DEPARTMENT OF INDUSTRIAL & ENTERPRISE SYSTEMS ENGINEERING

Part of a nationally top-ranked engineering college on a premier Big Ten university campus, the Department of Industrial & Enterprise Systems Engineering offers students a blend of intellectual challenge, excitement, and energy that is transformational—this is a campus where you can learn from a world-renowned faculty, study in the most technologically advanced engineering library in the nation, and contribute to research that has real impact. The University attracts the best students from across the country and around the world. You can choose from about 4,000 courses as well as a variety of sports, the arts, and student activities—you'll never lack amazing things to do.

You can explore your personal interests and goals in more than 50 professional and honor engineering societies, or the more than 1,000 other organizations across campus. These student-run groups offer opportunities to develop leadership skills, test technical competence, and serve society through volunteer projects.

Many students choose a study-abroad experience to gain a better understanding of other cultures, while also developing skills that make them more marketable in the global workplace. The Office of International Programs in Engineering coordinates travel and fellowships to countries all over the world. Engineering at Illinois is the only U.S. institution to offer an international minor in engineering as part of a regular degree program.

Graduate Degree Programs

The Department of Industrial and Enterprise Systems Engineering (ISE) offers graduate study leading to master’s and doctoral degrees in Industrial Engineering (IE) and Systems and Entrepreneurial Engineering (SEE). The program offers an approach to industrial engineering and systems engineering, engineering design, and entrepreneurial engineering that crosses disciplinary lines. The IE program is based in advanced studies that focus on operations research, optimization, supply chain management, financial engineering, quality and reliability engineering and production management, with the aim to advance modeling, simulation, analysis and decision making for complex engineering and economic systems. The SEE program is founded on the premise of dual competency in both traditional engineering and systems integration. The SEE program offers flexibility by permitting the student to select from a menu of advanced courses and take a wide range of electives to meet individual career goals. Graduates of these programs are prepared to enter academic and professional engineering positions in universities, industry, government, and private practice. Opportunity also exists for students to complete a(n):

1. Computational Science and Engineering (CSE) Concentration (M.S. and Ph.D.)
2. Energy and Sustainability Engineering (EaSE) Certificate

The Department is a joint sponsor with the Department of Finance for the M.S. degree in Financial Engineering (http://catalog.illinois.edu/graduate/graduate-majors/finance-eng).

Admission

Applicants who have completed degree requirements in an accredited engineering program or its equivalent are eligible to apply for admission.
A minimum grade point average of 3.25 (A = 4.00) for the last two years of undergraduate study is required.

Scores on the Graduate Record Examination (GRE) (http://www.ets.org) general test are required of all applicants. Based upon the previous preparation of the student for either program, prerequisite courses may be specified by the advisor, but the credit may not be applied toward a degree.

All applicants whose native language is not English must submit a minimum TOEFL (http://www.ets.org/toefl) score of 103 (iBT), or 613 (PBT); or minimum International English Language Testing System (IELTS) (http://www.ielts.org) academic exam scores of 7.0 overall and 6.0 in all subsections. Applicants may be exempt from the TOEFL if certain criteria (http://grad.illinois.edu/admissions/instructions/04c) are met. Full admission status is granted for those meeting the minimum requirements and having taken the TOEFL or IELTS since the scores required for admission to ISE are above the minimum scores demonstrating an acceptable level of English language proficiency.

Applicants to the joint M.B.A. degree program must meet the admissions standards for both programs and be accepted by both programs.

**Faculty Research Interests**

Faculty research by ISE faculty is pursued in the following fields:

- computer-aided design
- data analytics
- optimization
- design systems
- manufacturing systems
- nondestructive testing and evaluation
- system dynamics and simulation
- control
- robotics
- real-time decision making
- reliability
- financial engineering
- operations research/management science
- biomechanics

In ISE, research is conducted in operations research, production engineering, quality and reliability engineering, supply chain and logistics, transportation, financial engineering, and business analytics. Study in the areas of cognitive engineering, computer-aided manufacturing, ergonomics, facilities planning, human-machine interaction, large-scale systems analysis, machine tool systems design, mathematical programming and optimization, production planning and control, and project management is aimed at improving the design and implementation of integrated systems of persons, materials, planning, and equipment.

