RUTGERS

The State University of New Jersey

Graduate Handbook: Industrial and Systems Engineering

Academic Year 2024–2025

July 2024

RUTGERS

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Welcome to Industrial and Systems Engineering at Rutgers!

The department of Industrial and Systems Engineering at Rutgers is committed to providing 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, and systems engineering. 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 data analytics to design, control, and improve supply chain systems, quality control and monitoring systems, health care delivery systems, transportation and port operations, security systems, and advanced manufacturing systems. We analyze the reliability of electronic components and systems, the safety performance of airlines, and the performance of computer systems. 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 MEng., MS and Ph.D. degrees. 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 academic year.

Please feel free to contact us with your questions.

Professor, Mohsen Jafari, Department Chair (jafari@rutgers.edu)
Associate Professor, Zhimin Xi, Graduate Director (zhimin.xi@rutgers.edu)
Ms. Laura Kasica (lk405@soe.rutgers.edu) for administrative questions

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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 MEng, MS and Ph.D. degrees.

The newly established Master of Engineering in Industrial and Systems Engineering degree program is intended for students who are interested in pursuing public or private professional careers that require a proper mix of theory and applied training and skills to solve real life engineering problems. The MEng degree requires 30 credits of course work with at least 18 credits from the ISE department at Rutgers.

For the MS degree there are four options: Industrial and Systems Engineering, Quality and Reliability Engineering, Data Analytics, and Production and Manufacturing Systems Engineering. 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.

The Department of Industrial and Systems Engineering at Rutgers University maintains several specialized labs supporting both instruction and research. These include:

- The Human-Machine Simulation Lab, which provides resources for studying ergonomics, simulation, and machine learning, equipped with high-speed workstations and tools like eye-trackers and a driver simulator.
- The 3D-Printing Teaching Lab, which offers hands-on experience with 3D printing, featuring multiple 3D printers and workstations for model building.
- The Manufacturing Processes Lab, housing essential machining tools such as lathes and milling machines for studying metal part machining processes.
- The Quality and Reliability Engineering Lab, where students can practice quality control and reliability testing with equipment like tension testers, surface roughness machines, and environmental chambers.
- The Automation Lab, supporting robotics and CNC programming, features systems like autonomous material handlers and student-designed projects.
- The Energy Lab, which focuses on renewable energy research and battery reliability, allowing students to work with real-time data from a solar energy test bed and conduct battery performance tests.

These labs provide practical, research-driven learning environments for students to explore real-world engineering applications.

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.

The matriculation and course requirements enumerated in the Graduate Handbook at the time of your enrollment are the basic requirements you must fulfill in order to complete your requirements for a degree in ISE. Whenever there are modifications in curriculum and requirements, students entering before the modifications have been made will be eligible to choose the new curricular option should they wish to do so. All students must indicate in writing to Ms. Laura Kasica, which curricular option they are choosing to pursue.

If you have any administrative questions, please contact Ms. Laura Kasica (lk405@soe.rutgers.edu).

2. Academic Integrity

As an academic community dedicated to the creation, dissemination, and application of knowledge, Rutgers University is committed to fostering an intellectual and ethical environment based on the principles of academic integrity. All graduate students have a responsibility to understand and to uphold the standards of academic integrity in their academic work including **course work**, MS dissertation and Ph.D. thesis.

The principles of academic integrity require that:

- All work submitted in a course or related academic activity must be a student's own and must have been produced without the aid of unsanctioned materials or collaboration.
- All use of the ideas, results, or words of others including faculty members, classmates and friends, must be properly acknowledged and cited.
- All contributors to a given piece of work from others including faculty members, classmates and friends, must be acknowledged properly.
- The university policy on integrity and zero tolerance for cheating that is applied to cheating on any work assignment, including term projects, homework, midterm and final exams, presentation, etc.: any indication of such behavior of any scale will not be tolerated and will result in F in the course, possible probation and dismissal from the university.
- All data or results must be obtained by ethical means and reported accurately without suppressing any results inconsistent with the author's interpretation or conclusions.
  The full Policy on Academic Integrity may be found at http://academicintegrity.rutgers.edu.

3. Financial Support

The department provides support to graduate students through fellowships, teaching assistantships, and graduate research assistantships. This support includes a stipend along with tuition coverage. Additional students may receive partial financial assistance or be compensated on an hourly basis for participating 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. Fellowships, teaching assistantships, and or graduate research assistantships are provided to deserving Ph.D. students for a limited time only not exceeding 4 years.

4. Master of Engineering Degree and Certificates

4.1 Master of Engineering Program

The Master of Engineering in Industrial and Systems Engineering is intended for students who are interested in pursuing public or private professional careers that require a proper mix of theory and applied training and skills to solve real life engineering problems. Emphasis on applied problem-solving skills, the use of technology for engineering applications and unique internship opportunities will distinctively separate this program from other M.S. degree options. At the end of the first year of their program of study students can seek internship opportunities in industry of their choice. The department will be working with these students to find such opportunities, but the ultimate responsibility will lie with the students. Alternatively, students can choose to work with a faculty on applied projects. The program is designed to admit students with a B.S. degree in any of the engineering fields. Industry experience will be considered a plus but will not be an admission requirement. Students in the program will be required to take three core courses in the areas of optimization, decision-making and data analytics. With no specific prerequisite requirements, these courses will prepare students to utilize systems engineering and operations research techniques in tackling technical and management problems in different engineering applications. Students will be allowed to transfer up to 9 credit courses at master level to this program and can choose electives that closely match their professional interests. The M.Eng. is considered a terminal degree that does not lead to a Ph.D. and there is no thesis requirement.

Admission Requirements:

Below we provide some general guidelines for admission to M. Eng. in ISE.

- BS GPA (minimum): 3.0/4.0 (In India, first class)
- GRE is not required, but recommended
- GRE scores (average): Verbal 159; Quantitative 159; Analytical Writing 3.5
- TOEFL for International students (minimum): 557/220/writing 22, speaking 23, reading 21, listening 17. Also, we accept IELTS and the minimum score is band 7.
- Four semesters of calculus

Master of Engineering Degree Requirements:

The Master of Engineering in Industrial and Systems Engineering is intended for students who are interested in pursuing public or private professional careers that require a proper mix of theory and applied training and skills to solve real life engineering problems. The option requires 30 credits with at least 18 credits from the ISE department at Rutgers – these courses begin with the number 540.

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: M.Eng. students must either write project reports or give project presentations related to their coursework during their time at Rutgers. The report or presentation must be approved by course instructors, who must also be members of the Graduate Faculty. The recommended practice is to complete two course project reports or presentations so that two different instructors can sign Section C of the student's degree candidacy form, and either one of the instructors can sign Section B of the form.

