

# Industrial and Systems Engineering Master Program (ISE)

## Course Content

(3 ŞEHİR credits each, equivalent to 5 ECTS credits)

### ENGR 500 Research Methods

Teaching the principals of research methods and ethical issues in engineering research.

### ISE 521 Introduction to Operation Research and Industrial Engineering Topics

The term 'operations research (OR)' means "scientific approach to decision making". In OR, the objective is to optimally design and operate a system, usually under conditions that require allocation of limited resources, and usually under lack of complete information. This is a survey course in OR. Topics include linear programming, network analysis, probability theory, queueing theory, project management, dynamic programming, inventory theory, and nonlinear programming. The analysis of these models using Excel spreadsheets will be emphasized.

### ISE 523 Linear Programming and Extensions

This is a theoretical introductory course for first year graduate students. The primary objective is to provide the students with a deep understanding of the concepts that underlie all linear programming algorithms and also understand how and why some of the current algorithms solve linear programming models. Topics include: theory of linear programming; convexity; simplex and algorithmic aspects; duality and sensitivity; computational issues; decomposition and column generation; introduction to integer and nonlinear programming.

*Textbook: Linear Programming and Network Flows. Bazaraa, Jarvis, Sherali. Wiley, 2009.*

### ISE 524 Computer Simulation Techniques

This course builds a holistic framework for analyzing complicated systems in modern manufacturing and service industries. Process view of organizations is reinforced in a consistent manner and the analysis and improvement of such systems are studied using computer simulations. Simulation Basics; Queueing Applications; Inventory Applications; Validation and Verification; Group Project.

*Textbook: J. Banks, J. S. Carson B. L. Nelson, and D. M. Nicol. 2000. Discrete-Event System Simulation.*

### ISE 525 Dynamic Programming

Introduction to theory and computational aspects of dynamic programming and its application to sequential decision problems. Knap-sack problem, equipment replacement, travelling salesman problem. Stochastic dynamic programming.

*Textbook: Dynamic Programming and Optimal Control, Dimitri P. Bertsekas, Athena Scientific.*

### ISE 526 Stochastic Processes

Probabilistic models that are widely used in engineering and management science. Markov Chains; Renewal Theory; Markov Decision Processes: Queueing Theory; Inventory Control. A course in the theory of probability is a prerequisite.

*Textbook: Introduction to Probability Models, Sheldon Ross, John Wiley.*

### ISE 527 Graph Theory and Network Flows

An in-depth study of graph theory and network flow models in operations research with an emphasis on combinatorial solution approaches. All classical network flow models will be considered in detail; including shortest paths, maximum flow, and min-cost flow. A variety of techniques will be shown (including some data structures) for constructing efficient algorithms.

### ISE 528 - Nonlinear Programming

Introduction to theory of unconstrained and constrained nonlinear optimization, and algorithmic methods for solving such optimization problems. The theoretical part of the course will cover basic convex analysis and optimality conditions. As time permits, the algorithmic part will cover line search, trust region, conjugate gradient, and quasi-Newton methods for unconstrained nonlinear optimization; and penalty and augmented Lagrangian, sequential quadratic, and barrier and interior point methods for constrained nonlinear optimization.

### **ISE 531 Probability and Statistics for Engineers**

General probability and statistical concepts and techniques useful for engineers and researchers in engineering. Topics include : Combinatorial probability, independence, conditional probability, random variables, discrete and continuous probability models, expectation and moments, central limit theorem, estimation, confidence intervals, hypothesis testing, tests of means and variances, goodness-of-fit, regression, analysis of variance, and introduction to experimental design.

**Textbook:** *Jay DeVore, Probability and Statistics for Engineering and the Sciences, Duxbury.*

### **ISE 532 Reliability Engineering**

The reliability concept and the methods to measure the reliability of the complex engineering systems. Optimization theory and statistical analysis will be used to evaluate and optimize the system reliability. Reliability and hazard functions, system reliability evaluation, system reliability optimization, time and failure dependent reliability.

**Prerequisites:** Probability and Operation Research.

**Textbook:** *Reliability Engineering: Theory and Practice, Alessandro Birolini, Springer.*

### **ISE 533 Statistical Forecasting**

Simple and multiple regression models; relaxing the assumptions of the classical model: multi-collinearity, heteroscedasticity, autocorrelation, model specification. Topics in econometrics: regression on dummy variables, the LPM, logit and probit models, autoregressive and distributed lag models; simultaneous-equation models.

