Industrial Engineering

Administered by the Department of Industrial and Manufacturing Systems Engineering

Undergraduate Study

For the undergraduate curriculum in industrial engineering leading to the degree bachelor of science. The Industrial Engineering Program of this curriculum is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org/ .

The Industrial Engineering (IE) Program educates its future graduates to accomplish its educational objectives in their early careers. Specifically, the IE curriculum prepares its majors so that, within a few years after graduation, graduates' attainments are

1. industrial engineering decisions that result in well-reasoned, value-added solutions.

2. communications with stakeholders that are informative, persuasive, and constructive.

3. contributions to team goals through effective team interactions and leadership.

4. new skills and knowledge that advance professional practice and enable career advancement.

Details on industrial engineering program outcomes that foster the attainment of these objectives are available at appropriate sections of: www.imse.iastate.edu

The industrial engineering undergraduate curriculum provides students with fundamental knowledge in mathematics and science, engineering science, social science, and humanities as well as professional industrial engineering course work. Management electives provide students with an opportunity to become familiar with modern business practices that they will encounter in their career. A senior capstone design course provides students with an opportunity to solve open-ended industrial problems with an industrial partner. The cooperative education program provides students with real world experience in the profession and a good perspective on career choices. Students are encouraged to participate in international experiences through exchange programs and industrial internships.

Qualified juniors and seniors interested in graduate studies may apply to the Graduate College to concurrently pursue both B.S. and M.S. or M.Eng. degrees in Industrial Engineering, or B.S. and M.B.A. degrees.

Engineering Sales

The Engineering Sales Minor is multidisciplinary and open to undergraduates in the College of Engineering. The minor is earned by completing 15 credits including:

I E 450	Technical Sales for Engineers I	3
I E 451	Technical Sales for Engineers II	3
MKT 340	Principles of Marketing	3
MKT 343	Personal Sales	3
And one of the following:		3
I E 305	Engineering Economic Analysis	
FIN 301	Principles of Finance	
Total Credits		15

The minor must include at least 9 credits that are not used to meet any other department, college, or university requirement.

Graduate Study

The department offers programs for the degrees master of engineering, master of science and doctor of philosophy with a major in industrial engineering. A formal minor is available at the M.S. and Ph.D. levels to graduate students having a major in another department. The M.Eng. degree consists of coursework designed to improve professional expertise in industrial engineering. The M.S. and Ph.D. degrees are designed to improve the student's capability to conduct research as well as their professional expertise.

The prerequisite to major graduate work is the completion of a curriculum similar to that required of undergraduate students in engineering at this institution. Because of the diversity of industrial engineering topics, it is possible for a student to qualify for graduate study even though undergraduate or prior graduate training has been in a discipline other than engineering; e.g., mathematics or physics. However, completion of a calculus sequence through differential equations is required.

With the help of a program of study committee, a graduate student develops an educational program in areas within industrial engineering. Typical areas of concentration include ergonomics/human factors, engineering management, human computer interfaces, advanced manufacturing systems, operations research, and information engineering.

The department also offers master of engineering degrees in systems engineering and engineering management. These degrees are designed to prepare engineers for leadership/management positions within their organizations. Students gain the knowledge and skills necessary to manage and develop a highly qualified and trained staff of engineers, scientists, and technicians in a rapidly changing technological environment.

The department offers a certificate in advanced manufacturing, in collaboration with the mechanical engineering department, which consists of four graduate courses selected from an approved list in both departments.

For additional information about graduate degree programs, admission criteria, and procedures refer to https://www.imse.iastate.edu/graduate-program/ .

Curriculum in Industrial Engineering

Administered by the Department of Industrial and Manufacturing Systems Engineering.

Leading to the degree bachelor of science.

Total credits required: 122 cr. See also Basic Program and Special Programs. Transfer credit with a grade less than a C will not be approved for application to the program.

International Perspectives: 3 cr. [1]

U.S. Diversity: 3 cr. [1]

Communication Proficiency/Library requirements: 7 cr.

ENGL 150	Critical Thinking and Communication *	3
ENGL 250	Written, Oral, Visual, and Electronic Composition *	3
LIB 160	Information Literacy	1
Total Credits		7

* minimum grade of C

Remaining Communication courses: 6 cr.