**Facilities and Resources**

Members of the ISE Department have access to a wide range of excellent research facilities. These laboratories support a wide range of activity and are described at the department’s research laboratories Web site (http://ise.illinois.edu/research/ise-labs).

**Financial Aid**

Qualified students may compete for financial assistance in the form of teaching/graduate/research assistantships, fellowships, grants, and tuition waiver scholarships. Under certain conditions, fellowships may be augmented by part-time assistantships. All applicants, regardless of U.S. citizenship, whose native language is not English and who wish to be considered for teaching assistantships must demonstrate spoken English language proficiency (http://grad.illinois.edu/admissions/taengprof.htm) by achieving a minimum score of 24 on the speaking subsection of the TOEFL iBT or 8 on the speaking subsection of the IELTS. For students who are unable to take the iBT or IELTS, a minimum score of 4CP is required on the English Proficiency Interview (http://cte.illinois.edu/testing/oral_eng/epi_overview.html) (EPI), offered on campus. All new teaching assistants are required to participate in the Graduate Academy for College Teaching (http://citl.illinois.edu/professional-development/ta-orientation) conducted prior to the start of the semester.

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

**Industrial Engineering 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](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](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](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](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](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](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 & Anly of Experiments credit: 3 or 4 Hours. ([https://courses.illinois.edu/schedule/terms/IE/400](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 405 Computing for ISE credit: 3 or 4 Hours. ([https://courses.illinois.edu/schedule/terms/IE/405](https://courses.illinois.edu/schedule/terms/IE/405))

This course will introduce students to algorithm design, computer programming in C++, and database SQL queries. It will provide the fundamental methods, concepts and principles of these topics to give students enough breadth to use these techniques in their jobs and to prepare them to pursue advanced topics in these areas. There will be weekly programming assignments to implement algorithms and SQL covered in the class. 3 undergraduate hours. 4 graduate hours. Prerequisite: CS 101 or equivalent.

IE 410 Advanced Topics in Stochastic Processes & Applications credit: 3 or 4 Hours. ([https://courses.illinois.edu/schedule/terms/IE/410](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](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](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](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](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, Integer 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 519 Combinatorial Optimization credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/IE/519)
The course will cover a series of topics in combinatorial optimization. The emphasis will be on polyhedral theory, structural results and their applications to designing algorithms. Specific topics to be covered include: Matchings, b-matchings, T-matchings, T-flows, Arborascences, Branchings, Matroids, Matroid Intersection, Polymatroids, Submodular Functions, Directed Cuts, Multi-flows. Same as CS 586. 4 graduate hours. No professional credit. Prerequisite: Familiarity with linear programs (IE 411 or equivalent), Algorithms (CS 374 or equivalent), and Graph Theory (MATH 412 or equivalent).

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 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. Same as CS 547. 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 Health Care Engineering Systems  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.

SE Class Schedule (https://courses.illinois.edu/schedule/DEFAULT/DEFAULT/SE)

Systems Engineering and Design Courses

SE 100  Introduction to ISE  credit: 1 Hour. (https://courses.illinois.edu/schedule/terms/SE/100)
Overview of the engineering profession, the Industrial & Enterprise Systems Engineering Department, and the curricula in Industrial Engineering and Systems Engineering and Design.

SE 101  Engineering Graphics & Design  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/SE/101)
Computer-aided design (CAD) software modeling of parts and assemblies. Parametric and non-parametric solid, surface, and wireframe models. Part editing and two-dimensional documentation of models. Planar projection theory, including sketching of perspective, isometric, multiview, auxiliary, and section views. Spatial visualization exercises. Dimensioning guidelines, tolerancing techniques. Team design project. Credit is not given for both SE 101 and ME 170.

SE 199  Undergraduate Open Seminar  credit: 1 to 5 Hours. (https://courses.illinois.edu/schedule/terms/SE/199)
Undergraduate Open Seminar. May be repeated.

SE 261  Business Side of Engineering  credit: 1 or 2 Hours. (https://courses.illinois.edu/schedule/terms/SE/261)
Important elements and metrics of business and contemporary engineering economics: wealth creation, cash flow diagrams, internal rate of return, net present value, breakeven analysis, companies, corporations, profits, prices, balance sheets, income statements, and the basics of business plan writing. Particular emphasis is given to preparation for the economic analysis component of engineering practice.

