DEPARTMENT OF SYSTEMS ENGINEERING

Chairman

Dr. Hesham Al-Fares

Faculty

Abdur-Rahim	Abouhedaf	AlDurgam
Al-Amer	Andijani	Ayar
Ben-Daya	Cheded	Al-Dajani
Al-Dhaifallah	Duffuaa	Al-Fares
El-Ferik	Al-Haboubi	Haroun
Kara	Magdi	Mujahid
Mysorewala	Nahas	Osman
Pirim	Rougi	Al-Saif
Selim	El-Shafei	Al-Sunni
Al-Turki	Vaqar	

The Department of Systems Engineering offers graduate programs leading to the Master of Science, the Master of Engineering (non-thesis) and Doctor of Philosophy in two majors. The objective of the Systems Engineering programs is to prepare engineers who can function well in large scale, interdisciplinary projects and can do independent research to analyze, improve, design and install engineering systems. Currently the Department of Systems Engineering offers graduate programs in Industrial and Systems Engineering (ISE) and Systems & Control Engineering (SCE).

In ISE programs, the scientific methods applied to decision-making, allocation of resources and optimization of systems are emphasized. Operations Research models and techniques such as Linear Programming, Non-Linear Programming, Dynamic Programming, Queuing Theory, Network, Scheduling and Simulation are studied. In the Industrial Engineering programs, Quality, Reliability, Production and Inventory, Maintenance, Supply Chain Management, Human Factors and Work Measurements are essential elements of the programs. The overall emphasis is to integrate knowledge to operate, optimize, and improve systems productivity.

The SCE major emphasizes the analysis, design, synthesis, and optimization of systems in order to provide the best means of controlling their dynamic behavior to produce specified outputs. Automation, Control Theory, Process Control, etc. are essential parts of SCE programs. The current graduate programs provide students with advanced courses in the area of Automatic Control Systems as well as in Intelligent Instrumentation, Robotics, and Industrial Automation. The programs provide a wide variety of electives in different areas of concentration with flexibility in electives selection.

Systems engineering is a constituent department of the College of Computer Sciences & Engineering (CCSE). In addition to the college laboratories, the Department of Systems Engineering has ten laboratories for teaching and research. These laboratories are equipped with assorted equipment for running the experiments for students learning of practical concepts involved therein. Qualified technicians look after and maintain these laboratories. Four of these labs are used both for teaching and research purposes as mentioned against their names below; these are also used by graduate students for their study and research work.

- Condition based Maintenance & DSP lab (R)
- Digital & Embedded Control Systems Lab
- Industrial Automation Lab
- Control Systems Lab (R)
- Mechatronics Lab (R)
- Senior Project Lab
- Analog & Discrete Simulation Lab
- Instrumentation Lab
- Human Factor Lab
- Process Control Lab (R)

Admission Requirements

All applicants for admission to the department must satisfy the general Graduate School admission requirements. Graduates from Engineering, Computer Science and Mathematics from recognized institutions are eligible to apply.

MASTER OF SCIENCE IN INDUSTRIAL AND SYSTEMS ENGINEERING

Degree Requirements

(a) Core Courses (15 credit hours)		Credit Hours
Probabilistic Modeling in ISE	ISE 502	3
Linear Programming and Applications I	ISE 503	3
Advanced Production Systemsa and Inventory Control	ISE 508	3
Seminar	ISE 599	0
Thesis	ISE 610	6

(b) Elective Courses (15 credit hours)		Credit Hours
One ISE Elective Course	ISE xxx	3
Two ISE Restricted Elective Courses	ISE 5xx	6
Two Technical Elective Courses	XXX 5xx	6

Degree Plan

COURSE	TITLE	LT	LB	CR	COURSE	TITLE	LT	LB	CR
First Year									
ISE 502	Probabilistic Modeling in ISE	3	0	3	ISE 508	Adv. Production Sys. & Inventory Control	3	0	3
ISE 503	Linear Programming and Applications I	3	0	3	ISE 5xx	ISE Restricted Elective I (List 1)	3	0	3
ISE xxx	ISE Elective	3	0	3	XXX 5xx	Technical Elective I (List 2)	3	0	3
		9	**0**	**9**			**9**	**0**	**9**
Second Year									
ISE 5xx	ISE Restricted Elective II (List 1)	3	0	3	ISE 610	Thesis	0	0	6
XXX 5xx	Technical Elective II (List 2)	3	0	3					
ISE 599	Seminar	1	0	0					
ISE 610	Thesis	0	0	IP					
		7	**0**	**6**			**0**	**0**	**6**
Total credit hours required in Degree Program : 30									