ENGL 314	Technical Communication	3
SP CM 212	Fundamentals of Public Speaking	3
Total Credits		6

Social Sciences and Humanities Electives: 12 cr. [2]

Six of twelve credits must be from 200-level or above courses. Six credits must be sequential or related courses.

Basic Program: 27 cr. [3,4]

CHEM 167	General Chemistry for Engineering Students	4
ENGL 150	Critical Thinking and Communication	3
ENGL 250	Written, Oral, Visual, and Electronic Composition (see above for grade requirements)	3
ENGR 101	Engineering Orientation	R
I E 148	Information Engineering [3]	3
LIB 160	Information Literacy	1
MATH 165	Calculus I	4
MATH 166	Calculus II	4
PHYS 221	Introduction to Classical Physics I (see Basic Program rule)	5
Total Credits		27

Math and Physical Science: 17 cr.

MATH 265	Calculus III	4
MATH 267	Elementary Differential Equations and Laplace Transforms	4
PHYS 222	Introduction to Classical Physics II	5

STAT 231	Probability and Statistical Inference for Engineers	4
Total Credits		17

Industrial Engineering Core: 31 cr. [4]

I E 248	Engineering System Design, Manufacturing Processes and Specifications	3
I E 271	Applied Ergonomics and Work Design	3
I E 305	Engineering Economic Analysis	3
I E 312	Optimization	3
I E 413	Stochastic Modeling, Analysis and Simulation	4
I E 341	Production Systems	3
I E 348	Solidification Processes	3
I E 361	Statistical Quality Assurance	3
I E 441	Industrial Engineering Design	3
I E 448	Manufacturing Systems Engineering	3
Total Credits		31

Other Remaining Courses: 29 cr. [2]

MAT E 273	Principles of Materials Science and Engineering	3
E M 274	Statics of Engineering	3
E E 442	Introduction to Circuits and Instruments	2
M E 231	Engineering Thermodynamics I	3
Focus Electives		6
Management Electives		6
Engineering Topic Electives		6
Total Credits		29

Seminar/Co-op/Internships:

I E 101 Industrial Engineering Profession, R cr. Optional co-op/internship courses.

1. These university requirements will add to the minimum credits of the program unless the university-approved courses are also allowed by the department to meet other course requirements within the degree program. U.S. diversity and international perspectives courses may not be taken Pass/Not Pass.
2. For Social Sciences and Humanities, Focus, Management, and Engineering Topic Electives, choose from the department approved list.
3. See Basic Program for Professional Engineering Curricula for accepted substitutions for curriculum designated courses in the Basic Program.
4. 2.00 required including transfer courses.
5. 4-Year Plan of Study for Industrial Engineering. (https://nextcatalog.registrar.iastate.edu/planofstudy/engineering/#industrialengineeringbs)

Note: The Industrial and Manufacturing Systems Engineering Department requires a grade of C or better for any transfer credit course that is applied to the degree program.

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.

I E 148. Information Engineering.
(2-2) Cr. 3. F.S. *Prereq: Credit or enrollment in MATH 142*
Development of information solutions for engineering problems. Fundamentals of the software development process. Engineering computations and the human/computer interface. Data models and database development. Program connectivity and network applications.

I E 222. Design & Analysis Methods for System Improvements.
(3-0) Cr. 3. S. *Prereq: I E 248; credit or 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, inventory and waste minimization. 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: MATH 166 and PHYS 221. Credit or enrollment in I E 101 and MAT E 273.*
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 221*
Basic concepts of ergonomics and work design. Their impact on worker and work place productivity, and cost. Investigations of work physiology, biomechanics, anthropometry, work methods, and their measurement as they relate to the design of human-machine systems.

I E 298. Cooperative Education.
Cr. R. F.S.SS. *Prereq: Permission of department and Engineering Career Services*
First professional work period in the cooperative education program. Students must register for this course before commencing work.

I E 305. Engineering Economic Analysis.
(3-0) Cr. 3. F.S.SS. *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. Nonmajor graduate credit.

I E 312. Optimization.
(3-0) Cr. 3. F. *Prereq: Credit or 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. Nonmajor graduate credit.