SE 290  ISE Undergraduate Seminar  credit: 0 Hours. (https://courses.illinois.edu/schedule/terms/SE/290)
Lecture-discussion series by department faculty and visiting professional engineers addressing ethics, professional registration, the role of technical societies, and the relation of engineering to such disciplines as economics, sociology, and government. Approved for Letter and S/U grading.
SE 297 Independent Study credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/297)
Individual investigations of any phase of Systems Engineering and Design selected by the students and approved by the department. May be repeated. Prerequisite: Consent of instructor.

SE 298 Special Topics credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/298)
Subject offerings of new and developing areas of knowledge in general engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites.

SE 310 Design of Structures and Mechanisms credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/SE/310)
Fundamental concepts in the classical and computer-based analysis and design of structural and machine components and assemblies. External loads, internal forces, and displacements in statically determinate and indeterminate configurations; kinematics of linkages, gears, and cams; statics in machines. Prerequisite: CS 101, TAM 212, and TAM 251. Credit or concurrent enrollment in MATH 415.

SE 311 Engineering Design Analysis credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/SE/311)
Stress-strain conditions; analytical and numerical (CAD) solution techniques; analysis of various engineering materials and configurations as applied to the development and application of design analysis criteria. Prerequisite: SE 310; concurrent registration in SE 312.

SE 312 Instrumentation and Test Lab credit: 1 Hour. (https://courses.illinois.edu/schedule/terms/SE/312)
Preparation for experimental projects; mechanical and electrical instruments; mechanical testing of materials; experimental stress analysis and photoelastic methods. Prerequisite: SE 310; concurrent registration in SE 311.

SE 320 Control Systems credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/320)
Fundamental control systems and control systems technology. Sensors, actuators, modeling of physical systems, design and implementation of feedback controllers; operational techniques used in describing, analyzing and designing linear continuous systems; Laplace transforms; response via transfer functions; stability; performance specifications; controller design via transfer functions; frequency response; simple nonlinearities. Credit is not given for both SE 320 and either AE 353 or ME 340. Prerequisite: CS 101, MATH 285, and TAM 212; credit or concurrent registration in ECE 211.

SE 361 Emotional Intelligence Skills credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/SE/361)
Understanding emotions in ourselves and others. Assessment and improvement of interpersonal skills and emotional intelligence competencies including self-regulation, motivation, empathetic listening, communication, influence collaboration and cooperation, conflict management, leadership, teamwork, and managing change. Includes one Saturday laboratory session.

SE 397 Independent Study credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/397)
Individual investigations or studies of any phase of General Engineering selected by the students and approved by the department. May be repeated in same term. Prerequisite: Consent of instructor.

SE 398 Special Topics credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/398)
Subject offerings of new and developing areas of knowledge in general engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites.

SE 400 Engineering Law credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/400)
Nature and development of the legal system; legal rights and duties important to engineers in their professions; contracts, uniform commercial code and sales of goods, torts, agency, worker’s compensation, labor law, property, environmental law, intellectual property. 3 undergraduate hours. 4 graduate hours. Prerequisite: RHET 105.

SE 402 Comp-Aided Product Realization credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/402)
Computer-aided design, analysis, and prototyping tools used in the produce development process. Principles of computer graphics and geometric modeling, including transformations, coordinate systems, parametric solid modeling, spline curves, and surface modeling. Finite element and kinematics analyses. Rapid prototyping, product dissection, CAD-CAM-CAE operability issues, and CAD collaboration tools. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: SE 101 and SE 311.

SE 410 Component Design credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/SE/410)
Design of basic engineering components: structural members, machine parts, and connections. Principles applied include: material failure (yield, fracture, fatigue); buckling and other instabilities; design reliability; analytical simulation. 3 undergraduate hours. 3 graduate hours. This course is an approved Design Elective in the SE Undergraduate curriculum. Prerequisite: SE 311 and SE 320.

SE 411 Reliability Engineering credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/411)
Concepts in engineering design, testing, and management for highly reliable components and systems. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: IE 300.

SE 412 Nondestructive Evaluation credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/412)
Nondestructive Evaluation (NDE) principles and the role of NDE in design, manufacturing, and maintenance. Primary Nondestructive Testing and Evaluation (NDT&E) techniques, introduced from the fundamental laws of physics, including visual, ultrasonic, acoustic emission, acousto-ultrasonic, radiology, electro-magnetic, eddy-current, penetrant, thermal, and holographic. Industrial applications of probability of flaw detection, material properties characterization, impact and fatigue damage evaluation, adhesion, etc. Current literature. 3 or 4 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 300.