List 1: ISE 512, 521, 534, 535, 536, 543

List 2: SCE 5xx, ISE 5xx, ME 5xx, MSE 5xx, CHE 5xx, EE 5xx, CE 5xx, PETE 5xx, MATH 5xx, STAT 5xx, ICS 5xx, SWE 5xx, COE 5xx

MASTER OF ENGINEERING IN INDUSTRIAL AND SYSTEMS ENGINEERING

Degree Requirements

(a) Core Courses (12 credit hours)		Credit Hours
Probabilistic Modeling in ISE	ISE 502	3
Linear Programming and Applications I	ISE 503	3
Advanced Production Systemsa and Inventory Control	ISE 508	3
Master of Engineering Project	ISE 600	3

(b) Elective Courses (21 credit hours)		Credit Hours
One ISE Elective Course	ISE xxx	3
One ISE Elective Course	ISE 5xx	3
Two ISE Restricted Elective Courses	ISE 5xx	6
Two Technical Elective Courses	XXX 5xx	6
One Business/Management Elective Course	XXX 5xx	3

Degree Plan

COURSE	TITLE	LT	LB	CR	COURSE	TITLE	LT	LB	CR
First Year									
ISE 502	Probabilistic Modeling in ISE	3	0	3	ISE 508	Adv. Production Sys. & Inventory Control	3	0	3
ISE 503	Linear Programming and Applications I	3	0	3	ISE xxx	ISE Elective	3	0	3
ISE 5xx	ISE Restricted Elective I (List 1)	3	0	3	XXX 5xx	Technical Elective I (List 2)	3	0	3
		9	**0**	**9**			**9**	**0**	**9**
Second Year									
ISE 5xx	ISE Restricted Elective II (List 1)	3	0	3	XXX 5xx	Business/Management Elective	3	0	3
ISE 5xx	ISE Elective	3	0	3	ISE 600	Master of Eng. Project	0	0	3
XXX 5xx	Technical Elective II (List 2)	3	0	3					
		9	**0**	**9**			**3**	**0**	**6**
Total credit hours required in Degree Program : 33									

List 1: ISE 512, 521, 534, 535, 536, 543

List 2: SCE 5xx, ISE 5xx, ME 5xx, MSE 5xx, CHE 5xx, EE 5xx, CE 5xx, PETE 5xx, MATH 5xx, STAT 5xx, ICS 5xx, SWE 5xx, COE 5xx

PHD IN INDUSTRIAL AND SYSTEMS ENGINEERING

Degree Requirements

(a) Core Courses (12 credit hours)		Credit Hours
Seminar	ISE 699	0
PhD Pre-Dissertation	ISE 711	3
PhD Dissertation	ISE 712	9

(b) Elective Courses (30 credit hours)		Credit Hours
Five ISE Courses in Major Area	ISE 5xx	15
Three ISE Courses in Major Area	ISE 6xx	9
Two Courses in Minor Area	XXX 5xx	6

Degree Plan

COURSE	TITLE	LT	LB	CR	COURSE	TITLE	LT	LB	CR
First Year									
ISE 5xx	Major Area Elective I	3	0	3	ISE 5xx	Major Area Elective III	3	0	3
ISE 5xx	Major Area Elective II	3	0	3	ISE 6xx	Major Area Elective IV	3	0	3
XXX 5xx	Minor Area Elective I	3	0	3	ISE 6xx	Major Area Elective V	3	0	3
		9	**0**	**9**			**9**	**0**	**9**
Second Year									
ISE 5xx	Major Area Elective VI	3	0	3	ISE 6xx	Major Area Elective VIII	3	0	3
ISE 5xx	Major Area Elective VII	3	0	3	ISE 711	PhD Pre-Dissertation	0	0	3
ISE 699	Seminar	1	0	0					
XXX 5xx	Minor Area Elective II	3	0	3					
		10	**0**	**9**			**3**	**0**	**6**
Third Year									
ISE 712	PhD Dissertation	0	0	IP	ISE 712	PhD Dissertation	0	0	9
		0	**0**	**0**			**0**	**0**	**9**
Total credit hours required in Degree Program : 42									

