorial experiments, design and analysis of two level fractional factorial experiments, response surface methodology, and Taguchi approach to robust design. Three lecture hours a week for one semester. Mechanical Engineering 379M (Topic: Stat Methods in Manufacturing) and Operations Research and Industrial Engineering 370 may not both be counted. Prerequisite: For engineering majors, Mechanical Engineering 318M with a grade of at least C-, Mechanical Engineering 335 or the equivalent; for others, upper-division standing and written consent of instructor.

ORI 373. Facility Planning and Logistics.

Design and analysis of production systems, including plant layout and location, material flow, and flexible manufacturing. Three lecture hours a week for one semester. Only one of the following may be counted: Mechanical Engineering 373K, Operations Research and Industrial Engineering 371, 373. Prerequisite: For engineering majors, ME 318M or the equivalent with a grade of at least C, and M E 335 or the equivalent; for non-engineering majors, upper-division standing and written consent of instructor.

ORI 374. Production and Inventory Management.

Introduction to production and inventory models; basic factory dynamics; analysis of variability; push-and-pull production control; sequencing and dispatching. Three lecture hours a week for one semester. Only one of the following may be counted: Mechanical Engineering 375K, Operations Research and Industrial Engineering 372, 374. Prerequisite: For engineering majors, Mechanical Engineering 318M or the equivalent with a grade of at least C, Mechanical Engineering 335 or the equivalent; for non-engineering majors, upper-division standing and written consent of instructor.

ORI 177K, 277K, 377K. Projects in Operations Research and Industrial Engineering.

Independent project carried out under the supervision of a faculty member in operations research & industrial engineering. Student prepares a project proposal and a final report, each of which is evaluated by the faculty committee on individual projects. For 177K, three to five laboratory hours and one consultation hour with the faculty supervisor a week for one semester; for 277K, five to ten laboratory hours and one consultation hour with the faculty supervisor a week for one semester; for 377K, ten to fifteen laboratory hours and one consultation hour with the faculty supervisor a week for one semester. Prerequisite: A University grade point average of at least 2.50 and a grade point average in the major of at least 2.50; approval of project proposal by the faculty committee on individual projects.

Graduate Courses

ORI 180M, 280M, 380M, 680M, 980M. Research.

May be repeated for credit. Offered on the credit/no credit basis only. Prerequisite: Graduate standing in operations research and industrial engineering.

ORI 383. Healthcare Delivery Models.

Study the operations research literature on the use of models and techniques related to healthcare delivery. Discuss decomposition techniques for integer programs, simulation, Markov chains, and stochastic programming. Three lecture hours per week for one semester. Operations Research and Industrial Engineering 383 and 397 (Topic: Health Care Delivery Models) may not both be counted. Prerequisite: Second year or higher graduate standing; graduate courses in linear programming, integer programming, statistics, stochastic processes.

ORI 384. Emerging Trends in Operations Research and Industrial Engineering.

Explore the development and use of operations research and industrial engineering techniques via weekly presentations and speakers, including faculty and visiting experts. Three lecture hours a week for one semester. Operations Research and Industrial Engineering 384 and 397 (Topic: Emerging Topics in ORIE) may not both be counted. Prerequisite: Second year or higher graduate standing in Operations Research and Industrial Engineering, or related program.

ORI 390D. Topics in Analytics and Decision Making.

Discuss the tools and concepts to enable quantitative analysis and to support decisions under uncertainty. Three lecture hours per week for one semester. May be repeated for credit when the topics vary. Prerequisite: Graduate standing and an undergraduate calculus-based course in probability and statistics, or consent of instructor.