Required Courses:

540:501 Planning and Operations Engineering (Spring)

540:505 Decision Making under Uncertainty (Fall)

540:507 Data Analytics for Engineering Systems (Fall)

Recommended Technical Electives:

540:520 Supply Chain Engineering
540:530 Forecasting and Time Series Analysis
540:540 Computational Methods in IE
540:552 Production and Manufacturing Project
540:555 Simulation Modeling and Analysis
540:560 Production Analysis
540:565 Facilities Planning and Design
540:573 Advanced Manufacturing Processes
540:575 Advanced Engineering Economics
540:580 Quality Management
540:585 Systems Reliability Engineering I
540:694 Data Mining I
960:540 Statistical Quality Control
960:590 Design of Experiments

The following Recommended Technical Electives may not be offered every year depending on availability and needs at least 10 students registered

540:570 Applications of Robotics in Mfg. Systems
540:572 Manufacturing Processes and Control
540:568 Automation and Computer Integrated Manufacturing I

4.2 ISE BS/Master's Program

You can enhance your undergraduate degree by completing a master's in just one additional year. The degree completion timeline depends on the number of graduate courses taken as an undergraduate. Most students finish the master's degree within one year, though some may take courses during the summer session. Please note that SGS requires 120 credits to earn a bachelor's degree, meaning any credits beyond 120 may be eligible for transfer to the master's degree, pending the approval of the graduate program director.

Admission Criteria and Process

- Rutgers bachelor's degree with GPA 3.0 or above
- GRE is NOT required
- Application essay is NOT required
- Application fee is waived
- Transcript: Submit an original transcript with these three pages (or order one from ASB to be mailed to the ISE secretary.
- No letters of recommendation
- Application: complete the first 3 page of the Graduate School application (https://admissionservices.rutgers.edu/graduate/newApplicant.app), print it, and bring it to the secretary (Laura Kasica) in the office of the ISE.

4.3 Manufacturing Informatics Certificates

The proposed self-standing certificate in Manufacturing Informatics has the goal of preparing students to leverage data science to transform physical manufacturing and management. Manufacturing Informatics is about utilizing information technology to improve manufacturing productivity, quality, efficiency, flexibility, and sustainability as well as speeding up innovation and creating new business models. Manufacturing Informatics is the confluence of disruptive digital technologies that together carry the potential to change the manufacturing industry in general.

The movement has gained critical momentum as a number of factors have come together: an astonishing rise in data volume through industry IoT, computing power and connectivity, and the emergence of advanced data-analytics capabilities. Manufacturing Informatics has also benefited from the new forms of human-machine interaction, such as augmented reality and improvements in how digital outcomes are transferred to the physical world through advanced CNC machines, robotics, and digital manufacturing processes (e.g., 3D printing). Manufacturing Informatics extends from manufacturing shop floors to the overall manufacturing ecosystems of products and services, with connected processes, machines, and people internally, and connected supply chain companies, externally.

While the current and potential future applications for Manufacturing Informatics are impressive and imaginative, it is often very difficult to have a cohesive and comprehensive training on this emerging area. Therefore, it is imperative that professionals who wish to be manufacturing experts understand the fundamental principles behind major Manufacturing Informatics technologies, their advantages and limitations, and emerging applications. This new certificate offered by the School of Engineering through the NJ Advanced Manufacturing Institute (NJAMI) will offer comprehensive overview of many different Manufacturing Informatics technologies from fundamental science to applications.

Admission Criteria and Process

- BS degree in STEM.
- For international students, TOFEL score will be required.

The certificate will offer a rigorous and in-depth exposure to the broad set of core topics required in Manufacturing Informatics through a 12-credit sequence (3 required courses and 1 elective course).

Required Courses:

540:507 Data Analytics for Engineering Systems (Fall)
540:520 Supply Chain Engineering (Spring)
540:540 Computational Methods in Engineering (Spring)

Recommended Technical Electives:
540:501 Planning and Operations Engineering
540:505 Decision Making under Uncertainty
540:520 Supply Chain Engineering
540:530 Forecasting and Time Series Analysis

540:542 Applications of Industrial Analytics
540:555 Simulation Modeling and Analysis
540:560 Production Analysis
540:573 Advanced Manufacturing Processes
540:580 Quality Management
650:510 Computer-Aided Design
650:531 Additive Manufacturing
650:569 Mechanics of Advanced Manufacturing
137:602 Introduction to Cloud Computing and Big Data

5. Admission Criteria for MS and PhD Degrees

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, In Iran, 16/20); 3.2/4.0 for others
* MS GPA (minimum): 3.5/4.0 for Ph.D. applicants
* GRE is not required, but strongly recommended for MS and PhD applicants.
* GRE scores (average): Verbal 159; Quantitative 159; Analytical Writing 3.5
* TOEFL for International students (minimum): 557/220/writing 22, speaking 23, reading 21, listening 17. Also, we accept IELTS and the minimum score is band 7.

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
* A basic course in Linear Optimization – could be a course in Operations Research (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 pass them. 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 will be permitted to take 960:379 for credit.

If you have not taken Deterministic Methods or Operations Research, you may take Planning and Operations Eng. 540:501 for credit.

If you have not taken Engineering Economics, you could either take 540:343 Engineering Economics for NO credit or take Adv. Eng. Econ. 540:575 for credit.

If you have not taken Probability Models, you can take Probability Models in OR 540:338 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.

6. 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 study 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: MS students in the non-thesis option must either write project reports or give project presentations related to their coursework during their time at Rutgers. The report or presentation must be approved by course instructors, who must also be members of the Graduate Faculty. The recommended practice is to complete two course project reports or presentations so that two different instructors can sign Section C of the student's degree candidacy form, and either one of the instructors can sign Section B of the form.

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. The principles of academic integrity should be adhered to in preparation of the MS thesis. Most of our master's 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.
- ✓ Distribute the written proposal at least one week in advance to committee members.
- ✓ Give a formal 50-minute presentation on your proposal.
- ✓ **The proposal must be submitted at least one semester prior to the thesis defense**.
- ✓ The Graduate Director should be notified after the proposal is approved.

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.
- ✓ Distribute the written thesis at least fifteen days in advance to committee members. Make sure that your thesis includes only your original work.
- ✓ Give a formal one-hour presentation on your thesis.
- ✓ Upon completion of the oral thesis defense, the committee will vote either "PASS" or "NO PASS". No pass may mean a failure, or the student may be referred to Committee for revisions. This is at the discretion of the Thesis Committee.

Should a student enrolled in the M.S. program wishes so s/he must reapply to study towards a Ph.D. degree. This request can be made at any time during their studies, but not before the end of their first year at RUTGERS and not later than a month before their graduation.

MS Options: The ISE program offers the following MS options:

- Industrial and Systems Engineering
- Manufacturing Systems Engineering
- Quality and Reliability Engineering
- Systems Analytics

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

Requirement	ISE	Mfg	Quality	Analytics
Total credits	30	30	30	30
Minimum ISE credits	21	18	18	21
Seminar 3 semesters	Yes	Yes	Yes	Yes
Thesis option	Yes	Yes	Yes	Yes
Required courses	12 credits	12 credits	21 credits	9 credits

Summary of MS Requirements -three options

6.1 Industrial and Systems Engineering

The Industrial and Systems Engineering 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 department at Rutgers – these courses begin with the number 540.

Required courses:

540:510 Deterministic Models in Industrial Engineering (Fall)
540:515 Stochastic Models in Industrial Engineering (Spring)
540:555 Simulation Modeling and Analysis (Spring)
540:560 Production Analysis (Spring)

6.2 Production and Manufacturing Systems Engineering

The Production and Manufacturing Systems Engineering option offers students a rich specialty in production systems, simulation, supply chain engineering, automation and manufacturing. This option requires 30 credits of course work. Students take 4 required courses, six technical electives. At least 18 credits must be taken from the ISE program at Rutgers.

