RUTGERS

The State University of New Jersey

Graduate Handbook: Industrial and Systems Engineering

Academic Year 2007 – 2008

THE STATE UNIVERSITY OF NEW JERSEY
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Welcome to Industrial and Systems Engineering at Rutgers!

The department of Industrial and Systems Engineering at Rutgers is committed to provide the highest quality education for our students. We are committed to research, often in collaboration with industry and other disciplines, to advance the state of knowledge and practice in our field. Both our teaching and research are firmly rooted in scientific principles, and at the same time incorporate in-depth knowledge of problem areas including manufacturing and production systems, quality and reliability engineering, systems engineering and information technology. Our objective is to solve complex, relevant engineering problems facing industry and the public sector today and in the future.

In a time of rapidly changing technology, industrial and systems engineers are needed to design cost-effective, efficient systems that can integrate complex technologies into manufacturing, service, and government enterprises. Industrial and Systems Engineers apply mathematical and economic analysis, engineering sciences, and information technology to design, control, and improve supply chain systems, quality control and monitoring systems, health care delivery systems, biological systems, transportation and port operations, security systems, and automated manufacturing systems. We analyze the reliability of electronic components and systems, the safety performance of airlines, and the performance of computer systems. We design information systems to seamlessly integrate large enterprises. The graduate programs in industrial and systems engineering at Rutgers provide students with a strong technical background and prepare them for leadership careers in this exciting and challenging profession.

This handbook is for prospective and current students. It contains information about admission and financial support and the detailed requirements for the MS and Ph.D. degrees. This document can be found on the web at www.ise.rutgers.edu. For graduate applications go to http://gradstudy.rutgers.edu.

We encourage prospective students to learn more about our program and we welcome new and current students to a productive 2007-2008 academic year.

Please feel free to contact us with your questions.

Prof. Hoang Pham, Department Chair
Prof. Susan Albin, Graduate Director (salbin@rci.rutgers.edu)

Table of Contents

1. Introduction To Degree Programs in Industrial and Systems Engineering

This handbook contains information about the graduate program in Industrial and Systems Engineering (ISE) at Rutgers. Here you will find admission requirements and descriptions of our degree programs and options.

The ISE Graduate Program offers both MS and Ph.D. degrees. For the MS degree there are four options: Industrial and Systems Engineering, Quality and Reliability Engineering, Manufacturing Systems Engineering, and Information Technology. The MS degree requires either 30 credits of course work or 24 credits of course work and 6 credits of thesis research. The Ph.D. degree requires 48 credits of course work beyond the BS degree and 24 credits of dissertation research. In later sections, the courses, laboratories, and program requirements are described in detail.

There are four main research areas for the graduate program: production/manufacturing systems, quality/reliability engineering, systems engineering including simulation, logistics and aviation safety, and information technology. The faculty and graduate students are active in research in these areas with publications in leading Industrial and Systems Engineering journals. The research has been supported by agencies including the National Science Foundation, the Department of Defense, the Federal Aviation Administration, and private industry. The department focuses on applied research in engineering.

The department offers well-equipped laboratories that are available to the graduate students. These include: the Computer Integrated Manufacturing Lab, the Quality and Reliability Lab, the Facilities and Layout Lab, the Microcomputer Lab, the Microprocessor and Manufacturing Information Technology Lab, and the forthcoming Pharmaceutical Processing Lab.

The Industrial and Systems Engineering department has eleven full-time faculty members. In addition, graduate students collaborate with faculty in other graduate programs including Statistics, Mechanical Engineering, Mathematics, Operations Research, and Management.

Currently there are approximately 55 students in the program, 30 in the MS program and 25 in the Ph.D. program. Twenty percent are US students; 80 percent are studying full-time. Many graduate courses are offered in the evening making it possible to complete a masters degree program while working full time.

We offer full or partial financial support to many of the graduate students in the form of teaching assistantships, research assistantships, and fellowships. In general, Ph.D. students who have completed their MS degrees are given priority; however students who are in earlier stages of their studies may also be considered for financial support.

2. Admission Criteria

Admission to the graduate program depends on performance in undergraduate studies, GRE scores, recommendations, and evidence of research potential. Below we provide some guidelines to help you decide if you wish to apply. We emphasize that the following numbers are only guidelines for admission to the graduate program.

- BS GPA (minimum): 3.0/4.0 for engineers (In India, first class); 3.2/4.0 for others
- MS GPA (minimum): 3.5/4.0 for Ph.D. applicants
- GRE scores (minimum): Verbal 560; Quantitative 750; Analytical 690; Analytic Writing 4.0
- TOEFL for International students (minimum): 575/233

Below you will find a list of the required prerequisite undergraduate courses. The courses are described in detail in Section 14 of this handbook.

- Four semesters of calculus including differential equations and linear algebra
- High level computer language (C++ for example)
- Deterministic Methods in Operations Research including linear programming (equivalent to Rutgers ISE course 540:311 or math course 640:453 or 711:453)
- Probability - calculus based (equivalent to Rutgers ISE course 540:210)
- Engineering Economics (equivalent to Rutgers ISE course 540:343)

If you are missing one or more of the prerequisite courses you may be admitted to the graduate program conditionally; that is, you are accepted with the requirement that you take the prerequisites within the first year and receive a grade of B or better. If these conditions are not satisfied you may be dropped from the program. Part-time students are given additional time.

If you have not taken the calculus-based course in probability you must take 960:580 (or 960:582) and you will receive credit. However, MS students in the Manufacturing Systems option or the IT option will be permitted to take 960:379 for credit. (Note: this is a new rule starting in 2006 – previously all students were required to take 960:580 to receive credit.)

If you have not taken Deterministic Methods or Operations Research, you must take 540:311 or 640:453 for NO credit.

If you have not taken Engineering Economics, Adv. Eng. Eco 540:575 must be taken for credit. (Note: this is a new rule starting in 2006 – previously MS students were required to take Engineering Economics 540:343 for no credit.)

Sometimes it is difficult for the admissions committee to judge the content of a course from its title on the transcript. If you believe you have studied material in a course that is an admission condition, discuss it with the Graduate Director. Prepare yourself with a catalog description or course outline to show that you have already studied the required material.

3. Financial Support

The department currently supports about thirty graduate students with fellowships, teaching assistantships, and graduate research assistantships. The support includes a stipend of approximately $19,000 plus tuition. Other students receive partial support or are paid hourly to participate in research projects.

Graduate research assistants and teaching assistants are required to work for fifteen hours per week on the projects or courses to which they are assigned.

In funding new students, doctoral students receive first priority for support. Almost all offers of funding for new students go to doctoral students who have already completed their MS degrees.

Some MS students receive full or partial funding after they have joined the program. This funding may be hourly payment for research assistance or a limited term appointment as a teaching assistant or graduate research assistant. There are also many job opportunities on campus – assisting in research projects on an hourly basis, conducting recitations in calculus, and so on. It is unlikely that an international MS applicant will be offered financial support before joining the program.

When the admissions committee accepts a student, he or she is notified by letter and is placed on the list of students eligible for financial support. In March, offers for fellowships are sent out.

Financial support is highly competitive. The typical recipient has qualifications that far exceed the minimum admission requirements. In particular, the recipients show clear evidence of research potential, for example, detailed recommendations from a research advisor or a prize in recognition of excellent research.

4. MS Degree Requirements

Credits: The MS degree requires a minimum of 30 credits. Depending on the MS option that a student chooses, either 18 or 21 credits must be taken from the ISE department at Rutgers – these courses begin with the number 540. MS students in the thesis option may not take independent student course Special Problems 540:550 for degree credit.

Seminar: Each student must register three semesters for the ISE seminar (540:691 or 692), a zero credit course. In the ISE seminar, speakers from industry and academia present their latest research. The seminar course is pass/fail.

