

Industrial Engineering (IE)

IE 1990. Elective. (1-4 Hours)

Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

IE 2310. Introduction to Industrial Engineering. (4 Hours)

Provides an overview of the history of industrial engineering and of the most common methods that industrial engineers use to solve problems and design efficient processes. The emphasis is on how these methods are used to study, improve, and/or optimize a product or process. Topics include work design, ergonomic design, engineering statistics, quality engineering, engineering economics, project management, and process optimization. Also discusses the design of the production processes, facilities, and material handling systems. Studies applications in manufacturing, product design, and service industries. Laboratory experiments and written reports are required.

Prerequisite(s): MATH 1340 with a minimum grade of D- or MATH 1341 with a minimum grade of D-

Corequisite(s): IE 2311

Attribute(s): NUpath Writing Intensive

IE 2311. Recitation for IE 2310. (0 Hours)

Provides small group demonstration and hands-on labs for IE 2310.

Corequisite(s): IE 2310

IE 2990. Elective. (1-4 Hours)

Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

IE 3412. Engineering Probability and Statistics. (4 Hours)

Presents probability theory axiomatically, with emphasis on sample space presentation of continuous and discrete random variables. Covers descriptive statistics, expected value of random variables, covariance and correlation, sampling distribution, and point and interval estimations. Introduces hypothesis testing including tests for means, variances, and proportions.

Prerequisite(s): MATH 2321 with a minimum grade of D-

Attribute(s): NUpath Analyzing/Using Data

IE 3425. Engineering Database Systems. (4 Hours)

Examines the representation of data and its creation and management in engineering enterprises. Discusses the client/server model of database access. Presents the fundamentals of data modeling and management, data mining and warehousing, multitier applications, and the use of the SQL query language. Emphasizes the use and applications of database systems in engineering including design and manufacturing. Topics include design schema of tables, records and fields of databases, SQL statements, security issues, and the use of a scripting language such as Perl or Visual Basic.

Prerequisite(s): GE 1111 with a minimum grade of D- or GE 1502 with a minimum grade of D-

Corequisite(s): IE 3426

IE 3426. Recitation for IE 3425. (0 Hours)

Provides small group demonstration and problem solving for IE 3425.

Corequisite(s): IE 3425

IE 3500. Introduction to Healthcare Systems Engineering. (4 Hours)

Introduces systems engineering methods in healthcare system applications for students who are not industrial engineering majors. Using principles drawn from operations research and industrial engineering, this course focuses on analysis, design, management, and control of health systems (e.g., hospitals, emergency departments, surgery departments, and outpatient clinics) and processes which are critical to the delivery of quality healthcare. Topics include an overview of queueing, simulation, data envelopment analysis, and spreadsheet modeling as applied to real-world healthcare problems such as staffing and scheduling, resource allocation, patient flow management, process improvement, and medical decision making.

Prerequisite(s): IE 3412 with a minimum grade of D- or MATH 3081 with a minimum grade of D- or PHTH 2210 with a minimum grade of D- or MGSC 2301 with a minimum grade of D-

IE 3990. Elective. (1-4 Hours)

Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

IE 4510. Simulation Modeling and Analysis. (4 Hours)

Covers process model design and development, validation, and experimentation for discrete-event simulation models. Topics include problem formulation, data collection and analysis, random-variable generation, model development, scenario experimentation, statistical analysis of output, and resultant decision management. Utilizes a major industry-standard simulation software application with animation capabilities.

Prerequisite(s): (GE 1111 with a minimum grade of D- or GE 1502 with a minimum grade of D-); (IE 3412 with a minimum grade of D- or MATH 3081 with a minimum grade of D-)

IE 4512. Engineering Economy. (4 Hours)

Introduces students to economic modeling and analysis techniques for selecting alternatives from potential solutions to an engineering problem. Presents basic methods of economic comparison such as present worth, annual worth, rate of return, and benefit/cost techniques. Studies effects of taxes on investment analysis. Also covers decision tree analysis and statistical decision techniques.

IE 4515. Operations Research. (4 Hours)

Introduces deterministic models including linear programming; duality and postoptimality analysis; transportation and assignment problems; and network flow problems such as the shortest path, minimum spanning tree, and maximum flow.