Required courses:

540:520 Supply Chain Engineering (Spring)
540:555 Simulation Modeling and Analysis (Spring)
540:560 Production Analysis (Spring)
540:573 Advanced Manufacturing Processes (Fall)

Recommended Technical Electives:
540:507 Data Analytics for Engineering Systems
540:510 Deterministic Models in Industrial Engineering

540:530	Forecasting and Time Series Analysis
540:540	Computational Methods in IE
540:552	Production and Manufacturing Project

540:565 Facilities Planning and Design
540:575 Advanced Engineering Economics
960:540 Statistical Quality Control
960:590 Design of Experiments

The following Recommended Technical Electives may not be offered every year depending on availability and needs at least 10 students registered

540:570 Applications of Robotics in Mfg. Systems
540:572 Manufacturing Processes and Control
540:568 Automation and Computer Integrated Manufacturing I
540:650 Discrete Event Dynamic Systems
540:655 Performance Analysis
540:660 Stochastic Inventory Control
540:665 Theory of Scheduling
540:668 Automation and Computer Integrated Manufacturing II
540:673 Laser Based Micro-Manufacturing
540:682 Process Modeling and Control

Students who have taken a required course to fulfill requirements may substitute an additional elective in place of the required course such that the total number of graduate credits is at least 30.

6.3 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 option requires 30 credits with at least 18 from the ISE department at Rutgers – these courses begin with the number 540.

Required courses:

Industrial and Systems Engineering:

540:560 Production Analysis (Spring)
540:580 Quality Management (Fall)
540:585 Systems Reliability Engineering I (Fall)
540:685 Systems Reliability Engineering II (Spring)

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 course in the Statistics Department (course number is 960:xxx) the ISE graduate director can give you a prerequisite override form which you must use to register in person.

6.4 Systems Analytics

The Systems Analytics option in ISE graduate program has the goal of preparing graduate students to develop expertise in the analysis and optimization of engineered systems to solve problems and support decision-making. This track will enable students to address the growing need for

professionals who are trained in advanced engineering analytics and can transform complex engineering data and systems into understandable and actionable information for the purpose of making decisions.

This track is designed to help students acquire knowledge and skills to:

- Discover opportunities to improve systems, processes, and enterprises through data analytics
- Apply optimization, statistical, and machine-learning methods to solve complex problems involving large data from multiple sources
- Collect and store data from a variety of sources, including Internet of Things (IoT), an integrated network of devices and sensors, customer touch points, processes, social media, and people
- Work with technology teams to design and build large and complex SQL databases
- Use tools and methods for data mining, big-data algorithms, and data visualization to generate reports for analysis and decision making
- Create integrated views of data collected from multiple sources of an enterprise
- Understand and explain results of data analytics to decision makers

This track requires 30 credits with at least 21 credits from the ISE department at Rutgers – these courses begin with the number 540.

Required courses:

540:507	Data Analytics for Engineering Systems (Fall)
540:540	Computational Methods in Engineering (Spring)
540:694	Advanced Topics in IE – Data Mining (Fall)

Recommended Technical Electives:

540:505	Decision Making Under Uncertainty
540:510	Deterministic Models in Industrial Engineering
540:515	Stochastic Models in Industrial Engineering
540:530	Forecasting and Time Series Analysis
540:555	Simulation Modeling and Analysis
540:560	Production Analysis
540:580	Quality Management
540:585	Systems Reliability Engineering I
540:655	Performance Analyses of Manufacturing Systems
540:682	Process Modeling and Control

Students can take data-analytics-related graduate-level courses offered in the university and the electives in other programs must be approved by the program director. Some recommended electives are

960:563	Regression Analysis
960:567	Applied Multivariate Analysis
960:586	Interpretation of Data I
960:588	Data Mining
332:561	Machine Vision
198:314	Principles of Programming Languages
198:440	Introduction to Artificial Intelligence

7. 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.

Table Summary of Ph.D. Requirements

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	9	9
Dissertation	Yes	Yes
Qualifying Exam	Yes	Yes
Thesis Proposal	Yes	Yes
Elective courses	advisor approval	advisor approval

7.1 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 department at Rutgers.

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 department at Rutgers – these courses begin with the number 540. The procedure for transferring credits is given in Section 6.

Students are required to take the following courses:

- At least three ISE courses at the 600 level. In certain cases, two 600 level courses from ISE and one 600 level course from other departments can be approved by the Graduate Director.
- Training Future ISE Faculty (540:601)
- One course in math or statistics at the 500 level or above.

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

7.2 Qualifying Examination

7.2.1 For students who were admitted before Fall 2023 (old system)

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

- Optimization/Deterministic Models
- Stochastic Models
- Reliability
- Production/Manufacturing

Doctoral students take at least two sections of the qualifying exam after completing one year of course work and complete all sections after completing two years of course work. The students who arrive in Spring will be required to take at least two sections of the qualifying exam in the Fall of the next year, and to complete all sections after completing two and a half years of course work.

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 exam that is 3 hours long. Students are required to respond to all questions.

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. No exceptions.

Please Note: Non-PhD students may NOT take the qualifier unless s/he has approval from the Graduate Program Director.

7.2.2 For students who were admitted after Fall 2023 (new system)

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

- Optimization/Deterministic Models
- Stochastic Models
- Data Science/Statistics
- Reliability
- Production/Manufacturing

Students are given **the option to select only three of core courses** among the above five subjects.

Doctoral students take at least two sections of the qualifying exam after completing one year of course work and complete all sections after completing two years of course work. The students who arrive in Spring will be required to take at least two sections of the qualifying exam in the Fall of the next year, and to complete all sections after completing two and a half

years of course work.

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 exam that is 3 hours long. Students are required to respond to all questions.

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. No exceptions.

Please Note: Non-PhD students may NOT take the qualifier unless s/he has approval from the Graduate Program Director.

7.3 Dissertation 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 dissertation 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.
- ✓ Distribute the written proposal at least two weeks 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.
- ✓ **The proposal must be submitted at least one semester prior to the dissertation defense**.
- ✓ 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.

7.4 Dissertation Defense:

The Ph.D. dissertation is expected to be an original and significant contribution to the field of Industrial and Systems Engineering. The principles of academic integrity should be adhered to in preparation of the Ph.D. dissertation. 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.
- ✓ Distribute the written dissertation at least two weeks in advance to committee members. Make sure that your thesis includes only your original work.
- ✓ 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.
- ✓ Upon completion of the oral thesis defense, the committee will vote either "PASS" or "NO PASS". No pass may mean a failure or the student may be referred to Committee for revisions. This is at the discretion of the Thesis Committee.
- ✓ Submit your dissertation to the Graduate School carefully checking that you have followed the prescribed format.

TIME FOR REVIEW AND ASSESSMENT OF QUALIFYING PAPERS, THESES AND DISSERTATIONS

All material should be submitted by the student at least two weeks before an examination or other deadline and at least two weeks (but not more than six weeks) should be allowed the faculty member for informing students of the assessment.

8. 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 9 credits at Rutgers. The form for transfer of credit is available in the ISE Office and on-line from the Graduate School-New Brunswick.

