

# Descriptions of Courses

## ■ Undergraduate Courses

### IE 221 Production Management I

This course covers a background and the development of production management, plus current concepts and controls applicable to production management functions.

### IE 232 Operations Research : Stochastic Models

Stochastic OR models for performance evaluation and decision making are discussed. The topics include basic concepts of stochastic processes like Markov chains, Poisson processes, and renewal processes, and stochastic OR models like queueing models, inventory and reliability models, forecasting and time series analysis, decision analysis, Markov decision processes, and stochastic simulation. Modeling and basic concepts are emphasized. Related computer software is also introduced.

### IE 241 Engineering Statistics I

This course covers: Probabilistic and statistical methods for stochastic modeling and data analysis; Discrete and continuous random variables and the properties of their distributions.

### IE 242 Engineering Statistics II

This course is a continuation of Engineering Statistics I. Sampling distributions, parameter estimation, hypothesis testing, and simple regression analysis are covered.

### IE 251 Manufacturing process Innovation

This course introduces typical manufacturing processes and materials, as well as productivity and quality innovation methodology such as TPM (total productive maintenance) and six sigma. In addition, manufacturing automation will be covered including CNC, PLC programming and industrial robotics.

### IE 260 Data Structure and Analysis

This course teaches the basic of software programming and design, and the goal is nurturing the basic data analysis capability through programs. The major material is covering the storage and maintenance of data, and utilizing the data to solve the industrial engineering problems, i.e. production planning and SCM. Also, the course introduces simulations and heuristics in industrial engineering.

### IE 261 Introduction to Data Science for IE

This course reviews the application of information technology to various industrial engineering methods, providing the students an integrated perspective on problem solving paradigms in IE. IT application is studied in relation with such topics as O.R., statistics, stochastic systems, system simulation, and human-machine systems. The concepts and methods of artificial intelligence, HCI and UI design, and systems analysis / design are also introduced.

### IE202 You&IE

This course introduces various research and application fields in the Department of Industrial & Systems Engineering. It also provides opportunities for meeting friends in the department through a team project and an industrial visit. This course can be helpful to build a career plan for the students.

### IE 310 Work Study

This course covers the concepts and techniques of designing and improving work performance and productivity of man and man-machine systems. Topics include: productivity, methods study, value analysis, motion economy and analysis, work measurements, job analysis and evaluation, wage payments plan, etc. Laboratory work is also included.

### IE 312 Introduction to Human Engineering

This course deals with the consideration of human characteristics, expectations, and behaviors in the design of things people use in their work and of the environment.

### IE 322 Production Management II

This course is a continuation of IE 321. Emphasis is placed on capacity planning, facility location, line balancing and project planning.

### IE 331 Operations Research : Optimization

This course intends to cover basic materials in the areas of operations research that prove to be most effective in real world applications. Topics include Linear Programming, Nonlinear Programming, Transportation, Network Model, and Dynamic Programming. Special emphasis is placed on solving the problems drawn from real world situations.

### IE 342 Design and Analysis of Experiments

This course objective is to learn how to plan, design and conduct experiments efficiently and effectively, and analyze the resulting data to obtain scientific conclusions. Both experimental design and statistical analysis issues are discussed. Applications from various fields of engineering will be illustrated throughout the course. Interesting lab sessions will provide students with the opportunity to gain hands-on experimental design and data analysis.

- Learn how to plan, design and conduct experiments efficiently and effectively.

- Conduct statistical analysis on the resulting experimental data to obtain scientific conclusions.

### IE 343 Statistical Machine Learning

This course aims to provide both theoretical and practical understanding of modern statistical machine learning approaches. Topics include: linear regression, classification, sampling methods, model selection and regularization, decision tree, support vector machine, and unsupervised learning algorithms.

### IE 353 Product Development and Product Information Management

The purpose of this course is to introduce the basic theories of product development and related information management issues. The theories include product development concept, processes, performance indices, factors and methodologies. The information issues cover information structure, information creation, information route and information representation in product development.