Non -Thesis Option: To comply with a new policy from the Graduate School New Brunswick, MS students in the non-thesis option, starting with students entering in Fall 2007, must write a report and make a presentation at a public seminar on an ISE topic. Graduate students and at least three faculty members will attend the presentation.

Each student will identify a faculty member as his or her supervisor who will approve the topic. Possible topics include work that was done individually for a class project, an extension of class material, or review and synthesis of several journal articles.

The presentation will be 20 minutes long. Dates in October and November, February and March, will be set aside for presentations. Students will sign up in advance for a presentation date. The report must be approximately 20 pages, double-spaced, 12-font. The format will be typical of scientific papers: abstract, introduction, two or three sections of a body, conclusions, references, and appendices if necessary. The final report must be approved by at least three members of the Graduate Faculty. If the presentation and report is not accepted, the student will be required to make revisions.

Thesis: Students may elect to write an MS thesis in place of six credits of coursework. The thesis is a closely supervised project of original research. Most of our masters theses have been published in leading ISE journals. The administrative steps for students who write an MS thesis follow:

MS thesis proposal:

- ✓ By the end of the first year identify an advisor.
- ✓ Select a committee of at least three members of the ISE program.
- ✓ Set the date with the committee, reserve the conference room, and provide an abstract to the graduate secretary to distribute to faculty and graduate students. Submit proposal form electronically to the Graduate Director.
- ✓ Distribute the written proposal at least one week in advance to committee members.
- ✓ Give a formal 30-minute presentation on your proposal.

MS thesis defense:

- ✓ Prepare the Admission to Candidacy Form for the MS degree, which can be obtained from the ISE office.
- ✓ Fill in all your courses and submit it to the ISE office for verification.

- ✓ Set the date with the committee, reserve the conference room, and provide an abstract to the graduate secretary to distribute to faculty and graduate students. Submit defense form electronically to the Graduate Director.
- ✓ Distribute the written proposal at least ten days in advance to committee members.
- ✓ Give a formal one-hour presentation on your thesis.

MS Options: The ISE program offers four MS options:

- Industrial and Systems Engineering
- Manufacturing Systems Engineering
- Quality and Reliability Engineering
- Information Technology

The options vary in the proportion of required and elective courses. The advisor must approve all elective courses. Students who have taken a required course to fulfill undergraduate requirements may substitute an additional elective in place of the required course. For example, if a student has taken Computer Aided Design (a required course in the Manufacturing Systems option) as an undergraduate, the student obtains a waiver for the course, in writing, from the Graduate Director. The student does not retake it in graduate school but selects an additional elective such that the total number of graduate credits is 30.

The options are summarized in the following table and then described below.

Requirement	ISE	Mfg	Quality	IT
Total credits	30	30	30	30
Minimum ISE credits	21	21	18	18
Seminar 3 semesters	Yes	Yes	Yes	Yes
Thesis option	Yes	by arrangement	Yes	by arrangement
Required courses	15 credits	24 credits	21 credits	27 credits

Summary of MS Requirements - four options

4.1. Industrial and Systems Engineering Option

The Industrial and Systems Engineering option is the most flexible option allowing students the opportunity to select electives focusing on their areas of interest. The required courses provide a firm foundation in mathematical modeling, simulation, and production systems. The option requires 30 credits with at least 21 credits from the ISE program.

Required courses:

540:510	Deterministic Models in Industrial Engineering
540:515	Stochastic Models in Industrial Engineering
540:555	Simulation of Production Systems
540:560	Production Analysis
960:590	Design of Experiments

4.2. Manufacturing Systems Engineering

The Manufacturing Systems Engineering option offers students a rich specialty in automation and manufacturing processes. A special feature of the Manufacturing Systems option is the required course Manufacturing Project, a 3-credit, hands-on course where each student performs independent laboratory research in manufacturing.

This option requires 30 credits of course work. Students take 8 required courses. At least 21 credits must be taken from the ISE program.

Required Courses:

540:552	Manufacturing Project
540:555	Simulation of Production Systems
540:560	Production Analysis
540:568	Automation and Computer Integrated Manufacturing I
540:572 or 486	Mfg Processes and Control or Automated Manufacturing Systems
540:573	Advanced Manufacturing Processes
650:388	Computer Aided Design
960:590 or 540	Design of Experiments or Statistical Quality Control

4.3. Quality and Reliability Engineering

The Quality and Reliability option, offered in cooperation with the Statistics department, prepares students with a specialty focusing on design of experiments, process control, reliability and quality management.

The Quality and Reliability Engineering option requires 30 credits with at least 18 from the ISE program. Following are the required courses:

Industrial and Systems Engineering:

540:560	Production Analysis
540:585	Systems Reliability Engineering I
540:685	Systems Reliability Engineering II
540:580	Quality Management

Statistics

960:540	Statistical Quality Control I
960:542	Life Data Analysis
960:590	Design of Experiments

Prerequisite Override – Statistics courses: To register for a 960:540 Statistical Quality Control I, 960:542 Life Data Analysis, or 960:590 Design of Experiments the ISE graduate director can give you a prerequisite override form which you must use to register in person.

4.4. Information Technology

The option in Information Technology educates students in the design, implementation, and improvement of information systems in the manufacturing and service industries. Students will be trained in system integration, that is, utilizing technologies in software engineering, system design and analysis for the purpose of building a robust enterprise where information systems are seamlessly integrated into the enterprise functions. The option requires courses across disciplines including industrial and systems engineering, computer science, information technology, information systems and telecommunications.

The typical student will have a BS in engineering and possibly industrial experience. The Information Technology option requires 30 credits with at least 18 from the ISE program. There are 27 required credits and 3 elective credits. The required courses follow.

Industrial & Systems Engineering

540:485	Manufacturing Information Systems
540:540	Computational Methods in IE
540:542	Enterprise Integration
540:555	Simulation of Production Systems
540:568	Automation and CIM I

Electrical & Computer Engineering
332:543 Communication Networks

Computer Science
332:573 Data Structures & Algorithms (198:503)
198:505 Computer Structures

Graduate School of Business
010:622 Internet Technology

5. Ph.D. Degree Requirements

The program offers a Ph.D. degree in Industrial and Systems Engineering. Students complete the following requirements to graduate: course requirements, the written qualifying examination, the thesis proposal, and the dissertation defense. Details of these steps are summarized in the following table and then discussed below.

A student with an MS degree in Industrial Engineering or a closely related field takes the qualifying examination after the first year of study. The total period of study is approximately 4 years. Students with backgrounds other than Industrial Engineering and students who have only a BS degree upon entering the program may take longer.

Requirement	Ph.D. after BS	Ph.D. after MS
Total credits	72	54+18 transferred
Research credits	24	24
Course credits	48	30
Seminar all semesters	Yes	Yes
Minimum ISE credits	30	21
600 Level ISE credits	12	12
Dissertation	Yes	Yes
Qualifying Exam	Yes	Yes
Thesis Proposal	Yes	Yes
Required courses	DOE	DOE
Elective courses	advisor approval	advisor approval

Summary of Ph.D. Requirements

5.1. Course Requirements

A Ph.D. student entering with a BS degree takes 48 credits of course work and 24 credits of Ph.D. dissertation research. Of these 48 course credits, 30 must be in the ISE program.

A student entering the program with an MS from another university may transfer up to 18 credits (for appropriate courses with approval of the Graduate Director). The student takes at least another 30 credits of course work at Rutgers with at least 21 credits in the ISE program. The procedure for transferring credits is given in Section 6.

Students are required to take the following courses:

- At least four ISE courses at the 600 level
- Design of Experiments (960:590)

All doctoral students are required to register for and attend Seminar every semester. This is a zero-credit course that meets six times per semester for one hour featuring speakers from industry and academia.