9. 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. The relationship between a student and advisor is based on trust and honesty. It will be difficult to change your advisor once you have identified a faculty member who has agreed to advise you. Thus, it is very important to give serious consideration to this process before making your decision.

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. In rare cases that you may need to find another advisor, you need to get the approval of the ISE Graduate Committee to this change. At that point, ISE Graduate Committee will be convened to review your progress in the department. Please be advised that teaching assistantships, graduate assistantships, and fellowships are provided to deserving students for a limited time only not exceeding 4 years starting from the time of their enrollment at Rutgers University.

10. Registration

Guideline for the Selection of Courses for New Students: Please take the required courses and their prerequisite courses first (Section 17 Graduate Courses in Industrial and Systems Engineering to find out prerequisite courses for each course) if possible. If students took prerequisite courses in their institutions, they can email the transcripts along with a catalog description or course outline to show that they 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: Sometimes 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 in the Dr. Samuel Dewitt Proctor Hall, Busch Campus at 65 Davidson Street.

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 College Avenue Campus, Knight Express/Board Plan Office, 102 Records Hall, 620 George Street, New Brunswick, 848-932-8041; Busch Campus Housing Office, 581 Taylor Road, 848-445-0044; Cook/Douglass Housing Office, PAL Building, 848-932-9625, or Livingston Housing Office, Lynton Tower North, 848-445-2346.

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 or in the Undergraduate School of Engineering, 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 or any Statistics course, 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.

Period	1	2	3	4	5	6	7	8
Starts	8:30 AM	10:20 AM	12:10 PM	2:00 PM	3:50 PM	5:40 PM	7:30 PM	8:00 PM
Ends	9:50	11:40	1:30	3:20	5:10	7:00	8:50	10:40

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. 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).

11. 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 Ms. Laura Kasica 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 dissertation 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 Ms. Laura Kasica 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 ONLINE ONLY from http://registrar.rutgers.edu. The deadlines are normally January 2, April 1 and October 1. If you do not 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. More information on forms can be found here: https://grad.rutgers.edu/academics/forms

- ✓ 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

12. 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 every semester in writing. This form is filed permanently. 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.

13. Policies for CPT, OPT and Reduced Credit

Curricular Practical Training (CPT)

1. CPT is practical training related to the ISE curriculum. It is NOT for internships or part-time employment or full-time employment unless it is associated with a specific curriculum requirement with a course number. More information can be found: https://global.rutgers.edu/CPT

2. PhD students and MS-thesis students (with a designated adviser from the ISE graduate faculty) must have approval of an advisor to apply for CPT. For these students, CPT can be associated with research credits or course credits. The CPT form must be submitted to the ISE Graduate Director by the student's advisor, who must be aware of the answers to all questions.

3. Non-thesis MS students can only apply for CPT if the practical training is required or associated with a particular ISE course listed in the catalog. A student cannot register for the class 'Special Topics in ISE' (16:540:550) unless an ISE faculty member has agreed to supervise the course and gives approval for the CPT. **One course credit worth CPT will be approved at most two times**.

4. CPT is available only prior to completion of the academic program. CPT employment may not delay completion of the academic program.

5. Students have been a **full-time student for at least one academic year t**o apply for CPT.

6. A graduate student must be in good standing (GPA above 3.3) to apply for CPT. CPT will not be approved during the semesters that the student is a fellow or a teaching assistant.

7. No CPT forms can be submitted or considered if there have been unsatisfactory grades (U) or incomplete grades or 'no-grades assigned' for previous course work associated with CPT.

8. Graduate Director will discuss CPT with any student only if a specific meeting has been scheduled in advance.

Occupational Practical Training (OPT) and reduced credit

OPT and reduced credit forms are found online, to be filled out by student, submitted to global. More information can be found: https://global.rutgers.edu/opt

14. 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.

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.

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, and 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 (848)-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 (not academic year) appointments receive full tuition remission during the summer. For GAs the advisor's grant is the source of funding.

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 then 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 Graduate Director, Prof. Myong K Jeong, 848-445-4858 or stop by room 222 to schedule a meeting. 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 Administrator, Ms. Barthi Ponnuraj, room 204. 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 go to the cashier to register for your classes.

15. ISE Faculty and Staff Directory

The telephone number for the Industrial and Systems Engineering department is **(**848) 445-3654 and the fax number is (713) 743-4190. The area code and prefix is (848) 445 for all telephones – the extensions are given below.

NAMES	EXT	Room #	EMAIL
Baykal-Gürsoy, Melike	5465	218	gursoy@soe.rutgers.edu
Coit, David	2033	214	coit@soe.rutgers.edu
Elsayed, Elsayed A.	3859	226	elsayed@soe.rutgers.edu
Ezzat, Ahmed Aziz	3625	228	aziz.ezzat@rutgers.edu
Guo, Weihong 'Grace'	8556	220	wg152@soe.rutgers.edu
Jafari, Mohsen A.	3654	201	jafari@soe.rutgers.edu
Jeong, Myong	4858	222	mjeong@soe.rutgers.edu
Mieth, Robert	8503	616	robert.mieth@rutgers.edu
Ozel, Tugrul	1099	208	ozel@soe.rutgers.edu
Pham, Hoang	3654/5471	201	hopham@soe.rutgers.edu
Reagan, Randall	5469	212	randy.reagan@rutgers.edu
Wicks, Elin	8787	228	elin.wicks@soe.rutgers.edu
Xi, Zhimin	3657	224	zhimin.xi@rutgers.edu
Yousefian, Farzad	2238	218	farzad.yousefian@rutgers.edu
Staff:			
Kasica, Laura	3654/8506	201	lk405@soe.rutgers.edu
Ponnuraj, Barthi	3654/8507	204	barthi@soe.rutgers.edu
Powers, Max	5480	114	mp1841@soe.rutgers.edu
Laboratories:			
Human-Machine Simulation Laboratory		106	
3D-Printing Teaching Lab		110	
Manufacturing Processes Laboratory		112	
Quality and Reliability Engineering Laboratory		114	
Automation Laboratory		116	
Energy Lab		RWH22 2-224	

16. The Faculty

Melike Baykal-Gürsoy is a Professor and the Director of Laboratory for Stochastic Systems, and of GRIST- Game Research for Infrastructure SecuriTy Lab, in the department of Industrial and Systems Engineering at Rutgers University. She received her BS in Electrical Engineering and her MS in Electrical Engineering with a major in Control from Bogazici University, Istanbul, Turkey. Dr. Baykal-Gürsoy received her doctorate in Systems Engineering from the University of Pennsylvania, Philadelphia. Her specific fields of interest include stochastic modeling, queueing, Markov decision processes, stochastic games, and their applications. The current research in the Laboratory for Stochastic Systems focuses on the areas of modeling, optimization and control of stochastic systems, such as transportation and production/inventory networks. In GRIST Lab, Dr. Baykal- Gürsoy and her team are developing game-theoretic models and algorithms in order to protect infrastructure

networks and their users against adversaries. Her research and teaching have been supported through grants from NSF, United Nations, DOD, and Transportation Coordinating Council/Federal Transit Administration. Dr. Baykal-Gürsoy is the co-author of a book entitled "An Introduction to Probability and Statistics."

