

Industrial Engineering and Operations Research

The Department of Industrial Engineering and Operations Research (IEOR) offers three graduate programs: a Master of Engineering (MEng), a Master of Science (MS), and a PhD. These programs have been developed to meet the needs of individuals with backgrounds in engineering or the mathematical sciences who wish to enhance their knowledge of the theory, development, and use of quantitative models for design, analysis, risk management, and decision-making. This knowledge applies to complex systems in the industrial, service, or public sectors, including energy systems, supply chains, healthcare systems, and financial systems. Students may concentrate on theoretical studies in preparation for doctoral-level research, or on applications of state-of-the-art techniques to real world problems.

Master of Engineering (MEng)

The MEng is a professional, full-time, accelerated professional master's degree program. Students learn advanced techniques in IEOR and skills that prepare them to lead teams in developing new engineering solutions: skills in managing complex projects, motivating people, and directing financial and operational matters.

Master of Science (MS)

The MS is a full-time technical master's degree program. Students focus on both the theory of IEOR techniques and the application of those techniques. The MS is a terminal degree, meaning that students enrolled in the MS program do not typically continue further into the IEOR PhD program. Participants in the program are self-funded; the Department of IEOR does not offer funding and students will not be eligible for ASE (academic student employment) appointments funded by the department.

Doctor of Philosophy (PhD)

The paramount requirement of a doctoral degree is the successful completion of a thesis on a subject within Industrial Engineering and Operations Research. Research areas may include the investigation of the mathematical foundations of and computational methods for optimization or stochastic models, including risk analysis. Research also may be undertaken to develop methodologies for the design, planning, and/or control of systems in a variety of application domains, including supply chains, energy systems, healthcare systems, and financial systems.

Admission to the University

Minimum Requirements for Admission

The following minimum requirements apply to all graduate programs and will be verified by the Graduate Division:

1. A bachelor's degree or recognized equivalent from an accredited institution;
2. A grade point average of B or better (3.0);
3. If the applicant has completed a basic degree from a country or political entity (e.g., Quebec) where English is not the official language, adequate proficiency in English to do graduate work, as evidenced by a TOEFL score of at least 90 on the iBT test, 570 on

the paper-and-pencil test, or an IELTS Band score of at least 7 on a 9-point scale (note that individual programs may set higher levels for any of these); and

4. Sufficient undergraduate training to do graduate work in the given field.

Applicants Who Already Hold a Graduate Degree

The Graduate Council views academic degrees not as vocational training certificates, but as evidence of broad training in research methods, independent study, and articulation of learning. Therefore, applicants who already have academic graduate degrees should be able to pursue new subject matter at an advanced level without the need to enroll in a related or similar graduate program.

Programs may consider students for an additional academic master's or professional master's degree only if the additional degree is in a distinctly different field.

Applicants admitted to a doctoral program that requires a master's degree to be earned at Berkeley as a prerequisite (even though the applicant already has a master's degree from another institution in the same or a closely allied field of study) will be permitted to undertake the second master's degree, despite the overlap in field.

The Graduate Division will admit students for a second doctoral degree only if they meet the following guidelines:

1. Applicants with doctoral degrees may be admitted for an additional doctoral degree only if that degree program is in a general area of knowledge distinctly different from the field in which they earned their original degree. For example, a physics PhD could be admitted to a doctoral degree program in music or history; however, a student with a doctoral degree in mathematics would not be permitted to add a PhD in statistics.
2. Applicants who hold the PhD degree may be admitted to a professional doctorate or professional master's degree program if there is no duplication of training involved.

Applicants may apply only to one single degree program or one concurrent degree program per admission cycle.

Required Documents for Applications

1. **Transcripts:** Applicants may upload *unofficial* transcripts with your application for the departmental initial review. *If the applicant is admitted*, then *official* transcripts of all college-level work will be required. Official transcripts must be in sealed envelopes as issued by the school(s) attended. If you have attended Berkeley, upload your unofficial transcript with your application for the departmental initial review. *If you are admitted*, an official transcript with evidence of degree conferral *will not* be required.
2. **Letters of recommendation:** Applicants may request online letters of recommendation through the online application system. Hard copies of recommendation letters must be sent directly to the program, not the Graduate Division.
3. **Evidence of English language proficiency:** All applicants who have completed a basic degree from a country or political entity in which the official language is not English are required to submit official evidence of English language proficiency. This applies to institutions from Bangladesh, Burma, Nepal, India, Pakistan, Latin America, the Middle East, the People's Republic of China, Taiwan, Japan, Korea, Southeast Asia, most European countries, and Quebec (Canada). However, applicants who, at the time of application, have

already completed at least one year of full-time academic course work with grades of B or better at a US university may submit an official transcript from the US university to fulfill this requirement. The following courses will not fulfill this requirement:

- courses in English as a Second Language,
- courses conducted in a language other than English,
- courses that will be completed after the application is submitted, and
- courses of a non-academic nature.