5.2. The Qualifying Examination

The comprehensive exam tests students on their knowledge of the five core courses in Industrial and Systems Engineering, i.e.,

540:510	Deterministic Models in Industrial Engineering
540:515	Stochastic Models in Industrial Engineering
540:560	Production Analysis
540:585	Systems Reliability Engineering I
642:593	Mathematics Fundamentals in Industrial Engineering

Doctoral students take all sections of the qualifying exam after completing one year of course work. Under special circumstances students may obtain permission to take four sections after the first year and complete the remaining section the following year.

The exam is given the September of the fall semester. Students are asked to sign up to take the exam approximately one month in advance. Each part is an open book exam that is 3 hours long. Students are required to respond to all questions.

All students are required to take the mathematics course 642:593. Students must take all the exams. In addition, the mathematics course is only offered in alternate even numbered years, i.e., 2006, 2008, etc.

The exams focus on the topics covered in the courses. The questions, however, test the depth of your knowledge. It is not necessary to worry about obscure details. However, it is necessary to know in depth the material from the courses.

A committee of professors is assigned to compose and proctor each exam. The graduate committee that is chaired by the Graduate Director determines the final results. Students are notified about the results within two weeks of the exam at the latest.

If a student fails one or more sections of the exam, the graduate committee may recommend that the student repeat those sections. If a student fails several sections and shows a serious lack of comprehension, the graduate committee may recommend that a student withdraw from the program. Students may only repeat a section one time.

5.3. The Thesis Proposal

This is an oral examination that focuses on the student's dissertation proposal. The student will be questioned on the proposed research and knowledge relating to the research area. Here is a checklist of items in preparation for the thesis proposal:

- ✓ Select a committee of at least four members. At least three must be members of the ISE program and at least one must be an outside member, i.e., a qualified person in industry or academia outside the ISE graduate program.
- ✓ Set the date with the committee, reserve the conference room, and provide an abstract to the graduate secretary to distribute to faculty and graduate students. Submit the proposal form electronically to the Graduate Director.
- ✓ Distribute the written proposal at least one week in advance to committee members.
- ✓ Prepare the Admission to Candidacy Form, which can be obtained from the ISE office.
- ✓ The presentation should be approximately one hour long. The committee approves the proposal by signing the Candidacy Form at the conclusion of the proposal presentation.

- ✓ Hand deliver the candidacy form signed by your committee to the Graduate School, 25 Bishop Place, New Brunswick.

After the proposal is approved the student becomes a Ph.D. Candidate.

5.4. Dissertation Defense

The Ph.D. dissertation is expected to be an original and significant contribution to the field of Industrial and Systems Engineering. Upon completion of the dissertation, the student defends it at an open oral examination. Successful performance at the oral examination is the last requirement of the Ph.D. degree.

Here are some items that must be taken care of by the student before the dissertation defense.

- ✓ Set the date with the committee, reserve the conference room, and provide an abstract to the graduate secretary to distribute to faculty and graduate students. Submit the defense form electronically to the Graduate Director.
- ✓ Distribute the written dissertation at least ten days in advance to committee members.
- ✓ Obtain your Admission to Candidacy Form from the Graduate School and complete the form. Your committee members sign this form to approve the dissertation.
- ✓ Defend your dissertation. The presentation should be approximately one hour long.
- ✓ Submit your thesis to the Graduate School carefully checking that you have followed the prescribed format.

6. Transfer of Credits

Up to nine credits of course work may be transferred from another school towards an MS degree with the approval of the Graduate Director. Up to 18 credits of course work may be transferred towards the Ph.D. degree. Students may arrange the transfer after they have accumulated 12 credits at Rutgers. The form for transfer of credit is available in the ISE Office.

7. Faculty Advisors

For MS or Ph.D. students involved in thesis research, your advisor is the faculty member guiding your research. For all other students, such as first year students and MS students not participating in thesis research, the Graduate Director serves as advisor.

Identifying a research advisor is one of the most critical responsibilities of a student who intends to get involved in research. The first step is to find out the research areas of the faculty. A brief description appears in this handbook. You are encouraged to make appointments with faculty members and ask them about their research. If a seminar, article, or course particularly interests you, speak to faculty in that area of research.

After a general area has been identified and a faculty member has agreed to advise you, please inform the Graduate Director. You should identify an advisor and a general research area before the end of the first year at Rutgers.

8. Registration

New Students Must Meet With Graduate Director: As soon as you arrive on campus – the week before classes begin is convenient for many students – please call the ISE department and arrange a meeting with the Graduate Director to select your courses. This meeting is an opportunity for new students to discuss prerequisite courses that have been required for admission. If you feel that the requirement is unnecessary, bring a catalog description or course

outline to show that you have already studied the required material. Students must obtain waivers for prerequisite courses in the first semester.

Web Registration: All students, including new students, may register on the web. Registration is in mid-March for the Fall Term and Summer Session and in early October for the Spring Term for continuing students. It is your job to be aware of registration deadlines.

Registering in Person: Some times it is necessary to register in person because a deadline has been missed or you must present a prerequisite override form or there is some other complication. The Registrar is located in the Administrative Services Building (ASB), 65 Davidson Street, rooms 202 A, B, F, L.

Cashier's Office: It is possible to pay on-line. However to do so in person go to Records Hall, 620 George Street, on the College Avenue Campus. The office is open from 8:30 to 5pm.

Identification Card (RU Express Cards): You may obtain a Rutgers identification card at Records Hall, 620 George Street, on the College Avenue Campus. The office is open from 8:30 to 6pm.

Definition of Full-time Student: For loan, housing, and visa purposes 9 credits is considered full-time for all Rutgers graduate students. Students taking 9 or more credits will be charged full-time student fees. The credit charge will remain as in the past: students pay per credit up to 12 credits and pay the amount equal to 12 credits when registered for 12 or more credits. Graduate and Teaching Assistants usually carry 9 credits of course work.

Maximum Credits: The maximum that the Graduate School allows is 16 credits, which includes TA and GA credits but not fellowship credits.

Minimum Credits: Ph.D. candidates who have finished their required research credits but are still working on their dissertation must register for 1 credit of research each semester. MS students who are working on a thesis and have already completed the required 6 research credits may register for matriculation continued.

Matriculation Continued: This is for students who are taking a leave of absence from school for any reason. Do not just disappear from school. If you will be absent from campus for a semester, register for Matriculation Continued 540:800 or you will be automatically dropped from school and readmission will be required. You may register for 540:800 for only two consecutive semesters.

Research Credits: If you are participating in research be sure to register for research credits. This includes students in the early stages that are identifying topics and reading with a professor and students who have already taken the minimum required number of research credits but are still working on their dissertations. You may register for the number of credits that your advisor approves.

TA, GA and Fellow Credits: All TA's, GA's, and Fellows must register their appointments each semester for the appropriate number of credits. Students who are awarded a full assistantship or fellowship should register for 6 credits per semester, while those who receive a one-half appointment should register for 3 credits. For fellows, the credits don't count toward the 16 credit maximum; for GA and TAs, the credits do count. Students are not charged for these credits.

Course Numbering System: The Graduate School code is 16. The code for ISE is 540. Other codes often used: 14 is undergraduate Engineering; 01 is undergraduate Arts and Sciences.

Special Permission Numbers: To register for a course outside the graduate school (school 16) the student must obtain a special permission number from the department that offers the course.

For example, if a student wants to take a course in the Business school, a special permission number is needed from the relevant department.

Prerequisite Override – Statistics courses: To register for a 960:540 Statistical Quality Control I, 960:542 Life Data Analysis, or 960:590 Design of Experiments the ISE graduate director can give you a prerequisite override form which you must use to register in person.