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 reliability, optimization and energy systems modeling. In 1999, he was awarded a CAREER grant from the NSF to develop reliability optimization strategies that consider reliability estimation uncertainty. Previously, he worked for twelve 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, INFORMS.

E. A. Elsayed is Distinguished Professor of the Department of Industrial and Systems Engineering, 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 also 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. His recent book Reliability Engineering 2nd Edition, Wiley, 2012 received the 2013 Outstanding IIE Publication.

Dr. Elsayed is also a co-author of Analysis and Control of Production Systems, Prentice-Hall, 2nd Edition, 1994. His research has been funded by the DoD, FAA, NSF and industry. Dr. Elsayed has been a consultant for AT&T Bell Laboratories, Ingersoll-Rand, Johnson & Johnson, Personal Products, AT&T Communications, BellCore and other companies. He served as the Editor-in-Chief of the IIE Transactions and the Editor of the IIE Transactions on Quality and Reliability Engineering. He is Editor-in-Chief of Quality Technology and Quality Management. Dr. Elsayed is also the Editor of the International Journal of Reliability, Quality and Safety Engineering. He serves on the editorial boards of eight journals in different capacities. He served an external evaluator for many undergraduate and graduate programs.

Dr. Elsayed is a frequent keynote speakers in National and International Conferences and is the recipient of many awards including the Board of Trustees Award for Excellence in Research for the academic year 2015- 2016, Rutgers University, Golomski Award for the outstanding paper, several Best Paper awards, William Mong Distinguished Lecturers Award, David F. Baker Research Award of the Institute of Industrial Engineers for Research Contributions to the discipline of Industrial Engineering, inducted member of the Russian Academy for Quality, IIE (Institute of Industrial Engineers) Fellow Award, ASME Fellow, Senior Fulbright Award and the Recipient of 2011 Thomas Alva Edison Award for US Patent 7,115,089 B2.

Ahmed Aziz Ezzat is an Assistant Professor in the Department of Industrial and Systems Engineering. He received his Ph.D. in Industrial and Systems Engineering from Texas A&M University in 2019, and his M.Sc. and B.Sc. degrees in Industrial and Management Engineering from the Arab Academy for Science, Technology, and Maritime Transport in Alexandria, Egypt, in 2016 and 2013, respectively. His broad research interests are in the areas of spatio-temporal data science, quality and reliability engineering, with focus on renewable energy analytics and materials informatics. Dr. Ezzat's work has been published in journals such as The Annals of Applied Statistics, Technometrics, IEEE Transactions on Sustainable Energy, among others. His awards include the 2019 ISEN Outstanding Graduate Student at Texas A&M, INFORMS Outstanding Member of the Year at Texas A&M in 2018, First Place at the QSR Student Poster and Interaction Competition at the 2017 INFORMS Annual Meeting, Best Oral Presentation at the 2016 Texas A&M Conference on Energy, and the IISE Sierleja Memorial Fellowship in 2014. He has been nominated as a finalist for the Texas A&M 3 Minute Thesis (3MT) Competition in 2018 for his presentation titled: Wind Energy, A New Solution to a 5000 Year Old Problem. His teaching interests include quality engineering, applied statistics, industrial data

science, and energy analytics. He is a member of IISE, IEEE-PES, and INFORMS.

Weihong 'Grace' Guo is an Associate Professor in the Department of Industrial and Systems Engineering. She earned her B.S. degree in Industrial Engineering from Tsinghua University, China, in 2010 and her Ph.D. in Industrial & Operations Engineering from the University of Michigan, Ann Arbor, in 2015. Dr. Guo's research interests are in the areas of statistical quality control and process monitoring, data mining for manufacturing and healthcare systems modeling and improvement, and quality-oriented design and modeling of complex manufacturing systems. Her current research focuses on data fusion methods in the interface between applied statistics and system control/optimization. She is a member of IIE, INFORMS, and ASME. Dr. Guo is the recipient of the 2014 ISERC Quality Control & Reliability Engineering Best Student Paper Award Finalist, the 2014 International Conference on Frontiers of Design and Manufacturing Sciences Best Paper Award, the Rackham Predoctoral Fellowship from the University of Michigan, and the Wilson Prize for the Best Student Paper in Manufacturing. Her teaching interests include quality engineering, data analytics, and manufacturing systems.

Mohsen A. Jafari is a Professor and Chair of Industrial & Systems Engineering at Rutgers University and is a principal at the Rutgers Center for Advanced Infrastructure and Transportation, where he overseas Information Management Group and the newly established Laboratory for Energy Smart Systems (LESS). His current research interests include control and optimization of energy and transportation networks. He has been principal and co-principal investigator to over $23M R&D funding from the government agencies and industry. His work has led to 4 patents and 116 refereed publications. He actively collaborates with universities and national labs in the US and abroad. He has advised 25 Ph.D. theses and 7 post-doctoral & research fellows. He is a member of IEEE and was recipient of the *IEEE excellence award in service and research*, *SAP curriculum award and two Transportation safety awards*. He has been technical consultant to many U.S. and international companies.

Myong K. (MK) Jeong is a Professor in the Department of Industrial and Systems Engineering, RUTCOR (Rutgers Center for Operations Research), and DIMACS (Center for Discrete Mathematics and Theoretical Computer Science) at Rutgers University. Currently, he is the Director of Laboratory for Data Analytics and Process Insights. He received his BS in Industrial Engineering from Han Yang University, Seoul, Korea, in 1991, MS in Industrial Engineering from Korea Advanced Institute of Science and Technology, Taejon, Korea, in 1993, MS in Statistics from Georgia Institute of Technology, Atlanta, Georgia, in 2002, and Ph.D. in Industrial and Systems Engineering from Georgia Institute of Technology, Atlanta, Georgia, in 2004. He was formerly an Assistant Professor in the Department of Industrial and Information Engineering, the University of Tennessee, Knoxville. He worked as a senior researcher from 1993 to 1999 at the Electronics and Telecommunications Research Institute (ETRI).

He has focused on developing data mining and machine learning techniques for process monitoring and improvement. The applications include various industries such as gas/oil, semiconductor, transportation, bio- energy, computing, electronics, and automobile. He has published over 100 journal papers including *Technometrics, IEEE Transaction on Semiconductor Manufacturing, IEEE Transactions on Systems, Man, Cybernetics, Pattern Recognition Letters*, and *IIE Transaction on Quality and Reliability*. He received the Freund International Scholarship and the National Science Foundation (NSF) CAREER Award in 2002 and in 2007, respectively. His research has been supported by the National Science Foundation, National Transportation Research Center, United States Department of Agriculture, Qatar National Research Fund, Electronics and Telecommunications Research Institute, and various industries. He has been a consultant for Samsung Electronics, Intel, IBM Watson Research Lab., ETRI, KISTI, and other companies. He served as the President of Data Mining Society of INFORMS (Institute for Operations Research and Management Science). He served as an Associate Editor and Advisory Board Member of various journals including IEEE Transactions on Automation Science and Engineering, International Journal of Quality, Statistics and Reliability, and International Journal of Advanced Manufacturing Technology. He is a senior member of IEEE.