SE 413 Engineering Design Optimization credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/413)
Application of optimization techniques to engineering design problems. Emphasis on problem formulation, including applications in structural, mechanical, and other design domains. Important theoretical results and numerical optimization methods. Matlab programming assignments to develop software for solving nonlinear mathematical programming problems. 3 or 4 undergraduate hours. 3 or 4 graduate hours. Prerequisite: MATH 241 and MATH 415.
SE 420  Digital Control Systems  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/420)
Theory and techniques for control of dynamic processes by digital computer; linear discrete systems, digital filters, sampling signal reconstruction, digital design, state space methods, computers, state estimators, and laboratory techniques. 4 undergraduate hours. 4 graduate hours. Prerequisite: SE 320.

SE 422  Robot Dynamics and Control  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/422)
Fundamental concepts and analytical methods for analysis and design of robot systems. Laboratory experiments complement theoretical development. Same as ECE 489 and ME 446. 4 undergraduate hours. 4 graduate hours. Prerequisite: SE 320. Recommended: ECE 470.

SE 423  Mechatronics  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/SE/423)
Mechatronics concepts and practice: computer interfacing of physical devices (sensors, actuators); data acquisition; real time programming and real time control; human-machine interfaces; design principles of mechatronics in manufacturing systems and in consumer systems. 3 undergraduate hours. 3 graduate hours. Prerequisite: SE 320.

SE 424  State Space Design for Control  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/SE/424)
Design methods; time domain modeling; trajectories and phase plane analysis; similarity transforms; controllability and observability; pole placement and observers; linear quadratic optimal control; Lyapunov stability and describing functions; simulation. 3 undergraduate hours. 3 graduate hours. Prerequisite: SE 320 and MATH 415.

SE 450  Decision Analysis I  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/450)
Rules of thought that transform complex decision situations into simpler ones where the course of action is clear. Practical application of decision analysis in large organizations; methods to generate insights into real-life decision problems, avoid the common pitfalls in decision processes, and overcome the possible barriers to implementing a high-quality decision-making process for individual and organizational decision making; graphical representations of decision problems such as decision diagrams and utility diagrams. 3 or 4 undergraduate hours. 3 or 4 graduate hours. Prerequisite: IE 300.

SE 462  Leading Sustainable Change  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/SE/462)
Theories and process of change; systems thinking concerning change consequences; building coalitions and communities to support change; implementing and managing projects effectively. Processes to plan, implement, manage, and sustain change with an organization through alignment of change strategies with organizational and individual concerns. 3 undergraduate hours. 3 graduate hours.

SE 494  Senior Engineering Project I  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/SE/494)
Senior engineering project - team component. Student teams of three or four, guided by faculty advisors, develop solutions to real-world engineering problems provided by industry-partnering companies, subject to realistic constraints and supported by economic analyses and recommendations for implementation. Prototype solutions fabricated where practical. Multiple reports and presentations throughout the term. Several trips to company typical. Common project grade for all team members. SE 494 and SE 495 taken concurrently fulfill the Advanced Composition Requirement. Approval of the department is required to register. 3 undergraduate hours. No graduate credit. Prerequisite: SE 261, SE 390 and, SE 311, IE 300, IE 310, and TAM 335; or IE 310, IE 311, and IE Technical Elective; credit or concurrent registration in a SE Design Elective and IE Engineering Science Elective. Must enroll concurrently in SE 495.
This course satisfies the General Education Criteria for: Advanced Composition

SE 495  Senior Engineering Project II  credit: 2 Hours. (https://courses.illinois.edu/schedule/terms/SE/495)
Adjunct to SE 494. Senior engineering project – individual component. Individual grade for each team member. SE 494 and SE 495 taken concurrently fulfill the Advanced Composition Requirement. 2 undergraduate hours. No graduate credit. Prerequisite: Concurrent registration in SE 494.
This course satisfies the General Education Criteria for: Advanced Composition

SE 497  Independent Study  credit: 0 to 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/497)
Advanced problems related to General Engineering. 0 to 4 undergraduate hours. 0 to 4 graduate hours. Approved for Letter and S/U grading. May be repeated in same term. Prerequisite: Consent of instructor.