INDUSTRIAL AND SYSTEMS ENGINEERING

ISE 501 Deterministic Operations Research (3-0-3)
Model construction and modelling issues. Linear programming (LP) formulation, Simplex method: two-phase algorithm, dual simplex method, network simplex method. Duality, sensitivity analysis, economic interpretation and applications. Integer programming (IP), modelling techniques using zero-one variables. Branch and bound algorithm. Nonlinear programming formulation. Nonlinear programming optimality conditions. Computer packages and case studies.
Note: Not to be taken for credit by ISE students
Prerequisite: Graduate Standing

ISE 502 Probabilistic Modeling in ISE (3-0-3)
Axioms of probability, joint conditional probability, independence, continuous, discrete and mixed random variables, functions of random variables, expectations and conditional expectations, variances and co-variances, correlation, multi-dimensional random variables. Markov chains, Poisson processes, Applications in inventory control, quality, reliability and renewal theory.
Prerequisite: Graduate Standing

ISE 503 Linear Programming and Applications I (3-0-3)
Review of linear programming, revised simplex method, product form of the inverse, duality, dual simplex method, primal dual simplex method, sensitivity analysis, parametric programming, bounded variable linear programs, decomposition principle, classical networks, shortest path problem, maximal flow problem, Dantzig-Wolfe multi-commodity networks. Additional topics may be selected from complementarity, fractional programming and computational efficiency of linear programming algorithms. Case studies.
Prerequisite: Graduate Standing, Consent of Instructor

ISE 504 Optimization Methods in Data Mining (3-0-3)
The course emphasizes the basic concepts of data analysis related to unsupervised and supervised learning. Specifically, in unsupervised learning the focus is on clustering (partition, density based and hierarchical), correlation analysis, and dimension reduction. Optimization methods in regression (linear and regularized), classification (linear, kernel, trees and boosting), handling data uncertainty and robust optimization, model selection, and model validation (cross validation and bootstrapping) will also be considered. The topics will be covered w.r.t Operations Research viewpoint.
Prerequisite: Graduate Standing

ISE 505 Supply Chain Management (3-0-3)
This course introduces supply Chain Management (SCM) concepts and issues. The major content of the course is divided into three modules: supply chain integration, supply chain decisions, and supply chain management and control. A variety of instructional tools including lectures, case discussions, and group projects and presentations are employed.
Prerequisite: Graduate Standing

ISE 507 Mathematical Models in Maintenance (3-0-3)
Review of mathematical models for maintenance, capacity planning models, planning and scheduling models, inspection models, preventive maintenance models, component replacement models, Block replacement models, models for spare parts provisioning, models for condition based models including proportional hazard models. Integrated models that include maintenance, production and quality.
Prerequisite: ISE 502, ISE 503

ISE 508 Advanced Production Systems and Inventory Control (3-0-3)
Analysis of production and inventory systems, forecasting, single and multi-period deterministic inventory models, stochastic inventory models, deterministic and stochastic production planning, Multistage and dynamic production planning models, MRP systems, Pull, Push and Just-in-Time Systems.
Prerequisite: Graduate Standing

ISE 509 Reliability Engineering (3-0-3)
Reliability engineering applications, reliability measures, static and dynamic reliability models. Bath-tub curve, reliability; series, parallel and r-out-of-n configuration. Reliability data analysis using the exponential, Weibull and lognormal distributions, catastrophic failure models: hazard rate models. System reliability: approximation methods and reliability bounds. Accelerated life testing. Case studies and applications.
Prerequisite: ISE 502