Robert Mieth is an Assistant Professor in the Industrial and Systems Engineering. He is the funder and PI of the Reliability, Operation, and Planning of Power and Energy Systems (ROPES) Lab. Before joining Rutgers in fall 2023, Robert was a Leopoldina Postdoctoral Fellow in the Electrical and Computer Engineering Department at Princeton University. From 2021 to 2022 he was a Postdoc in the Department of Electrical and Computer Engineering of New York University's Tandon School of Engineering as part of the ARPA-E funded PERFOM project. Robert received the Doctorate in Engineering (Dr.-Ing.) degree from the Technical University of Berlin in cooperation with NYU, where he was a visiting researcher from 2017 through 2020. His research and academic trajectory have been supported by prestigious fellowships including the German National Academic Foundation, the Rainer-Lemoine Foundation, and the German Academy of Sciences (Leopoldina). Robert's research interests include risk analysis, stochastic optimization, and data methods for power system operations and electricity markets. Research Interests**:** Risk analysis, stochastic optimization, and data methods for power system operations and electricity markets.

Tuğrul Özel is a Professor and Director of Manufacturing & Automation Research Laboratory in the Department of Industrial and Systems Engineering at Rutgers. He received his Ph.D. degree from Ohio State University in 1998. He previously worked at NSF funded Engineering Research Center for Net Shape Manufacturing at Ohio State and was a summer faculty fellow at NASA Glenn Research Center. His research interest includes advanced manufacturing including laser processing and additive manufacturing, modeling and optimization of manufacturing processes, physics-based process simulations, mechatronics, automation and control, micro/nano manufacturing systems. Dr. Özel has established an internationally recognized research program in the machining of advanced materials such as titanium and nickel-based superalloys. His other work has focused on laser processing of polymers and ceramic materials for microfluidics and microelectronics applications, micro-manufacturing of polymer microneedles for biomedical device applications, and most recently laser powder bed fusion based additive manufacturing of nickel-based superalloys for aerospace applications. His research has been well funded by National Science Foundation, US Department of Commerce - NIST, NASA/New Jersey Space Grant Consortium, Rutgers Research Council and automotive, aerospace, machine tool, and medical device industry. He is the Editor-in-Chief of the *International Journal of Mechatronics and Manufacturing Systems* and has been serving as associate editor, guest editor or editorial board member for several international journals including *International Journal of Machine Tools and Manufacture, Production Engineering Research and Development, International Journal of Manufacturing Engineering, International Journal of Manufacturing Research*. He is the co-author of three edited books "Intelligent Machining", (ISTE-Wiley, 2009), "Micro-Manufacturing: Design and Manufacturing of Micro- Products", (Wiley, 2010); and "Biomedical Devices: Design, Prototyping, and Manufacturing", (Wiley, 2017). He has published over 70 peer-reviewed articles in engineering journals such as *International Journal of Machine Tools and Manufacture, Journal of Materials Processing Technology*, *Materials and Manufacturing Processes*, *Production Engineering Research and Development, Additive Manufacturing*, *ASME Journal of Manufacturing Science and Engineering*, and *International Journal of Advanced Manufacturing Technology* and authored over 65 peer-reviewed conference publications. He has been member of scientific or program committee over 50 international conferences. Dr. Özel has advised numerous undergraduate students, 6 Ph.D. and 15 Masters' graduates and supervised 11 visiting students, 1 post-doctoral trainee, and hosted 4 visiting professors. He is senior member of SME, ASME, North American Manufacturing Research Institute and associate member of CIRP- International Academy for Production Engineering. 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.

Hoang Pham is Distinguished Professor 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. He received his Ph.D. from the State University of New York at Buffalo. His research areas include reliability modeling of systems with competing risks and random environments, software reliability, and statistical inference. He is the editor-in-chief of the International Journal of Reliability, Quality and Safety Engineering and an associate editor and editorial board member of several journals, and the editor of Springer Series in

Reliability Engineering. His several awards include the 2009 IEEE Reliability Society Engineer of the Year Award. Dr. Pham is the author/coauthor of 6 books, edited 17 books and has published over 190 journal articles. He has delivered over 40 invited keynote and plenary speeches at many international conferences and institutions. He is a Fellow of IEEE and IIE.

Randell Reagan is an Assistant Teaching Professor in the Department of Industrial and Systems Engineering. B.S. in Mechanical Engineering from the New Jersey Institute of Technology. M.S. in Mechanical Engineering from the University of Michigan. M.B.A. from New York University. He received his Ph.D. in Industrial Engineering from the New Jersey Institute of Technology. Dissertation research focused on resource assignment in short life technology-intensive new product development. Dr. Reagan also serves as the Undergraduate Director for the department, helping students navigate academic requirements and achieve their career goals. Current teaching interests are in: Design- Human factors- Project management- Work systems- Quality management- Production Operations- Engineering management. More than 30 years of industry experience as a senior leader in small, medium and large companies, a startup and a non-profit. Most recently managing development of heavy equipment and tools for oil & gas, power generation and mining industries. Also, recent experience in developing tools and components for the transportation and structural industries. Major career experience in the design and development of telecommunications and optical fiber communications systems. Led design and manufacturing teams that developed and launched over 500 new products, including many award-winning products and many that have established new industry standards. Awarded 90 patents for design innovation.

Elin M. Wicks is an Associate Teaching Professor in the Department of Industrial and Systems Engineering at Rutgers University. With expertise in engineering economics, engineering education, and active learning, she plays a pivotal role in undergraduate education and advising. Her educational background includes a Ph.D. in Industrial and Systems Engineering from Virginia Tech and both M.S. and B.S. degrees in Industrial Engineering from Rutgers University.

Zhimin Xi is an Associate Professor in the Department of Industrial and Systems Engineering at Rutgers University, where he also serves as the Graduate Program Director. His research focuses on design for reliability, with applications in autonomous vehicles, lithium-ion batteries, and additive manufacturing. Dr. Xi has an extensive academic background, including a Ph.D. in Mechanical Engineering from the University of Maryland. He is a well-published scholar, with over 80 papers in esteemed journals and conferences, and has received numerous accolades, such as the DARPA Young Faculty Award and the ASME Design Automation Young Investigator Award. Dr. Xi is also actively involved in cutting-edge research supported by prominent organizations like the National Science Foundation and the Department of Energy. His work includes contributions to the Energy Lab at Rutgers, where he investigates the reliability of battery performance in renewable energy systems. Additionally, he is dedicated to providing hands-on learning opportunities for both undergraduate and graduate students through his involvement in lab research and classroom challenges.

Farzad Yousefian Farzad Yousefian is currently an Assistant Professor in the Department of Industrial and Systems Engineering at Rutgers University—New Brunswick. Prior to joining Rutgers, he was an Assistant Professor from 2015 to 2021 and a tenured Associate Professor from 2021 to 2022 at Oklahoma State University (OSU). He received his Ph.D. in Industrial Engineering from the University of Illinois at Urbana-Champaign in 2013. He obtained his B.Sc. and M.Sc. degrees in Industrial Engineering from Sharif University of Technology in 2006 and 2008, respectively. His research interest lies in distributed optimization in multi-agent networks, stochastic and large-scale optimization, nonconvex optimization, hierarchical optimization, variational inequalities, computational game theory, and applications in machine learning and transportation systems. He is a recipient of the National Science Foundation (NSF) Faculty Early Career Development (CAREER) award in 2020. He is also a recipient (jointly with his co-authors) of the Best Theoretical Paper award at the 2013 Winter Simulation Conference (WSC). His teaching has been recognized through the 2020 OSU College of Engineering, Architecture, and Technology Excellent Teacher Award.