Undergraduate Courses for CREDIT: A maximum of 9 credits at the 300 and 400 level may be applied towards a graduate degree. Put "G" in the Credit Hour Prefix box to indicate "graduate credit." Graduate students need a special permission number to register for undergraduate courses (including ISE undergraduate courses).

Undergraduate Courses for NO CREDIT: Some new students are required to take undergraduate prerequisite courses for no credit. Graduate students need special permission numbers to register for undergraduate courses (including ISE undergraduate courses). If you are taking the course for no credit put "N" in the credit hour prefix box to indicate no credit.

Undergraduate Course Periods: Undergraduate courses mostly meet during the day. The time periods are as follows for the Busch campus. Starting in Fall 2005 there will be a temporary revision of these to accommodate road construction between the campuses:

Period	1	2	3	4	5	6	7
Starts	8:40 AM	10:20 AM	12:00 noon	1:40 PM	3:20 PM	5:00 PM	6:40 PM
Ends	10:00	11:40	1:20	3:00	4:40	6:20	8:00

Class periods - standard start and end times

ISE Seminar: ISE Seminar has course number 540:691 in the Fall and 540:692 in the Spring. All MS students must register for the seminar for three semesters. Starting in Fall 2005, all Ph.D. students must register for the seminar every semester. The number of credits is 0.

Schedule of Classes: The Rutgers website for scheduling is kept up-to-date and is an excellent source of scheduling information: http://www.acs.rutgers.edu/soc Each semester the ISE office will distribute a list of courses available for the following semester.

Courses Offered Every Year: The schedule of courses changes from year to year, however there are some constants. Every Fall we offer Deterministic Models in ISE (510), Manufacturing Project (552), Quality Management (580), Systems Reliability Engineering I (585), and ISE Seminar (691). Every Spring we offer Stochastic Models in ISE (515), Manufacturing Project (552), Simulation of Production Systems (555), Production Analysis (560), Reliability II (685) and ISE Seminar (692).

9. Filing for Graduation

In order to graduate there are two forms that must be completed: (1) Admission to Candidacy, which checks that you have completed all requirements; and (2) Graduate Diploma Application, which is used to prepare the actual diploma. Degrees are awarded in January, May and October. The deadline for filing the candidacy admission form is announced each semester. It is usually the third day in January, May, and October, respectively. Try to get it in early.

Admission to Candidacy for MS students: Early in the semester in which you plan to graduate obtain a form from the ISE office entitled Admission to Candidacy for the MS degree. Fill it out, including all your courses. Submit it to Cindy Ielmini in the ISE Office, who will check it for

accuracy and obtain faculty signatures. Then hand carry it to the Graduate School where it is checked again. If there are no problems you are put on the list of graduates.

Admission to Candidacy for Ph.D. students: Before your thesis defense obtain your Admission to Candidacy for the Ph.D. degree form from the Graduate School where you filed it at the time you passed your thesis proposal. Complete the form including all your courses. Submit it to Cindy Ielmini, in the ISE Office, who will check it for accuracy. Bring it to your defense. When your thesis is approved your committee will sign it. Then you must hand carry it to the Graduate School where it is checked again. If there are no problems you are put on the list of graduates.

Graduate Diploma Application for All: This form is obtained from the I.E. office. The deadlines are normally January 2, April 1 and October 1. If you don't graduate at the planned time, you must file this form again.

Checklist: In preparing candidacy forms here are the items to check. Your transcript and candidacy form must show that you have

- ✓ the required number of credits
- ✓ the required number of credits that begin 540:xxx
- ✓ specific required courses
- ✓ three semesters of Seminar
- ✓ prerequisite courses or waivers from the Graduate Director

10. Academic Performance

Grades less than B. Course work performance of graduate students is evaluated at the end of every semester (including summer). A grade less than B is not considered acceptable in the graduate program. A student who receives a passing grade below B will receive a warning letter. A student who receives a failing grade or a second grade below B will be put on academic probation. If a student on probation receives a grade below B, a committee of the graduate faculty may vote to recommend dismissal from the program due to unacceptable academic performance. These rules apply to all courses including graduate and undergraduate courses taken for credit or for no credit.

Minimum GPA. The minimum GPA is 3.0. A student with GPA below 3.0 will be put on academic probation. If a student on probation does not improve in the following semester, a committee of the graduate faculty may vote to recommend dismissal from the program due to unacceptable academic performance. These rules apply to all courses including graduate and undergraduate courses taken for credit or for no credit.

Research Progress. A Graduate Faculty meeting is held after each semester to discuss the progress of each Ph.D. student. Your research advisor will give you feedback. If a student is having difficulty, the faculty will recommend a course of action to improve the situation. Evidence of progress in research is necessary to remain in the program and is necessary for continued funding.

Seven-Year Rule. Ph.D. students are expected to complete within seven years. The norm is 5 years for full-time students. The Graduate School will identify a doctoral student who will be enrolled for seven years and notify the student and the program. The student must file a request for extension, which includes statements by the students committee, the graduate program director, and the student explaining and justifying the request. The request must include an estimate of the completion date. The ISE program must decide whether to recommend the extension. Rejection of the request means that procedures to dismiss the student from the program must be initiated.

Incompletes. A grade of incomplete may be assigned if the instructor believes a time extension is justified. For graduate courses, you have 2 semesters to complete the course. If you don't complete within the 2 semesters, an incomplete remains on your record. You can apply for an extension signed by the graduate director and the professor.

For undergraduate courses (either for no credit or for credit) you have 2 semesters to complete the course. After the deadline, the incomplete automatically turns into an F.

For all courses, graduate and undergraduate, your registration can be blocked if you have 3 or more incomplete grades on your record.

11. General Information

Departmental Office: The Industrial and Systems Engineering Department office is located on the second floor of the CORE Building (Room 201). The office has copies of most forms. Office hours are 8:30-4:30 PM, Monday through Friday and the office is closed for lunch between 12:00 - 1:00 PM.

Photocopying: Graduate students can copy material in each of the libraries on the Busch campus and in the SERC classroom building. Materials required by TAs in their instructional duties can be copied through the department office.

Mailboxes: Full-time students have a mailbox in Room 201. Check your mailbox regularly for both messages and mail.

Electronic Mail: All Rutgers students may obtain a computer account on the Eden machine in order to send and receive email. Go to the Micrographic Center in the basement of the Hill Center, Room 17, and the counselor there will show you how to create your account. The phone number is 445-2296 and they are open 10-6 PM Monday through Saturday. Please send your address to Professor Albin (salbin@rci) and to Cindy Ielmini (ielmini@rci). We will send you notices and announcements via email.

Employment Opportunities: Job announcements are posted on the bulletin boards and distributed via email. Students are encouraged to make use of the Career Development and Placement Office on Busch campus.

Graduate Student Offices: We have two locations for graduate student desks. These are assigned with the following priorities: teaching assistants, graduate research assistants, fellowship students, other Ph.D. students, other MS students. In the past year we have been able to accommodate all students who wanted a desk. Desks are reassigned each semester.

Telephones: There is a telephone in the graduate student office, room 104, in the CoRE building. The phone number is (732)-445-3602. This phone and most of the telephones in research and instructional laboratories cannot be used to dial outside the university.

Tuition Remission for Summer Session for TAs, GAs, and Fellows: Those with calendar year appointments receive full tuition remission during the summer. For GAs the advisor's grant is the usual source of funding.

Extra Pay for TAs, GAs, and Fellows: These students may hold up to half another award; that is, the student may work up to an additional 7.5 hours and earn up to half of their stipend.

Health Insurance: If a student is registered for 12 or more credits, health insurance is included in student fees. If a student is registered for less than 12 credits than insurance may be purchased for approximately $100. In addition students can purchase Major Medical Insurance by going to any

Student Health Center. Full appointment TAs and GAs receive university employee health insurance. Fellows and partial appointment TAs and GAs do not.

