**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 of 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:

- IE 450 Technical Sales for Engineers I (3 cr.
- IE 451 Technical Sales for Engineers II (3 cr.
- MKT 340 Principles of Marketing (3 cr.
- MKT 343 Personal Sales (3 cr.
- And one of the following: (3 cr.
  - IE 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 of 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 of 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.

#### Communication Proficiency/Library requirements: 7 cr.

- ENGL 150 Critical Thinking and Communication (3 cr.
- ENGL 250 Written, Oral, Visual, and Electronic Composition (3 cr.
- LIB 160 Information Literacy (1 cr.

Total Credits: 7

#### Remaining Communication courses: 6 cr.

- ENGL 314 Technical Communication (3 cr.
- SP CM 212 Fundamentals of Public Speaking (3 cr.

Total Credits: 6

#### Social Sciences and Humanities Electives: 12 cr.

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

#### Basic Program: 27 cr.

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

Total Credits: 27

#### Math and Physical Science: 17 cr.

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

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\* minimum grade of C

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to analyze and quantify the impact of changes.

Study of system improvement methods and strategies. Specific areas of lean
systems, just-in-time, lean work stations, and continuous improvement methods.

(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
systems 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.

(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.

(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 profilometers. 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.

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.

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.

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:

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.

(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.

(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

I E 537. Reliability and Safety Engineering.
(3-0) Cr. 3. Prereq: STAT 231 or STAT 401
IE 571. Occupational Biomechanics. (3-0) Cr. 3. Prereq: E M 274, STAT 231

IE 572. Design and Evaluation of Human-Computer Interaction. (3-0) Cr. 3. Prereq: IE 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.

IE 576. Human Factors in Product Design. (3-0) Cr. 3. Prereq: IE 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.

IE 577. Human Factors. (3-0) Cr. 3. Prereq: IE 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.

IE 581. e-Commerce Systems Engineering. (Dual-listed with IE 481), (3-0) Cr. 3. Alt. F., offered 2012. 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.

IE 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.

IE 583. Knowledge Discovery and Data Mining. (Dual-listed with IE 483), (3-0) Cr. 3. Alt. F., offered 2012. Prereq: IE 148, IE 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.

IE 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.

IE 586. 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 accurate and adequate data for entities internal and external to the enterprise to achieve best manufacturing practices.


IE 599. Creative Component. Cr. arr. Repeatable.


Courses for graduate students:


IE 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.

IE 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.

IE 632. Integer Programming. (3-0) Cr. 3. Prereq: IE 534
Integer programming including cutting planes, branch and bound, and Lagrangian relaxation. Introduction to complexity issues and search-based heuristics.

IE 634. Computational Optimization. (3-0) Cr. 3. Alt. S., offered 2014. Prereq: IE 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.

IE 642. Simultaneous Engineering in Manufacturing Systems. (3-0) Cr. 3. Prereq: IE 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.

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

IE 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.

IE 697. Engineering Internship. Cr. R. Repeatable. F.S.S. Prereq: Permission of department Professional work period for a maximum of one semester per academic year. Offered on a satisfactory-fail basis only.

