

# INDUSTRIAL ENGINEERING (IE)

IE Class Schedule (<https://courses.illinois.edu/schedule/DEFAULT/DEFAULT/IE>)

## Courses

**IE 199 Undergraduate Open Seminar credit: 1 to 5 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/199>)

May be repeated.

**IE 297 Independent Study credit: 1 to 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/297>)

Individual investigations of any phase of Industrial Engineering. May be repeated in separate terms. Prerequisite: Consent of instructor.

**IE 300 Analysis of Data credit: 3 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/300>)

Nature of probabilistic models for observed data; discrete and continuous distribution function models; inferences on universe parameters based on sample values; control charts, acceptance sampling, and measurement theory. Credit is not given for both IE 300 and CEE 202. Prerequisite: MATH 241.

**IE 310 Deterministic Models in Optimization credit: 3 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/310>)

Linear Optimization - Simplex method, duality, and sensitivity analysis, Transportation and Assignment Problems, Network Optimization Models, Dynamic Programming, Nonlinear optimization, and Discrete optimization. Credit is not given for both IE 310 and CEE 201. Prerequisite: Credit or concurrent registration in MATH 415.

**IE 311 Operations Research Lab credit: 1 Hour.** (<https://courses.illinois.edu/schedule/terms/IE/311>)

Applications of OR models with the use of software tools. Prerequisite: Concurrent registration in IE 310.

**IE 330 Industrial Quality Control credit: 3 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/330>)

Contemporary concepts and methods for quality and productivity design and improvement; philosophies of Deming, Taguchi, and others leading the quality management and engineering movement; Shewhart's methods for statistical process control; process capability analysis; statistical methods for tolerance assessment; process control methods employing attribute data; design of experiments, concepts, and methods. Prerequisite: IE 300.

**IE 340 Human Factors credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/340>)

Introduction to human factors, ergonomics, engineering psychology, history of ergonomics, human-machine relations, displays and controls, human-computer interaction, industrial and aviation systems, physiology of work and anthropometrics, cognitive ergonomics, human reliability, human as manual controller, human-machine systems design, prototyping, professional practice and ethics, laboratory exercises. Same as PSYC 358. Prerequisite: PSYC 100, PSYC 103, or consent of instructor.

**IE 360 Facilities Planning and Design credit: 3 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/360>)

Facility planning, plant layout design, and materials handling analysis; determination of facilities requirements, site selection, materials flow, use of analytical and computerized techniques including simulation, and applications to areas such as manufacturing, warehousing, and office planning. Prerequisite: Credit or concurrent enrollment in IE 310.

**IE 361 Production Planning & Control credit: 3 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/361>)

Scope of production systems and activities involved in their design, establishment, management, operation, and maintenance; mathematical and computer models for planning and control of facilities, human resources, projects, products, material, and information in production systems. Prerequisite: IE 310.

**IE 370 Stochastic Processes and Applications credit: 3 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/370>)

Introduction to stochastic processes with applications in decision-making under uncertainty. Topics include newsvendor problem, discrete-time Markov chain (including classification of states, stationary distribution, absorbing states), Poisson processes (including time-homogenous, time-nonhomogeneous, thinning Poisson), continuous-time Markov chain (including Markov property, generator matrix, stationary distribution), queuing theory (including M/M/k queue, open Jackson network), and Markov decision processes (including finite-horizon models, infinite-horizon models). Prerequisite: IE 300 and IE 310.

**IE 397 Independent Study credit: 1 to 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/397>)

Individual investigations or studies of any phase of Industrial Engineering. May be repeated in separate terms. Prerequisite: Consent of instructor.

**IE 398 Special Topics credit: 1 to 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/398>)

Subject offerings of new and developing areas of knowledge in industrial engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. May be repeated in the same or separate terms if topics vary.

**IE 400 Design & Anlys of Experiments credit: 3 or 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/400>)

Concepts and methods of design of experiments for quality design, improvement and control. Simple comparative experiments, including concepts of randomization and blocking, and analysis of variance techniques; factorial and fractional factorial designs; Taguchi's concepts and methods; second-order designs; response surface methodology. Engineering applications and case studies. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: IE 300.