17. Graduate Courses in Industrial and Systems Engineering

16:540:501 Planning and Operations Engineering (3) Planning and operations models are used in a wide variety of applications. This course focuses on developing problem formulations that are appropriate for the situation at hand. The course will use a number of applications from industrial, mechanical, civil and electrical engineering, financial optimization models, health care systems, environmental ecology, and forestry. The problems will span many types of solution methods, such as linear programming, integer programming, quadratic assignment problem, nonlinear convex problems and black-box models. Multi-criteria optimization will be discussed, and how to incorporate randomness into optimization models, such as chance-constraint programming and scenario-based stochastic programming.

16:540:505 Engineering Decision Making under Uncertainty (3) This course is intended for first year graduate students with the objective of teaching them how to account for sources of short- and long-term uncertainties in design, operation and planning of engineering systems; engineering applications in energy, transportation and production systems, and the use of software packages for problem solving will be emphasized. Two parts will be included: Part I deals with basics of probability and stochastic processes and Part II deals with risk and decision making under uncertainty. Prior probability knowledge is required.

16:540:507 Data Analytics in Engineering Systems (3) Application of data analytics tools to for the design and improvement of engineering systems including semiconductor manufacturing, energy systems, transportation systems, and others. Database access, descriptive analytics, signal processing, classification, predictive analytics, regression and clustering analysis.

16:540:510 Deterministic Models in Industrial Engineering (3) Deterministic models of operations research. Linear programming, the simplex method, duality, and dynamic programming. Prerequisite: 16:540:501 or 14:540:311 (undergraduate introduction to operations research).

16:540:515 Stochastic Models in Industrial Engineering (3) Stochastic models of operations research applied to queuing, reliability, inventory, supply chain, and other problems; Poisson processes; discrete-time and continuous-time Markov chains; renewal processes; transient and steady-state analyses. Prerequisite: Calculus-based course in probability.

16:540:520 Supply Chain and Logistics Engineering (3) Methods and techniques of operations research applied to the design and analysis of marketing and distribution systems. Topics include sales forecasting, single- and multiechelon inventory and distribution systems, routing and scheduling of product delivery. Prerequisites: Calculus, some knowledge of probability.

16:540:530 Forecasting and Time Series Analysis (3) Alternate linear and nonlinear, stationary and nonstationary time-series models for purposes of prediction. Smoothing techniques, estimating trend and seasonality, multivariate time series, and state-space models. Various estimation and forecasting techniques. Prerequisites: Statistics and 16:540:515, or permission of instructor.

16:540:535 Network Applications in Industrial and Systems Engineering (3) Flow problems in networks. Topics include shortest-route problems, critical path, and PERT. Prerequisite: 14:540:311 (undergraduate introduction to operations research).

16:540:540 Computational Methods for Industrial Engineering (3) Computational methods in modeling, planning, and control of production systems; importance sampling, MCMC, numerical methods; artificial intelligence techniques; exact and heuristic search methods; and computational strategies for larger-scale systems.

16:540:542 Enterprise Integration (3) 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. Prerequisite: 14:540:485.

16:540:550 Special Problems in Industrial Engineering (BA) Investigations in selected areas of industrial and systems engineering and operations research. Prerequisite: Permission of instructor.

16:540:552 Manufacturing Project (3) Understanding of the state of technology in discrete, batch, and continuous manufacturing; hands-on experience. Prerequisite: Permission of instructor.

16:540:555 Simulation Modeling and Analysis (3) 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. Prerequisites: Probability and computer programming.

16:540:560 Production Analysis (3) Analysis of production engineering, with emphasis on planning and control of manufacturing and service systems. Prerequisites: Probability and linear programming.

16:540:568 Automation and Computer-Integrated Manufacturing I (3) Design of automated and computer-integrated manufacturing systems using programmable automation. Modeling of discrete and continuous control systems, design and analysis of control architecture, implementation of programmable controllers, and shop floor data acquisition systems. Prerequisite: 14:540:382 or permission of instructor.

16:540:570 Applications of Robotics in Manufacturing Systems (3) Integration of robots in manufacturing systems, design of robot workstations, materials handling, and interactions among manufacturing cells. Economic feasibility and robot selection. Prerequisites: 14:540:343, 453, and undergraduate course in computer control is helpful but not required.

16:540:572 Manufacturing Processes and Control (3) 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 machine systems. Prerequisites: 14:540:303, 382, or permission of instructor.

16:540:573 Advanced Manufacturing Processes (3) Introduction to computational modeling and optimization of manufacturing processes. Modeling and optimization of precision manufacturing processes (micro-machining), advanced manufacturing processes (laser and energy beam based), additive manufacturing processes (selective laser sintering and melting). Emphasis on process physics and analytical and computational methods to predict and optimize process performance and product quality. Prerequisite: 14:540:303 or permission of instructor.

16:540:575 Advanced Engineering Economics I (3) Economic decision models for engineers involving allocation of resources; evaluation of strategic alternatives; advanced risk and uncertainty analysis; and weighing and evaluating nonmonetary factors. Prerequisite: 14:540:343.

16:540:580 Quality Management (3) Quality management philosophies, Deming, Juran; quality planning, control, and improvement; quality systems, management organizations for quality assurance. Role of operations research. Prerequisite: Permission of instructor.

16:540:585 System Reliability Engineering I (3) Methods of measuring the reliability and effectiveness of complex engineering systems, including optimization theory, preventive maintenance models, and statistical analysis. Prerequisites: 16:960:580 required; a course in stochastic modeling is helpful.

16:540:586 Maintenance Modeling and Optimization (3) Maintenance issues; technical foundations for modeling such large-scale systems; approaches for condition maintenance; and optimization methodologies for optimum inspection, repair, and maintenance schedules. Prerequisite: 16:540:585.

16:540:594 Risk Analysis and Mitigation (3) Concept of risk and probabilistic models for risk analysis. Expert judgment elicitation and incorporation into risk models. Causal chain, fault-tree, consequence analysis, risk management, and communication. Case studies in transportation, homeland security, health care systems, supply chain systems, and natural hazards. Prerequisites: Simulation and probability.

16:540:595 Software Reliability I (3) 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. Prerequisite: 16:540:515 or 16:960:580.

16:540:601 Training Future ISE Faculty (0) Required of all doctoral students. Topics include learning styles, teaching tools, and methodology. Students will also intern in industrial and systems engineering introductory laboratories.

16:540:615 Advanced Stochastic Modeling in ISE (3) Stochastic modeling and control fundamentals of

complex systems; renewal theory, Markov decision processes, martingales, and Brownian motion. Applications in reliability, transportation, telecommunication, and supply chains are emphasized. Prerequisite: 16:540:515.

16:540:650 Discrete Event Dynamic Systems (3) Supervisory control of discrete event dynamic systems, process monitoring, Petri nets, functional analysis, performance analysis, control specification, and control verification and validation. Prerequisite: 16:540:515.

16:540:655 Performance Analysis ~~of Manufacturing Systems~~ (3) Modeling and analysis of queueing systems such as communication, transportation, health care, and manufacturing systems. Topics include problems of failures and repairs, the role of buffers, capacity and server allocation. Prerequisite: 16:540:515.