If applicants have previously been denied admission to Berkeley on the basis of their English language proficiency, they must submit new test scores that meet the current minimum from one of the standardized tests. Official TOEFL score reports must be sent directly from Educational Test Services (ETS). The institution code for Berkeley is 4833. Official IELTS score reports must be sent electronically from the testing center to University of California, Berkeley, Graduate Division, Sproul Hall, Rm 318 MC 5900, Berkeley, CA 94720. TOEFL and IELTS score reports are only valid for two years.

Where to Apply

Visit the Berkeley Graduate Division application page (<http://grad.berkeley.edu/admissions/apply/>).

Normative Time Requirements

Normative Time to Advancement

Total normative time to advancement is 2-3 years.

Step I: This process normally takes 1 year (to take the entrance exam).

Step II: After passing the preliminary or entrance exam, students prepare for their PhD oral qualifying examination. This step lasts one to two years. With the successful passing of the orals, students are advanced to candidacy for the PhD degree.

Normative Time in Candidacy

Step III: Students undertake research for the PhD dissertation under a three-person committee in charge of their research and dissertation. The students then write a dissertation based on the results of this research. On completion of the research, workshops, and approval of the dissertation by the committee, the students are awarded the doctorate.

Total Normative Time

Total normative time is 5-6 years or 10-12 semesters.

Time to Advancement

Doctoral Entrance Exam

Every doctoral student is required to take the doctoral entrance examination. Students entering without an MS degree are required to complete all MS degree requirements and may do so by completing the MS course requirements and passing the doctoral entrance exam.

The entrance examination consists of three parts:

1. An optimization exam: Students are required to take IND ENG 262A and at least one other course in Group A (see below) to be prepared for this exam.
2. A stochastic processes exam: Students are required to take IND ENG 263A and at least one other course in Group B (see below) to be prepared for this exam.
3. An exam on modeling and applied operations research: Students are required to take two courses in Group C (see below) to be prepared for this exam.

All required courses for the doctoral entrance examination must be taken for a letter grade.

The entrance examination will be offered near the end of every spring semester, approximately one week before finals. Passing the entrance examination is based on both superior performances on all parts of the exam, and on previous coursework. Students are required to take the entire exam at the same time. In order to take the exam, students are expected to perform sufficiently well in their first-year courses. During the middle of the spring semester, a faculty committee will review the performance of first-year doctoral students, and students who have performed sufficiently well on their coursework (so that a superior performance on all parts of the exam will lead to passing) will be permitted to take the exam.

All students who would like to be considered for the doctoral program are expected to take this exam no later than their third semester in this department. In particular, students who enter in the fall are expected to take the exam at the end of the spring semester in the same academic year.

Curriculum

Advanced undergraduate courses in linear algebra (equivalent to MATH 110) are prerequisites for the PhD program. Students who have not taken these courses prior to entering the graduate program are required to do so during their first year.

Some students have specific research interests and goals when they enter a doctoral program; for others, these interests develop in the process of taking courses and preparing for the entrance examination. In either case, it is imperative that students begin their research as soon as possible after completing their entrance examination. One of the important initial steps in this process is finding a faculty member who will agree to supervise the dissertation (thesis advisor). Every student is required to complete at least one unit of independent study with a faculty member each semester after passing the entrance examination until finding a thesis adviser.

A minimum of nine graduate courses is required in the major, including those taken prior to the entrance examination. Usually, these are courses taken in this department, but to a very limited extent, courses taken in other departments or at other institutions may be counted as part of this requirement. These courses should provide depth in the student's probable research area.

In addition, course work is required in two minor areas. This is a College of Engineering requirement, which specifies that two or three courses (of advanced undergraduate or graduate level) typically represent a minimum program for a minor. This loose wording reflects the diverse needs of the College. In this department, each minor must consist of six units at the graduate level, at least three of which must be taken for a letter grade. A minor may serve either to strengthen theoretical foundations (e.g., measure-theoretic probability theory), or as an area

of application (e.g., transportation). At most one course of one minor can be a course from within this department, as long as this course is distinct from the major. Both minors should be selected to strengthen the student's background in his or her research area, and subject to the approval of the head graduate adviser. Graduate courses at other institutions may make up part of a minor if the subject matter is appropriate.

The thesis advisor, once known, should be consulted about all matters regarding the program of study.

