INDUSTRIAL ENGINEERING (I E)

Any experimental courses offered by I E can be found at:
registrar.iastate.edu/faculty-staff/courses/explistings/ (http://www.registrar.iastate.edu/faculty-staff/courses/explistings/)

Courses primarily for undergraduates:

I E 101: Industrial Engineering Profession
Cr. R. F.S.
(1-0) Introduce students to the industrial engineering profession, its scope, industrial engineering tools, and future trends. Offered on a satisfactory-fail basis only.

I E 148: Information Engineering
(2-2) Cr. 3. F.S.
Prereq: Credit or concurrent enrollment in MATH 143

I E 222: Design & Analysis Methods for System Improvements
(3-0) Cr. 3. S.
Prereq: Credit or concurrent enrollment in I E 271
Study of system improvement methods and strategies. Specific areas of lean system improvements include continuous improvement, setup reduction, workplace organization, and inventory and waste reduction. Methods and strategies to analyze and quantify the impact of changes.

I E 248: Engineering System Design, Manufacturing Processes and Specifications
(2-2) Cr. 3. F.
Prereq: Credit or concurrent enrollment in (I E 101; MAT E 273); MATH 166; PHYS 231
Introduction to metrology, engineering drawings and specifications. Engineering methods for designing and improving systems. Theory, applications, and quality issues related to machining processes.

I E 271: Applied Ergonomics and Work Design
(3-0) Cr. 3. S.
Prereq: PHYS 231; PHYS 231L
Basic concepts of ergonomics and work design. Their impact on worker and work place productivity, and cost. Investigations of work physiology, biomechanics, anthropometry, work sampling, work evaluation methods, and their measurement as they relate to the design of human-machine systems.

I E 305: Engineering Economic Analysis
(3-0) Cr. 3. F.S.S.
Prereq: MATH 166
Economic analysis of engineering decisions under uncertainty. Financial engineering basics including time value of money, cash flow estimation, and asset evaluation. Make versus buy decisions. Comparison of project alternatives accounting for taxation, depreciation, inflation, and risk.

I E 312: Optimization
(3-0) Cr. 3. F.
Prereq: Credit or concurrent enrollment in MATH 267
Concepts, optimization and analysis techniques, and applications of operations research. Formulation of mathematical models for systems, concepts, and methods of improving search, linear programming and sensitivity analysis, network models, and integer programming.

I E 341: Production Systems
(3-0) Cr. 3. F.
Prereq: Credit or concurrent enrollment in I E 312; STAT 231
Introduction of key concepts in the design and analysis of production systems. Topics include inventory control, forecasting, material requirement planning, Kanban systems, project planning and scheduling including Critical Path Method (CPM) and Program Evaluation Review Technique (PERT), operations scheduling, and other production systems such as Just-In-Time (JIT), warehousing, and global supply chains.

I E 348: Solidification Processes
(Cross-listed with MAT E). (2-2) Cr. 3. S.
Prereq: I E 248 and MAT E 273, or MAT E 215
Theory and applications related to metal casting, welding, polymer processing, powder metallurgy, and composites manufacturing, and related rapid manufacturing processes.

I E 361: Statistical Quality Assurance
(Cross-listed with STAT). (2-2) Cr. 3. F.S.
Prereq: STAT 231, STAT 301, STAT 326, STAT 401, or STAT 587
I E 403: Introduction to Sustainable Production Systems  
(Dual-listed with I E 503). (3-0) Cr. 3.  
Prereq: Credit or concurrent enrollment I E 341  
Quantitative introduction of sustainability concepts in production planning and inventory control. Review of material recovery (recycling) and product/component recovery (remanufacturing) from productivity perspectives. Sustainability rubrics ranging from design and process to systems. Application to multi-echelon networks subject to forward/backward flow of material and information. Closed-loop supply chains. Comparative study of sustainable vs. traditional models for local and global production systems.