ISE 511 Condition Monitoring Technologies (3-0-3)
Condition monitoring technologies in predictive maintenance, in depth study of the use of vibration analysis, acoustic emission, infrared thermograph, leak detection, oil analysis, and emission monitoring. Devices and products for condition monitoring. Data acquisition and use of predictive maintenance software to analyze and interpret the results of condition monitoring, base line database development. Case studies and computer applications.
Prerequisite: Graduate Standing

ISE 512 Advanced Supply Chain Modeling (3-0-3)
This course adopts a modeling approach to supply chains problems. Topics covered include supply chain design, multi-location inventory-distribution models, transportation and vehicle routing, supply chain distribution network design, integrated production, inventory and distribution problem, and reverse logistics. The key insights provided by such system-wide models will be illustrated through the use of spreadsheets and software packages such as CPLEX, presentations of research papers for emerging supply chain optimization problems.
Prerequisite: ISE 502, ISE 503

ISE 513 Advanced Linear Programming (3-0-3)

Convexity and optimality conditions. Review of simplex, duality, and Lagrange duality. Interior point methods. The decomposition principle. Dantzig-Wolfe decomposition, Benders decomposition. Application of the decomposition principle to solve large scale linear programs. Case studies.
Prerequisite: ISE 503 or equivalent

ISE 521 Non-Linear Programming & Applications I (3-0-3)
Formulation of engineering problems as nonlinear programs; Optimality conditions for nonlinear programs; Algorithms for unconstrained optimization; algorithms for constrained non-linear program; methods of feasible directions (Sequential unconstrained minimization techniques), comparison of algorithms for nonlinear programs. Case Studies.
Prerequisite: Graduate Standing, Consent of Instructor

ISE 522 Advanced Stochastic Simulation (3-0-3)
Fundamental concepts of mathematical and simulation models; efficient generation of random variants, construction of discrete event simulation models, discussion of available computer languages, variance reduction techniques, Jacknifying and classical methods, output analysis.
Prerequisite: Graduate Standing

ISE 525 Network Modeling and Algorithms (3-0-3)
Modeling with graphs and networks, data structures for network and graphs, shortest path algorithms, properties of the matrix, label setting and label correcting algorithms, spanning tree algorithms, maximum flow algorithms, maximum flow minimum cut theorem, algorithms for the assignment, semi-assignment and the transportation problems, minimum-cost flow algorithms, the simplex method on a graph, out-of-kilter algorithm, embedded networks, constrained network and generalized network, multi-commodity network. Modeling with network includes cases from production, facility location, distribution and inventory and human resource planning.
Prerequisite: ISE 503 or equivalent

ISE 526 Graph Mining and Optimization for Data Analytics (3-0-3)
Graph theory with a data mining focus adopting an optimization perspective. Descriptive Analysis of Networks Optimization models used in graph mining. Similarity Metrics, Clustering and Classification, Community Detection, Validation Techniques, Mathematical programming. Summarizing graphs, graph partition formulations, k-club problem, cliques and sub-groups. Software applications and use. Case studies. Course project.
Prerequisite: Graduate Standing

ISE 527 Decision Making (3-0-3)
Structuring decision problems: single criterion versus multiple criteria, certainty versus

risk and uncertainty versus conflict, criteria and attributes, payoffs and losses. Utility function for decision making. Decision making with single and multiple criteria under certainty: selected discrete MCDM models. Decision making under risk: decision trees, single and multiple stages. Value of information. Decision making under uncertainty. Decision making under conflict: game theory. Decision support systems. Case studies.
Prerequisite: Graduate Standing

ISE 529 Maintenance Management (3-0-3)
Maintenance Strategy, Organizing the maintenance structure, Maintenance management techniques, Designing maintenance organization, maintenance processes, planning and scheduling, quality assurance in maintenance systems, maintenance management information systems, measuring and benchmarking maintenance performance, auditing and improving maintenance systems. Case studies.
Prerequisite: Graduate Standing

ISE 531 Systems Reliability/Maintainability (3-0-3)
Tools for reliability analysis such fault trees, failure mode and effect analysis and root cause analysis. Maintainability concepts and measures, system effectiveness and operational readiness, Repairable systems: methods based on renewal theory, system availability. Reliability centered maintenance, Design for maintainability. Practical applications and case studies.
Prerequisite: ISE 509