**IE 410 Stochastic Processes & Applic credit: 3 or 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/410>)

Modeling and analysis of stochastic processes. Transient and steady-state behavior of continuous-time Markov chains; renewal processes; models of queuing systems (birth-and-death models, embedded-Markov-chain models, queuing networks); reliability models; inventory models. Familiarity with discrete-time Markov chains, Poisson processes, and birth-and-death processes is assumed. Same as CS 481. 3 undergraduate hours. 4 graduate hours. Prerequisite: IE 310.

**IE 411 Optimization of Large Systems credit: 3 or 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/411>)

Practical methods of optimization of large-scale linear systems including extreme point algorithms, duality theory, parametric linear programming, generalized upper bounding technique, price-directive and resource-directive decomposition techniques, Lagrangian duality, Karmarkar's algorithm, applications in engineering systems, and use of state-of-the-art computer codes. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: IE 310 and MATH 415.

**IE 412 OR Models for Mfg Systems credit: 3 or 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/412>)

Operations research techniques applied to problems in manufacturing and distribution. Single and multi-stage lot sizing problems, scheduling and sequencing problems, and performance evaluation of manufacturing systems. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: IE 310.

**IE 413 Simulation credit: 3 or 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/413>)

Use of discrete-event simulation in modeling and analysis of complex systems. Data structures and event-list management; verification and validation of simulation models; input modeling, including selection of probability distributions and random variate generation; statistical analysis of output data. Same as CS 482. 3 undergraduate hours. 4 graduate hours. Prerequisite: CS 101 and IE 310.

**IE 420 Financial Engineering credit: 3 or 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/420>)

Introduction to the theory and practice of financial engineering: basics of derivative securities and risk management; Markowitz portfolio theory and capital asset pricing model; interest rate and bonds; forward and futures contracts, hedging using futures contracts; option contracts and arbitrage relationship; binomial model, no-arbitrage pricing, risk-neutral pricing, and American options pricing; Brownian motion, Black-Scholes-Merton model, delta hedging, Greek letters, implied volatility, and volatility smile. 3 undergraduate hours. 4 graduate hours. Prerequisite: IE 300.

**IE 430 Economic Found of Quality Syst credit: 3 or 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/430>)

Total quality systems for planning, developing, and manufacturing world-class products. Economic foundations of total quality. Product value, cost, pricing, environmental quality, activity-based costing, design for assembly, organization structure, lead time, innovation, Taguchi methods, simulation-based significance testing, Strategic Quality Deployment, statistical process control, and conjoint analysis. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: IE 300.

**IE 431 Design for Six Sigma credit: 3 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/431>)

Quality Engineering principles and the Six Sigma Define-Measure-Analyze-Improve-Control (DMAIC) process. Application of concepts and methods of statistical process control, designed experiments, and measurement systems analysis to cases of quality and productivity improvement; application of the fundamentals of quality engineering and the Six Sigma to areas of produce development, service enterprise, and manufacturing processes. 3 undergraduate hours. 3 graduate hours. Prerequisite: IE 300.

**IE 445 Human Performance and Cognition in Context credit: 3 or 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/445>)

Same as EPSY 456 and PSYC 456. See EPSY 456.

**IE 497 Independent Study credit: 1 to 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/497>)

Independent study of advanced problems related to industrial engineering. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated. Prerequisite: Consent of instructor.

**IE 498 Special Topics credit: 1 to 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/498>)

Subject offerings of new and developing areas of knowledge in industrial engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated in the same or separate terms if topics vary to a maximum of 9 hours.

**IE 510 Applied Nonlinear Programming credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/510>)

Optimization of nonlinear systems; survey of classical methods and concepts such as the Lagrangian method, the Jacobian method, and Kuhn-Tucker conditions; modern algorithms; numerical methods for digital computers; applications in engineering design; use of state-of-the-art computer codes. Prerequisite: IE 310.