I E 405: Advanced Engineering Economy for Complex Engineering Projects  
(Dual-listed with I E 505). (3-0) Cr. 3.  
Prereq: MATH 265, MATH 267, STAT 231 and I E 305, or permission by instructor  

I E 413: Stochastic Modeling, Analysis and Simulation  
(4-0) Cr. 4. F.  
Prereq: MATH 265, STAT 231  
Development of probabilistic and simulation models using a simulation language. Introduction to Markov processes and other queuing models. Application to various areas of manufacturing and service systems such as assembly, material handling, and customer queues. Fitting of statistical distributions to data. Utilization of model output towards improved decision-making.

I E 420: Engineering Problem Solving with R  
(Dual-listed with I E 520). Cr. 3. S.  
Prereq: An introductory statistics course: Stat 231 or equivalent  

I E 430: Entrepreneurial Product Engineering  
(Cross-listed with ENGR). Cr. 3. F.Alt. S., offered irregularly.  
Prereq: Junior classification  
Process of innovative product development in both entrepreneurial and intra-preneural settings. Define, prototype and validate a product concept based on competitive bench-marking, market positioning and customer requirement evaluation in a target market into a product design that is consistent with defined business goals and strategies. Combination of lecture, discussion, problem solving and case study review.

I E 432: Industrial Automation  
(2-3) Cr. 3. S.  
Prereq: PHYS 232; PHYS 232L  
Overview of electrical circuit theory and its relationship to industrial control systems. Theory and application of transducers in the form of sensors and actuators, with applications in manufacturing, distribution and mechanical systems. Programmable Logic Controllers (PLC), their programming and use for automation solutions. Introduction of automated identification systems such as Radio Frequency Identification (RFID) and Bar Coding technologies.

I E 437: Reliability and Safety Engineering  
(Dual-listed with I E 537). (3-0) Cr. 3.  
Prereq: STAT 231 or STAT 305 or STAT 587  

I E 441: Industrial Engineering Design  
(1-6) Cr. 3. F.S.  
Prereq: I E 248, I E 271, I E 361; credit or enrollment in I E 341, I E 413, and I E 448  
A large, open-ended design project related to an enterprise. Application of engineering design principles including problem definition, analysis, synthesis, and evaluation.

I E 444: Micro/Nano Scale Additive Printing  
(Dual-listed with I E 544). (3-0) Cr. 3. F.  
Prereq: I E 348 or equivalent manufacturing engineering course  
Introduction of physical theory, design, analysis, fabrication, and characterization of micro/nano scale fabrication and manufacturing systems; introduction of micro/nano scale additive manufacturing; and deep understanding of additive printing for micro/nano scale applications. Focus on the fabrication/manufacturing of important types of microstructures used in micro/nano devices using additive printing, and the techniques and tools used to characterize them. Students are expected to finish a team projected related applying additive printing experimentally or theoretically to the design of a sensor.
I E 445: Additive Manufacturing and Rapid Production Methods
(Dual-listed with I E 545). (3-0) Cr. 3.
Prereq: I E 248 or similar manufacturing engineering course, MATH 265. For I E 545: Undergraduates at Senior Standing if given permission by instructor.
Introduction to additive manufacturing and other rapid prototyping and manufacturing methodologies. Operating principles and characteristics of current and developing processes. Use of rapid prototypes in product design, development, and service. Selection of rapid prototyping and manufacturing systems, from design to mass production. Hybrid manufacturing and other integration of rapid production methods.

I E 446: Geometric Variability in Manufacturing
(Dual-listed with I E 546). (3-0) Cr. 3.
Prereq: I E 348 or MAT E 216 or M E 324
Assessment, accommodation, and control of geometric variability in manufacturing processes, specifically composites, metalcasting, welding, machining, powder metallurgy and additive processing. Techniques include the design of the component, tooling, process plan and inspection methodology.

I E 447: Biomedical Design and Manufacturing
(Dual-listed with I E 547). (Cross-listed with B M E). (3-0) Cr. 3.
Prereq: Undergraduate students with three semesters or less before graduation while graduate standing for graduate students
Exploration of biology, materials, body mechanics, manufacturing, quality control, and ethics and the intersection of these subjects as they relate to biomedical manufacturing. Study of medical data (CT, MRI, etc.) processing, biomedical design, 3D bioprinting and additive manufacturing concepts.