Coursework is comprised of an approved study list based on the student's research interest, which must include the following:

IND ENG 262A	Mathematical Programming I	4
IND ENG 263A	Applied Stochastic Process I	4
IND ENG 298	Group Studies, Seminars, or Group Research	1
Group A: Optimization: Select a minimum of one of the following:		3
IND ENG 262B	Mathematical Programming II [3]	
IND ENG 264	Computational Optimization [3]	
IND ENG 266	Network Flows and Graphs [3]	
IND ENG 269	Integer Programming and Combinatorial Optimization [3]	
Group B : Stochastic Modeling: Select a minimum of one of the following:		3
IND ENG 231	Introduction to Data Modeling, Statistics, and System Simulation [3]	
IND ENG 261	Experimenting with Simulated Systems [3]	
IND ENG 263B	Applied Stochastic Process II [3]	
IND ENG 267	Queueing Theory [3]	
IND ENG 268	Applied Dynamic Programming [3]	
Group C: Modeling and Applied Operations Research: Select a minimum of two of the following: ¹		6
IND ENG 215	Analysis and Design of Databases [3]	
IND ENG 220	Economics and Dynamics of Production [3]	
IND ENG 221	Introduction to Financial Engineering [3]	
IND ENG 250	Introduction to Production Planning and Logistics Models [3]	
IND ENG 251	Facilities Design and Logistics [3]	
IND ENG 253	Supply Chain Operation and Management [3]	
IND ENG 254	Production and Inventory Systems [3]	
IND ENG 265	Learning and Optimization [3]	
IND ENG 268	Applied Dynamic Programming [3]	

¹ In addition to the courses listed here, many occasionally-offered 290 series courses fit into this category, such as IND ENG 290A (Dynamic Production Theory and Planning Models) and IND ENG 290R (Topics in Risk Theory; check with the head graduate advisor about specific courses which may be approved).

Foreign Language(s)

In addition to English, the program does not require another language.

Qualifying Examination (QE)

The Qualifying Examination is an oral examination with a written component administered by four faculty members. Three of these faculty members are required to be IEOR faculty members and the fourth faculty member must be from another department with expertise in one of

the student's minor areas of study. Students are expected to take the Qualifying Examination within three semesters after passing the Doctoral Entrance Exam. Priority in department funding (especially NRTs) will be given to students who have passed their Doctoral Entrance Exams and are in their 3rd, 4th, and 5th semesters. Although it is necessary for a student to identify a potential research area and some potential dissertation topics in order to complete this exam, it is not necessary for the student to do a substantial amount of research in the area of the examination.

The student is required to have completed or be currently enrolled in courses that will complete at least one of the two minors at the time of the Qualifying Examination. At least one of the minors completed or being completed at the time of the Examination must consist entirely of courses from outside the department. In addition, at the time of the Qualifying Examination, the student is required to have a specific plan for completing the other minor within two semesters.

Prior to the exam, the student is required to identify a research area (broadly defined) in which he or she will be able to demonstrate expertise during the oral part of the examination. In addition, the student must be prepared to demonstrate expertise in one minor field. The objective of the exam is to assess the student's ability to demonstrate knowledge in a broad research area, and to identify potential research topics within this area.

At least six weeks prior to the approximate date of the Qualifying Examination, the student needs to begin to arrange for Graduate Division approval of the exam committee. The application form is available in your CalCentral under "Student Resources" and "Submit a Form". Select "Higher Degree Committees Form". Once the date and the exam committee are decided upon, the student must also request a room in which the exam can be held. Meanwhile, the student should prepare a list of topics, called a syllabus, which will form the basis of the Exam. The syllabus should include topics from the three subject areas to be listed on the "Application for Qualifying Examination" form, i.e., equivalent to several courses, together with topics from one of the minor areas.

At least one month before the exam date, the student must also prepare and submit the following documents to Head Graduate Advisor: a white Program of Study card that includes all major and minor courses taken or planned (whether or not they are included in the syllabus), a transcript, a list of faculty members who will serve on the exam committee, a syllabus, a preliminary draft of the technical report for the exam committee, and the student's advisor's signature to approve the intended date and topics. Both the Graduate Division's "Application for Qualifying Examination" form and the Program of Study card must be approved and signed by the Head Graduate Advisor.

At least two weeks prior to the exam, the student must submit his or her Qualifying Exam Report, to the qualifying exam committee. This report should be in the form of a research proposal, and should include both a substantial survey and critical evaluation of the literature in the likely area of the dissertation, and a potential research agenda in this area. If the student has completed preliminary research in this area, it is also appropriate to include a report of this research in this document. However, preliminary results are not required, and cannot make up the bulk of the document.

The Qualifying Exam document will be reviewed by the three professors who represent the major on the student's Qualifying Examination Committee, to determine adequacy of preparation for the research area. For students who follow these guidelines and the recommendations

of the Graduate Adviser and Thesis Adviser, this usually results in quick approval. However, if preparation is judged to be inadequate, they may recommend additional course work and postponement of this Examination.