16:540:660 Stochastic Inventory Control (3) Modeling of supply chain and logistic systems with stochastic demand and lead times. Characterization of optimal control policies via stochastic dynamic programming, Markov decision processes, stochastic games and analysis of single as well as multi-item systems with single and multiple echelons, multiple retailers. Recent research issues are investigated. Prerequisite: 16:540:515.

16:540:665 Theory of Scheduling (3) Advanced topics in sequencing and scheduling for manufacturing and service systems; flow shop, job shop-static and dynamic models; multiprocessor parallel machining; preempt-resume algorithms; optimal due-date problems; probabilistic sequencing; simulation and applied operations research models. Prerequisites: Undergraduate production course and advanced calculus.

16:540:668 Automation and Computer-Integrated Manufacturing II (3) Design of automated and computer-integrated manufacturing systems using programmable automation. Modeling, specification, and implementation of factory information systems. Reference models and control architecture for discrete parts manufacturing, batch process manufacturing, and semiconductor manufacturing industries. Prerequisite: 14:540:486 or permission of instructor.

16:540:673 Laser-Based Micromanufacturing (3) Introduction to laser materials processing, micromanufacturing, and MEMS. Advances and opportunities made possible by application of laser-based micromanufacturing processes. Applications of laser micromachining, laser thin-film processing, laser microheat treatment, laser microwelding, and laser microrapid prototyping. Process modeling, planning, and integration issues. Prerequisite: 16:540:573.

16:540:675 Advanced Engineering Economics II (3) 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. Prerequisite: 16:540:575 or permission of instructor.

16:540:679 Optimization and Performance Models in Service Systems (3) Optimization and stochastic models for design and operation of service systems including health care and emergency services, security, warehousing, and call centers. Multiobjective optimization, location models, queueing systems, scheduling, resource allocation, workforce management. Prerequisites: Optimization (e.g., 16:540:510) and stochastic processes (e.g., 16:540:515).

16:540:680 Production and Quality Engineering (3) Doctoral seminar course employing journal articles in quality engineering, production systems, and topics relevant to the participating students including data mining, process control, energy, reliability, maintenance, security, sensor technology, and health care. Prerequisites: Open only to doctoral students in industrial and systems engineering, statistics, or operations research.

16:540:682 Process Modeling and Control (3) Linear stationary (ARMA) and nonstationary (ARIMA), nonlinear (ARCH, GARCH) time-series models for process control; Kalman filters; various automatic process control (APC) strategies; statistical process control (SPC) methods and integration of APC and SPC. Prerequisites: 16:540:515.

16:540:685 System Reliability Engineering II (3) Advanced topics in reliability theory and engineering; availability models of multistate devices; theory of preventive maintenance, replacement, and inspection; accelerated life reliability models. Prerequisite: 16:540:585.

16:540:690 Component Reliability (3) 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. Prerequisite: 16:540:685.

16:540:691,692 Seminar in Industrial and Systems Engineering (0,0) Speakers from industry and academia describe their current research.

16:540:694 Advanced Topics in Industrial Engineering (3) Seminar for doctoral students in a selected area of industrial engineering. Based on current literature. Prerequisite: Permission of instructor.

16:540:695 Software Reliability II (3)
Advanced topics in software reliability modeling, calibrating models, software-related problems, software-hardware reliability modeling, software cost models, optimum release policies, and fault-tolerant software modeling.
Prerequisite: 16:540:595 or permission of instructor.

16:540:701,702 Research in Industrial and Systems Engineering (BA, BA)

17.1 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 Industrial 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.

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)

18. Laboratories in the Department

- **CoRE-106 Human-Machine Simulation Laboratory**
  This laboratory supports instruction in the areas of simulation, work design, ergonomics, statistical modeling and machine learning. The lab includes several Workstations that are high-speed computers equipped with graphical cards to allow students to process large amounts of data and display models. These computers are standard Windows operating system but have access to any of the university software library or the department licensed software. The lab includes a driver simulator which allows ergonomics evaluation of driver reactions, and Univ.

of Michigan ergonomics simulation software for body motion. The lab is also equipped with eye-trackers for use in ergonomic visual tracking evaluation and design.

- **CoRE-110 3D-Printing Teaching Lab**
  This laboratory is home to the 3D printing lab for teaching 3D printing principles and applications. There are several workstations equipped with software for building 3D models and six 3D printers for instructional purposes.
- **CoRE-112 Manufacturing Processes Laboratory.**
  This laboratory contains basic and computerized machine tools including lathes, milling machines, drill press, band saws and a grinding machine for metal part machining. These machines are used to machine parts with engineering materials while studying the effect of chip formation, tool life, cutting forces, temperature, chip metallurgy, and power consumption.
- **CoRE-114 Quality and Reliability Engineering Laboratory**
  This laboratory allows students to have hands-on experience in actual methods of quality control and reliability engineering. The laboratory has a wide array of materials testing equipment including the hardness testing machine, roundness testing machine, surface roughness machine, tension testing machine and the vibration testing machine. The lab has two environmental temperature chambers for conducting reliability testing. This lab is home to the optical comparator for precision measurement, the coordinate measuring system for large component coordinate mapping, a gauge height instrument, scales for weight measurement and calipers for manual measurement. The lab has a variety of software such as JMP software for developing sampling plans and designing experiments. There is large impact testing machine which is physically located in CORE-116.
- **CoRE-116 Automation Laboratory**
  The laboratory is equipped with a CNC milling machine and a CNC lathe. The lab contains two robot programing stations for robot-to-robot communication and control applications. The lab includes a programmable gantry storage and retrieval system used for developing optimized logistics in loading and unloading materials. This lab is home to several machines and systems that were developed in student projects such as the autonomous soccer ball dispenser, the tennis ball retriever and automated laminating machines. This lab also provides a central location for current research and design projects including ergonomic lifting designs and extensive work with walking and mobile robots and drone applications. The lab currently operates a high-end scanner with 3D printing capability, built as part of a design project. There is also a prototype sheet-metal fabrication capability including, sheer, notcher, punch and nibbler capable of developing creative folded sheet metal patterns for different applications.
- **RWH222 / RWH 224 Energy Lab**
  This laboratory provides active research renewable and sustainability energy with a test bed that collects real-time measurements of a solar energy plant. The test bed collects measurements of solar energy generation, plant health and performance, and forecasting efficiency in operations and maintenance. Students can participate in research to evaluate the effects cloud cover, wind speed, temperature, and other factors on the solar plant. The sky imager allows students to understand forecasting and prediction of solar performance based on weather conditions. This lab also features research into autonomous vehicle control. The research includes building new approaches to navigation and energy usage under automated control in manufacturing, autonomous wheelchair control and more. Students participate in hardware and software development related to the energy applications or automated control. The laboratory also specializes in education and research focused on the reliability study of lithium-ion batteries. It is equipped with an Arbin test machine for battery characterization and aging tests. Students have the opportunity to conduct battery tests and collect data. This data is crucial for various analyses related to battery quality, reliability, and health management. There are several servers in the lab for storing real time data collected from the testbeds.

ISE Laboratory Technician: Mr. Max Powers, CORE 114