I E 448: Manufacturing Systems Engineering
(3-0) Cr. 3. S.
Prereq: I E 248
Fixturing and tooling requirements for manufacturing process planning, geometric dimensioning and tolerancing, computer aided inspection, cellular and flexible manufacturing, facility layout and controlled flow production.

I E 449: Computer Aided Design and Manufacturing
(Dual-listed with I E 549). (3-0) Cr. 3.
Prereq: Prereq: I E 248 or similar manufacturing engineering course, MATH 265.
Representation and interpretation of curves, surfaces and solids. Parametric curves and surfaces and solid modeling. Use of CAD software and CAD/CAM integration. Computer numerical control, CNC programming languages, and process planning.

I E 450: Technical Sales for Engineers
(3-0) Cr. 3. F.
Prereq: Credit or concurrent enrollment in I E 305
Sales process methodology, techniques for building professional relationships, sales automation software, prospecting and account development, market analysis and segmentation, responding to RFQ’s and RFP’s in written and verbal form. Developing technical value propositions and competitive positioning, evaluating organizational decision processes and people, technical marketing strategies, sales closing strategies.

I E 452: Introduction To Systems Engineering And Analysis
(Cross-listed with AER E). Cr. 3. SS.
Prereq: Junior classification in an Engineering major
Principles of systems engineering to include problem statement formulation, stakeholder analysis, requirements definition, system architecture and concept generation, system integration and interface management, verification and validation, and system commissioning and decommissioning operations. Introduction to discrete event simulation processes. Students will work in groups to propose, research, and present findings for a systems engineering topic of current relevance.

I E 468: Large-Scale Complex Engineered Systems (LSCES)
(Dual-listed with I E 568). (Cross-listed with AER E). (3-0) Cr. 3. S.
Prereq: Senior classification in College of Engineering or Permission of Instructor
Introduction to the theoretical foundation and methods associated with the design for large-scale complex engineered systems, including objective function formation, design reliability, value-driven design, product robustness, utility theory, economic factors for the formation of a value function and complexity science as a means of detecting unintended consequences in the product behavior.

I E 470: Systems Engineering and Project Management
(Dual-listed with I E 570). (3-0) Cr. 3.
Prereq: Prerequisite I E 305 and course in basic statistics.
Systems view of projects and the processes by which they are implemented. Focuses on qualitative and quantitative tools and techniques of project management. Topics will include organizational structure types; project selection methodologies; simulation and optimization; and earned value management. Case studies will be included, and a group project required.
I E 472: Design and Evaluation of Human-Computer Interaction
(Dual-listed with I E 572). (3-0) Cr. 3.
Prereq: I E 271 or graduate classification
Human factors methods applied to interface requirements, design, prototyping, and evaluation. Concepts related to understanding user characteristics, design principles, usability analysis, methods and techniques for design and evaluation of the interface. The evaluation and design of the information presentation characteristics of a wide variety of interfaces: web sites (e-commerce), mobile applications, and information presentation systems (cockpits, instrumentation, etc.).

I E 481: e-Commerce Systems Engineering
(Dual-listed with I E 581). (3-0) Cr. 3.
Prereq: I E 148
Design, analysis, and implementation of e-commerce systems. Information infrastructure, enterprise models, enterprise processes, enterprise views. Data structures and algorithms used in e-commerce systems, SQL, exchange protocols, client/server model, web-based views.

I E 483: Data Mining
(Dual-listed with I E 583). (3-0) Cr. 3.
Prereq: I E 148, I E 312, and STAT 231
Foundations of classification, data clustering and association rule mining. Techniques for data mining, with focus on tree-based methods for classification (simple trees, random forest and boosted trees), ensemble learning, optimization algorithms and deep learning with neural networks. Performance metrics and resampling methods for evaluating model quality. A computing project in R is required.