ISE 532 Intelligent Maintenance Systems (3-0-3)
Predictive and analytic prognosis tools for machine monitoring, emerging technologies, that include information and communication technologies (ICT), analysis of big data in maintenance, clustering and forecasting, e-maintenance, integration of maintenance quality, production and scheduling.
Prerequisite: ISE 502, ISE 503

ISE 533 Advanced Work Measurement and Analysis (3-0-3)
Design of industrial operations with emphasis on the effective uses of the human body. An examination of the problems of establishing time standards and proposed solutions. Learning curves, fatigue allowances, variations of the MTM system, computerized work measurement systems, staffing problems. Term project on industrial methods design.
Prerequisite: Graduate Standing

ISE 534 Advanced Quality Control (3-0-3)
Statistical methods in the design and analysis of quality control systems: sampling inspection plans, attributes and variables; inspection errors; comparison of sampling plans; control charts design; adaptive quality control; total quality control. Machine and process capability studies; organizing for quality; machine case studies/projects with local industries.

Prerequisite: Graduate Standing

ISE 535 Design of Experiments (3-0-3)
A scientific and engineering approach to experimentation and analysis of data. Single-factor experiments; Latin squares etc., factorial experiments. Missing data analysis; nested factorial design; multifactor design; fractional replications. Case studies.
Note: Can not be taken for credit with STAT 530
Prerequisite: Graduate Standing

ISE 536 Human Factors Engineering (3-0-3)
Design of man-machine systems utilizing results from various disciplines including anthropometric data and engineering research. Emphasis is placed on making optimal use of human capabilities. Includes consideration of research techniques in human factors engineering.
Prerequisite: Graduate Standing

ISE 539 Systems Safety Engineering (3-0-3)
A basic methodology course in Occupational Safety and Health. Topics cover a spectrum of contemporary safety and risk management problems drawn from process as well as manufacturing industries. Problems will be handled using methods of Operations Research and Simulation. A project is a part of the course.
Prerequisite: Graduate Standing

ISE 541 Queuing Models & Theory I (3-0-3)
Queuing Systems; some important random processes, birth-death queuing systems in equilibrium; Markovian queues in equilibrium. Network of queues.
Prerequisite: ISE 502 or equivalent

ISE 543 Stochastic Processes I (3-0-3)
Introduction to stochastic process, stationary, ergodicity, Poisson process, linear models, Markov chains, renewal theory, Markov renewal processes, semi-Markov processes and Applications in queuing and other areas.
Note: Can not be taken for credit with EE 570
Prerequisite: ISE 502

ISE 548 Sequencing and Scheduling (3-0-3)
Variety of sequencing and scheduling problems in O.R., job shop and flow shop scheduling, discussion of performance measures, dynamic programming, integer programming, computational complexity and NP-completeness results, discussion of well solved problems, branch and bound methods, variety of heuristic approaches for intractable practical problems, guaranteed accuracy heuristics.
Prerequisite: Graduate Standing, Consent of Instructor

ISE 570 Optimization Methods for Engineering Designs (3-0-3)
Examples of optimization problems in engineering design: flexural systems, stressed systems, mechanical systems, digital filters. Optimality conditions. Single and multivariable unconstrained optimization. Constrained optimization. Survey of global optimization: exact and non-exact methods. Each student is expected to solve an optimal design problem related to his background.
Note: Can not be taken for credit by SE students
Prerequisite: Graduate Standing

ISE 571 Heuristic Search Methods (3-0-3)
Greedy methods for continuous and discrete variables. Concept of neighbor solution and neighborhood size. Penalty and Lagrange Methods for handling constraint models. Examples of combinatorial optimization problems in engineering. Simulated annealing, genetic algorithms, tabu search, evolutionary methods and neural networks. Hybrid methods. Application to large engineering optimization problems. Term project.
Note: Can not be taken for credit with EE 556
Prerequisite: Graduate Standing

ISE 590 Special Topics in Industrial and Systems Engineering (3-0-3)
This course covers new and recent topics in Industrial and Systems Engineering. A faculty member shall propose the independent study topics and shall be approved by the department council and the graduate council.
Prerequisite: Consent of Instructor