New International Students: On arrival, go to the International Center, 180 College Ave and bring your passport and visa documents. The Center holds orientation programs in the week before classes begin. There are free workshops and a weeklong orientation that includes several workshops, trips, and social activities with a charge of about $45. During orientation you can obtain a Social Security card on campus. At other times you can go to the US government office, 52 Charles St., New Brunswick. You will receive a receipt, which suffices until you receive your card in approximately 2-3 weeks.

New Students: No later than the week before classes, plan to arrive at Rutgers. Call the ISE office, 732-445-3654, and ask for Cindy Ielmini to schedule a meeting with the Graduate Director, Prof. Susan Albin, room 206. You will plan courses for the coming year and fill out your course request form. If you have questions about prerequisite requirements, bring appropriate documentation to show you have covered the required course material. Plan on spending 45 minutes.

TAs, GAs, & Fellows - Payroll Information: Meet with the ISE Administrative Assistant, Helen Pirrello, room 201. Bring your appointment letter and sign the attached waiver accepting the conditions of the position. If you didn't receive this letter and waiver in advance, you will receive it when you visit the ISE department. It is critical that you bring your social security receipt or card.

TAs, GAs, & Fellows - Tuition Remission Card, the RT100: At the time you submit your payroll forms to the ISE office you will be given a tuition remission card, the RT100, that is used to pay for your tuition. GAs and Fellows will get it signed in the ISE office. TAs must go to the School of Engineering, Room B114, and the accountant will sign it. Take the signed card with you when you to the cashier to register for your classes.

12. ISE Faculty and Staff Directory

The telephone number for the Industrial and Systems Engineering department is **(**732) 445-3654 and the fax number is (732) 445-5467. The area code and prefix is (732) 445 for all telephones - the extensions are given below.

NAMES	EXT	Room #	EMAIL
Faculty:			
Albin, Susan L.	2238	206	salbin@rci.rutgers.edu
Altiok, Tayfur	2829	216	altiok@rci.rutgers.edu
Boucher, Thomas O.	3657	224	tboucher@rci.rutgers.edu
Chaovalitwongse, Art	5469	212	wchaoval@rci.rutgers.edu
Coit, David	2033	214	coit@rci.rutgers.edu
Elsayed, Elsayed A.	3859	226	elsayed@rci.rutgers.edu
Gursoy, Melike B.	5465	218	gursoy@rci.rutgers.edu
Jafari, Mohsen A.	3627	220	jafari@rci.rutgers.edu
Luxhoj, James T.	3625	210	luxhoj@rci.rutgers.edu
Ozel, Tugrul	1099	208	ozel@rci.rutgers.edu
Pham, Hoang	3654/5471	201	hopham@rci.rutgers.edu
Staff:			
Ielmini, Cindy	3654	201	ielmini@rci.rutgers.edu
Lippencott, Joseph	5480	114	lippen@rci.rutgers.edu

Smith-Perrillo, Helen	3654	201	helen@rci.rutgers.edu

Laboratories:		
CAD/CAM Lab	5480	116
MicroLab	3671	106
Reliability Lab	5480	114
Facility Design Lab		110
Manufacturing Processing Lab		112
Conference Room		203

13. The Faculty

Susan L. Albin is Professor and Director of the Graduate Program in the Department of Industrial and Systems Engineering. She teaches and does research in the areas of quality engineering, on-line process control, multivariate statistics, and data mining. Her work has been applied in semiconductor manufacturing, plastics recycling, food processing, medical devices, and advanced display technologies. The NSF, FAA, DOD, and United States Army, as well as industrial partners, have supported Dr. Albin's research. Dr. Albin received her Ph.D. from Columbia University in 1981. She is elected Secretary of INFORMS, the Institute for Operations Research and the Management Sciences, and was a member of its board of directors. She is Focus Issue Editor for *IIE Transactions/Quality and Reliability Engineering.* She was elected a Fellow of IIE in 2006. She received the Exxon Education Foundation Award and is listed in American Men and Women of Science and Who's Who in Science and Engineering.

Tayfur Altiok is a Professor in the Department of Industrial and Systems engineering. He received his Ph.D. from North Carolina State University at Raleigh. He spent the 1992-1993 academic year in Universite Pierre et Marie Curie in Paris, France. He was awarded a Fulbright Fellowship in 1993 to teach performance analysis/queueing theory in Turkey. Dr. Altiok's research has been supported by the NSF, Department of Homeland Security, and a number of industrial sponsors. His research interests are in the areas of queueing theory, performance analysis of manufacturing systems, distributed computer systems as well as marine terminals and port security systems. Dr. Altiok has published in numerous scientific journals. His book entitled "Performance Analysis of Manufacturing Systems" was published in 1997, New York and "Simulation Modeling and Analysis with Arena" was published in 2001. His research has been applied in the areas manufacturing systems, client/server type transaction processing systems, continuous-flow mineral handling systems, bulk port marine terminals, and port security.

Associate Professor **Melike Baykal-Gursoy**, Ph.D., received her B.S. in Electrical Engineering and her MS in Electrical Engineering with a major in Control from Bogazici University, Istanbul, Turkey. She received her doctorate in Systems Engineering from the University of Pennsylvania, Philadelphia. She has been a visiting professor at the Industrial Engineering department at Bogazici University. She received grants from the NSF, United Nations, and DOD for research and teaching. Her research interests are in the areas of Markov decision processes, stochastic games, queueing; stochastic modeling and control of telecommunication/transportation networks and supply chains. She teaches courses in optimization, stochastic processes, queueing theory, inventory control, process modeling and control. She is currently involved in two projects. One is investigating incident management strategies for intelligent transportation systems. The other is finding optimal inventory control policies for retailers selling substitutable products. She is a member of INFORMS.

Professor **Thomas Boucher** received his BS in Electrical Engineering from the University of Rhode Island, a MBA from Northwestern University, and an MS and Ph.D. in Industrial Engineering from Columbia University. His teaching and research interests include engineering economics, manufacturing automation, and production planning and control. His research has been sponsored by NSF, the Defense Logistics Agency, and industry. He is the author of

"Computer Automation in Manufacturing," (Chapman-Hall, 1996) and co-author of "Design of Industrial Information Systems" (Elsevier, 2006) and "Analysis and Control of Production Systems," (Prentice-Hall, 1994). He was awarded the 2007 IIE/Joint Publishers Book-of-the-Year Award, is a four-time winner of the Eugene L. Grant Award for his journal articles in *Engineering Economics* and the 2002 recipient of the Wellington Award for outstanding contributions in the field of engineering economics. Dr. Boucher has served as a department editor for *The Engineering Economist* and *IIE Transactions*. He is currently Area Editor, Public Policy Analysis for *The Engineering* Economist. He is a senior member of IIE, SME, and IEEE and is listed in Who's Who in Science and Engineering and Who's Who in America.

Wanpracha (Art) Chaovalitwongse is an Assistant Professor in the department of Industrial and Systems Engineering. He received a B.S. degree in Telecommunication Engineering from King Mongkut Institute of Technology Ladkrabang, Thailand, in 1999 and M.S. and Ph.D. degrees in Industrial and Systems Engineering from University of Florida in 2000 and 2003. He previously worked as a Post-Doctoral Associate in the NIH-funded Brain Dynamics Laboratory, Brain Institute and in the departments of Neuroscience and Industrial and Systems Engineering at University of Florida. Before joining Rutgers, he worked for one year at the Corporate Strategic Research, ExxonMobil Research & Engineering, where he managed research in developing efficient mathematical models and novel statistical data analyses for upstream and downstream business operations. His teaching and research interests are in the areas of global optimization, combinatorial optimization, data mining, supply chain and logistics, and chaos theory with biomedical applications and computational biology. His work in epilepsy was awarded for Excellence in Research from the University of Florida, and he also holds a patent of novel optimization techniques adopted in the development of seizure prediction system. He has articles published in *Mathematical Programming, Operations Research Letters, Annals of Operations Research, IEEE transactions on Bio-medical Engineering, Journal of Combinatorial Optimization, Optimization Methods and Software, Computational Statistics and Data Analysis, Epilepsy Research, Journal of Clinical and Neurophysiology,* and *Epilepsia*. His articles were also awarded the William Pierskalla best paper for research excellence in Operations Research and Health Care applications by Institute of Operations Research and the Management Sciences (INFORMS) and ranked 5th in Top 25 Articles in Operations Research Letters by ScienceDirect (1st quarter of 2005). He is a member of MPS, SIAM, INFORMS and AES (American Epilepsy Society) and is listed in Who's Who in America and Who's Who in the World (Marquis edition).