I E 341. Production Systems.
(3-0) Cr. 3. F. *Prereq: STAT 231; credit or enrollment in I E 312*
Introduction of key concepts in the design and analysis of production systems. Topics include inventory control, forecasting, material requirement planning, project planning and scheduling, operations scheduling, and other production systems such as Just-In-Time (JIT), warehousing, and global supply chains. Nonmajor graduate credit.

I E 348. Solidification Processes.
(2-2) Cr. 3. S. *Prereq: I E 248 and Mat E 273.*
Theory and applications related to metal casting, welding, polymer processing, powder metallurgy, and composites manufacturing. Nonmajor graduate credit.

I E 361. Statistical Quality Assurance.
(Cross-listed with STAT). (2-2) Cr. 3. F.S. *Prereq: STAT 231, STAT 301, STAT 326 or STAT 401*
Statistical methods for process improvement. Simple quality assurance principles and tools. Measurement system precision and accuracy assessment. Control charts. Process capability assessment. Experimental design and analysis for process improvement. Significant external project in process improvement. Nonmajor graduate credit.

I E 396. Summer Internship.
Cr. R. Repeatable. SS. *Prereq: Permission of department and Engineering Career Services*
Summer professional work period.

I E 397. Engineering Internship.
Cr. R. Repeatable. F.S. *Prereq: Permission of department and Engineering Career Services*
Professional work period for a maximum of one semester per academic year. Offered on a satisfactory-fail basis only.

I E 398. Cooperative Education.
Cr. R. F.S.SS. *Prereq: I E 298, permission of department and Engineering Career Services*
Second professional work period in the cooperative education program. Students must register for this course before commencing work. Offered on a satisfactory-fail basis only.

I E 403. Introduction to Sustainable Production Systems.
(Dual-listed with I E 503). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: Credit or 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 413. Stochastic Modeling, Analysis and Simulation.
(4-0) Cr. 4. F. *Prereq: MATH 267, STAT 231*
Development and analysis of simulation models using a simulation language. Application to various areas of manufacturing and service systems such as assembly, material handling, and customer queues. Utilizing model output to make important business decisions. Fitting of data to statistical distributions. Introduction to Markov processes and other queuing models. Nonmajor graduate credit.

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. Nonmajor graduate credit.

I E 446. Geometric Variability in Manufacturing.
(Dual-listed with I E 546). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: I E 348, or MAT E 216, or M E 324*
Assessment, accommodation, and control of geometric variability of manufacturing processes. Use of CMMs, vision and scanning systems, and prolifometers. Techniques to successfully accommodate variation through design of product, tooling or process plan including plastic injection molding, metalcasting, welding, machining, powder metallurgy. Methodologies to control geometric variability.

I E 448. Manufacturing Systems Engineering.
(3-0) Cr. 3. S. *Prereq: I E 248, I E 305*
Fixturing and tooling requirements for manufacturing process planning, geometric dimensioning and tolerancing, computer aided inspection, cellular and flexible manufacturing, and facility layout. Lean manufacturing principles and controlled flow production. Nonmajor graduate credit.

I E 449. Computer Aided Design and Manufacturing.
(Dual-listed with I E 549). (3-0) Cr. 3. Alt. F., offered 2012. *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 I.
(3-0) Cr. 3. F. *Prereq: Credit or 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. Nonmajor graduate credit.

I E 451. Technical Sales for Engineers II.
(3-0) Cr. 3. S. *Prereq: I E 450*
Case studies and experiential lessons on the development and application of technical sales strategies. Specific topics include developing pricing and distribution strategies, managing a sales staff and channel, developing sales teams and global sales plans, bid and negotiation strategies, time management skills, and implementing sales automation technologies. Nonmajor graduate credit.

I E 466. Multidisciplinary Engineering Design.
(Cross-listed with A E, AER E, CPR E, E E, ENGR, M E, MAT E). (1-4) Cr. 3. Repeatable. F.S. *Prereq: Student must be within two semesters of graduation and receive permission of instructor*
Application of team design concepts to projects of a multidisciplinary nature. Concurrent treatment of design, manufacturing, and life cycle considerations. Application of design tools such as CAD, CAM, and FEM. Design methodologies, project scheduling, cost estimating, quality control, manufacturing processes. Development of a prototype and appropriate documentation in the form of written reports, oral presentations and computer models and engineering drawings.