**IE 511 Integer Programming credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/511>)

Optimization of linear systems over discrete decision domains. Topics to be covered include Modeling, Polyhedral theory, Integral Polyhedra, Totally Unimodular Matrices, Total Dual Integrality, Computational Complexity, Cutting plane method, Branch and Bound method, and Lagrangian Dual. Structured integer programs involving Matchings, Knapsack, Cuts and Matroids will be studied as applications. 4 graduate hours. No professional credit. Prerequisite: IE 411 or MATH 482.

**IE 512 Network Analysis of Systems credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/512>)

Basic concepts, theories, and techniques of systems analysis, including modeling of large scale systems, forecasting, planning, control, and information handling; modeling of systems with network techniques, including distance, flow, and project networks; advanced network topics such as out-of-kilter algorithm and project resource analysis. Prerequisite: IE 361 or CEE 201.

**IE 513 Optimal System Design credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/513>)

This course is designed to address the fundamental mathematical theories for complex engineering system (product) design optimization in multidisciplinary environment. The course starts with the basics of nonlinear programming (continuous optimization), then expands to the area of multidisciplinary design optimization (MDO) in depth. Analytical Target Cascading (ATC) - a well-established hierarchical optimization method - is covered in-depth with assignments in written and programming forms. After a successful completion of the course, the students will be able to model and solve basic MDO problems and apply MDO in a research-based semester project. Prior experience in coding (in Matlab or similar) will be helpful but not required. 4 graduate hours. No professional credit. Prerequisite: IE 310.

**IE 514 Optimization Methods for Large-Scale, Network-Based Systems credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/514>)

The course will cover topics related to optimization over large-scale networks. We will look at data-driven methodologies by which very large-scale optimization problems, primarily integer programs, can be solved. We will consider motivations from application areas such as airline scheduling, vehicle routing, and communications. Topics covered include shortest paths; multi-commodity flows; decomposition techniques; Lagrangean relaxation; set-covering and set-partitioning problems (with special characteristics); column generation and branch-and-price and cut; composite variables; large-scale neighborhood search techniques; modeling robustness and uncertainty; stochastic modeling in large-scale integer programs; data-driven optimization. The course will include real-world modeling examples from applications including vehicle routing, freight logistics, and airline schedule planning. 4 graduate hours. No professional credit. Prerequisite: IE 411 or the equivalent.

**IE 515 Stochastic Simulation credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/515>)

Random variable generation; sample path generation; variance reduction; simulation optimization; introduction to Sequential Monte Carlo and MCMC; applications in finance. Prerequisite: IE 410 and STAT 410.

**IE 520 Variational Inequalities credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/520>)

Finite dimensional variational inequality and complementarity problems; characterization of solutions; nonsmooth Newton methods; interior-point methods; projected gradient schemes; applications of variational inequalities in game theory. Prerequisite: One of ECE 490, IE 510, IE 521, MATH 484.

**IE 521 Convex Optimization credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/521>)

Finite dimensional convex optimization problems; characterization of optimal solutions; iterative algorithms for differentiable and nondifferentiable problems; distributed optimization algorithms; robust problems and solutions; applications of convex optimization models. Prerequisite: ECE 490 or IE 411; MATH 415; MATH 444.

**IE 522 Statistical Methods in Finance credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/522>)

Methods of statistical modeling of signals and systems with an emphasis on finance applications. Review of linear algebra, probability theory, and spectral analysis; Linear Time Invariant (LTI) and ARX models; least-squares, maximum-likelihood, non-parametric, and frequency-domain methods; convergence, consistency and identifiability of linear models; asymptotic distribution of parameter estimates; techniques of model validation; Principle Component Analysis (PCA) for dimension reduction; ARCH and GARCH processes and their related models; implementation, application, and case-studies of recursive identification; Monte Carlo simulation. Credit is not given for both IE 522 and GE 524. Prerequisite: MATH 415.

**IE 523 Financial Computing credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/523>)

Visual Basic (VB) types and loops, macros, arrays, and objects; C++ structures, classes, overloading, inheritance, and I/O; C++ standard libraries; financial computing case studies; illustrations of financial engineering topics using VB and illustrations of the same topics for financial markets using .NET. Prerequisite: CS 225.