Associate Professor **David W. Coit** received his BS in Mechanical Engineering from Cornell University, an MBA from Rensselaer Polytechnic Institute, and MS and PhD degrees in Industrial Engineering from the University of Pittsburgh. His research interests are in the areas of system reliability modeling and optimization, risk analysis, and multiple-objective optimization. In 1999, he was awarded a CAREER grant from the NSF to study reliability optimization considering reliability estimation uncertainty and risk. Previously, he worked for over ten years at IIT Research Institute (IITRI), Rome, NY, where he was a reliability engineer and project manager, and then later, the Manager of Engineering at IITRI's Assurance Technology Center. He is a member of IIE and INFORMS. He is a Department Editor for *IIE Transactions*, and serves on the Editorial Board for the journals *Reliability Engineering & System Safety* and *Journal of Risk & Reliability.*

Dr. Elsayed A. Elsayed is a Professor in the Department of Industrial and Systems Engineering at Rutgers University. He is also the Director of the NSF / Industry / University Co-operative Research Center for Quality and Reliability Engineering. His research interests are in the areas of quality and reliability engineering and production planning and control. He is a co-author of "Quality Engineering in Production Systems," McGraw Hill Book Company, 1989. He is the author of "Reliability Engineering," Addison-Wesley, 1996. These two books received the 1990 and 1997 IIE Joint Publishers Book-of-the-Year Award respectively. He is also the co-author of

"Analysis and Control of Production Systems," Prentice-Hall, 2nd Edition, 1994. He is the author and co-author of work published in the *IIE Transactions*, *IEEE Transactions*, and the *International Journal of Production Research*. His research has been funded by DoD, FAA, NSF, Honda Research Institute and industry. Dr. Elsayed has been a consultant for AT&T Bell Laboratories, Ingersoll-Rand, Johnson & Johnson, Personal Products, AT&T Communications, Ethicon and other companies. He was the Editor-in-Chief of the *IIE Transactions* and the Editor of the *IIE Transactions on Quality and Reliability Engineering*. He is also an Editor for the *International Journal of Reliability, Quality and Safety Engineering*. He serves on the editorial boards of other journals such as *International Journal of Production Research*, *Journal of the Korean Institute of Industrial Engineers*, *International Journal on Quality Technology and Quantitative Management* and *Computers and Industrial Engineering*.

Professor **Mohsen A. Jafari**, Ph.D., received his M.Sc. and doctorate in Industrial Engineering and Operations Research and an M.Sc. in Computer Science from Syracuse University. Dr. Jafari's current teaching and research interests are in the areas of discrete event systems theory with applications in manufacturing systems, business transactions processing, and Internet applications. He is currently working on developing intelligent control methodologies for designing dependable and re-configurable systems. He is also working on several multi-disciplinary funded research projects in the area of layered manufacturing and its applications in smart sensor and actuator technology. Recently he has also been recipient of several research projects in the area of e-learning. Presently he is an EXCOM member and the secretary of the IEEE SMC society. He has taught previously at Syracuse University and is a member of the IIE and IEEE.

Professor **James T. Luxhoj**, Ph.D., was a Visiting Professor at Aalborg University in Denmark from 1994-1995 and Fall 2001. Dr. Luxhoj received his Ph.D. in Industrial Engineering and Operations Research from Virginia Polytechnic Institute and State University in 1986. His research interests include decision support systems, risk analysis and system safety. The Federal Aviation Administration and NASA have supported Dr. Luxhøj's research in aviation safety risk analysis. He is a past Chairman and Director of the engineering economy divisions of the American Society for Engineering Education and the Institute of Industrial Engineers. Dr. Luxhoj was the recipient of a SAE Ralph R. Teetor Award for Engineering Education Excellence (1989), a Sigma Chi Outstanding Professor for Rutgers University Award (1991), the Rutgers University Parents' Association Teacher of the Year Awards for the College of Engineering (1997), and Engineering Governing Council's Excellence in Teaching Awards (2006, 2007). He currently serves as the IIE Faculty Advisor and the ISE Undergraduate Director. Dr. Luxhoj is a former Department Editor for the IIE Transactions on Operations Engineering. He is a member of IIE, Tau Beta Pi, Alpha Pi Mu, and Sigma Xi and is the co-author of "Engineering Economy," 13th ed. (Prentice-Hall, 2006).

Assistant Professor **Tugrul Özel** received his B.S. degree in Aeronautical Engineering from Istanbul Technical University, Turkey in 1987, an M.S. degree in Mechanical Engineering from Dokuz Eylul University, Turkey in 1991 and M.S. and Ph.D. degrees in Mechanical Engineering from Ohio State University in 1998. Dr. Özel previously worked four years at NSF funded Engineering Research Center for Net Shape Manufacturing and taught three years at Cleveland State University. He was a summer faculty fellow at NASA Glenn Research Center in 1999, where he conducted research on micromanufacturing sciences. His teaching and research interest include computational modeling of manufacturing processes, automated manufacturing and process control, optimization of processes and systems, and micro-manufacturing sciences. NASA/NJ Space Consortium and industry have funded his research. He has research articles published in *International Journal of Machine Tools and Manufacture*, *Journal of Materials Processing Technology*, *International Journal of Advanced Manufacturing Technology, ASME Journal of Manufacturing Science and Engineering,* and *Transactions of North American Manufacturing Research Institute*. He is a member of SME, ASME, IEEE and North American Manufacturing Research Institute (NAMRI). He is an editorial board member of *the International*

Journal of Machining and Machinability of Materials, and a guest editor for *the International Journal of Materials and Product Technology*. He is listed in The Marquis Who's Who in the World, Who's Who in America, and Who's Who in Science and Engineering. He received the *Best Paper Award in 8th CIRP International Workshop on Modeling of Machining Operations* in 2005 and his article co-authored with Y. Karpat ranked 1st in Top 25 Articles in International Journal of Machine Tools and Manufacture in 2006.

Hoang Pham is Professor and Chairman in the Department of Industrial and Systems Engineering at Rutgers University. Before joining Rutgers, he was a Senior Engineering Specialist with the Idaho National Engineering Laboratory and Boeing Company. Dr. Pham received his Ph.D. from the State University of New York at Buffalo. His research areas include system reliability modeling, maintenance, and software reliability. Dr. Pham is the Editor-in-Chief of the *International Journal of Reliability*, *Quality and Safety Engineering* and an Associate Editor of the *IEEE Transactions on Systems, Man and Cybernetics*. He is also the Editor of *Springer Series in Reliability Engineering* and an editorial board member of several other journals including *IIE Transactions on Quality and Reliability Engineering*, and *International Journal of Systems and Science*. Dr. Pham is the author of 4 books, edited 10 books and has published more than 90 journal articles. He is a fellow of IEEE.

14. Graduate Courses In Industrial and Systems Engineering

540:510 Deterministic Models in Industrial Engineering
Prerequisite: 540:311 (Undergraduate introduction to OR)
Deterministic models of operations research. Linear programming, the simplex method, duality and dynamic programming.