ISE 599 Seminar (1-0-0)
Graduate students working towards either M.S. or Ph.D. degrees, are required to attend the seminars given by faculty, visiting scholars, and fellow graduate students. Additionally each student must present at least one seminar on a timely research topic. Among other things, this course is designed to give the student an overview of research in the department, and a familiarity with the research methodology, journals and professional societies in his discipline. Graded on a Pass or Fail basis.
Prerequisite: Graduate Standing

ISE 600 Master of Engineering Project (0-0-3)
In this course the student conducts a project where he applies the knowledge gained in the course work to a problem in his area under the supervision of a faculty member in ISE and prepares a report. The report is expected to include an introduction, literature review, research methodology, model building and or data analysis, recommendations, references and appendices. This course requires a final project presentation and a report. It is required for all M. Eng students.
Prerequisite: ISE 502, ISE 503

ISE 603 Linear Programming and Applications II (3-0-3)
Algorithms for solving large scale linear programs. Interior and exterior point methods and their convergence properties. Computational complexity of linear programing algorithms . Efficient implementation for large scale LP, computer project.
Prerequisite: ISE 503

ISE 606 Independent Research (3-0-3)
This course is intended to allow students to conduct research in advanced problems in his MS research area. The faculty offering the course should submit a research plan to be approved by the graduate program committee. The student is expected to deliver a public seminar and a report on his research outcomes at the end of the courses. Graded on a Pass or Fail basis.
Prerequisite: ISE 502, ISE 503, Prior arrangement with an instructor

ISE 608 Advanced Production Systems (3-0-3)
Advanced forecasting models including Box and Jenkins approach. Advanced aggregate production planning models includes linear, quadratic and nonlinear programming models. Desegregation schemes. Lot sizing techniques for material requirement planning. Nervousness and freezing just-in-time manufacturing philosophy. Group technology. Algorithms for part family formation. Flexible manufacturing systems. World-class manufacturing. Effects of maintenance and quality on production. Research papers from various journals in the field are covered. Term projects.
Prerequisite: ISE 508

ISE 610 M. S. Thesis (0-0-6)
A student has to identify a specific problem, analyze it in depth, identify research objectives, and conduct the research to achieve the objectives under a supervision of a faculty member. In this course students have to demonstrate that they can conduct a research or a research-based design project individually and independently.
Corequisite: ISE 599

ISE 621 Nonlinear Programming & Applications II (3-0-3)
Elements of Convex analysis, optimality conditions for smooth optimization problems, duality theory for Nonlinear programs, formulation of quadratic programs as linear complementarity problems (LCP), successive linear programming or quadratic programming methods for NLP, convergence of nonlinear programming algorithms, complementary pivot method for LCP, complementary pivot methods for fixed point computing and their application to NLP, survey of other methods for constrained NLP (Frank-Wolfe method, methods of feasible directions, reduced gradient methods, penalty and barrier methods, gradient projection methods, active set methods and others), case studies.
Prerequisite: ISE 521 or equivalent

ISE 625 Network Algorithms (3-0-3)
Extension to the classical network problem formulation including constrained, multi-commodity and nonlinear networks. Uni-modularity property, assignment and matching, Lagrangian relaxation and network optimization. The decomposition approach for solving constrained and multi-commodity network. Traveling salesman problem, routing models, branch and bound and heuristics for routing problems. Polynomial time scaling algorithms, strongly polynomial algorithm for network problems. Algorithms for nonlinear networks. Complexity of network algorithms.
Prerequisite: ISE 525

ISE 626 Stochastic Programming (3-0-3)
Different formulations of the stochastic programming problem. Chance constrained problems, the recourse problem, linear programming under uncertainty. Decision rules in chance constrained programming, deterministic equivalence in stochastic programming, multi-stage stochastic programming, Duality and Computational issues in stochastic programming, Problems of existence of solution and optimality conditions in stochastic programming, stability of solutions in stochastic programming.
Prerequisite: ISE 502, ISE 503