I E 487: Big Data Analytics and Optimization
(Dual-listed with I E 587). Cr. 3. S.
Prereq: I E 312, Stat 231

I E 490: Independent Study
Cr. 1-5. Repeatable.
Prereq: Senior classification, Permission of Instructor
Independent study and work in the areas of industrial engineering design, practice, or research.

I E 490H: Independent Study: Honors
Cr. 1-5. Repeatable.
Prereq: Senior classification, Permission of Instructor
Independent study and work in the areas of industrial engineering design, practice, or research.

Courses primarily for graduate students, open to qualified undergraduates:

I E 501: I E Graduate Seminar
Cr. R. Repeatable.
Prereq: Enrollment in graduate program in Industrial Engineering. Research presentations by internal and external scholars.
Principles and practices for research tasks at the M.S. level including proposal writing, presentations, paper preparation, and project management. Offered on a satisfactory-fail basis only.

I E 503: Introduction to Sustainable Production Systems
(Dual-listed with I E 403). (3-0) Cr. 3.
Prereq: Credit or concurrent enrollment I E 341
Quantitative introduction of sustainability concepts in production planning and inventory control. Review of material recovery (recycling) and product/component recovery (remanufacturing) from productivity perspectives. Sustainability rubrics ranging from design and process to systems. Application to multi-echelon networks subject to forward/ backward flow of material and information. Closed-loop supply chains. Comparative study of sustainable vs. traditional models for local and global production systems.

I E 505: Advanced Engineering Economy for Complex Engineering Projects
(Dual-listed with I E 405). (3-0) Cr. 3.
Prereq: MATH 265, MATH 267, STAT 231 and I E 305, or permission by instructor

I E 508: Design and Analysis of Allocation Mechanisms
(3-0) Cr. 3.
Prereq: I E 312 or MATH 307
Market-based allocation mechanisms from quantitative economic systems perspective. Pricing and costing models designed and analyzed with respect to decentralized decision processes, information requirements, and coordination. Financial Engineering Techniques. Case studies and examples from industries such as regulated utilities, semiconductor manufacturers, and financial engineering services.
I E 510: Network Analysis  
(3-0) Cr. 3.  
Prereq: I E 312  
Formulation and solution of deterministic network flow problems including shortest path, minimum cost flow, and maximum flow. Network and graph formulations of combinatorial problems including assignment, matching, and spanning trees. Solution algorithm design and analysis based on optimality conditions and duality.

I E 513: Analysis of Stochastic Systems  
(3-0) Cr. 3.  
Prereq: STAT 231  
Introduction to modeling and analysis of manufacturing and service systems subject to uncertainty. Topics include the Poisson process, renewal processes, Markov chains, and Brownian motion. Applications to inventory systems, production system design, production scheduling, reliability, and capacity planning.

I E 514: Production Scheduling  
(3-0) Cr. 3.  
Prereq: I E 312, I E 341  
Introduction to the theory of machine shop systems. Complexity results for various systems such as job, flow and open shops. Applications of linear programming, integer programming, network analysis. Enumerative methods for machine sequencing. Introduction to stochastic scheduling.

I E 519: Simulation Modeling and Analysis  
(3-0) Cr. 3.  
Prereq: COM S 311, STAT 231 or equivalent basic stat courses  
Event scheduling, process interaction, and continuous modeling techniques. Introduction of Bayesian simulation techniques and commonly used numerical methods. Probability and statistics related to simulation parameters including run length, metrics, inference, design of experiments, variance reduction, and stopping rules. Simulation of stochastic concepts and processes. Aspects of simulation languages. A computing project in a programming language is required.

I E 520: Engineering Problem Solving with R  
(Dual-listed with I E 420). Cr. 3. S.  
Prereq: An introductory statistics course: Stat 231 or equivalent  

I E 531: Quality Control and Engineering Statistics  
(Cross-listed with STAT). (3-0) Cr. 3.  
Prereq: STAT 401 or STAT 587; STAT 342 or STAT 447 or STAT 588  
Statistical methods and theory applicable to problems of industrial process monitoring and improvement. Statistical issues in industrial measurement; Shewhart, CUSUM, and other control charts; feedback control; process characterization studies; estimation of product and process characteristics; acceptance sampling, continuous sampling and sequential sampling; economic and decision theoretic arguments in industrial statistics.