In many departments, including IEOR, it has been the practice for students to schedule their own Qualifying Examinations. This exam is to be scheduled for three hours, at a time when all Committee members can attend.

The oral portion of the Qualifying Examination has two parts. In the first part, the student presents a 45-minute talk based on his or her Qualifying Examination Report. The Committee will ask questions pertaining to the report and presentation at this time. During the second part of the oral examination, the committee will ask more general questions to determine the student's level of expertise in the broadly defined research area specified by the student (and described in the syllabus). During this time, the outside committee member will also ask questions about one of the student's minor areas.

If the student's performance is judged to be unsatisfactory, the Committee may recommend reexamination, possibly after additional preparation has been completed. If the reasons for the unsatisfactory performance are judged to be major and fundamental, the Committee may recommend that a second attempt be denied.

Time in Candidacy

Advancement

After passing the qualifying examination, the student should file an application for advancement to candidacy in CalCentral, which sets up a three-person guidance committee for the dissertation. Once this is approved, the student is eligible for reduced fees. After advancing to candidacy, the student is expected to spend full time doing research on his or her dissertation, and on related teaching tasks.

Required Professional Development

Teaching Opportunities

The Department of IEOR strives to provide every student with an opportunity to gain teaching experience. Every year, students work as teaching assistants responsible for discussion or laboratory sections (Graduate Student Instructors, or GSIs) and serve as readers assisting with grading but not conducting independent teaching.

Professional Conference Attendance

Workshops

At least once a year after passing the qualifying examination, the student is required to hold a dissertation workshop. A form signed by the committee chair must be submitted to the student services office annually. Each dissertation workshop has two primary objectives:

1. It provides the department an opportunity to review the progress of students who have passed the qualifying examination, toward completion of their doctoral dissertation.
2. It facilitates interaction between the student and the dissertation committee and provides the basis for useful and consistent guidance. While the dissertation committee is primarily responsible for providing guidance, feedback from other faculty and from students is sought as well.

During the workshop, the candidate is expected to present a prospective of, and results from, the dissertation research. Dissertation advisers should advise students about the appropriate time for the workshops. However, initiation of the workshops is the student's responsibility. The student needs to notify the department at least one month in advance of the desired workshop date, and coordinate this date with the dissertation committee. At least two weeks prior to each workshop, the student shall distribute to the dissertation committee a report called the dissertation prospectus. Announcement of the workshop will be made through all the channels used to announce departmental seminars.

Each workshop is divided into two parts. The first part is devoted to a public presentation by the student and subsequent discussion. This part is conducted as a seminar and is open to all faculty and students. Graduate students and faculty who have research interests that relate to the workshop are encouraged to attend; this may be their best opportunity to provide constructive feedback to the candidate. (Graduate students who have not yet reached this stage in their own program often find that participating in workshops is a valuable educational experience.) The dissertation committee moderates the presentation and discussion, controls the asking of questions by the audience, and calls an end to the first part of the workshop.

In the second part of the workshop, which immediately follows the public presentation, the dissertation committee and other interested faculty members will reconvene in private with the candidate for the purpose of giving more feedback and specific guidelines for continuing research. At this time, the committee may decide that the candidate's progress is unsatisfactory. Should the committee reach this conclusion, it will be reported in writing, with proper justification, to the candidate and the department chair. The committee may require an additional workshop sooner than one year after the unsatisfactory one. Recurrent failure to present a satisfactory prospectus workshop may result in the disqualification of the student and termination of doctoral candidacy.

Dissertation Defense Workshop

Once the candidate has completed his or her research and completely written the thesis, a defense workshop must be scheduled and held. A completed copy of the thesis must be distributed to the committee at least two weeks before this final workshop. This workshop will follow the same format as other workshops. The committee will inform the candidate about any remaining problems or issues with the thesis. If the committee has serious issues with the thesis, it may require an additional defense workshop. A form signed by the student's committee chair must be submitted to the Student Services Office immediately after the workshop.

Unit Requirements

Students are required to complete 24 semester units of upper division and graduate coursework, 12 units of which must be graduate courses in the major taken for a letter grade. IND ENG 298 units do not count towards this requirement.

Curriculum

All students are required to take 1 unit of IND ENG 298; at least one course each from the following categories: Optimization, Stochastic Models, and Modeling (see below); and additional courses.

Beyond these requirements, the program is quite flexible. No more than two units of IND ENG 299 may be counted toward the degree. The remainder of the program can include electives outside the department. Entering students are expected to have two years of undergraduate mathematics, primarily calculus but including linear algebra. In addition,

they are expected to have completed at least one semester each of upper division courses in probability and in statistics. They should also have competency in a scientific programming language.