Topic 1: Analytics and Data Science. Examine theory and methods to draw inferences from data and apply these insights to support decision making in uncertain environments. Additional prerequisite: Operations Research and Industrial Engineering 390R (Topic 1).
Topic 2: Decision Analysis. Examine the theory and principles required to make good decisions in the face of uncertainty. Discuss expected utility theory, families of utility functions, Bayesian inference, value of information, probability elicitation, scoring rules, and the verification of probabilistic forecasts. Explore how these apply to areas including engineering, business, public policy, healthcare, and sports. Operations Research and Industrial Engineering 390D (Topic 2) and 390R (Topic 17) may not both be counted. Additional prerequisite: Operations Research and Industrial Engineering 390R (Topic 1).
Topic 3: Decision Engineering. Examine the tools, methods, and processes required to apply decision analysis to applied problems. Explore creativity, framing, ideation, modeling, approximations, and decision biases that can degrade decision making. Operations Research and Industrial Engineering 390D (Topic 3) and 390R (Topic 18) may not both be counted. Additional prerequisite: Operations Research and Industrial Engineering 390R (Topic 1) and 390D (Topic 2).
Topic 4: Decision Theory. Explore the fundamental axioms supporting decision analysis and challenges to this approach. Examine behavioral decision making, subjective probability, alternative approaches to decision making, and advanced decision analytic tools. Additional prerequisite: Operations Research and Industrial Engineering 390D (Topic 2).
Topic 5: Markov Decision Processes. Discuss the theory and application of Markov decision processes. Examine finite horizon models, average-cost and discounted-cost infinite horizon problems, discrete-time and continuous-time frameworks. Explore approximate dynamic programming, reinforcement learning, and stochastic bandit problems. Operations Research and Industrial Engineering 390D (Topic 5) and 390R (Topic 16) may not both be counted. Additional prerequisite: Operations Research and Industrial Engineering 390R (Topic 5) or consent of instructor.
Topic 6: Systems Modeling and Decision Making. Explore the application of operations research, decision analysis, economics, and management science tools and concepts to the modeling of human-designed and natural systems with the goal of improving decisions that involve these systems. Examine models that integrate engineering, economics, natural science, and policy. Only one of the following may be counted: Operations Research and Industrial Engineering 390D (Topic 6), 390Q (Topic 8), 397 (Topic: Systems Modeling). Additional prerequisite: A course in optimization, or consent of instructor. Prior coursework in microeconomics is helpful but not required.

ORI 390Q. Industrial Engineering.

Industrial engineering techniques for quantitative solution of contemporary systems and management problems. Three lecture hours a week for one semester. May be repeated for credit when the topics vary. Prerequisite: Graduate standing and consent of instructor.

Topic 1: Project Management. Methods for organizing, coordinating, and controlling resources to minimize risk and conflict and to maintain budgets and schedules. Topics include evaluation of competing alternatives, organization of a project, scheduling of tasks and resources, and the role of management over time.
Topic 2: Production and Inventory Control. Issues in inventory control with known and unknown demand, materials requirement planning, just-in-time, pull control systems, operations scheduling, dispatching and aggregate planning, and the basic dynamics of production and inventory control.
Topic 4: Modeling and Analysis of Manufacturing Systems. Applications of analysis to manufacturing processes, using mathematical models, optimization, and stochastic analysis. Economic evaluation, identification of bottlenecks, estimation of resources requirements, and system design.
Topic 5: Scheduling Theory and Applications. Modeling, analysis, and solution techniques for production and service scheduling problems, machine scheduling in deterministic and stochastic settings, exact and heuristic algorithms, and industrial applications, including semiconductor manufacturing and airlines applications. Prerequisite: Operations Research and Industrial Engineering 391Q (Topic 4) or the equivalent.
Topic 7: Statistical Methods in Manufacturing. Same as Mechanical Engineering 392Q (Topic 10: Statistical Methods in Manufacturing). Statistical monitoring of manufacturing processes; methods and applications of various control charts; formal design of experiments (DOE), including the statistical evaluation of main and interaction effects, as well as intelligent experimentation through reduced factorial experimental design; Taguchi's design philosophy as applied to response surface methods and gradient-based search techniques; and advanced issues in quality control and design of manufacturing systems. Additional prerequisite: Knowledge of basic probability and statistics and consent of instructor.

ORI 390R. Statistics and Probability.

Concepts of probability and mathematical statistics; application of these analytical methods to planning and evaluation of research and industrial experimentation. Three lecture hours a week for one semester. May be repeated for credit when the topics vary. Prerequisite: Graduate standing, and an undergraduate calculus-based course in probability and statistics or consent of instructor.