540:515 Stochastic Models in Industrial Engineering
Prerequisite: Calculus based course in Probability
Stochastic models of operations research applied to queuing, reliability, inventory, supply chain, and other problems. Poisson processes, Markov chains, Markov processes, renewal processes.

540:520 Supply Chain and Logistic Engineering
Prerequisite: Calculus, 540:311, and some knowledge of Probability
Methods and techniques of operations research applied to the design and analysis of marketing and distribution systems. Topics include sales forecasting, single- and multi-echelon inventory and distribution systems and routing and scheduling of product delivery.

540:522 Case Studies in Supply Chain Engineering
Prerequisite: 540:520
Supply chain practices in industry. Case studies from industrial participants. Customer segmentation, centralization/ decentralization, transparency and key customer integration requirements, and process organization and technology models. Quantitative approaches introduced.

540:525 Applied Queueing Theory
Prerequisite: 540:515
Markovian and non-Markovian queueing models, networks of queues, numerical solutions, approximations, emphasis on queueing applications in telecommunication, production, supply chain and logistics.

540:530 Forecasting and Time Series Analysis
Prerequisite: statistics
Alternative Stationary and nonstationary time-series models for purposes of prediction. Smoothing techniques, Estimating trend probability and regression analysis, seasonality. Various estimation and econometric analysis.forecasting techniques. Smoothing techniques.

540:535 Network Applications in ISE
Prerequisite: 540:311 (undergraduate introduction to OR)
Flow problems in networks. Topics include shortest-route problems, critical path and GERT.

540:540 Computational Methods for Industrial Engineering
Prerequisite: Programming in C is helpful but not required
Computational methods in modeling, planning and control of production systems, numerical methods, AI techniques, exact and heuristic search methods and computational strategies for large scale systems.

540:542 Enterprise Integration
Prerequisite: Manufacturing Information Systems 540:485
Building and integrating information systems into manufacturing, engineering, and business functions in an enterprise. Methodological and practical aspects including client-server models, internet based three-tiered system architecture, legacy systems, data transfer, and distributed computing. Project involves prototyping of small enterprise information systems from design to implementation.

540:545 Applications of Human Factors to Decision Systems Engineering
Prerequisite: Instructor's Consent
Human factors engineering techniques applied to specific design problems. Decision theory, decision elements in complex man-machine decision systems, concepts of prompting, expert systems and artificial intelligence. Introduction of psychological scaling techniques.

540:550 Special Problems in Industrial Engineering
Prerequisite: Instructor's Consent
Investigations in selected areas of Industrial and Systems Engineering and operations research.

540:552 Manufacturing Project
Prerequisite: Instructor's Consent
Understanding of the state of technology in discrete, batch, and continuous manufacturing, hands on experience.

540:555 Simulation of Production Systems
Prerequisite: Probability, FORTRAN
Discrete event simulation applied to problems in manufacturing, inventory control, and engineering economics. Topics include simulation languages, estimating production system operating characteristics, comparing alternative systems and validating approximate analytical models.

540:560 Production Analysis
Prerequisite: Probability and Linear Programming
Analysis of production engineering, with emphasis on planning and control of manufacturing and service systems.

16:540:564 Supply Chain and Logistics Engineering II
Prerequisite 540:520
Advanced methods and techniques of analysis applied to the design and operation of supply chains under uncertainty. Topics include inventory control of perishable items, multi-echelon inventory systems, transportation system planning and analysis, joint inventory and transportation planning models, supply chain contracts.

540:565 Facilities Planning and Design
Prerequisite: 540:311
Operations Research methodologies applied to facilities planning and design problems. Facilities layout and location problems, assembly line balancing, conveyor design and automated warehousing problems.

540:568 Automation and Computer Integrated Manufacturing I
Prerequisite: 540:382 (Computer Control) or permission of the instructor
Design of automated and computer integrated manufacturing systems using programmable automation. Modeling of discrete and continuous control systems, design and analysis of control architectures, implementation of programmable controllers and shop floor data acquisition systems. (revised from catalog)

540:570 Applications of Robotics in Manufacturing Systems
Prerequisite: 540:343, 540:453, and undergraduate course in computer control is helpful but not required
Integration of robots in manufacturing systems, design of robot workstations, materials handling and interactions among manufacturing cells. Economic feasibility and robot selection.

540:572 Manufacturing Processes and Control
Prerequisite: 540:303 (Manufacturing Processes), and 540:382 (Computer Control) or permission of the instructor

Overview of manufacturing processes and computer numerically controlled machines, basic digital control theory, design and simulation of advanced controllers, tracking control in machine tools, precision engineering, sensors-based advanced monitoring of machining systems. (revised from catalog)

540:573 Advanced Manufacturing Processes
Prerequisite: 14:540:303 (Manufacturing Processes) or permission of instructor
Introduction to modeling of manufacturing processes. Metal cutting theory and modeling advanced machining processes such as hard turning and high speed milling. Modeling of non-traditional manufacturing processes (laser, water jet, electrical discharge machining, electro-chemical machining). Additive processes and rapid prototyping. Emphasis on process physics and analytical and computational procedures to predict manufactured product quality and production rate. (revised from catalog)

540:575 Advanced Engineering Economics I
Prerequisite: 540:343 (undergraduate engineering economics)
Economic decision models for engineers involving allocation and scheduling of resources, evaluation of factual and strategic alternatives, advanced risk and uncertainty analysis, weighing and evaluating non-monetary factors.

540:580 Quality Management
Prerequisite: Instructor's Consent
Quality management philosophies, Deming, Jran, quality planning, control, and improvement, quality systems, management organizations for quality assurance. Role of Operations Research.

540:585 Systems Reliability Engineering I
Prerequisite: undergraduate probability required; first course in stochastic OR helpful
Methods of measuring the reliability effectiveness of complex engineering systems, including optimization theory, preventive maintenance models, and statistical analysis.

16:540:586 Maintenance Modeling and Optimization
Prerequisite: Systems Reliability I 540:585
Maintenance issues, technical foundations for modeling such large-scale systems, approaches for condition maintenance and optimization methodologies for optimum inspection, repair and maintenance schedules.

540:590 Design of Engineering Experiments
Prerequisite: Statistics
The efficient design, analysis, and interpretation of engineering experiments using statistical methods. Analysis of variance and covariance. Designs commonly used in engineering experimentation. Analysis of response surface. Computer applications.

540:595 Software Reliability I
Prerequisite: 540:515 or 960:580 Basic Probability
Software reliability issues, software errors, faults, and failures, software design for reliability, data collection, formal methods for reliability, software fault tolerance, modeling growth in software reliability, cost modeling and estimation, and software quality management.

540:615 Nonlinear Programming
Prerequisite: 14:540:311 or equivalent.
Some methods and applications of nonlinear programming, approximate methods; Kuhn-Tucker theory; quadratic programming; integer linear programming; gradient methods; stochastic programming; computer solutions.

540:650 Discrete Event Dynamic Systems
Prerequisite: 540:515
Supervisory control of discrete event dynamic systems, process monitoring, Petri nets, functional analysis, performance analysis, control specification, control verification and validation.

540:655 Performance Analysis of Manufacturing Systems
Prerequisite: 540:515, 540:525
Modeling of manufacturing systems such as flow-shops, transfer lines, job-shops and flexible manufacturing systems. Topics include problems of failures and repairs, the role of buffer inventories, capacity allocation and machine interference problem.

540:660 Inventory Control
Prerequisite: 540:515
Modeling of supply chain and logistic systems with stochastic demand and lead times. Characterization of optimal control policies and analysis of single as well as multi-item systems with single and multiple echelons, multiple retailers. Computational issues are emphasized.