ISE 627 Multi Criteria Decision Making (3-0-3)
Structuring decision problems with multiple criteria. Fundamentals and recent advances in multiple criteria decision making (MCDM) models. Selected approaches for discrete MCDM. Multiple criteria optimization: schemes for generating efficient solutions selected approaches: Goal programming, interactive approaches, surrogate worth tradeoff. Group decision making and negotiation. MCDM support systems. Case studies.
Prerequisite: ISE 503 or equivalent, Consent of Instructor

ISE 643 Stochastic Processes II (3-0-3)
Characterization and Specification of stochastic processes, stationary and ergodicity, correlation function and power spectra, wiener, Poisson, Markov and Gaussian processes; Martingales; orthogonally principle and mean square estimation; stochastic integrals. Introduction to stochastic differential equations and stochastic calculus.
Prerequisite: ISE 543

ISE 651 Integer Programming (3-0-3)
Formulation examples, computational complexity of algorithms and problems, P, NP-complete and NP-hard classes of problems, cutting plane theory, branch and bound, knapsack problem, Bender decomposition, partial enumeration and implicit enumeration methods, Lagrangian relaxation, local search and other heuristic approaches, simulated annealing, computer project.
Prerequisite: ISE 503

ISE 653 Dynamic Programming (3-0-3)
Multi-Stage problems and recursive algorithms, application in a variety of areas, Markov

renewal programming and discrete dynamic programming, applications to optimal control.
Prerequisite: ISE 503

ISE 691 Special Topics in Operations Research (3-0-3)
The objective of this course is to select a specific area in Operations & Research and study cases and research papers to enable the student to conduct research at the frontier of this area. The specific contents of the special topics will be given in detail at least one semester in advance of that in which it will be offered. It is also subject to the approval of the graduate council.
Prerequisite: ISE 502, ISE 503

ISE 693 Special Topics in Production Systems & Quality Control (3-0-3)
The objective of this course is to select a specific area in Production Systems and Quality Control, and study cases and research papers in it to enable the student to conduct research at the frontier of the area. The specific contents of the special topic will be given in detail at least one semester in advance of that in which it will be offered. It is also subject to the approval of the graduate council.
Prerequisite: ISE 508

ISE 695 Special Topics in Man-Machine Systems (3-0-3)
The objective of this course is to select a specific area in Man-Machine Systems, and study cases and research papers in it to enable the student to conduct research at the frontier of the area. The specific contents of the special topic will be given in detail at least one semester in advance of that in which it will be offered. It is also subject to the approval of the graduate council.
Prerequisite: Consent of Instructor

ISE 699 Seminar (1-0-0)
Graduate students working on their Ph.D. degree are required to attend seminars and contribute to the general area of their dissertation research. Grades will be Pass or Fail.
Prerequisite: Admission to Ph.D. Program

ISE 701 Directed Research I (0-0-3)
This course is intended to allow the student to conduct research in advanced problems in his Ph.D research area. The faculty offering the course should submit a research plan to be approved by the graduate program committee. The student is expected to deliver a public seminar and a report on his research outcomes at the end of the courses. Graded on a Pass or fail basis.
Prerequisite: Prior arrangement with an instructor

ISE 702 Directed Research II (0-0-3)
This course is intended to allow the student to conduct research in advanced problems in his Ph.D research area. The faculty offering the course should submit a research plan to be approved by the graduate program committee. The student is expected to deliver a

public seminar and a report on his research outcomes at the end of the courses. Graded on a Pass
or fail basis.
Prerequisite: Prior arrangement with an instructor

ISE 711 Ph.D. Pre-Dissertation (0-0-3)
This course enables the student to submit his Ph.D. Dissertation Proposal and defend it in public. The student passes the course if the Ph.D. Dissertation Committee accepts the submitted dissertation proposal report and upon successfully passing the Dissertation Proposal Public Defense. The course grade can be NP, NF or IC.
Prerequisite: Ph.D. Candidacy, ISE 699

ISE 712 Ph.D. Dissertation (0-0-9)
This course enables the student work on his Ph.D. Dissertation as per the submitted dissertation proposal, submit its final report and defend it in public. The student passes this course if the Ph.D. Dissertation Committee accepts the submitted final dissertation report and upon successfully passing the Dissertation Public Defense. The course grade can be NP, NF or IP.
Prerequisite: ISE 711