Topic 1: Applied Probability. Basic probability theory, combinatorial analysis of random phenomena, conditional probability and independence, parametric families of distributions, expectation, distribution of functions of random variables, limit theorems.
Topic 2: Mathematical Statistics. Sampling distributions, properties of estimators, point and interval estimation, hypothesis testing, introduction to multivariate and nonparametric statistics.
Topic 3: Time-Series Modeling, Analysis, and Control. Same as Mechanical Engineering 384Q (Topic 3: Time-Series Modeling, Analysis, and Control). Methods for analytical modeling, analysis, prediction, and control of linear, stationary time series. Includes examples of advanced research in nonstationary time-series modeling and applications in manufacturing, financial engineering, geosciences, and other areas. Students complete a project on a topic of their choice. Additional prerequisite: Graduate standing, Mechanical Engineering 364L or the equivalent, an undergraduate calculus-based course in probability and statistics or consent of instructor.
Topic 4: Reliability Theory and Modeling. Theory of probabilistic and statistical models of aging elements, reliability, replacement, and repair maintenance, and their integration in surveillance, quality control, and manufacturing problems.
Topic 5: Applied Stochastic Processes. Poisson process, renewal theory, discrete and continuous-time Markov chains, queueing and reliability applications.
Topic 6: Regression and Analysis of Variance. Fitting equations to data; joint confidence regions; partial correlation analysis; general

linear hypotheses; dummy variables; diagnostics and remedial measures; design of experiments; fixed, random, and mixed models; factorial and nested designs. Additional prerequisite: Operations Research and Industrial Engineering 390R (Topic 2) or consent of instructor.

Topic 8: Queueing Theory. Introduction to the classical and modern theories of queueing systems. Simple Markovian queues; the M/G/1 and G/G/1 queues; Jackson and Kelly networks; multiclass networks; stability, scheduling, and routing in queueing networks; fluid and diffusion approximations. Additional prerequisite: Operations Research and Industrial Engineering 390R (Topic 1) or consent of instructor.

Topic 9: Systems Simulation. Random number generation, simulation experiments, statistical verification, clock routines, simulation language applications, industrial problems.

Topic 14: Special Topics in Probability, Stochastic Processes, and Statistics. Study of specialized topics, such as advanced stochastic processes, Bayesian statistics, simulation, and stochastic optimization, intended to introduce and stimulate further research. Additional prerequisite: Consent of instructor.

ORI 391Q. Optimization.

Mathematical optimization techniques with applications to engineering and industrial problems. Three lecture hours a week for one semester. May be repeated for credit when the topics vary. Prerequisite: Graduate standing and a course in operations research methods.

Topic 1: Nonlinear Programming. Theory and solution techniques for nonlinear, continuous optimization problems. Topological properties of functions, general convexity, optimality conditions, line search methods, unconstrained techniques, and algorithms for constrained formulations. Lagrangian duality theory and bundle methods for nondifferentiable optimization.

Topic 2: Dynamic Programming. Systems that require sequential decisions. Problem modeling and solution algorithms for deterministic and stochastic systems.

Topic 3: Network Flow Programming. Optimization problems related to network flows, shortest path, maximum flow, minimum cost flow, generalized networks, nonlinear costs. Modeling, theory, and computational methods.

Topic 4: Integer Programming. Models, theory, and computational methods for problems with discrete decision alternatives. Greedy algorithms, branch and bound, cutting plane methods, Lagrangian relaxation, and heuristics. Additional prerequisite: Operations Research and Industrial Engineering 391Q (Topic 5).

Topic 5: Linear Programming. Models, algorithms, and theory of linear programming. Linear programming geometry, primal, dual and revised simplex algorithms, duality theory, optimality conditions, sensitivity analyses, interior point methods, and computer implementations.

Topic 6: Algorithms for Mixed Integer Programming. Methods and software for solving large-scale mixed integer programming problems: intelligent heuristics, decomposition, lower bounding schemes, limited enumeration, and simple methods for quickly finding good feasible solutions. Numerous examples taken from industry. Additional prerequisite: Operations Research and Industrial Engineering 391Q (Topic 4).

Topic 8: Combinatorial Optimization. Optimization of combinatorial structures; computational complexity; stable marriages, shortest paths, maximum flows, minimum-cost flows, matching problems; approximation algorithms for NP-hard problems.

Topic 9: Large-Scale Systems Optimization. Mathematical programs with special structure, Dantzig-Wolfe decomposition, partitioning and relaxation procedures, duality and decomposition, compact inverse methods, applications in engineering and management.

Topic 10: Stochastic Optimization. Optimization of mathematical programming models under uncertainty; model formulations; exact, bounding-and-approximation, and Monte Carlo sampling-based solution techniques that exploit special structures; applications; use of algebraic modeling language.

Topic 11: Advanced Mathematical Programming. Advanced topics in modeling and algorithms for linear, integer, nonlinear, and network programming. Model formulation considerations, decomposition algorithms, interior point and active set methods, duality, modern optimization software. Additional prerequisite: Operations Research and Industrial Engineering 391Q (Topic 5).