I E 467. Multidisciplinary Engineering Design II.
(Cross-listed with AER E, CPR E, E E, ENGR, MAT E, M E). (1-4) Cr. 3. Repeatable, maximum of 2 times. F.S. *Prereq: Student must be within two semesters of graduation or receive permission of instructor.*
Build and test of a conceptual design. Detail design, manufacturability, test criteria and procedures. Application of design tools such as CAD and CAM and manufacturing techniques such as rapid prototyping. Development and testing of a full-scale prototype with appropriate documentation in the form of design journals, written reports, oral presentations and computer models and engineering drawings.

I E 481. e-Commerce Systems Engineering.
(Dual-listed with I E 581). (3-0) Cr. 3. Alt. F., offered 2012. *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. Knowledge Discovery and Data Mining.
(Dual-listed with I E 583). (3-0) Cr. 3. Alt. F., offered 2012. *Prereq: I E 148, I E 312, and STAT 231*
Introduction to data warehouses and knowledge discovery. Techniques for data mining, including probabilistic and statistical methods, genetic algorithms and neural networks, visualization techniques, and mathematical programming. Advanced topics include web-mining and mining of multimedia data. Case studies from both manufacturing and service industries. A computing project is required. Nonmajor graduate credit.

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 490A. Independent Study: Manufacturing.
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 490B. Independent Study: Human Factors.
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 490C. Independent Study: Operations Research.
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 490D. Independent Study: Enterprise Computing and Information Management.
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 490E. Independent Study: Engineering Management.
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.

I E 498. Cooperative Education.
Cr. R. Repeatable. F.S.SS. *Prereq: I E 298, permission of department and Engineering Career Services*
Third and subsequent professional work periods in the cooperative education program. Students must register for this course before commencing work. Offered on a satisfactory-fail basis only.

Courses primarily for graduate students, open to qualified undergraduates:

I E 501. M.S. Research Basics and Communications.
Cr. R. Repeatable.
Principles and practices for research tasks at the M.S. level including proposal writing, presentations, paper preparation, and project management.

I E 503. Introduction to Sustainable Production Systems.
(Dual-listed with I E 403). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: Credit or enrollment in 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. A course project is required for graduate credit.

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. Introduction to deterministic and stochastic dynamic programming.

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 401*
Event scheduling, process interaction, and continuous modeling techniques. Probability and statistics related to simulation parameters including run length, inference, design of experiments, variance reduction, and stopping rules. Aspects of simulation languages.

I E 531. Quality Control and Engineering Statistics.
(Cross-listed with STAT). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: STAT 401; STAT 342 or STAT 447*
Wu. 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 2014. *Prereq: STAT 342 or STAT 432 or STAT 447*
Meeker. 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 recurrence data; planning studies to obtain reliability data.

I E 534. Linear Programming.
(3-0) Cr. 3. *Prereq: I E 312*
Develop linear models. Theory and computational aspects of the simplex method. Duality theory and sensitivity analysis. Introduction to interior point methods and column generation. Multiobjective linear programs.

I E 537. Reliability and Safety Engineering.
(3-0) Cr. 3. *Prereq: STAT 231 or STAT 401*
Mathematical basics for dealing with reliability data, theory, and analysis. Bayesian reliability analysis. Engineering ethics in safety evaluations. Case studies of accidents in large technological systems. Fault and event tree analysis.

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 543. Wind Energy Manufacturing.
(3-0) Cr. 3. Alt. S., offered 2014. *Prereq: Undergraduate engineering degree or permission of instructor.*
Materials, processes and systems required to produce the major components (blades, towers, nacelles) of megawatt scale wind turbines. Transportation, manufacturing siting and procurement decisions as it relates to these large components in an expanding industry.

I E 545. Rapid Prototyping and Manufacturing.
(3-0) Cr. 3. *Prereq: Prereq: I E 248 or similar manufacturing engineering course, Math 265. Undergraduates: Permission of instructor.*
Introduction to rapid prototyping processes and other rapid manufacturing methodologies. Operating principles and characteristics of current and developing rapid prototyping processes. Use of rapid prototypes in product design, development, and service. Selection of rapid prototyping systems based on rapid methodologies used in manufacturing processes and rapid tooling approaches.