**Textbook:** *Business Forecasting, Hanke & Wichern, 2009. Prentice Hall.*

### **ISE 534 Data Mining**

Definitions, introduction, examples, and the process data preparation and reduction, brief review of regression, decision trees, neural networks, k-nearest neighbor, cluster analysis, association rule mining, Principal components, pruning, boosting, bagging, cross-validation, bootstrapping.

**Textbook:** *Introduction to Data Mining: Tan, Steinbach, and Kumar; Addison Wesley, 2006.*

### **ISE 535 Quality Design and Improvement**

Introduction, overview. Historical development of Quality Management. Quality improvement in today's business environment. Lean Enterprise. Six Sigma. Some common statistical tools for Statistical Process Control (SPC). Conceptual framework for Statistical Process Control (SPC). Control charts for variables. Rational sampling and process capability. Additional SPC techniques for variables. Control charts for attributes. Quality control and reliability. Time-dependent reliability of components and systems. Failure modes, event-tree, and fault-tree analyses. Reliability testing. Maintainability and availability. Warranties

### **ISE 537 Applied Data Analysis**

Basic concepts and techniques in applied data analysis including regression modeling, analysis of variance, and experimental design. Multiple regression, logistic regression, analysis of variance, and experimental designs (one-way, randomized block designs, multi-way factorials, incomplete blocks, and repeated measures). Statistical methods and models that are widely used across many disciplines.

**Textbook:** *Applied Linear Statistical Models, Kutner, Nachtsheim, Neter, Li, McGraw Hill/Irwin.*

### **ISE 538 Design of Experiments**

Principles of experimental design: randomization, blocking, transformations, fixed and random effects. Single factor experiments, Latin squares, factorial experiments, analysis of covariance, response surface design.

**Textbook:** *Design and Analysis of Experiments, Douglas Montgomery, 2008. Wiley.*

### **ISE 541 Lean Manufacturing and Operations**

Overview of lean principles; Lean philosophy, history and basic methods; Lean system design: current state, optimal state and pull design; Pull system mechanics: Kanban, containerization, tools to determine and control inventory; Factory layout for lean manufacturing: basic models and options; Lean system design: analysis of throughput, cycle time, bottlenecks, material flow; Impact of supply chain; Integration of six-sigma into lean; (Prerequisite: Senior standing).

**Textbook:** *Design and Analysis of Lean Production Systems, R G Askin, J B Goldberg, Wiley India Pvt. Ltd.*

### **ISE 542 Advanced Materials Science for Engineers**

Principles of structure and processing on advanced materials for functional use. Methods of treatment and processing for structural improvement. Materials under stress and strain, defect mechanisms and flow. Electrical, optical and magnetic properties of materials with comprehensive coverage of electronic properties in metals, semiconductors, and insulators at a fundamental level. Mechanical and electrical

test and analytical methods. Fundamental solid-state properties and new technologies that lead to nanomaterials, thin film technologies and cutting-edge products.

**Textbook:** *Materials Science and Engineering : Introduction*, by William Callister, ISBN: 9780471736967, Publisher: John Wiley & Sons

#### **ISE 543 Micro-fabrication**

This graduate and senior undergraduate course presents a broad overview of micro-nanofabrication technologies and the science of miniaturization to engineering and science students. This science comprises an understanding of the intended application, knowledge of the different manufacturing options, familiarity with all material choices, and an understanding of scaling laws. Different options to make very small machines (micro and nano size) are reviewed and materials choices are discussed.

**Textbook:** *"Fundamentals of Microfabrication, The Science of Miniaturization"* Second Edition by Marc Madou, CRC Press 2002.

#### **ISE 544 Design for Manufacturability**

Interactive relations between material, design, manufacturing, and service for a product will be discussed using case studies. Design for manufacturability and sustainability will be exercised on open-ended industrial problems. Impact of design on manufacturing, part and service cost; Impact of design on manufacturability, assembly, waste; energy utilization; case studies.

**Textbook:** *Selected readings and presentations.*

#### **ISE 545 Modern Manufacturing Technologies**

In this course, several modern manufacturing processes and system types will be discussed with real examples and cases from industry. Developments in traditional manufacturing process technologies; non-traditional manufacturing processes; manufacturing system types and emerging paradigms; selection of manufacturing processes and systems for selected products.