### IE 361 Human-Computer Interaction Design

Students are exposed to both theory and practice of designing human-computer interfaces specifically in the context of human decision making. Human-machine cooperative problem solving that combines human capacity and industrial engineering techniques is emphasized. The techniques and tools for visualization of problem structures and information, aiding human cognitive tasks, and combining human and machine intelligence are acquired. Students work on a series of practical design exercises.

### IE 363 Introduction to Modeling and Simulation

This course covers basic concepts and modern techniques of system modeling and simulation for the analysis & design of discrete event systems in manufacturing and service sectors. Case studies will be conducted using commercial simulation packages SIGMA®, IFS®, and ARENA®. There will be Lab sessions for practicing with simulation packages.

### IE 371 Service System Engineering

The course introduces basic concepts for services and service systems, which have been growing in economic volume and making significant innovations. It focuses on engineering methods for modern technology-oriented service systems such as information system services, communication services, healthcare services, and financial services, and large complex service systems.

#### IE 413 Aesthetic Engineering

This course deals with the sensory and aesthetic aspects of man-machine interface design to enhance the system usability and image. Topics include Multidimensional Scaling, Semantic Differential Method, Human Sensation, Fuzzy Sets and Control, Neural Network, etc.

#### IE 414 Cognitive Science and Systems

This course is an introduction to cognitive issues in modern information-based systems such as human cognition and decision-making, computer modeling, and intelligent aiding approaches, with emphasis on application to systemic design and analysis of human-computer systems. Topics extends to general cognitive systems engineering concepts such as intelligent interface and joint cognitive systems that are essential in modern technologically complex environments.

#### IE 421 Engineering Economy and Cost Analysis

This course deals with economic analysis for decision making among alternative courses of action in engineering, business, government and personal finance. Use of compound interest calculations to compare the consequences of different alternative decisions is emphasized. Effects of depreciation accounting methods, national income taxes, simple risk and uncertainty, and the selection of appropriate minimum attractive rates of return are considered in problems relating to multiple alternatives, sunk cost, incremental cost, replacement, resource allocation and publicly financed projects.

#### IE 423 Logistics Management

This course deals with the material management, material flow, and physical distribution system. The topics include Systematic layout planning, quantitative facilities planning models, vehicle routing and scheduling and case studies.

#### IE 425 Project Management

The course deals with project management concepts, scheduling models and algorithms, work breakdown structure, project management processes, project management systems, and their applications to engineering projects and SW development / system integration projects.

#### IE 426 Supply Chain Management

This course deals with logistic processes improvements, including processes between enterprises and product design, inter-business processes integration by information sharing and transmission system, logistics system design, planning methods and systems, and partnerships and strategic alliance.

#### IE 431 Introduction to Optimization Theory

The purpose of this course is to introduce a variety of optimization techniques that are required for operations research. Topics include difference and differential method, piecewise concavity and convexity, Hessian matrix method, simplex algorithm, Gauss elimination, dynamic programming, gradient method, Lagrangean relaxation, branch-and-bound technique, combinatorial theory, and traveling salesman problem procedure. The associated problem complexities and heuristics procedures are also discussed.

#### IE 432 Decision Analysis and Risk Management

We depict decision problems under uncertainty via three approaches: 1) decision trees (dynamic programs and dynamic stochastic control), 2) optimization of Monte Carlo (policy) simulations, and 3) multi-stage stochastic programs.

#### IE 434 Introduction to Telecommunication Service and Systems

This course reviews current basic technical concepts and related telecommunications operations. Topics include basic terminology, voice networks signaling, modulation, multiplexing and voice digitization. This course also deals with transmission and switching systems, information theory and traffic analysis.

#### IE 435 Telecommunication Management and Policy

This course addresses the key non-technical aspects of telecommunications. Topics include aspects of regulation and deregulation, common carriers, tariffs, domestic and international standards and management. This course also reviews the development and future trends in telecommunications.