The requirements for each concentration follow the course lists for the three categories, below.

Optimization courses

IND ENG 160	Nonlinear and Discrete Optimization	3
IND ENG 162	Linear Programming and Network Flows	3
IND ENG 262A	Mathematical Programming I or EL ENG C22 Introduction to Convex Optimization	4
IND ENG 262B	Mathematical Programming II	3
IND ENG 266	Network Flows and Graphs	3
IND ENG 269	Integer Programming and Combinatorial Optimization	3

Stochastic Models courses

IND ENG 165	Engineering Statistics, Quality Control, and Forecasting	4
IND ENG 166	Decision Analytics	3
IND ENG 173	Introduction to Stochastic Processes ¹	3
IND ENG 231	Introduction to Data Modeling, Statistics, and System Simulation	3
IND ENG 261	Experimenting with Simulated Systems	3
IND ENG 263A	Applied Stochastic Process I	4
IND ENG 263B	Applied Stochastic Process II	3
IND ENG 267	Queueing Theory	3

Modeling courses

IND ENG 150	Production Systems Analysis	3
IND ENG 153	Logistics Network Design and Supply Chain Management	3
IND ENG 215	Analysis and Design of Databases	3
IND ENG 220	Economics and Dynamics of Production	3
IND ENG 221	Introduction to Financial Engineering	3
IND ENG 250	Introduction to Production Planning and Logistics Models	3
IND ENG 251	Facilities Design and Logistics	3
IND ENG 253	Supply Chain Operation and Management	3
IND ENG 254	Production and Inventory Systems	3
IND ENG 265	Learning and Optimization	3
IND ENG 268	Applied Dynamic Programming	3
IND ENG 290	Special Topics in Industrial Engineering and Operation Research (With approval of advisor)	2-3

¹ IND ENG 173 replaced IND ENG 161. Student will receive no credit for IND ENG 173 after taking IND ENG 161.

Course Requirements by Concentration

Operations Research Concentration

IND ENG 262A	Mathematical Programming I (fulfills Optimization requirement)	4
IND ENG 263A	Applied Stochastic Process I (fulfills Stochastic Models requirement)	4
IND ENG 298	Group Studies, Seminars, or Group Research	1

Select two from the following (at least one must be a Modeling course):

IND ENG 221	Introduction to Financial Engineering [3]
IND ENG 261	Experimenting with Simulated Systems [3]
IND ENG 262B	Mathematical Programming II [3]
IND ENG 263B	Applied Stochastic Process II [3]
IND ENG 264	Computational Optimization [3]
IND ENG 266	Network Flows and Graphs [3]
IND ENG 267	Queueing Theory [3]
IND ENG 268	Applied Dynamic Programming [3]
IND ENG 269	Integer Programming and Combinatorial Optimization [3]

Production & Service Operations Concentration

When selecting options below, please be sure to select at least one course from each category: Optimization, Stochastic Models, and Modeling (see above).

IND ENG 298	Group Studies, Seminars, or Group Research	1
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Select two of the following:

IND ENG 250	Introduction to Production Planning and Logistics Models [3]
IND ENG 251	Facilities Design and Logistics [3]
IND ENG 254	Production and Inventory Systems [3]

Select one of the following:

IND ENG 150	Production Systems Analysis [3]
IND ENG 151	Service Operations Design and Analysis [3]
IND ENG 153	Logistics Network Design and Supply Chain Management [3]

Select one of the following:

IND ENG 130	Methods of Manufacturing Improvement [3]
IND ENG 150	Production Systems Analysis [3] (if not select above)
IND ENG 151	Service Operations Design and Analysis [3] (if not selected above)
IND ENG 153	Logistics Network Design and Supply Chain Management [3] (if not selected above)
IND ENG 165	Engineering Statistics, Quality Control, and Forecasting [4]

Simulation & Decision Technology Concentration

IND ENG 115	Industrial and Commercial Data Systems (fulfills Modeling requirement)	3
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or IND ENG 215 Analysis and Design of Databases

IND ENG 261	Experimenting with Simulated Systems (fulfills Stochastic Models requirement)	3
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IND ENG 298	Group Studies, Seminars, or Group Research	1
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Select two of the following (one must be from the Optimization category):

IND ENG 166	Decision Analytics [3]
IND ENG 262A	Mathematical Programming I [4] or EL ENG C Introduction to Convex Optimization

UGBA 147	Special Topics in Operations and Information Technology Management [1-4]
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Financial Systems Concentration

IND ENG 221	Introduction to Financial Engineering (fulfills Modeling requirement)	3
IND ENG 222	Financial Engineering Systems I	3
IND ENG 223	Financial Engineering Systems II	3
IND ENG 298	Group Studies, Seminars, or Group Research	1

Master of Science Thesis (Plan 1)

Students may complete the requirements by writing a thesis, rather than taking a comprehensive examination. The course requirements under the thesis option are the same as under the comprehensive option. Under the thesis option, the minimum unit requirement of regular course work is 20 units, not including the thesis. A committee of three professors, including one from outside the IEOR Department, will be formed to guide and approve the thesis.