**Textbook:** *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*, Mikell Groover, John Wiley and Sons.

#### **ISE 546 Manufacturing Systems**

Modern manufacturing systems; Manufacturing system types and classification; Major differences and interactions between different manufacturing systems; Manufacturing system design, analysis and simulation (Prerequisite: Consent of instructor).

**Textbook:** *Analysis and modeling of manufacturing systems*, S. B. Gershwin, Yves Dallery, Chrissoleon T. Papadopoulos, Kluwer Academic Publishers.

#### **ISE 548 Product Design and Innovation**

New product development requires teams of technical and non-technical people to work across disciplines. This course covers a wide range of topics concerning customer driven product innovation, new product development processes, tools, techniques, and organizational skills.

**Textbook:** *Innovation Management and New Product Development*, Trott, 2008. Prentice Hall.

#### **ISE 549 Renewable Energy Systems**

The class outlines the relevance of photovoltaics today and in the future. Then follows an introduction to the physical background of solar cells and the most important materials and technologies, with emphasis on future developments and prospects. Efficiency and performance of PV systems; Competing forms of renewable energy. Introduction to renewable energy concepts

Other Types of Energy Sources covered Wind Energy, Tidal Energy, Biomass Energy, Geothermal Energy

**Textbook:** *A collection of book chapters and articles from various resources. Photovoltaic Energy Generation*, Goetzberger and Hoffmann, Springer 2010, ISBN-10: 3642062601. *Solar Electric Power Generation - Photovoltaic Energy Systems: Stefan Krauter*, Springer 2010.

#### **ISE550 Nano-Manufacturing and Devices**

Overview of the main directions in nanotechnology/nanoscience; bottom-up manufacturing; existing applications; future visions of nanotechnology; key concepts and state of the art research in the areas of nanotubes, nanowires, nanoparticle applications, nanoelectronics, nanophotonics, nanobiotechnology, and biomedical nanotechnology.

**Textbook:** *A collection of book chapters and articles from various resources: Gabor L. Hornyak, John J. Moore, H.F. Tibbals, and Joydeep Dutta, "Fundamentals of Nanotechnology" 2008, CRC Press. Charles P. Poole, Jr., Frank J. Owens, "Introduction to Nanotechnology", Wiley 2003.*

#### **ISE 551 Advanced Topics in Project Management**

Developing basic PM skills; Initiating a project; Planning and acquiring resources; Assessing risk; Developing the project plan; Budgeting; Execution and controlling outcome; Assemble team; Problem resolution; Monitor project processes; Close-out the project.

**Textbook:** A collection of book chapters and articles from various resources: Kim Heldman, PMP, *Project Management-Jump Start*. Wiley, 2005. Rory Burke, *Project Management Techniques*. Burke Publishing, 2007. Robert Heller, *Managing Teams*, DK Publishing Inc., 1998.

#### **ISE 552 Logistics and Supply Chain Management**

Demand Forecasting; Logistics Network Design; Contracting in Supply Chains; Bullwhip Effect, Information Sharing, Vendor-Managed Inventory; Supply Chain Design – Efficient vs. Responsive Supply Chains; Sourcing; Procurement Auctions, Forward Buying; Quality and Supply Risks; Pricing: Dynamic Pricing, Revenue Management. A background in Production Operations Management is needed.

**Textbook:** *Designing and Managing the Supply Chain: Concepts, Strategies, and Cases*. David Simchi-Levi, Philip Kaminsky.

#### **ISE 553 Engineering Management**

The course will address the organizational behavior and challenges for engineers, especially dynamics of globally distributed work teams. It will focus on developing practical new approaches to typical managerial problems faced in all sizes of corporate local or global companies. There will be emphasis on converting problematic situations into opportunities for improvement. Understand role and function of management in an organization; Alternative strategies to generic problems; Leadership and enhancing creativity; Successful work teams and communication skills; Conflict resolution; Time and stress management.

**Textbook:** A collection of book chapters and articles from various resources.

#### **ISE 554 Technology and R&D Management**

Historical Development. Functions of Technology Management: Planning and Forecasting, Decision Making, Human Aspects of Organizing, Leading Technical People, Controlling. Managing Technology: Managing Research and Development, Managing Engineering Design, Planning Production Activity, Managing Production Operations, Engineers in Marketing and Service Activities. Managing Projects: Project Planning and Acquisition, Project Organization, Leadership, and Control. Engineering Ethics. Globalization and Challenges for the Future.