**IE 524 Optimization in Finance credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/524>)

Basic optimization models, theory and methods for financial engineering including linear, quadratic, nonlinear, dynamic integer, and stochastic programming; applications to portfolio selection, index fund tracking, asset management, arbitrage detection, option pricing and risk management; optimization software for classes of optimization problems. Projects requiring building optimization models based on financial market data and solutions using optimization solvers. Prerequisite: FIN 500 and MATH 415.

**IE 525 Numerical Methods in Finance credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/525>)

Numerical methods of the pricing and risk management of financial derivatives: Monte Carlo simulation; variance reduction techniques; quasi-Monte Carlo methods; finite difference methods for partial differential equations; time discretization schemes; free boundary problems for American options. Prerequisite: FIN 500.

**IE 526 Stochastic Calculus in Finance credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/526>)

Stochastic calculus approach to the pricing and risk management of derivative securities; no arbitrage pricing; Brownian motion; stochastic calculus; the Black-Scholes-Merton mode; risk neutral valuation; Feynman-Kac theorem; transform methods; exotic derivatives; change of numeraire; term structure interest rate mode; stochastic volatility and jump models. Prerequisite: IE 525.

**IE 527 MSFE Professional Development credit: 1 Hour.** (<https://courses.illinois.edu/schedule/terms/IE/527>)

This course is required to encourage participation in professional development activities. Students will be required to be in attendance for at least 70% of the Practitioner Speaker Series in addition to other sanctioned MSFE Events. The Practitioner Speaker Series is an essential part of the MSFE curriculum. It allows firsthand interaction with Quantitative Practitioners. Exposure to insights on how the financial world is changing; regarding new products and needs, evolving data and information systems, and much more. Other events might include but are not limited to special seminars, workshops and conversation groups. 1 graduate hour. No professional credit. Approved for S/U grading only. May be repeated in separate terms up to 2 hours. Note that this course is for 1 credit hour during your first and second semester and will require a mandatory final paper. Prerequisite: Graduate MS: Financial Engineering Students only.

**IE 528 Computing for Data Analytics credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/528>)

Hands-on programming course on select topics in data science and big data with major emphasis on a semester long project. Course will cover a variety of topics and tools in big data including Hadoop MapReduce Framework, HBase, and Storm; Machine Learning; and Optimization. 4 graduate hours. No professional credit. Prerequisite: CS 242, CS 446. All ISE graduate students and students enrolled in the Master of Science in Advanced Analytics (MSAA) are eligible to take the course.

**IE 529 Stats of Big Data & Clustering credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/529>)

This course will cover various foundational topics in data science. Parametric and non-parametric methods. Hypothesis testing; Regression; Classification; Dimension reduction; and Regularization. Unsupervised and semi-supervised learning, along with a few case studies. 4 graduate hours. No professional credit. Prerequisite: MATH 415 and IE 300 or equivalent. All ISE graduate students and students enrolled in the Master of Science in Advanced Analytics (MSAA) are eligible to take the course.

**IE 530 Optimization for Data Analytics credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/530>)

Basic optimization methods for data analytics, optimization modeling languages such as AMPL and GAMS, and optimization software including the NEOS server. Linear and integer, and their applications to compressed sensing, data mining, and pattern classification. 4 graduate hours. No professional credit. Prerequisite: IE 411. All ISE graduate students and students enrolled in the Master of Science in Advanced Analytics (MSAA) are eligible to take the course.

**IE 531 Algorithms for Data Analytics credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/531>)

This course will introduce the student to a set of algorithms for data analytics which include: hashing, indexes, caching; algorithms for structured datasets; streaming data modes; PageRank algorithms for market-basket models; clustering algorithms; and case studies. 4 graduate hours. No professional credit. Prerequisite: IE 411, CS 225. ISE graduate students and students enrolled in the Master of Science in Advanced Analytics (MCAA) are eligible to take the course.