I E 533: Reliability  
(Cross-listed with STAT). (3-0) Cr. 3. Alt. S., offered even-numbered years.  
Prereq: STAT 342 or STAT 432 or STAT 447 or STAT 478 or STAT 578 or STAT 588  
Probabilistic modeling and inference in engineering reliability; lifetime models, product limit estimator, probability plotting, maximum likelihood estimation for censored data, Bayesian methods in reliability, system reliability models, competing risk analysis, acceleration models and analysis of accelerated test data; analysis of recurrent events and degradation data; planning studies to obtain reliability data.

I E 534: Linear Programming  
(3-0) Cr. 3.  
Prereq: I E 312  
Formulation of optimization problems as mathematical models, such as linear programming, integer programming, and multi-objective optimization. Introduction to classic optimization algorithms, such as Simplex and cutting plane algorithms. Basic concepts of duality theory and sensitivity analysis. Using computer solvers to obtain optimal solutions to optimization models.

I E 537: Reliability and Safety Engineering  
(Dual-listed with I E 437). (3-0) Cr. 3.  
Prereq: STAT 231 or STAT 305 or STAT 587  

I E 541: Inventory Control and Production Planning  
(3-0) Cr. 3.  
Prereq: I E 341  
Economic Order Quantity, dynamic lot sizing, newsboy, base stock, and (Q,r) models. Material Requirements Planning. Just-In-Time (JIT), variability in production systems, push and pull production systems, aggregate and workforce planning, and capacity management. Supply Chain Contracts.
I E 544: Micro/Nano Scale Additive Printing
(Dual-listed with I E 444). (3-0) Cr. 3. F.
Prereq: I E 348 or equivalent manufacturing engineering course
Introduction of physical theory, design, analysis, fabrication, and
characterization of micro/nano scale fabrication and manufacturing
systems; introduction of micro/nano scale additive manufacturing;
and deep understanding of additive printing for micro/nano scale
applications. Focus on the fabrication/manufacturing of important types
of microstructures used in micro/nano devices using additive printing,
and the techniques and tools used to characterize them. Students are
expected to finish a team project related applying additive printing
experimentally or theoretically to the design of a sensor.

I E 545: Additive Manufacturing and Rapid Production Methods
(Dual-listed with I E 445). (3-0) Cr. 3.
Prereq: I E 248 or similar manufacturing engineering course, MATH 265. For I
E 545: Undergraduates at Senior Standing if given permission by instructor.
Introduction to additive manufacturing and other rapid prototyping and
manufacturing methodologies. Operating principles and characteristics
of current and developing processes. Use of rapid prototypes in product
design, development, and service. Selection of rapid prototyping and
manufacturing systems, from design to mass production. Hybrid
manufacturing and other integration of rapid production methods.

I E 546: Geometric Variability in Manufacturing
(Dual-listed with I E 446). (3-0) Cr. 3.
Prereq: I E 348 or MAT E 216 or M E 324
Assessment, accommodation, and control of geometric variability in
manufacturing processes, specifically composites, metalcasting, welding,
machining, powder metallurgy and additive processing. Techniques
include the design of the component, tooling, process plan and inspection
methodology.

I E 547: Biomedical Design and Manufacturing
(Dual-listed with I E 447). (3-0) Cr. 3.
Prereq: Undergraduate students with three semesters or less before
graduation while graduate standing for graduate students
Exploration of biology, materials, body mechanics, manufacturing, quality
control, and ethics and the intersection of these subjects as they relate
to biomedical manufacturing. Study of medical data (CT, MRI, etc.)
processing, biomedical design, 3D bioprinting and additive manufacturing
concepts.