#### IE 436 Case Studies for Industrial & Systems Engineering

The course introduces the problem solving processes and methods for real R&D and consulting project cases from the faculty and the industry. A case study includes customer requirement identification, problem definition & design, problem solving methods and processes, implementation, evaluation and measurement, and proposal and report writing. Students hear lectures by the project managers and discuss with them.

#### IE 437 Data-Driven Decision Making and Control

This course introduces various static and dynamic decision-making methodologies to derive optimal decision-making using data. This class introduces various probabilistic-based dynamic modeling techniques for modeling uncertain dynamic systems, and then introduces optimal control techniques for the target dynamic systems. In addition, it provides hands-on lessons on how to use the latest reinforcement learning algorithms based on deep neural networks to solve complex engineering problems.

#### IE 438 Applied Analysis and Probability for Engineers

This course introduces some basic concepts in mathematical analysis and probability for industrial engineering. Some topological ideas, differentiation, and integration of real functions, convergence of function sequences are covered. Finally, students learn martingales in finite sample space.

#### IE 441 Quality Control

This course is an introduction to the theory and applications of quality control techniques. Topics include: total quality management; graphical methods for quality; Shewhart control charts and other process control techniques; lot-by-lot, continuous and other acceptance sampling plans; process improvement using designed experiments, Taguchi methods, and evolutionary operation (EVOP).

#### IE 451 IT Service Engineering

The course introduces modern IT service engineering principles and methodologies across the whole life cycle of information systems, including requirement engineering, process analysis and innovation, system design, development, implementation, operation, and after-service. We introduce not only baseline methods in IT service engineering but also best practices from leading system integrators (SI) covering various industries such as manufacturing industry, financial industry, logistics industry, and telecom-service industry.

#### IE 452 System Design Project

This is a capstone design course for designing systems including manufacturing systems and products, service systems and services, healthcare systems and services, communication systems and services, information systems, military systems, logistics/transportation systems, financial service systems and products, etc. Individual students or teams learn system design problems by performing problem definition, customer requirement identification, functional requirement definition, system architecture and function design, operation methods and operation system design, development and implementation, evaluation and improvement, etc.

#### IE 453 Conceptual Design for Engineering Products

In the world of design, it has been said that 80% of final design outcome quality is determined at the early, conceptual design stage. This is because the conceptual design phase is where a problem to be solved is unambiguously defined and creative solutions are explored. A conceptual design phase consists of a few key elements: understanding customers' and stakeholders' needs, defining requirements from the needs, generating solution concepts

and identify superior set of alternatives, and conducting preliminary analysis. In this course, students learn about a conceptual design phase of product development. The course discusses various design methods and tools to understand how they facilitate creative but structured design thinking.

#### IE 461 Business Process Engineering and Management

In this course students learn business strategy planning methodologies, strategy-aligned process reengineering methodologies, process modeling techniques (using international standard notation), process implementation technologies, and enterprise-wide process architecture management and governance processes.

#### IE 463 Information Systems Engineering and Management

In this course students learn the state of art processes, methodologies and technologies to plan, analyze, design, implement and operate the enterprise architecture and the information systems to support dynamically changing business strategies.

#### IE 471 Artificial Intelligence for Finance

This course aims to build up the basic knowledge on various financial instruments as well as quantitative models for investment management. We study equities, fixed-income securities, and derivatives and discuss about their pricing models and investment strategies.

#### IE 472 Socio-Economic Systems Modeling

Socio-economic systems are ubiquitous, and understanding them is integral to management, public policy, and decision-making. This course will provide the fundamentals of modeling socio-economic systems, such as how agents constitute socio-economic systems, and more importantly, how to model the interactions between the agents and the systems.

#### IE 473 Financial Economics

This goal of this course is twofold: (1) to provide an introduction into the workings of financial markets and (2) to analyze the role of financial markets for the broader macroeconomy.

#### IE 481 Special Topics in Industrial Engineering I

The course provides an overview of topics not included in regular undergraduate courses in Industrial Engineering. New developments in IE (*e.g.*, results of dissertation research) may be presented in the class as demand or interest warrants.