Prerequisite(s): MATH 2341 with a minimum grade of D-

IE 4516. Quality Assurance. (4 Hours)

Reviews the distributions and statistical approximations commonly applied in statistical quality control methods. Introduces analysis of variance and simple linear regression. Covers basic principles to state-of-the-art concepts and application of statistical process control and design. Applies principles to a variety of products. Topics include product quality measures and controls, Shewhart control charts, quality cost, Pareto analysis, discrete and variable sampling, and military standards in quality control.

Prerequisite(s): IE 3412 with a minimum grade of D- or MATH 3081 with a minimum grade of D-

IE 4520. Stochastic Modeling. (4 Hours)

Covers the analytical development and solution to stochastic models in operations research. Topics include Markov chains, queuing theory, and dynamic programming.

Prerequisite(s): IE 3412 with a minimum grade of D- or MATH 3081 with a minimum grade of D-

IE 4522. Human-Machine Systems. (4 Hours)

Emphasizes and addresses human sensory and motor performance, information processing, learning and training methodology, skilled-task development, psychophysical models, response time, and relevant aspects of attention and memory. Topics include system design and development, hazard and error evaluation, and properties of effective visual displays. Endorses experimentation as a source of knowledge of human performance characteristics. Covers research and statistical analyses related to human-asset engineering, fundamentals of vision, audition, somesthesia, signal detection, and some aging effects. Safety and usability of environments, machines, products, and devices consider principles of human-machine interaction, decision making, and anthropometric characteristics. Laboratory experiences include literature review, experimental design, data collection and analysis, hypothesis testing, and generation of reports to inform the design of safe, usable, and marketable engineering products, processes, and systems.

Prerequisite(s): (IE 3412 with a minimum grade of D- or MATH 3081 with a minimum grade of D-); (ENGL 1111 with a minimum grade of C or ENGL 1102 with a minimum grade of C or ENGW 1111 with a minimum grade of C or ENGW 1102 with a minimum grade of C)

Corequisite(s): IE 4523

IE 4523. Lab for IE 4522. (1 Hour)

Accompanies IE 4522. Covers topics from the course through various activities.

Corequisite(s): IE 4522

IE 4525. Logistics and Supply Chain Management. (4 Hours)

Introduces the analysis, design, control, and operation of logistics and supply chain management systems. Includes the integration of supply chain components, logistics information systems, forecasting, production scheduling, inventory management, transportation and warehousing, and facility location planning.

Prerequisite(s): (IE 3412 with a minimum grade of D- or MATH 3081 with a minimum grade of D-); IE 4515 with a minimum grade of D-

IE 4530. Manufacturing Systems and Techniques. (4 Hours)

Focuses on manufacturing and design and their impact on each other. Covers the basics of design-manufacturing integration, manufacturing systems, manufacturing processes and techniques, manufacturing automation, and production planning and control. Topics include concurrent engineering, design for assembly, design for manufacturability, rapid prototyping, mechanical tolerancing, bill of materials, group technology, computer-aided process planning, NC part programming, programmable logic controllers, flexible manufacturing systems, computer-integrated manufacturing, and just-in-time philosophy. Topics also include traditional manufacturing processes such as casting, forming, machining, welding, molding, and particulate processing, and nontraditional manufacturing processes such as electrical discharge machining, laser machining, and water-jet machining. Students are required to conduct manufacturing-related experiments in the manufacturing lab to gain hands-on experience.

Corequisite(s): IE 4531

IE 4531. Lab for IE 4530. (1 Hour)

Accompanies IE 4530. Covers topics from the course through various activities.

Corequisite(s): IE 4530

IE 4535. Human-Machine Systems in a Global Context. (5 Hours)

Introduces human-machine systems in an international setting. Offers students an opportunity to travel to a foreign country to develop theoretical understanding while experiencing the issues and human factor considerations in a global environment. Topics include human performance, information processing, learning, memory; vision, visual performance, interface display design; audition, noise, hearing, and auditory signals; human anthropometric characteristics; and cognition, usability testing, and principles of human-machine interface design. Laboratory experiences include design of experiments, data collection, analysis, and laboratory reports generation. Includes a project that focuses on applications that allow students to delve into issues that affect engineering and technology development in their host country.