SE 498  Special Topics  credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/498)
Subject offerings of new and developing areas of knowledge in general 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.

SE 520  Analysis of Nonlinear Systems  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/520)
Same as ECE 528 and ME 546. See ECE 528.

SE 521  Multivariable Control Design  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/521)
Same as AE 555. See AE 555.

SE 523  Discrete Event Dynamic Systems  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/523)
Modeling, analysis, control, and performance evaluation of discrete event dynamic systems (DEDS), which are characterized by state changes only at discrete points in time in response to the occurrence of particular events. Discrete-state and discrete-event models decidability, computational issues, forbidden-state problems, forbidden-string problems, enforcing safety and liveness properties via supervision, generalized semi-Markov processes, sensitivity analysis via likelihood ratio and infinitesimal perturbation methods. 3 or 4 graduate hours.
No professional credit. Prerequisite: CS 173 or MATH 213; CS 225; MATH 415; MATH 461.
SE 524  Data-Based Systems Modeling credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/524)
Identification and building of mathematical and computational models directly from data. Systems and model types, such as state-space and distributed-parameter; parametric estimation methods, such as regression and least-squares recent subspace identification methods; data preprocessing techniques; model validation methods. Assignment applications to a wide range of dynamical systems, including biological, electro-mechanical, and economic. 4 graduate hours. No professional credit. Prerequisite: SE 424 and IE 300.

SE 525  Control of Complex Systems credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/525)
Control methodologies for complex (i.e., interconnected) dynamic systems. A unified framework based on the vector Liapunov functions concept is used to examine various methodologies: decentralized overlapping control; optimal control of interconnected systems; multiplayer differential game theory; decentralized optimization and its link with the multi-criteria optimization. Illustrative examples in areas such as control of groups of unmanned vehicles, control of power systems, and coverage control. 4 graduate hours. No professional credit. Prerequisite: SE 424.

SE 530  Multiattribute Decision Making credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/530)
Tools for subjective multiple attribute decision making when present or future states of nature are uncertain. Exploration of current research in developing computer aids to decision making. Issues in descriptive versus normative approaches in the context of the interface between operations research and artificial intelligence. Multiattribute utility analysis from theoretical foundations through assessment procedures, practice, and pitfalls of potential cognitive bases. 4 graduate hours. No professional credit. Prerequisite: CEE 202 or IE 300.

SE 550  Decision Analysis II credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/550)
Continuation of SE 450. Fundamental requirements of a decision-making system; comparison of different decision-making methods; “paradoxes” in decision making; foundations and history of probability as a degree of belief; Bayesian vs. classical statistics; entropy of a random variable; experimentation and optimal stopping; invariance formulations in utility and probability; one-switch preferences; graph-based methods to incorporate dependence in multiattribute utility functions. 3 or 4 graduate hours. No professional credit. Prerequisite: SE 450.

SE 590  Seminar credit: 0 Hours. (https://courses.illinois.edu/schedule/terms/SE/590)
Presentations by graduate students, staff, and guest lecturers of current topics in research and development in General Engineering. 0 graduate hours. No professional credit. Approved for Letter and S/U grading. May be repeated. Required of all graduate students each term.

SE 594  Project Design credit: 1 to 8 Hours. (https://courses.illinois.edu/schedule/terms/SE/594)
Engineering design projects emphasizing advanced engineering analysis, synthesis, optimization, and engineering economics. 1 to 8 graduate hours. No professional credit. May be repeated to a maximum of 8 hours for credit toward the Master’s degree.

SE 597  Independent Study credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/597)
Advanced problems related to General Engineering. 1 to 4 graduate hours. No professional credit. May be repeated. Prerequisite: Consent of instructor.

SE 598  Special Topics credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/SE/598)
Subject offerings of new and developing areas of knowledge in general engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. 1 to 4 graduate hours. No professional credit. May be repeated in the same or separate terms if topics vary to a maximum of 12 hours.

SE 599  Thesis Research credit: 0 to 16 Hours. (https://courses.illinois.edu/schedule/terms/SE/599)
Thesis Research. 0 to 16 graduate hours. No professional credit. Approved for S/U grading only. May be repeated to a maximum of 16 hours for credit toward the Master’s or PhD degree.