The Comprehensive Exam or Project (Plan 2)

In addition to course and waiver exam requirements, students are required to complete one of two options: a comprehensive exam or a master's project and oral presentation of this project. The structure of the comprehensive exam may vary from year to year but is designed so that students whose curriculum includes 12 units of graduate courses in the major and satisfies the group distribution listed above should be prepared to take the exam. At the current time, the comprehensive exam consists of a short oral presentation to a panel of two or three faculty of a solution to a case study, for which the students will be given at least two weeks to prepare, followed by relevant questions from the faculty panel.

Relation to Doctoral Requirements

In general, the first year doctoral requirements meet the requirements of the MS degree, but the reverse is not necessarily true. Students who are interested in earning a PhD should apply to enter the MS/PhD if they do not yet have an MS degree. More detailed information on the entrance exam may be found on the Doctoral Degree Requirements tab.

Unit Requirements

Minimum number of units to complete degree: 25 semester units.

Curriculum

Technical Course work (must be taken for a letter grade):

- **Core Courses:** All students are required to take IND ENG 240 and IND ENG 241. Students in the FinTech program are also required to take IND ENG 242.
- **Technical Electives:** Students must complete a minimum of 6 units of IND ENG 200 level technical electives for letter grades from the lists below. FinTech students must select two of the following: IND ENG 221, IND ENG 222, IND ENG 224. Data Analytics & IP Strategy must select one of the following: IND ENG 215, IND ENG 221, IND ENG 224, IND ENG 290 / IND ENG 235 (DataX).

Leadership Courses (must be taken for a letter grade)

- All students must complete 8 semester units of core leadership courses, which must be in the 200-series.
- The Innovation Lecture Series (IND ENG 295 taken S/U), is optional.

Capstone Project Courses:

- Students must take the capstone integration course each semester.
- All students must complete 5 units of capstone courses: 2 units in the fall semester and 3 units in the spring semester (see the course lists below).

Required Technical Courses

IND ENG 240	Optimization Analytics	3
IND ENG 241	Risk Modeling, Simulation, and Data Analysis	3

Technical Electives

IND ENG 221	Introduction to Financial Engineering	3
IND ENG 222	Financial Engineering Systems I	3
IND ENG 223	Financial Engineering Systems II	3
IND ENG 224	Portfolio and Risk Analytics	3
IND ENG C227B	Convex Optimization and Approximation	3
IND ENG 242	Applications in Data Analysis	3
IND ENG 250	Introduction to Production Planning and Logistics Models	3
IND ENG C253	Supply Chain and Logistics Management	3
IND ENG 262A	Mathematical Programming I	4
IND ENG 262B	Mathematical Programming II	3
IND ENG 263A	Applied Stochastic Process I	4
IND ENG 263B	Applied Stochastic Process II	3
IND ENG 265	Learning and Optimization	3
IND ENG 266	Network Flows and Graphs	3
IND ENG 267	Queueing Theory	3
IND ENG 290	Special Topics in Industrial Engineering and Operation Research ((Fundamentals of Machine Learning & Data Analytics))	2-3

Required Leadership Courses

ENGIN 270A	Organizational Behavior for Engineers	1
ENGIN 270B	R&D Technology Management & Ethics	1
ENGIN 270C	Teaming & Project Management	1
ENGIN 295	Communications for Engineering Leaders	1

Required Capstone Courses

ENGIN 296MA	Master of Engineering Capstone Project (Fall)	2
ENGIN 296MB	Master of Engineering Capstone Project (Spring)	3

Industrial Engineering and Operations Research

Expand all course descriptions [+]Collapse all course descriptions [-]

IND ENG 210 Python for Analytics 3 Units

Terms offered: Not yet offered

This introductory course provides students with sufficient background in Python programming language for use in analytics applications as well as potentially conducting research in the area. The course is designed to prepare students for the applied analytics problems and projects they will encounter in advanced analytics courses. It will start with basic programming topics using Python and cover using powerful Python packages such as Numpy, Scipy, Pandas, and Matplotlib that are essential for descriptive, predictive, and prescriptive analytics. Students will work on group projects along with the instructor in order to solidify the lectures into practical experience using Python for analytics.