Prerequisite(s): (IE 3412 with a minimum grade of D- or MATH 3081 with a minimum grade of D-); (ENGL 1111 with a minimum grade of C or ENGL 1102 with a minimum grade of C or ENGW 1111 with a minimum grade of C or ENGW 1102 with a minimum grade of C)

IE 4625. Facilities Planning and Material Handling. (4 Hours)

Explores engineering tools, techniques, and concepts for the design of facilities. The term facility is defined broadly. Industrial plants, schools, hospitals, or places in which things are produced or services are provided to a customer are all considered facilities. Provide students with a broad but practical understanding of the facilities planning and design process. The critical nature of material handling is discussed and approaches to designing optimal handling systems are examined. The tools of operations, research, statistical methods, and software applications are the focus of the problem-solving activities.

Prerequisite(s): IE 3412 with a minimum grade of D- or MATH 3081 with a minimum grade of D-

IE 4699. Special Topics in Industrial Engineering. (4 Hours)

Focuses on advanced industrial engineering project agreed upon between the student and instructor. May be repeated without limit.

IE 4990. Elective. (1-4 Hours)

Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

IE 4991. Research. (4 Hours)

Offers an opportunity to conduct research under faculty supervision.

Attribute(s): NUpath Integration Experience

IE 4993. Independent Study. (1-4 Hours)

Offers theoretical or experimental work under individual faculty supervision. May be repeated without limit.

IE 5137. Computational Modeling in Industrial Engineering. (4 Hours)

Builds computational models for industrial engineering applications. Offers students an opportunity to learn how to identify the problem, split it into subsystems, develop mathematical models of each sub-system, and implement in Python. Selected problems are specific to industrial engineering applications with examples of inventory systems, queuing systems, production planning and control, supply chain management, transportation, network flows, forecasting, scheduling, Monte Carlo simulation, regression analysis, sensitivity analysis, and decision support systems in data science and machine learning to test and learn from models. Students also have an opportunity to learn how to use Python libraries to implement the corresponding data structures and algorithms.

Prerequisite(s): GE 1111 with a minimum grade of D- or GE 1502 with a minimum grade of D- or graduate program admission

IE 5374. Special Topics in Industrial Engineering. (4 Hours)

Offers topics of current interest in industrial engineering. May be repeated up to two times.

IE 5390. Structured Data Analytics for Industrial Engineering. (4 Hours)

Covers fundamental knowledge and skills for using structured data analytics for IE applications. Offers students an opportunity to learn data cleaning and preparation, as well as analytics of data sets, and coding in VBA (writing macros and creating GUI), both as a driver of spreadsheet formulas and as a stand-alone programming language. A final project involves the development and presentation of a structured data analytics application that addresses industrial engineering concepts.

Prerequisite(s): (IE 4515 with a minimum grade of D- or OR 6205 with a minimum grade of C-); (IE 3412 with a minimum grade of D- or IE 6200 with a minimum grade of C-)

IE 5400. Healthcare Systems Modeling and Analysis. (4 Hours)

Discusses the key functions of healthcare operations management, such as patient and process flow, process improvement, facility layout, staffing and scheduling, capacity planning, and resource allocation. Focuses on analysis, design, management, and control of health systems and processes that are necessary to provide clinical care. The applications of systems engineering methods, such as optimization, simulation, and queuing models, are discussed through papers and case studies in different care settings (e.g., hospitals, emergency departments, surgery departments, and outpatient clinics) for different diseases (e.g. diabetes, cancer, mental health, cardiovascular disease). Uses spreadsheet tools to model and solve simulation and optimization problems. Requires equivalent course work if prerequisites are not met.

Prerequisite(s): IE 4515 with a minimum grade of D- or OR 6205 with a minimum grade of C-

IE 5500. Systems Engineering in Public Programs. (4 Hours)

Introduces the design, development, analysis, and application of mathematical modeling for addressing public programs and societal needs. Systems engineering and mathematical models form the basis for decision making in both public and private applications. Focusing on societal applications, offers students an opportunity to discover how to incorporate public objectives and characteristics of large systems in the development of models and policies. Examines applications in the operation of public programs (e.g., public health systems, government programs) and public safety (e.g., security, emergency preparedness, and disaster response). Modeling techniques include game theory, data envelopment analysis, cost-benefit analysis, simulation, differential equations, and stochastic optimization. Requires equivalent course work if prerequisites are not met.