540:665 Theory of Scheduling
Prerequisite: undergraduate production course and advanced Calculus
Advanced topics in sequencing and scheduling for manufacturing and service systems, flow-shop job-shop static and dynamic models, multi-processor parallel machining, preemptive-resume algorithms, optimal due date problems, probabilistic sequencing, simulation and applied operations research models.

540:668 Automation and Computer Integrated Manufacturing II
Prerequisite: 540:482 or permission of the instructor
Design of automated and computer integrated manufacturing systems using programmable automation. Modeling, specification, and implementation of factory information systems. Reference models and control architectures for discrete parts manufacturing, batch process manufacturing, and semiconductor manufacturing industries.

540:673 Laser-Based Micromanufacturing
Prerequisite: 16:540:573
Introduction to laser materials processing, micromanufacturing and MEMS. Advances and opportunities made possible by the application of laser-based micromanufacturing processes. Applications of laser micromachining, laser thin film processing, laser micro heat treatment, laser microwelding, laser micro rapid prototyping. Process modeling, planning, and integration issues.

540:675 Advanced Engineering Economics II
Prerequisite: 540:575 or Instructor's Consent
Focuses on engineering economic decision making. Application of analytical techniques to the evaluation of industrial projects, the relationship of project selection to long-range planning, and the relationship between the economics of technical choice and industrial productivity.

540:680 Production and Quality Engineering
Prerequisite: Production, Statistical Quality Control, Stochastic Processes
This course integrates research in Quality and Production. Topics include models that relate quality and inventory policies, set-up costs, lot sizing, production cycles, scrap, rework, repair, location of inspection stations, process control and electronics testing and manufacturing.

540:682 Process Modeling and Control
Prerequisite: 540:515, 540:568
Stationary (ARMA), non-stationary (ARIMA) time series models for process control, various automatic process control (APC) strategies, statistical process control (SPC) methods, integration of APC and SPC.

540:685 Systems Reliability Engineering II
Prerequisite: Systems Reliability Engineering I
Advanced topics in reliability theory and engineering, availability models of multi-state devices, theory of preventive maintenance, replacement and inspection. Accelerated reliability models.

540:690 Component Reliability
Prerequisite: 540:685
The course emphasizes reliability estimation of components stressed under different conditions of thermal, electric field, humidity, vibration and fatigue. Burn-in testing, reliability estimation from degradation data and relationships between accelerated stresses and normal operating conditions.

540:691, 692 Seminar in Industrial and Systems Engineering
Prerequisite: none
Speakers from industry and academia describe their current research.

540:694 Advanced Topics in Industrial Engineering
Prerequisite: Permission of Instructor
Seminar for doctoral students in a selected area of Industrial Engineering. Based on current literature.

540:695 Software Reliability II
Prerequisite: Permission of Instructor or 16:540:595 Software Reliability I
Advanced topics in software reliability modeling, calibrating models, software-related problems, software-hardware reliability modeling, software cost models, optimum release policies, fault-tolerant software modeling.

540:701,702 Research in Industrial Engineering

14.1. Other Courses of Interest

540:311 Deterministic Methods in OR
Prerequisite: none (linear algebra is helpful)
Elements of problem solving and algorithmic design. Use of numerical analysis and linear algebra to solve industrial engineering problems. Linear programming, optimization techniques.

540:343 Engineering Economics
Prerequisite: none
Economic decisions involving engineering alternatives; annual cost, present worth, rate of return, and benefit-to-cost; before and after tax replacement economy; organizational financing; break-even charts; unit and minimum-cost public sector studies.

540:485 Manufacturing Information Systems
Design of information systems for integrated manufacturing. Modeling, specification, and implementation of factory information systems. Relational database model and structured query language. Methods of automatic data acquisition and integration of factory floor information with factory host database for production planning and control.

540:486 Automated Manufacturing Systems
Prerequisite: 540:303 (Manufacturing Processes) and 540:382(Computer Control)
Introduction to computer-aided design and computer-aided manufacturing (CAD/CAM), numerical control, computer numerical controlled (CNC) machining, process planning and engineering, robotics hardware and programming, machine vision, data communications and local-area networks in manufacturing systems. (revised from catalog)

642:611 Mathematics Fundamentals for Industrial Engineering
Prerequisite: 2 Years of Calculus
The structure of mathematical modeling; topics in linear algebra; optimization of continuous and discrete functions; transforms; topics in differential and difference equations.

960:580 or 582 Introduction to the Methods and Theory of Probability
Prerequisite: one year of calculus
Emphasis on methods and problem solving. Topics include probability spaces, basic distributions, random variables, expectations, distribution functions, conditional probability and independence, sampling distributions.

960:590 Design of Experiments
Prerequisite: Probability and some knowledge of statistics
Fundamental principles of experimental design; completely randomized variance component designs, randomized blocks, Latin squares, incomplete blocks, partially hierarchic mixed model experiments, factorial experiments, fractional factorials, response surface exploration. (960:490 is suitable too)

15. Laboratories in the Department

Manufacturing Automation Laboratory: This laboratory is equipped with state-of-the-art equipment in CAD/CAM (Computer Aided Design and Computer Aided Manufacturing) and manufacturing automation equipment. It includes production type CNC milling machines, a CNC lathe equipped with force dynamometers and an acoustic emission sensor, a mini-CNC laser-

micro machining station, a sheet folding machine, an impact testing machine, an automated storage and retrieval system, a material handling carousel and a robot assembly work station.

Manufacturing Processing Laboratory: Basic machine tools such as turning, milling, drilling, grinding and measuring machines are available to help the student become familiar with metal-processing operations. The equipment is also used to perform laboratory experiments in heat treatment, tool life and chip formation assessments.

Computer Laboratory: This lab is equipped with state-of-the-art PCs. The lab has the latest simulation software such as ARENA, Matlab/Simulink, and optimization software LINDO, GINO,...etc. It has software for Quality Control, Plant Layout, Production Control, Statistical Analysis and text processing. It also has CAD/CAM/CAE software including AutoCAD, SolidWorks, ABAQUS and FeatureCAM The lab includes multimedia equipment such as VCR, video cameras, recording and editing software to enable students to make high quality multimedia presentations. The laboratory is connected to a university-wide network and the Internet.

Quality and Reliability Engineering Laboratory: This lab has been developed to allow the students to have hands on experience in actual methods for quality control and reliability engineering. A variety of software for control charts, sampling plans and design of experiments is available. The laboratory has a wide array of metrology equipment such as digital calipers and micrometers, a roundness measurement equipment, surface profilometers and a coordinate measuring machine. It also has various materials testing equipment, a Rockwell hardness tester temperature chambers, vibration test stands, and failure analysis equipment such as voltage stressing equipment, and measuring microscopes. LABVIEW and STATGRAPHICS software are available for students use.

Information Technology Laboratory. The laboratory has the state-of-the-art client/server network with Apache and WebLogic application servers, database, and middleware. This lab is mainly used for graduate dissertation research, collaborative projects with industrial partners in typical areas of logistics of supply chains, distribution systems, marine ports and port security. The lab is equipped with various simulation modeling software, SAP's IDES training system as well as software for mathematical analysis including Mathcad and Mathematica. The IT research in the lab includes operations at marine terminals, waterways, C/S transaction processing middleware design, and military ammunition supply chain operations among many others.

Computer Control and Manufacturing Information Laboratory: This laboratory is located in the WINLAB and/or Engineering Building, Room 113 on Busch Campus. Students learn to use programmable logic controllers (PLC's) and other electronic controllers, as well as sensors and actuator devices to control manufacturing processes and equipment. The lab includes local area networks for integrating controllers in peer-to-peer communication and with databases, as well as a Lonworks local area network for distributed control of intelligent sensors and actuators.

ISE Laboratory Technician: Mr. Joseph Lippencott, CORE 114

Last Update August 14, 2007