I E 549: Computer Aided Design and Manufacturing
(Dual-listed with I E 449). (3-0) Cr. 3.
Prereq: I E 248 or similar manufacturing engineering course, MATH 265.
Representation and interpretation of curves, surfaces and solids.
Parametric curves and surfaces and solid modeling. Use of CAD
software and CAD/CAM integration. Computer numerical control, CNC
programming languages, and process planning.

I E 560: Engineering Risk Analysis
(3-0) Cr. 3.
Prereq: Coursework in basic probability and statistics
Overview of probabilistic risk analysis, modeling risks, and risk
management. Topics include probability, influence diagrams, subjective
probability assessment, fault tree analysis, decision making with
uncertainty, risk perception, risk communication, and intelligent
adversary. Use of Monte Carlo simulation to combine different sources
of uncertainty and risk to generate probability distributions over
an outcome. Application of probabilistic risk analysis to business
investments, engineering systems, critical infrastructure, defense and
security, and health systems.

I E 561: Total Quality Management
(3-0) Cr. 3.
Prereq: Course in quality control
Perspectives for how to analyze and implement total quality management
in different organizations, to include manufacturing firms, service
industries, the non-profit sector, and government agencies. Topics
include the different viewpoints of quality (from the customer, workforce,
and process perspective); aligning quality in an organization’s goals;
performance measurement; quality in supply chain management; and
reliability. Some advanced statistical elements of quality control will also
be discussed.

I E 563: Engineering and Systems Management
(3-0) Cr. 3.
Prereq: Prerequisite I E 305 and course in basic statistics
Introduction to engineering management concepts and examples
relevant to the engineering manager today. Topics include decision trees
and associated probabilities; personnel issues and challenges; working
with management, client and the project team; personality types; and
documents/forms that are useful for the engineering manager. Case
studies, and a group project required.
I E 564: Decision Analysis
(3-0) Cr. 3.
Prereq: Course in probability and statistics.
Application of normative decision theory to problems with uncertainty and/or multiple objectives. The first decision framework will be a single-objective decision problem with uncertainty that takes into account a decision maker’s attitude towards risk. The second decision framework will be a multi-criteria decision problem in which a decision maker has multiple objectives. Topics include utility theory, value of information, sensitivity analysis, value-focused thinking, cost-effectiveness analysis, influence diagrams, and behavioral decision making. Examples will be drawn from business, systems engineering and design, and government.

I E 565: Systems Engineering and Analysis
(Cross-listed with AER E, E E). (3-0) Cr. 3.
Prereq: Coursework in basic statistics
Introduction to organized multidisciplinary approach to designing and developing systems. Concepts, principles, and practice of systems engineering as applied to large integrated systems. Life cycle costing, scheduling, risk management, functional analysis, conceptual and detail design, test and evaluation, and systems engineering planning and organization. Not available for degrees in industrial engineering.

I E 566: Applied Systems Engineering
(3-0) Cr. 3.
Prereq: I E 565
Design for reliability, maintainability, usability, supportability, producibility, disposability, and life cycle costs in the context of the systems engineering process. Students will be required to apply the principles of systems engineering to a project including proposal, program plan, systems engineering management plan, and test and evaluation plan. Not available for degrees in industrial engineering.

I E 568: Large-Scale Complex Engineered Systems (LSCES)
(Dual-listed with I E 468). (Cross-listed with AER E). (3-0) Cr. 3. S.
Prereq: Senior classification in College of Engineering or Permission of Instructor
Introduction to the theoretical foundation and methods associated with the design for large-scale complex engineered systems, including objective function formation, design reliability, value-driven design, product robustness, utility theory, economic factors for the formation of a value function and complexity science as a means of detecting unintended consequences in the product behavior.

I E 570: Systems Engineering and Project Management
(Dual-listed with I E 470). (3-0) Cr. 3.
Prereq: Prerequisite I E 305 and course in basic statistics.
Systems view of projects and the processes by which they are implemented. Focuses on qualitative and quantitative tools and techniques of project management. Topics will include organizational structure types; project selection methodologies; simulation and optimization; and earned value management. Case studies will be included, and a group project required.