Prerequisite(s): (IE 4515 with a minimum grade of D- or OR 6205 with a minimum grade of C-); (IE 3412 with a minimum grade of D- or IE 5374 with a minimum grade of D- or MATH 3081 with a minimum grade of D- or IE 5374 with a minimum grade of C- (Graduate) or IE 6200 with a minimum grade of C-)

IE 5617. Lean Concepts and Applications. (4 Hours)

Covers the fundamentals of lean thinking and how to apply this knowledge to practical problems. Lean thinking is imperative for organizations aspiring to stay competitive in global markets. It calls for process changes to eliminate waste, shorten product delivery time, improve product quality, and curtail costs, while improving customer satisfaction. Offers students an opportunity to learn concepts, a kit of process improvement tools, implementation methods, and best practices for lean workforce development. Makes extensive use of active learning exercises and simulations, and case studies from different disciplines, to help students learn how lean principles are applied in manufacturing and also in less traditional areas such as knowledge work and healthcare systems.

Corequisite(s): IE 5618

IE 5618. Recitation for IE 5617. (0 Hours)

Accompanies IE 5617. Provides small group demonstrations, exercises, and team activities.

Corequisite(s): IE 5617

IE 5620. Mass Customization. (4 Hours)

Provides students with conceptual understanding and implementation strategies of mass customization (MC). MC is both a business and production paradigm where a company provides the customers with goods and services that suit their individual needs but does so with the efficiency and costs of mass production. MC is important in many sectors including computers, automotive, healthcare, banking, insurance, and tourism. It is based on principles of industrial engineering, mechanical engineering, management science, and marketing. Topics include typology of mass-customized production systems, manufacturing processes for MC, information needs of MC, customer focus, marketing issues, technology enablers, implementation methods, and case studies. Methodology includes lectures, case discussions, plant visits, guest lectures, and a term project. Cross-disciplinary activities, particularly between engineering and business students, are encouraged wherever possible.

IE 5630. Biosensor and Human Behavior Measurement. (4 Hours)

Emphasizes the measurement of human behavior in complex human-machine interaction. Topics include introduction of complex human-machine interactions; research methods in complex human-machine interactions; various kinds of human psychophysiological signals/cues, including physiological cues, facial expressions, eye-gaze movement, head movement, contextual cues; human cues and behavior relationship; transducers and measurement for these human cues/signals; basic principles of biosensors; general classification of biosensors; current technologies for building biosensors; conventional transducers and new technologies including micro-/nanotechnology; general systematic design process for biosensors; application of biosensors to understand human behavior in human-machine interactions. Also introduces the latest relevant research advancements in sensor fusion, affective computing, and emotion recognition.

IE 5640. Data Mining for Engineering Applications. (4 Hours)

Introduces data mining concepts and statistics/machine learning techniques for analyzing and discovering knowledge from large data sets that occur in engineering domains such as manufacturing, healthcare, sustainability, and energy. Topics include data reduction, data exploration, data visualization, concept description, mining association rules, classification, prediction, and clustering. Discusses data mining case studies that are drawn from manufacturing, retail, healthcare, biomedical, telecommunication, and other sectors.

Prerequisite(s): IE 3412 with a minimum grade of D- or MATH 3081 with a minimum grade of D- or IE 6200 with a minimum grade of C-

IE 6200. Engineering Probability and Statistics. (4 Hours)

Studies fundamental concepts of probability. Topics include events, sample space, and discrete and continuous random variables; density functions, mass functions, cumulative probability distributions, and moment generating functions; expectation of random variables; common discrete and continuous probability distributions including binomial, Poisson, geometric, uniform, exponential, and normal; multivariate probability distributions, covariance, and independence of random variables; sampling and descriptive statistics; and parameter estimation, confidence intervals, and hypothesis testing. Also introduces analysis of variance. Requires knowledge of multivariate calculus.