#### IE 482 Special(Invited) Lecture I

The course is provided for a short course, an invited lecture, a training and lab, etc., which requires effort equivalent to 1 credit unit.

#### IE 483 Special(Invited) Lecture II

The course is provided for a short course, an invited lecture, a training and lab, etc., which requires effort equivalent to 2 credit units.

#### IE 490 B.S. Thesis

This course includes research or project work leading to a B.S. thesis.

#### IE 495 Individual Study

This is an individual research in a specific topic in IE, which is carried out independently under the supervision of a faculty member.

#### IE 496 Seminar in BS

There will be a total of 7 seminar sessions, once every two weeks, in e-Business and manufacturing innovation related subjects. Graduates of the IE Department who are working in e-Business and manufacturing innovation areas will be invited as speakers.



## ■ Graduate Courses

### IE 511 Human Centered Systems Design

This course covers the application of information on man's capabilities and limitations in the design process. Also included in the course are mechanical and physical environments and their effects on man as well as his performance. Emphasis is placed on the use of the Human Engineering data in the design of man-machine system. The topics covered include: Man-machine systems; human sensory processes; anthropometry; arrangement of work space; work environments (thermal, noise, vibration, light, pressure, dusts, ventilation); displays; controls.

### IE 522 Advanced Topics in Engineering Economy & Cost Analysis

Following on the basic course in engineering economy and cost analysis, this course develops further sophistication in economic decision making within an industrial environment. The principal purpose is to indicate how engineering economy analysis can be utilized to cast light on the process of managerial decision-making and to help improve the quality of these decisions. Topics include: Application of computer simulation techniques to engineering economy problems; application of statistical techniques and model construction to industrial financial activities; principles and methods of capital budgeting decisions; current techniques in capital investment analysis; depreciation policies in the management of capital assets; use of cost information in the decision-making process; the role of costs in pricing decisions; capital investment analysis, and other decision areas.

### IE 523 Production System Design

This course is an introduction to the design, evaluation, and control of production systems using mathematical, computational, and other modern analytical techniques. Areas investigated will include costs, theory of production systems, forecasting, mathematical models for production planning, inventory control, material requirements planning, in-plant material flow systems, and project scheduling techniques.

### IE 524 Optimal Location of Facilities

This course covers theory and methodology for determining an optimal location of production and service facilities. Area and point location problems in discrete and continuous space are examined. Private and public sector applications are considered.

### IE 531 Linear Programming

This course will intensively cover the theoretical, computational and application-directed aspects of linear programming problems. Also covered will be the solution methods and applications of large scale linear programming problems. Major topics include: Simplex method, revised simplex method, dual simplex method, duality theory, sensitivity analysis, Danzig-Wolfe decomposition method, numerical implementation, introduction to computational complexity, and introduction to polyhedral theory.

### IE 532 Simulation and System Modeling

An advanced course on complex system modeling and simulation. Major topics include: system modeling formalism, world views, network system modeling, next-event simulation methodology, random number generation, input modeling, output analysis and variance reduction techniques, etc. Application case studies will be conducted using commercial simulation languages.

### IE 533 Systems Engineering

This class involves analytical work on optimal design and management in system integration activities. Major topics include feasibility study, system analysis, conceptual and preliminary system design, system optimization, system evaluation, system reliability, and system supportability.

### IE 535 Network Theory and Applications

This course covers network models for industrial logistics systems, transportation systems and other applications. Emphasis is put on algorithms for shortest routes, minimum cost flow, the traveling salesman problem, facility location and network design.

#### IE 536 Scheduling Theory and Applications

Various prototypes of scheduling problems in production systems, project management, and computer systems are discussed in view of resources and tasks, problem structure, performance measures, and complexity. Complexity analysis, specialized solution algorithms for each prototype, and the use of general solution techniques like mixed integer programming, network and combinatorial optimization techniques, dynamic programming, branch and bound techniques, and other recent search techniques are explained. Also, queueing theory, stochastic analysis, and simulation techniques for dynamic or stochastic scheduling problems are also introduced.