I E 571: Occupational Biomechanics
(3-0) Cr. 3.
Prereq: Course in statics such as C E 274

I E 572: Design and Evaluation of Human-Computer Interaction
(Dual-listed with I E 472). (3-0) Cr. 3.
Prereq: I E 271 or graduate classification
Human factors methods applied to interface requirements, design, prototyping, and evaluation. Concepts related to understanding user characteristics, design principles, usability analysis, methods and techniques for design and evaluation of the interface. The evaluation and design of the information presentation characteristics of a wide variety of interfaces: web sites (e-commerce), mobile applications, and information presentation systems (cockpits, instrumentation, etc.).

I E 576: Human Factors in Product Design
(3-0) Cr. 3.
Prereq: I E 572 or I E 577
Investigation of the human interface to consumer and industrial systems and products, providing a basis for their design and evaluation. Discussions of human factors in the product design process: modeling the human during product use; usability; human factors methods in product design evaluation; user-device interface; safety, warnings, and instructions for products; considerations for human factors in the design of products for international use.
I E 577: Human Factors
(3-0) Cr. 3.
Prereq: IE 271 or graduate classification
Physical and psychological factors affecting human performance in systems. Signal detection theory, human reliability modeling, information theory, and performance shaping applied to safety, reliability, productivity, stress reduction, training, and human/equipment interface design. Laboratory assignments related to system design and operation.

I E 581: e-Commerce Systems Engineering
(Dual-listed with IE 481). (3-0) Cr. 3.
Prereq: IE 148
Design, analysis, and implementation of e-commerce systems. Information infrastructure, enterprise models, enterprise processes, enterprise views. Data structures and algorithms used in e-commerce systems, SQL, exchange protocols, client/server model, web-based views.

I E 582: Enterprise Modeling and Integration
(3-0) Cr. 3.
Prereq: 3 credits in information technology or information systems
The design and analysis of enterprise models to support information engineering of enterprise-wide systems. Representation of system behavior and structure including process modeling, information modeling, and conceptual modeling. Applications in enterprise application integration, enterprise resource planning systems, product data management systems, and manufacturing execution systems.

I E 583: Data Mining
(Dual-listed with IE 483). (3-0) Cr. 3.
Prereq: IE 148, IE 312, and STAT 231
Foundations of classification, data clustering and association rule mining. Techniques for data mining, with focus on tree-based methods for classification (simple trees, random forest and boosted trees), ensemble learning, optimization algorithms and deep learning with neural networks. Performance metrics and resampling methods for evaluating model quality. A computing project in R is required.

I E 585: Requirements and Architecture Engineering
(3-0) Cr. 3.
Prereq: 3 credits in information technology or information systems
Principles and practices for requirements engineering as part of the product development process with emphasis on software systems engineering. Problem definition, problem analysis, requirements analysis, requirements elicitation, validation, specifications. Case studies using requirements engineering methods and techniques.

I E 587: Big Data Analytics and Optimization
(Dual-listed with IE 487). Cr. 3. S.
Prereq: IE 312, Stat 231

I E 588: Information Systems for Manufacturing
(3-0) Cr. 3.
Prereq: IE 148, IE 448
Design and implementation of systems for the collection, maintenance, and usage of information needed for manufacturing operations, such as process control, quality, process definition, production definitions, inventory, and plant maintenance. Topics include interfacing with multiple data sources, methods to utilize the information to improve the process, system architectures, and maintaining adequate and accurate data for entities internal and external to the enterprise to achieve best manufacturing practices.

I E 590: Special Topics
Cr. 1-3. Repeatable.
Advanced study of a research topic in the field of industrial engineering.

I E 599: Creative Component
Cr. arr.
Offered on a satisfactory-fail basis only.

Courses for graduate students:

I E 613: Stochastic Production Systems
(3-0) Cr. 3.
Prereq: IE 513
Modeling techniques to evaluate performance and address issues in design, control, and operation of systems. Markov models of single-stage make-to-order and make-to-stock systems. Approximations for non-Markovian systems. Impact of variability on flow lines. Open and closed queuing networks.