IE 6300. Manufacturing Methods and Processes. (4 Hours)

Focuses on manufacturing and its relationship to design and computers. Examines the relationship between design and various aspects of manufacturing. Covers manufacturing systems, manufacturing processes, bill of materials, group technology, mechanical tolerancing, QC, SPC, QPC, TQM, process planning and CAPP, NC part programming, supply chain management, production scheduling, JIT, lean manufacturing, flexible manufacturing systems, CIM cells, and manufacturing control via, say, programmable logic controllers.

IE 6500. Human Performance. (4 Hours)

Explores a wide range of human-machine systems. Focuses on human performance, human system integration, evaluation, and applications and how they can improve productivity, efficiency, safety, and quality of work life. Involves designing of machines, operations, jobs, and work environments in systems so that they are compatible with human capabilities, characteristics, and limitations. Discusses a variety of human-machine systems and interactions, including transportation, healthcare, human-computer, human-robot, consumer products, and service industries.

IE 6600. Computation and Visualization for Analytics. (4 Hours)

Offers students an opportunity to learn how to use visualization tools and techniques for data exploration, knowledge discovery, data storytelling, and decision making in engineering, healthcare operations, manufacturing, and related applications. Covers basics of Python and R for data mining and visualization. Introduces students to static and interactive visualization charts and techniques that reveal information, patterns, interactions, and comparisons by focusing on details such as color encoding, shape selection, spatial layout, and annotation.

IE 6700. Data Management for Analytics. (4 Hours)

Covers the theory and applications of database management to support data analytics, data mining, machine learning, and artificial intelligence. Discusses the fundamental concepts and emerging technologies in database design and modeling, database systems, data storage, and the evolving world of data warehousing and data governance. Presents a balanced theory-practice focus and covers relational databases, NoSQL databases, data integration, data quality, data governance, big data, and data processing for analytics.

IE 6800. Foundations for Data Analytics Engineering. (4 Hours)

Offers topics and skills designed to prepare students for advanced courses in data analytics engineering. Covers basic concepts and implementation of methods related to probability, eigenvalues and eigenvectors, cluster analysis, text mining, and time series analysis. Offers students an opportunity to learn how to work with modern data structures and apply computational methods for data cleaning and data wrangling operations.

IE 6962. Elective. (1-4 Hours)

Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

IE 7200. Supply Chain Engineering. (4 Hours)

Presents modern quantitative techniques for designing, analyzing, managing, and improving supply chains using deterministic and probabilistic models. Topics include a macro view of supply chains, demand forecasting, aggregate planning, sequencing and scheduling, inventory analysis and control, materials requirement planning, pricing and revenue management, contracts decisions, transportation decisions, location and distribution decisions, supplier selection methods, and global supply chains.

Prerequisite(s): (IE 5374 with a minimum grade of D- or IE 5374 with a minimum grade of C- (Graduate) or IE 6200 with a minimum grade of C- or MATH 7241 with a minimum grade of C); OR 6205 with a minimum grade of C-

IE 7215. Simulation Analysis. (4 Hours)

Covers elementary queuing models, simulation and modeling, simulation model design, a survey of simulation languages with one language covered in detail, input data analysis and distribution fitting, model verification and validation, output analysis and transient/steady-state response, terminating/nonterminating systems, model experimentation and optimization, random number/random variate generation, and variance reduction techniques.

Prerequisite(s): IE 5374 with a minimum grade of D or IE 5374 with a minimum grade of C (Graduate) or IE 6200 with a minimum grade of C or MATH 7241 with a minimum grade of C

IE 7270. Intelligent Manufacturing. (4 Hours)

Covers advanced and emerging topics in manufacturing. Discusses fundamentals of digital and cyber-physical manufacturing including machine communication protocols, control architectures, agent-based and holonic systems, cloud-based and service-oriented manufacturing, and applications of artificial intelligence in manufacturing.