Python for Analytics: Read More [+]

Objectives & Outcomes

Student Learning Outcomes: LEARNING GOALS

Upon completion of the course students will have learned how to:

- # use Python and core scientific packages to solve complex analytics problems;
- # develop custom Python scripts and functions to perform analytic computations;
- # visualize analytic results in graphical form;
- # understand the array of mathematical toolkits provided by the Python packages covered.

Hours & Format

Summer: 2 weeks - 15 hours of lecture and 10 hours of laboratory per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructors: Aswani, Grigas, Pirutinsky

Python for Analytics: Read Less [-]

IND ENG 215 Analysis and Design of Databases 3 Units

Terms offered: Fall 2022, Spring 2022, Spring 2021

Advanced topics in information management, focusing on design of relational databases, querying, and normalization. New issues raised by the World Wide Web. Research projects on current topics in information technology.

Analysis and Design of Databases: Read More [+]

Rules & Requirements

Prerequisites: Graduate standing

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of lecture and 1 hour of laboratory per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Goldberg

Analysis and Design of Databases: Read Less [-]

IND ENG 220 Economics and Dynamics of Production 3 Units

Terms offered: Spring 2017, Spring 2016, Spring 2015

Analysis of the capacity and efficiency of production systems. Development of analytical tools for improving efficiency, customer service, and profitability of production environments. Design and development of effective industrial production planning systems. Modelling principles are illustrated by reviewing actual large-scale planning systems successfully implemented for naval ship overhaul and for semiconductor manufacturing.

Economics and Dynamics of Production: Read More [+]

Rules & Requirements

Prerequisites: 262A (may be taken concurrently), Mathematics 104 recommended

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Leachman

Economics and Dynamics of Production: Read Less [-]

IND ENG 221 Introduction to Financial Engineering 3 Units

Terms offered: Fall 2022, Spring 2022, Fall 2021

A course on financial concepts useful for engineers that will cover, among other topics, those of interest rates, present values, arbitrage, geometric Brownian motion, options pricing, & portfolio optimization. The Black-Scholes option-pricing formula will be derived and studied. Stochastic simulation ideas will be introduced and used to obtain the risk-neutral geometric Brownian motion values for certain types of Asian, barrier, and lookback options. Portfolio optimization problems will be considered both from a mean-variance and from a utility function point of view. Methods for evaluating real options will be presented. The use of mathematical optimization models as a framework for analyzing financial engineering problems will be shown.

Introduction to Financial Engineering: [Read More](#) [+]

Rules & Requirements

Prerequisites: 162 or 262A, course in probability, or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructors: Adler, Oren, Ross

Introduction to Financial Engineering: [Read Less](#) [-]

IND ENG 222 Financial Engineering Systems I 3 Units

Terms offered: Fall 2022, Spring 2022, Spring 2021

Introductory graduate level course, focusing on applications of operations research techniques, e.g., probability, statistics, and optimization, to financial engineering. The course starts with a quick review of 221, including no-arbitrage theory, complete market, risk-neutral pricing, and hedging in discrete model, as well as basic probability and statistical tools. It then covers Brownian motion, martingales, and Ito's calculus, and deals with risk-neutral pricing in continuous time models. Standard topics include Girsanov transformation, martingale representation theorem, Feynman-Kac formula, and American and exotic option pricings. Simulation techniques will be discussed at the end of the semester, and MATLAB (or C or S-Plus) will be used for computation.

Financial Engineering Systems I: [Read More](#) [+]

Rules & Requirements

Prerequisites: 221 or equivalent; 172 or Statistics 134 or a one-semester probability course

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Guo

Financial Engineering Systems I: [Read Less](#) [-]

IND ENG 223 Financial Engineering Systems II 3 Units

Terms offered: Fall 2022, Fall 2021, Fall 2020

Advanced graduate course for Ph.D. students interested in pursuing a professional/research career in financial engineering. The course will start with a quick review of 222: the basics of Brownian motion, martingales, Ito's calculus, risk-neutral pricing in continuous time models. It then covers rigorously and in depth the most fundamental probability concepts for financial engineers, including stochastic integral, stochastic differential equations, and semi-martingales. The second half of the course will discuss the most recent topics in financial engineering, such as credit risk and analysis, risk measures and portfolio optimization, and liquidity risk and models.

Financial Engineering Systems II: Read More [+]

Rules & Requirements

Prerequisites: 222 or equivalent; 173 or 263A or equivalent

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Guo

Financial Engineering Systems II: Read Less [-]

IND ENG 224 Portfolio and Risk Analytics 3 Units

Terms offered: Spring 2019, Spring 2018

The course aims to train students in hands-on statistical, optimization, and data analytics for quantitative portfolio and risk management. In addition, the course will introduce elements of financial markets and asset classes. The emphasis will be on computational methods such as variants of GARCH, Black-Litterman, conic optimization, Monte Carlo simulation for risk and optimization, factor modeling. Students will undertake computational assignments and a group project. They will also manage hypothetical portfolios throughout the course.