#### IE 537 Business Telecommunication Systems

This course provides an introduction to business data communications including wide-area networks, local-area networks, protocols and network survivability. Transmission, media, signal encoding, link control and multiplexing are discussed. Network topologies, switching, and protocol fundamentals are presented and compared using the OSI model. Interconnectivity issues are discussed including circuit and packet switching, X.25, frame relay, and ATM. Integration of computer assets using LAN is covered. Internet-working and transport protocols (TCP/IP) are also examined.

#### IE 538 Genetic Algorithms and Applications

Heuristic procedures for optimization are studied. Theories and computer implementation of Genetic Algorithm and Tabu search are covered. Encoding / representation, operators, selection methods, schema and parallel GA are included for the Genetic Algorithm. Fundamentals, short-term and long-term memory are examined in Tabu search.

#### IE 539 Convex Optimization

We consider the convex optimization problem which is a special case of nonlinear optimization. We study the theoretical backgrounds, duality, interior point methods, conic programming, semidefinite programming. Applications in engineering, communications, financial engineering, data mining, and other areas will be examined.

#### IE540 Dynamic Programming and Reinforcement Learning

This course provides the mathematical formulation of dynamic decision making as MDP(Markov decision process), then dynamic programming is introduced as a solution to MDP. Also, for the cases where state transition or reward function is unknown, model-free reinforcement learning methods which allows to learn from interactions with environment will be introduced. Students will have a chance to look into case studies using DP & RL for manufacturing industry.

#### IE 541 Advanced Engineering Statistics

This course covers the theoretical foundations for statistical machine learning. Topics include: probability and distribution, convergence, maximum likelihood, hypothesis testing, Bayesian inference, nonparametric statistics and bootstrap resampling.

#### IE 542 Regression Analysis: Theory and Practice

This course reviews general theories of linear regression models with applications to industrial engineering problems. Topics include: Principles of least squares method; multivariate normal distribution and quadratic forms; estimation and hypothesis testing; residual analysis; polynomial regression and ridge regression; regression model building; response surface methodology, etc. Computational aspects of regression analysis are also emphasized.

#### IE 551 Manufacturing System and Supply Chain

This course aims to provide analysis and design methodologies for manufacturing system and supply chain, as well as planning and execution of various manufacturing processes. Also



included are the trend of manufacturing industry transformation and efficient management of supply chain. Main topics are taxonomy of manufacturing systems, evolution of manufacturing system, manufacturing and supply system modeling methodology, manufacturing information system framework, supply chain management.

#### IE 552 CAD/CAM and Geometric Modeling

The purpose of this course is to deliver the fundamental theory of geometric modeling and CAD / CAM required for product design and manufacturing. Main topics are definition / classification of geometric models, curve / surface / solid representations, 3D CAD, 3D CAM, CAPP, feature extraction, and reverse engineering.

#### IE 553 Product Lifecycle Management

The purpose of this course is to provide concepts, state-of-the-art, and research trend in Product Lifecycle Management (PLM). In the early half of the course, various aspects and techniques of product lifecycle management will be covered. In the latter half, selected research papers in PLM will be discussed and the practice of the commercial PLM system will be provided. Furthermore, the product knowledge management issues will be covered as a future technology.

#### IE 554 Knowledge-Based Design System

Computers are replacing more of human work which require low level of intelligence. This class covers methodologies and systems for knowledge-based design, which can be used for engineering design such as rule-based approach, ontology, hybrid approach, TRIZ, expert system, knowledge-based design system, KMS, and configuration design. By applying basic principles, commercial systems are used for the term project.