Prerequisite(s): IE 5374 with a minimum grade of D- or IE 5374 with a minimum grade of C- (Graduate) or IE 6200 with a minimum grade of C-

IE 7275. Data Mining in Engineering. (4 Hours)

Covers the theory and applications of data mining in engineering. Reviews fundamentals and key concepts of data mining, discusses important data mining techniques, and presents algorithms for implementing these techniques. Specifically covers data mining techniques for data preprocessing, association rule extraction, classification, prediction, clustering, and complex data exploration. Discusses data mining applications in several areas, including manufacturing, healthcare, medicine, business, and other service sectors.

Prerequisite(s): IE 5374 with a minimum grade of D or IE 5374 with a minimum grade of C (Graduate) or IE 6200 with a minimum grade of C or MATH 7241 with a minimum grade of C

IE 7280. Statistical Methods in Engineering. (4 Hours)

Discusses statistical models for analysis and prediction of random phenomena. Topics include review of descriptive statistics and hypothesis testing, linear models, both regression and ANOVA. Introduces design of experiments. Covers experiments with single and multiple factors of interest, and considers experiments with high-order experimental restrictions.

Prerequisite(s): IE 5374 with a minimum grade of D or IE 5374 with a minimum grade of C (Graduate) or IE 6200 with a minimum grade of C or MATH 7241 with a minimum grade of C

IE 7285. Statistical Quality Control. (4 Hours)

Designed to study the fundamental concepts of quality planning and improvements. Studies analysis and application of modern statistical process control methods including cusum, EWMA, multivariate, and modified control charts. Covers inspection error and design of sampling plans. Topics include software quality assurance, and study of the concepts of Deming, Ishikawa, Feigenbum, and Taguchi's approach in quality planning, organization, and improvement.

Prerequisite(s): IE 6200 with a minimum grade of C or MATH 7241 with a minimum grade of C

IE 7290. Reliability Analysis and Risk Assessment. (4 Hours)

Studies principles of the methods of risk assessment and reliability analysis including fault trees, decision trees, and reliability block diagrams. Discusses classical, Bayesian, and median rank methods for analysis of components and systems reliability. Presents various factors that determine the stress and strength of components and their impact on system reliability. Uses practical applications, examples, and problems to cover a broad range of engineering fields, such as mechanical, electrical, industrial, computer, structures, and automatic control systems.

Prerequisite(s): IE 6200 with a minimum grade of C or MATH 7241 with a minimum grade of C

IE 7295. Applied Reinforcement Learning in Engineering. (4 Hours)

Covers fundamentals of reinforcement learning (RL) and its applications in engineering areas. Provides an overview of the RL concepts and important algorithms. Demonstrates applications of RL to address engineering problems in manufacturing, supply chain, healthcare, and engineering economics. Offers students an opportunity to master their skills to apply RL to practical engineering projects through a series of lab sessions.

Prerequisite(s): IE 6200 with a minimum grade of C-

IE 7300. Statistical Learning for Engineering. (4 Hours)

Covers statistical models and methods for data analytics. Reviews fundamentals and key concepts in statistical inferences and learning theory. Presents important statistical learning techniques and algorithms for implementation. Discusses ordinary least square for regression, overfitting and regularization, generalized linear models, and nonlinear and nonparametric models. Applies Bayesian statistics for classification problems. Offers theoretical aspects including the statistical learning framework, conditional probabilistic methods, and their applications in several areas including manufacturing, healthcare, and business.

Prerequisite(s): IE 6800 with a minimum grade of C-

IE 7315. Human Factors Engineering. (4 Hours)

Offers students an opportunity to acquire the necessary knowledge and skills to recognize and analyze existing or potential human factors problems and to identify, design, and possibly implement feasible solutions. Includes introduction to human factors and ergonomics; engineering anthropometry and biomechanics; physiology related to human factors and workstation design; cognition and information processing; decision making, attention, and workload; human error and accidents; human-machine interface design; controls and displays; and human factors applications in transportation, aerospace, consumer product design, and so forth.

IE 7374. Special Topics in Industrial Engineering. (4 Hours)

Offers topics of interest to the staff member conducting this class for advanced study. May be repeated without limit.

IE 7440. Industrial Engineering Leadership Challenge Project 1. (4 Hours)

Offers students an opportunity to develop and present a plan for the demonstration of a marketable technology product or prototype with an industrial-engineering focus. Constitutes the first half of a thesis-scale project in technology commercialization. Requires work/training with a sponsoring organization or employer to improve a process or develop a project that is of significant value to the organization and demonstrates a quantifiable market impact while enhancing the student's technological and engineering depth and fostering the student's leadership development.