**Textbook:** *Managing Engineering and Technology*, Lucy C. Morse, Dan L. Babcock, Prentice Hall, 2010.

#### **ISE 555 Future Readiness**

This course provides an understanding of work environment in the 21<sup>st</sup> century, skills needed for success and how to be prepared for the future. This collaborative learning “Share and Learn” style course is also includes instructor’s over 25 years of successful business and leading technology experiences in the USA. The overarching goal of this course is to take learners life to the next level by awareness of critical skills needed in the real world and getting ready for the increasingly fast changing chaotic work environment.

#### **ISE 556 Strategic Management**

Strategic Management Approaches, The Tree of Business, Corporate Vision. Three Hierarchical Levels of Strategy, Strategy Pyramid. Strategic Programming Model for Stable Environment. Environmental Analysis, Competitive Analysis, Strategy Formulation, SWOT Analysis. Strategy Implementation, Strategic Leadership, Performance Management: Balanced Scorecard.

**Textbook:** *Concepts in Strategic Management & Business Policy*, Wheelen & Hunger, 2010. Prentice Hall.

#### **ISE 561 Decision Analysis**

Economic parameters play a significant role in decision making. This course introduces key economic, financial and accounting concepts for the engineering student and builds a framework for managerial decision making. Time Value of Money; Cash Flow Analysis; Risk Analysis, Decision Trees and Real Options; Cost Accounting Basics; Managerial Accounting.

**Textbook:** *Engineering Economic Analysis*, Donald Newnan, Ted Eschenbach, and Jerome Lavelle.

#### **ISE 529 System Dynamics**

The course aims to equip students with advanced dynamical simulation concepts, methods, tools and softwares. The course involve both theoretical and application based aspects of system dynamics modeling. Especially, how to formulate & model real-world dynamical problems and then how to improve system performance or efficiency using system dynamics modeling.

#### **ISE 562 Managerial Decision Making**

The typical decision-making process involves defining the problem, identifying alternatives, using a particular technique to select the best alternative and monitoring results. The problem definition may include a set of requirements and decision criteria.

The course will discuss how successful managers and business leaders make their decisions and provide prescriptions for positive decision-making practices. The students will learn to build a framework for both strategic and tactical problem-solving – an asset for any managers faced with making important decisions about their businesses. Topics will include:

Decision making using deterministic models, Developing model formulation skills, Decision trees, Sensitivity analysis, Decision making under uncertainty, Simulation, Value of information, Modeling preferences.

### **ISE 571 Facility Layout Planning**

Design of production, distribution and inventory systems. Process design, materials handling, work area design, storage and warehousing, service area planning. Machine scheduling; number, size and location of facilities in a system; capacity planning; design of delivery routes.

**Textbook:** *Facilities Planning and Design*, Garcia-Diaz & Smith, 2008. Prentice Hall.

### **ISE 572 Game Theory**

Decision making under uncertainty; Simultaneous move games; Stackelberg leadership model; Double Marginalization in Supply Chains and Supply Chain Coordination; Bargaining Models: Theory and Practice; Cooperative Game Theory; Principle-Agent Model; Mechanism Design; Optimal Auction Design.

**Textbook:** *An Introduction to Game Theory*, Martin J. Osborne. Oxford University Press, 2003.

*Game Theory with Economic Applications*, Bierman & Fernandez. Prentice Hall, 1998.

### **ISE 580 - Systems Engineering**

The class begins with an introduction to the general concepts of systems, and then examines classical linear systems theory as applied traditionally in engineering. It is shown how industrial engineering design can be viewed as a control system problem. The concepts of systems engineering are in turn applied to industrial engineering design.

**Textbook:** David G. Luenberger. *Introduction to Dynamic Systems: Theory, Models, and Applications*, Wiley.

### **ISE 582 Data Science for Business**

Data Science for Business introduces the fundamental principles of data science, and walks you through the "data-analytic thinking" necessary for extracting useful knowledge and business value from the data you collect. The class provides examples of real-world business problems to illustrate these principles. You'll not only learn how to improve communication between business stakeholders and data scientists, but also how to participate intelligently in your company's data science projects. You'll also discover how to think data-analytically, and fully appreciate how data science methods can support business decision-making.

### **ISE 588 Agile Methods**

The course aims to make students familiar with the agile methods, fundamental principles and practices associated with each agile method. Several agile methods will be described, but the emphasis is on Scrum and XP.