#### IE 561 Advanced Information System Engineering

The course teaches professional knowledge and methodologies for design and development of various complex information systems, which utilize data, information, and knowledge for system operation and decision, such as business information systems, manufacturing information systems, service operation systems, distributed simulation systems, and decision support systems. The topics are state-of-art system engineering and SW engineering methods and tools including customer and user identification, user requirement definition, functional requirement specification and functional design, SW architecture design and functional specification, process/object/service/scenario/data modeling, model-based architecture & engineering, BPM(Business Process Management), web services, SOA(Service Oriented Architecture), communication architecture and application services, real-time and distributed applications, interoperability, verification and testing, middleware, knowledge engineering processes for large-scale system modeling & design, standards, and so on. Cases and labs for some of BPMS, geometric modeling systems, PLM(Product Life Cycle Management) systems, semiconductor fab planning and control system, automation SW systems, real-virtual integrated distributed simulation systems, user interfaces, etc are included. The focus and cases can be accommodated.

#### IE 565 Information Security Policy and Management

In this lecture, we will discuss national cyber security issues and policies, various managerial issues and methods related to information security in an organization, and information security business strategy.

#### IE 566 Human-Computer Interaction: Theory and Design

This course acquaints the students to principles and practice in human-computer interaction design. The context of computer supporting of human decision-making tasks is emphasized. Based on relevant background knowledge from the perspectives of cognitive science, information design, and human factors engineering, more specific topics including task-based design methodologies, cognitive task analysis, strategy analysis, and information aiding and visualization are taught.

#### IE 570 Military Operations Research Theory and Applications

The course objective is to introduce the students to military operations research theory (such as Target detection and allocation theory, Target kill probability and damage assessment theory, System reliability, game theory, etc.). This course will increase the student's capability to analyse military decision problems.

#### IE 571 War Game Modeling

This course covers the basic tools and concepts of ground combat modeling which is both large scale and high resolution ground combat operations. The primary course objective is for the student to understand the enduring fundamentals of how ground combat models are built and used to support decision-making.

#### IE 572 Analysis of Weapon Systems

This course aims to introduce the students the theory and case studies related with the military operations research and to develop the capability of OR application in military analysis problems. Main contents are the cost and operational effectiveness analysis of weapon systems, the reliability, availability and maintainability of weapon systems, etc.

#### IE 573 Healthcare Service Delivery Systems

A healthcare service system is one of the most interesting, complex systems in the modern society. The concepts underlying this course are to deal with technical and socio-economic issues in delivery of healthcare services, and to consider how systems perspectives and methods can be used to address them. The course presents growing body of research literature on related topics and incorporate practical considerations about how to improve the performance of complex healthcare delivery organizations.

#### IE 574 Portfolio management and Financial Optimization

We will study various topics relevant to portfolio management including but not limited to: traditional portfolio selection, asset pricing, financial optimization, stock analysis, equity derivatives, and stock portfolio management strategies.

#### IE 575 Structuring and Pricing of Financial Products

This course provides the mathematical background and efficient implementation skills required for the quantitative jobs in financial industry. We introduce the risk-neutral pricing models (through binomial and Black-Scholes frameworks) , and guide the financial software design in step-by-step manner. The students will have a chance to design their own financial derivatives. Finally, we study portfolio management and optimization.

#### IE 576 Risk Management

This course covers modeling and analytical tools for many risk factors that appear in finance, insurance, and other operations. By introducing concepts and quantitative methods, we aim to provide students with practical skills which are desirable in this field.

#### IE 577 Fundamentals of Systems Engineering

In this course, we discuss system design and engineering process for large, complex system design and development. Specifically, procedures and techniques from the "V" model in traditional system engineering will be presented to enhance the students' capability as a system designer&engineer. This course is offered in collaboration with Aerospace Engineering Department, and diverse cases from aerospace, manufacturing, logistics, defense systems will be discussed.

#### IE 578 Research in Financial Economics

The course will discuss the basic role of financial markets, the types of financial assets and how they are traded. We will introduce a number of technical tools for valuing risk, pricing financial assets and creating portfolios. Finally, we will employ these insights to discuss issues

of broader relevance for the macro economy, with special emphasis on the current financial and economic crisis.

#### IE 579 Game Theory and Multi-Agent Reinforcement Learning

The course first provides an overview of game theory in both modeling and computational perspectives. The course then mainly discusses how learning concepts can be used with game-theory modeling techniques to derive the optimum operational strategies for a multi-agent system. Students also learn how to employ the state of art multi-agent reinforcement learning algorithms based on deep neural networks to solving complex multi-agent problem.