IE 7442. Industrial Engineering Leadership Challenge Project 2. (4 Hours)

Continues IE 7440, further developing a thesis-scale project in technology commercialization. Offers students an opportunity to demonstrate their development of a marketable technology product or prototype with an industrial engineering focus and produce a written documentary report on the project to the satisfaction of an advising committee. Requires work/training with a sponsoring organization or employer to improve a process or develop a project that is of significant value to the organization and demonstrates a quantifiable market impact while enhancing the student's technological and engineering depth and fostering the student's leadership development.

Prerequisite(s): IE 7440 with a minimum grade of C-

IE 7500. Applied Natural Language Processing in Engineering. (4 Hours)

Covers fundamentals of natural language processing and its applications in engineering areas. Presents an overview of the NLP concepts and important algorithms. Demonstrates applications of NLP to address engineering problems in transportation, civil engineering, manufacturing, healthcare, business, commerce, and selected other areas of engineering. A substantial course project offers students an opportunity to solidify their skills to apply NLP to practical engineering problems.

Prerequisite(s): IE 6200 with a minimum grade of C-

IE 7615. Neural Networks and Deep Learning. (4 Hours)

Covers the theory and applications of neural networks in engineering. Reviews basics of machine learning, discusses important neural network architectures, and presents neural network training methods and algorithms. The specific neural network models covered in this course include feedforward neural networks such as deep learning architectures, radial basis function networks, support vector machines, self-organizing feature maps, and recurrent networks. Discusses neural network applications in several areas including manufacturing, healthcare, medicine, business, and diagnostics and prognostics.

IE 7945. Master's Project. (4 Hours)

Offers theoretical or experimental work under individual faculty supervision.

IE 7962. Elective. (1-4 Hours)

Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

IE 7978. Independent Study. (1-4 Hours)

Offers theoretical or experimental work under individual faculty supervision. An independent study must be petitioned and approved by the academic advisor. The petition must clearly state the reason for taking the course; a brief description of goals; as well as the expected outcomes, deliverables, and grading scheme. Master's degree students in thesis or project options are not eligible to take independent study.

IE 7986. Research. (0 Hours)

Offers students an opportunity to conduct full-time research under faculty supervision.

IE 7990. Thesis. (1-8 Hours)

Offers analytical and/or experimental work conducted under the direction of the faculty in fulfillment of the requirements for the degree. Requires first-year students to attend a graduate seminar program that introduces the students to the methods of choosing a research topic, conducting research, and preparing a thesis. Requires successful completion of the seminar program. May be repeated without limit.

IE 7996. Thesis Continuation. (0 Hours)

Continues thesis work conducted under the supervision of a departmental faculty member.

IE 8960. Candidacy Preparation—Doctoral. (0 Hours)

Offers students an opportunity to prepare for the PhD qualifying exam under faculty supervision. Intended for students who have completed all required PhD course work and have not yet achieved PhD candidacy; students who have not completed all required PhD course work are not allowed to register for this course. May be repeated once.

IE 8986. Research. (0 Hours)

Offers students an opportunity to conduct full-time research under faculty supervision. May be repeated without limit.

IE 9000. PhD Candidacy Achieved. (0 Hours)

Indicates successful completion of program requirements for PhD candidacy.

IE 9986. Research. (0 Hours)

Offers students an opportunity to conduct full-time research under faculty supervision. May be repeated without limit.

IE 9990. Dissertation Term 1. (0 Hours)

Offers dissertation supervision under individual faculty supervision.

Prerequisite(s): IE 9000 with a minimum grade of S

IE 9991. Dissertation Term 2. (0 Hours)

Offers dissertation supervision by members of the department.

Prerequisite(s): IE 9990 with a minimum grade of S

IE 9996. Dissertation Continuation. (0 Hours)

Offers continuing dissertation supervision under individual faculty supervision.

Prerequisite(s): IE 9991 with a minimum grade of S or Dissertation Check with a score of REQ