**IE 532 Analysis of Network Data credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/532>)

This course will focus on statistical aspects analyzing network data. It will review illustrative problems relating to aggregation of information, decision-making, and inference tasks over various graphical models and networks. 4 graduate hours. No professional credit. Prerequisite: MATH 412. ISE graduate students and students enrolled in the Master of Science in Advanced Analytics (MCAA) are eligible to take the course.

**IE 533 Big Graphs and Social Networks credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/533>)

This course will cover the fundamentals of graph theory and network optimization. It will focus on algorithmic challenges associated with big graphs and intertwine the Hadoop Framework for solving example problems like shortest paths, link analysis, graph association and inexact graph matching. Applications in social network analysis will include study of network types, random graph models, exact and approximate computation of centrality measure, finding high value individuals, community detection, diffusion processes and cascading models, and influence maximization. 4 graduate hours. No professional credit. Prerequisite: MATH 213, IE 300, IE 411. ISE graduate students and students enrolled in the Master of Science in Advanced Analytics (MCAA) are eligible to take the course.

**IE 534 Deep Learning credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/534>)

This course provides an introduction to neural networks and recent advances in deep learning. Topics include training and implementation of neural networks, convolution neural networks, recurrent neural networks (LSTM and gated recurrent), residual networks, reinforcement learning, and Q-learning with neural networks. A part of the course will especially focus on recent work in deep reinforcement learning. The course will also cover deep learning libraries (e.g., Chainer, Tensorflow) and how to train neural networks using GPUs and GPU clusters. 4 graduate hours. No professional credit. Prerequisite: CS 446 or equivalent. Graduate students only.

**IE 542 Cooperative Problem Solving credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/542>)

Advanced graduate seminar on problem-solving models and taxonomies, models of coordination of activity and communication among multiple agents, design of human-machine cooperative problem-solving systems, adaptive automation, and intelligent decision support. Readings drawn from work in pragmatics, distributed artificial intelligence, cognitive engineering, and related areas. 4 graduate hours. No professional credit. Prerequisite: Credit or concurrent registration in either CS 440 or PSYC 527.

**IE 546 Human Factors in HCES credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/546>)  
Same as EPSY 546. See EPSY 546.

**IE 547 Healthcare Operations and Systems credit: 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/547>)

Delivers an introduction of healthcare systems and strategic issues in their operations, and a background of healthcare, health systems, hospitals and elements of care centers. The course blends quantitative and qualitative material, modeling and practical perspectives, and includes demand management, forecasting methods, workforce planning, inventory and materials planning, supply chain management in healthcare, process improvement and patient flow, facility design and planning, and operations scheduling. Financial performance and metrics, as well as case studies and project work will be included. 4 graduate hours. No professional credit. Prerequisite: The student should have a Bachelors Degree in Industrial Engineering, Operations Management, or closely related disciplines. Specifically, they should have: (1) Basic Calculus sequence (Calc I, II and III at UIUC these are MATH 220, MATH 231, and MATH 241; MATH 234 can also be used); (2) Elementary Probability and Statistics (IE 300 or STAT 400, MATH 463 or equivalent); (3) Notions or Linear Algebra (MATH 415) and preference for Linear Programming (IE 310/IE 311). Priority will be given to students enrolled in the Healthcare Engineering Systems Concentration of M.Eng. degree program.

**IE 590 Seminar credit: 0 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/590>)

Presentation and discussion of significant developments in industrial engineering. Approved for S/U grading only. May be repeated.

**IE 597 Independent Study credit: 1 to 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/597>)

Independent study of advanced problems related to industrial engineering. May be repeated in the same or separate terms if topics vary to a maximum of 12 hours. Prerequisite: Consent of instructor.

**IE 598 Special Topics credit: 0 to 4 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/598>)

Subject offerings of new and developing areas of knowledge in industrial engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. Approved for letter and S/U grading. May be repeated in the same or separate terms if topics vary.

**IE 599 Thesis Research credit: 0 to 16 Hours.** (<https://courses.illinois.edu/schedule/terms/IE/599>)

Approved for S/U grading only. May be repeated.