#### IE 624 Analysis of Inventory Management Systems

This is an introduction to the design, planning, and control of inventory management systems using mathematical, computational and other modern analytical techniques. Topics include analytical structures of inventory systems; static inventory systems under risk and uncertainty; dynamic inventory systems under risk and uncertainty; multi-product inventory systems; perishable goods; lot-sizing; etc.

#### IE 631 Integer Programming

Formulation, Theory and Algorithmic aspects of Integer Programming are discussed. We study how to formulate the real problems as integer programming models and discuss computational complexity, the description of the convex hull of feasible solutions. For computational methods, we study branch-and-bound, Lagrangian relaxation, strong cutting-plane method, etc. (Prerequisite: IE531 Linear Programming or permission of the Instructor).

#### IE 632 Stochastic Modeling I

The course deals with stochastic modeling and performance analysis methods for system design and operation of complex engineering systems such as production / manufacturing systems, computer / communication systems, and service systems. The course covers more advanced mathematical modeling and analysis than OR-II. Topics include basic concepts, modeling and analysis, and applications for fundamental stochastic models, including Poisson processes, renewal processes, Markov chains, stationary processes, Brownian and diffusion processes, stochastic Petri nets, basic queueing models and queueing networks, and Markov decision processes. Advanced topics like Markov renewal processes, Martingales, large deviation theories, and advanced traffic models can be introduced depending on the class.

#### IE 633 Queueing Theory

Waiting phenomena that occur in service systems, manufacturing systems, communication systems, and computer systems are modeled and analyzed. Basic single queue models ( $M / M / s$  and other Markovian queues,  $M / G / 1$ ,  $G / M / 1$ , and  $G / G / 1$ ) and their variations (including vacation models and polling models) are studied. Theory of product form queueing networks (Jackson, Gordon-Newell, BCMP, and others), including open / closed / mixed / multi-class / multi-chain, Markov routing / general routing, reversibility and quasi-reversibility, PASTA, Norton's Theorems, are presented. Some basic algorithms and applications for scheduling, FMS, LAN, computer systems, and telecommunication systems are also introduced. Non-product form queueing networks and various approximation algorithms (including blocking approximation, renewal approximations, and diffusion approximation) are also introduced. Statistical issues, computational issues, queue control issues, and queueing networks with blocking are briefly presented.

#### IE 635 Combinatorial Optimization

This course covers theories and applications of various combinatorial optimization problems. Topics include the matching problem, the traveling salesman problem and their variations, other combinatorial optimization problems in graphs, integrality of polyhedra, matroid and sub-modular functions, and the applications of semidefinite programming to combinatorial optimization.

#### IE 636 Intelligent Systems & Soft Computing

The first objective is to learn what kind of role precision and imprecision have in engineering and engineering system design. The second objective is to understand the need to use soft-computing in designing intelligent systems. The third objective is to have a basic understanding of different kinds of soft-computing methodologies as well as hybrid methodologies. The fourth objective is to design and build a fully functional Fuzzy Logic Controller / fuzzy application in a real world project case.

#### IE 638 Wireless and Cellular Communication Systems

This course provides an overview of wireless communication with an emphasis on cellular communication. The goal is to cover the basics of radio, duplexing and multiple access, cellular, mobile systems, standards, and applications.

#### IE 639 Supply Chain Optimization

This course tackles the issue of supply chain optimization in an integration approach of various operations research models for supporting industrial service and resource supply activities under e-Business environment. Major topics for the issue include flow network design of supply chain systems at strategic level, based upon which the associated sourcing, production planning, and logical routing topics are investigated at a tactical level. Therewith, scheduling, inventory, and vehicle routing topics are to be integrated together in an optimal manner at the operational level.