### **ISE 615 Advanced Topics in Management Information Systems**

This course is about building and integrating information systems into manufacturing and service operation systems including engineering, business and customer functions in an enterprise.

**Outline:** Client-server models for both practical and methodological cases; System architecture for intranet and internet-based systems; Legacy systems and their integration issues into modern information system architecture; Distributed computing and data management; Project based on real case problems involving prototyping small-to-medium info systems from design to implementation.

**Textbook :** *Management Information Systems, 11/e*, Laudon & Laudon, Prentice Hall, 2010.

### **ISE 620 Nonlinear and Dynamic Programming**

**Outline:** Convex sets and functions, optimality conditions, duality, nonlinear programming algorithms (steepest descent, Newton's method, penalty and barrier methods, SQP methods). Introduction to theory and computational aspects of dynamic programming and its application to sequential decision problems.

### **ISE 623 Industrial Applications of Optimization**

**Outline:** This course provides the students an overview about the optimization problems encountered in the industry and involves mainly reading and presenting papers in addition to preparing a final project.

**Textbook:** A collection of book chapters and articles from various resources.

### **ISE 624 Combinatorial Optimization**

Pure, mixed, and zero-one integer programming problems. Network flows, packing, covering and partitioning.

**Outline:** Branch and bound methods. Cutting planes and polyhedral approach. Heuristic methods and dynamic programming. Complexity theory: NP-completeness. Computer implementation and applications in industry.

**Textbook:** *Introductory Combinatorics*, Richard A. Brualdi, Pearson, 2010.

### **ISE 628 Advanced Topics in Operations Research**

This course examines theory, models, and applications of Markov Decision Processes (MDPs). MDPs are sometimes referred to as controlled Markov chains and the underlying theory is called stochastic dynamic programming (SDP). MDPs have applications in many areas including revenue management, artificial intelligence, transportation, and financial engineering. **Outline:** Model formulation; deterministic DP; finite horizon and infinite horizon models; total-reward and average reward criteria; Bellman's equation; value and policy iteration; linear programming methods; partially-observed MDPs and approximate DP. Applications and computer assignments.

**Textbook:** *Markov Decision Processes: Discrete Stochastic Dynamic Programming* by Martin L. Puterman.

### **ISE 633 Advanced Topics in Quality Engineering**

Total Quality Management; history, concepts, principles, tools and models. Principles of quality control systems, process control and capability concepts, control charts, acceptance sampling plans, cost of quality, modern concepts in quality control and management. Textbook: Modern Methods For Quality Control and Improvement by Harrison M. Wadsworth, Kenneth S. Stephens, and A. Blanton Godfrey, 2001.

**ISE 636 Financial Econometrics**

**Outline:** Econometric and statistical methods as applied to finance. Topics include: Overview of Statistical Methods; Predictability of asset returns; Discrete time volatility models; Efficient Portfolio and CAPM; Multifactor Pricing Models; Intertemporal Equilibrium and Stochastic Discount Models; Expectation and present value relation; Simulation methods for financial derivatives; Econometrics of financial derivatives; Forecast and Management of Market Risks; Multivariate time series in finance; Nonparametric methods in financial econometrics.

Textbook: Financial Econometrics: From Basics to Advanced Modeling Techniques. Svetlozar T. Rachev, Stefan Mittnik, Frank J. Fabozzi, Sergio M. Focardi. Wiley, 2007.

**ISE 654 Production and Operations Management**

This course builds a framework for evaluating and improving operations in the manufacturing and service industries. The course spans a range of topics from inventory management and process analysis to supply chain management and quality control. Basic tools and concepts are reviewed with an emphasis on practical applications.

**Outline:** Operations Strategy; Process Analysis: Cycle time, work-in-process inventory, bottleneck analysis; Inventory management: EOQ, newsvendor model, (Q,r) model; Capacity planning and variability; push and pull systems; Material Requirements Planning and ERP systems; Quality: Six-sigma, Lean; Global Sourcing.

Textbook: Factory Physics, Wallace Hopp, Mark Spearman.

**ISE 671 Energy and Energy Efficiency**

Review of energy production; Future of various technologies; Efficiency in energy production and distribution; Review of green energy: Technology, efficiency and cost.

Textbook: Renewable energy, Godfrey Boyle, Oxford University Press, 2004.

**ISE 592 (ISE 592A Independent Study I)**

**ISE 593 (ISE 592B - Independent study II)**

**ISE 595 Graduate Project**

**ISE 599 Master Thesis**