Topic 12: Metaheuristics. Reactive and adaptive tabu search methods, simulated annealing, genetic algorithms, and greedy randomized adaptive search methods. Emphasis on theoretical context of methods and on similarities and distinguishing characteristics.

Topic 14: Computational Optimization. Computer programming methods and tools for implementing advanced optimization algorithms, working with data, and visualizing results. Code organization techniques, debugging, and building complex software. Prerequisite: Coursework in computer programming, algorithms and optimization, and probability; or consent of instructor.

Topic 15: Convex Optimization. Same as Electrical and Computer Engineering 381K (Topic 18). The fundamentals of convex optimization with a focus on modeling, computation and scale: convex sets and functions, unconstrained optimization via first and second-order methods, duality, constrained optimization, SDPs, stochastic and sub-gradient descent methods, ADMMs, and applications. Only one of the following may be counted: Electrical and Computer Engineering 381K (Topic 18), Electrical Engineering 381K (Topic 18), 381V (Topic: Large Scale Optimization), Operations Research and Industrial Engineering 391Q (Topic 15). Additional prerequisite: Consent of instructor.

Topic 16: Optimization in Engineering Systems. Same as Electrical and Computer Engineering 380N (Topic 11). Formulation and solution of continuous optimization problems in engineering design and operations. Only one of the following may be counted: Electrical and Computer Engineering 380N (Topic 11), Electrical Engineering 380N (Topic 11), Operations Research and Industrial Engineering 391Q (Topic 16).

Topic 17: Optimization Under Uncertainty. Introduction to optimization models and methodologies for addressing uncertainty-affected decision problems. Examine fundamental techniques from stochastic programming, robust optimization, and distributionally robust optimization. Explore theory through concrete examples from production planning, supply chain management, project management, portfolio selection, machine learning. Three lecture hours per week for one semester. Operations Research and Industrial Engineering 391Q (Topic 17) and 397 (Topic: Optimzatn Under Uncertainty) may not both be counted. Additional prerequisite: Graduate-level knowledge of linear programming, integer programming, nonlinear programming, probability, and statistics. Knowledge of convex optimization and analysis is beneficial.

Topic 18: Computational and Variational Methods for Inverse Problems. Introduction to the numerical solution of inverse problems that are governed by systems of partial differential equations (PDEs). Explore variational formulations, ill-posedness, regularization, adjoint methods for gradients and Hessians, variational discretization, and efficient large-scale optimization algorithms for inverse problems. Examine the Bayesian framework and draw connections between the classical and the Bayesian interpretations of inverse problems. Additional prerequisite: Courses or background in linear algebra and differential equations.

ORI 397. Current Studies in Operations Research and Industrial Engineering.

The equivalent of three class hours a week for one semester. May be repeated for credit when the topics vary. Prerequisite: Graduate standing and consent of the graduate adviser.

ORI 197K, 297K, 397K. Graduate Seminar.

One, two, or three lecture hours a week for one semester. Normally required of all students in operations research and industrial engineering. May be repeated for credit. Offered on the credit/no credit basis only. Prerequisite: Graduate standing.

ORI 397M. Graduate Research Internship.

Students conduct research in an industrial setting to gain practical experience in their area of interest. Twenty to forty hours of fieldwork a week for one semester. Offered on the credit/no credit basis only. Prerequisite: Graduate standing and consent of the graduate adviser and supervising faculty member.

ORI 197P, 297P, 397P. Projects in Operations Research and Industrial Engineering.

Independent project carried out under the supervision of a faculty member in operations research and industrial engineering. Three, six, or nine laboratory hours a week for one semester. May be repeated for credit. Prerequisite: Graduate standing and consent of instructor and the graduate adviser.

ORI 698. Thesis.

The equivalent of three lecture hours a week for two semesters. Offered on the credit/no credit basis only. Prerequisite: For 698A, graduate standing in operations research and industrial engineering and consent of the graduate adviser; for 698B, Operations Research and Industrial Engineering 698A.

ORI 398R. Master's Report.

Preparation of a report to fulfill the requirement for the master's degree under the report option. The equivalent of three lecture hours a week for one semester. Offered on the credit/no credit basis only. Prerequisite: Graduate standing in operations research and industrial engineering and consent of the graduate adviser.

ORI 399W, 699W, 999W. Dissertation.

May be repeated for credit. Offered on the credit/no credit basis only. Prerequisite: Admission to candidacy for the doctoral degree.

Professional Courses