#### IE 642 Forecasting and Time Series Analysis

This course teaches a comprehensive treatment of current statistical forecasting techniques and their applications. Major topics include general forecasting theories, decomposition, moving averages, exponential smoothing, regression, forecasting error analysis, Box-Jenkins model, Bayesian approach, etc. (Prerequisite: CC 511, IE 641).

#### IE 643 Design and Analysis of Experiments

Theories of experimental design and analysis methods of experimental data with applications to industrial problems are taught in this course. Characteristics of various experimental designs and analysis of variance method are covered. Emphasis is put on experimental methods for the design and improvement of products or processes and on optimal experimental design considering the cost and statistical efficiency.

#### IE 644 Life Testing and Survival Analysis

This course covers statistical theory and application of survival analysis and life test methods. Topics include: lifetime distributions and their properties; parametric and nonparametric lifetime data analysis and inference; parametric regression and proportional hazard models; theory of competing risks; accelerated life testing and related topics; design of life test plans, etc.

#### IE 645 Quality Engineering

This course deals with theories and applications of advanced statistical quality control techniques. Topics include design and analysis of control charts, process capability analysis, real-time process control, design of sampling inspection plans, multivariate and bulk sampling inspection plans, screening plans, and robust design methodology.

#### IE 646 Data Mining

Topics include basic concepts, models and algorithms, case studies and deployment strategies. Major techniques are data visualization, clustering, association rules, decision trees and artificial neural networks. Web mining and CRM applications are also covered.

#### IE 661 Applications of AI/DM Technology

The discipline of Industrial engineering utilizing artificial intelligence and expert systems in diverse applications: i.e. operation planning by planners of artificial intelligence (AI), expert systems (ES) with bayesian networks, and quality control via machine learnings. This lecture introduces the basics of artificial intelligence and expert systems for students at the dept. of

industrial and systems engineering.

#### IE 671 Stochastic Modeling II

This course intends to provide graduate students with necessary tools that one might find indispensable to conduct independent research in the areas of applied probability, operations research, management science, or financial engineering. The course will cover broad topics such as mathematical analysis and probability, martingale theory, Markov processes, renewal theory, regenerative processes, Brownian motion and functional limit theorems. A lot of care will be taken to make contents accessible for people with a limited background in mathematics.

#### IE 722 Material Storage & Handling Systems

Design, operation and control systems to effectively handle materials in manufacturing industries are covered in this course. Topics include systematic handling analysis, stock location in a warehouse, design and scheduling of automated storage and retrieval systems, carousel systems, palletizing, hoist, closed loop conveyor, automatic guided vehicle system, and automatic transfer lines.

#### IE 761 Cognitive Engineering

Approaches to enhance human performance in problem solving and decision making by computer and other methods are considered. Systems engineering point of view is exercised while covering models of human and machine intelligence, prescriptive and descriptive theories of human decision making, and models to combine human and machine resources. Application-oriented issues are emphasized.

#### IE 801 Special Topics in Industrial Engineering II

This course is offered to meet the ad hoc demand of students in special areas of IE which is not covered by regular courses.

#### IE 802 Invited Lecture I

The course is provided for a short course, an invited lecture, a training and lab, etc., which requires effort equivalent to 1 credit unit.

#### IE 803 Invited Lecture II

The course is provided for a short course, an invited lecture, a training and lab, etc., which requires effort equivalent to 2 credit units.

#### IE 960 Thesis (M.S.)

Master Thesis Research

#### IE 965 Individual Study (Maximum 3)

Research on a specific topic is carried out independently under the direction of a faculty member. The research results are to be submitted in a report format.

#### IE 966 Seminar (M.S.)

Regularly held seminars on up-to-date topics help M.S. students grasp the current direction of development and applications in the general IE areas.

#### IE 980 Thesis (Ph.D.)

Ph.D. Dissertation Research

#### IE 985 Individual Study (Maximum 3)

Research on a specific topic is carried out independently under the direction of a faculty member. The research results are to be submitted in a report format.

#### IE 986 Seminar (Ph.D.)

Regularly held seminars on up-to-date topics help doctoral students grasp the current direction of development and applications in the general IE areas.