I E 631: Nonlinear Programming
(3-0) Cr. 3.
Prereq: IE 534
Develop nonlinear models, convex sets and functions, optimality conditions, Lagrangian duality, unconstrained minimization techniques. Constrained minimization techniques covering penalty and barrier functions, sequential quadratic programming, the reduced gradient method, nonlinear control concepts.
I E 632: Integer Programming
(3-0) Cr. 3.
Prereq: I E 534
Integer programming including cutting planes, branch and bound, and Lagrangian relaxation. Introduction to complexity issues and search-based heuristics.

I E 633: Stochastic Programming
(3-0) Cr. 3.
Prereq: I E 513 or STAT 447, I E 534 or equivalent
Mathematical programming with uncertain parameters; modeling risk within optimization; multi-stage recourse and probabilistically constrained models; solution and approximation algorithms including Benders decomposition and progressive hedging; and applications to planning, allocation and design problems.

I E 634: Computational Optimization
(3-0) Cr. 3.
Prereq: I E 534 or equivalent.
Theory, algorithm, and computer implementation of optimization models. Simplex, Benders decomposition, computational complexity, mixed integer linear program, linear program with complementarity constraints, inverse optimization, bilevel discrete optimization. Open source and commercial optimization solvers will be introduced and used.

I E 642: Simultaneous Engineering in Manufacturing Systems
(3-0) Cr. 3.
Prereq: I E 549 or M E 415
Current engineering methods for the product life cycle process. Feature-based design, computer-aided process planning, and data-driven product engineering.

I E 671: Research Practicum in Human Factors and Ergonomics
(3-0) Cr. 3. Repeatable.
Prereq: I E 571 or I E 577 or IE 572
Research topic development, literature evaluation, experimental design, use of bioinstrumentation, data collection, basic data interpretation, statistical analysis, manuscript preparation.

I E 672: Human Factors in Automation Design
(3-0) Cr. 3. Alt. F., offered even-numbered years.
Prereq: Graduate classification
Concepts in human-automation systems, including levels of automation, types of automation, and level of control. Implications of how adaptive automation affects error, trust, workload, situation awareness, and performance. Understand how human operators are affected by automation implementation in real-world systems. Apply human factors concepts to the design and assessments of human-automation systems.

I E 673: Spine Biomechanics
(3-0) Cr. 3. Repeatable, maximum of 3 times. Alt. F., offered odd-numbered years.
Prereq: I E 571 or equivalent
Gross and fine anatomy of spine, mechanism of pain, epidemiology, in vitro testing, psychophysical studies, spine stability models, bioinstrumentation: intradiscal pressure, intra-abdominal pressure and electromyography. Biomechanics of lifting and twisting, effects of vibration, effects of posture/lifting style, lifting belts, physical models, optimization models, mathematical models, muscle models, finite element models, current trends in medical management and rehabilitation, chiropractic.

I E 681: Cognitive Engineering
(Cross-listed with HCI). (3-0) Cr. 3.
Prereq: I E 572 or I E 577 or PSYCH 516 or HCI/PSYCH 521 or equivalent
Provides an overview of human cognitive capabilities and limitations in the design of products, work places, and large systems. Contexts vary broadly and could range from simple use of mobile devices to an air-traffic control or nuclear plant command center. Course focuses on what we can infer about users’ thoughts and feelings based on what we can measure about their performance and physiological state. Covers the challenge of designing automated systems.

I E 690: Advanced Topics
Cr. 1-3. Repeatable.
Prereq: Permission of the instructor
Advanced topics related to Ph.D. research in industrial engineering under the direction of the instructor.

I E 697: Engineering Internship
Cr. R. Repeatable. F.S.SS.
Prereq: Permission of department
One Fall OR Spring semester combined with one summer, maximum per academic year. Excludes Fall/Spring combination. Professional work period. Offered satisfactory/fail basis only. (With Instructor Permission). Offered on a satisfactory-fail basis only.

I E 699: Research
Cr. arr. Repeatable.