I E 546. Geometric Variability in Manufacturing.
(Dual-listed with I E 446). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: I E 348, or MAT E 216, or M E 324*
Assessment, accommodation, and control of geometric variability of manufacturing processes. Use of CMMs, vision and scanning systems, and prolifometers. Techniques to successfully accommodate variation through design of product, tooling or process plan including plastic injection molding, metalcasting, welding, machining, powder metallurgy. Methodologies to control geometric variability.

I E 549. Computer Aided Design and Manufacturing.
(Dual-listed with I E 449). (3-0) Cr. 3. Alt. F., offered 2012. *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 561. Continuous Quality Improvement of Process.
(3-0) Cr. 3. *Prereq: I E 361*
Methods for continuous quality improvement in process analysis. The systems analysis for process improvement model based on W. Edwards Deming. Quality function deployment methods. Case studies of applications to manufacturing and other heavy industries. Use of process analysis computerized programs and tools for design analysis.

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 570. Systems Engineering and Project Management.
(3-0) Cr. 3. *Prereq: Coursework 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. Specific systems concepts, methodologies, and tools for effective management of both simple and complex projects. Introduction of important performance parameters for planning, cost control, scheduling, and productivity, including discussions of traditional and state of the art tools and systems.

I E 571. Occupational Biomechanics.
(3-0) Cr. 3. *Prereq: E M 274, STAT 231*
Anatomical, physiological, and biomechanical bases of physical ergonomics. Anthropometry, body mechanics, strength of biomaterials, human motor control. Use of bioinstrumentation, passive industrial surveillance techniques and active risk assessment techniques. Acute injury and cumulative trauma disorders. Static and dynamic biomechanical modeling. Emphasis on low back, shoulder and hand/wrist biomechanics.

I E 572. Design and Evaluation of Human-Computer Interaction.
(3-0) Cr. 3. *Prereq: I E 577*
Human factors methods applied to interface design, prototyping, and evaluation. Concepts related to understanding user characteristics, 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), computer games, information presentation systems (cockpits, instrumentation, etc.), and desktop virtual reality.

I E 576. Human Factors in Product Design.
(3-0) Cr. 3. *Prereq: 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: I E 271, STAT 231 or STAT 401*
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 I E 481). (3-0) Cr. 3. Alt. F., offered 2012. *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 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. Knowledge Discovery and Data Mining.
(Dual-listed with I E 483). (3-0) Cr. 3. Alt. F., offered 2012. *Prereq: I E 148, I E 312, and STAT 231*
Introduction to data warehouses and knowledge discovery. Techniques for data mining, including probabilistic and statistical methods, genetic algorithms and neural networks, visualization techniques, and mathematical programming. Advanced topics include web-mining and mining of multimedia data. Case studies from both manufacturing and service industries. A computing project and an additional project with more theoretical content are required.

I E 585. Requirements 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 588. Information Systems for Manufacturing.
(3-0) Cr. 3. *Prereq: I E 148, I E 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. Repeatable.

I E 599A. Creative Component: Industrial Engineering.
Cr. arr. Repeatable.

I E 599C. Creative Component: Operations Research.
Cr. arr. Repeatable.

Courses for graduate students:

I E 601. Ph.D. Research Basics and Communications.
Cr. R. Repeatable.
Principles and practices for conducting research at the Ph.D. level, including problem definition, proposal writing, presentations, conference proceedings, paper preparation, and project management.

I E 613. Stochastic Production Systems.
(3-0) Cr. 3. *Prereq: I E 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: I E 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.

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 634. Computational Optimization.
(3-0) Cr. 3. Alt. S., offered 2014. *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. CPLEX, Matlab, and Tomlab will be used for computer implementation.

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 Ergonomics.
(3-0) Cr. 3. Repeatable. *Prereq: I E 571 or I E 577*
Ergonomics research topic development, literature evaluation, experimental design, use of bioinstrumentation, data collection, basic data interpretation, statistical analysis, manuscript preparation.

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*
Professional work period for a maximum of one semester per academic year. Offered on a satisfactory-fail basis only.

I E 699. Research.
Cr. arr. Repeatable.

I E 699A. Research: Industrial Engineering.
Cr. arr. Repeatable.

I E 699C. Research: Operations Research.
Cr. arr. Repeatable.