Portfolio and Risk Analytics: Read More [+]

Rules & Requirements

Prerequisites: A basic understanding of statistics and optimization, as well as fluency in a programming language is required

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Alper Atamturk

Portfolio and Risk Analytics: Read Less [-]

IND ENG C227A Introduction to Convex Optimization 4 Units

Terms offered: Prior to 2007

The course covers some convex optimization theory and algorithms, and describes various applications arising in engineering design, machine learning and statistics, finance, and operations research. The course includes laboratory assignments, which consist of hands-on experience. Introduction to Convex Optimization: Read More [+]

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 2 hours of laboratory per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructors: El Ghaoui, Wainwright

Formerly known as: Electrical Engineering C227A/Industrial Engin and Oper Research C227A

Also listed as: EL ENG C227T

Introduction to Convex Optimization: Read Less [-]

IND ENG C227B Convex Optimization and Approximation 3 Units

Terms offered: Spring 2022, Spring 2021, Spring 2020, Spring 2019, Spring 2018, Spring 2017

Convex optimization as a systematic approximation tool for hard decision problems. Approximations of combinatorial optimization problems, of stochastic programming problems, of robust optimization problems (i.e., with optimization problems with unknown but bounded data), of optimal control problems. Quality estimates of the resulting approximation. Applications in robust engineering design, statistics, control, finance, data mining, operations research.

Convex Optimization and Approximation: Read More [+]

Rules & Requirements

Prerequisites: 227A or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: El Ghaoui

Also listed as: EL ENG C227C

Convex Optimization and Approximation: Read Less [-]

IND ENG 230 Economics of Supply Chains 3 Units

Terms offered: Not yet offered

This course is geared towards understanding operational, strategic, and tactical aspects of supply chain management. Topics covered are from a broad range that includes demand modeling, inventory management, facility location as well as process flexibility, contracting, and auctions. Important models (both centralized and decentralized) for understanding the design, operation, and evaluation of supply chains will be discussed with the goal of developing a holistic understanding of supply chain management. Students will be exposed to the key concepts through a mixture of foundational theory and case studies from a variety of businesses. The course is intended for graduate students at the Masters level looking for a concrete introduction

Economics of Supply Chains: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: Basics Optimization and Probability (IndEng 240, IndEng 241, or equivalent)

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Udwani

Economics of Supply Chains: Read Less [\[-\]](#)

IND ENG 231 Introduction to Data Modeling, Statistics, and System Simulation 3 Units

Terms offered: Spring 2017, Spring 2015, Spring 2014

This course uses simulation models for analyzing and optimizing systems where the underlying processes and/or parameters are not fully known, but data may be available, sampled, or artificially generated. Monte Carlo simulations are used in a weekly laboratory to model systems that may be too complex to approximate accurately with deterministic, stationary, or static models; and to measure the robustness of predictions and manage risks in decisions based on data-driven models.

Introduction to Data Modeling, Statistics, and System Simulation: Read More [\[+\]](#)

Objectives & Outcomes

Course Objectives: Students will understand the similarities and differences in methods for simulating the dynamics of complex, stochastic systems and apply these to model real systems. Special techniques for experimenting with computer simulations and analyzing the results will be used to understand the trade-offs in risk and performance in the presence of uncertainty.

Rules & Requirements

Prerequisites: 262A, 263A or equivalents and some programming experience

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of lecture and 1 hour of laboratory per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructors: Schruben, Guo, Lim

Introduction to Data Modeling, Statistics, and System Simulation: Read Less [\[-\]](#)

IND ENG 235 Applied Data Science with Venture Applications 3 Units

Terms offered: Spring 2022, Fall 2021

This is an advanced project course in data science that offers a "maker" and/or "innovation" viewpoint. The course is focused first on developing an open-ended-real world project relating to data science. Related concepts of computer science tools and theoretical concepts are covered to support the project. These concepts include filtering, prediction, classification, LTI systems, and spectral analysis. After reviewing each concept, we explore implementing it in Python using libraries for math array functions, manipulation of tables, data architectures, natural language, and ML frameworks.

Applied Data Science with Venture Applications: Read More [+]

Rules & Requirements

Prerequisites: Prerequisites include: ability to write code in Python, and a probability or statistics course

Hours & Format

Fall and/or spring:

15 weeks - 3 hours of lecture per week

15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Sidhu

Applied Data Science with Venture Applications: Read Less [-]

IND ENG 240 Optimization Analytics 3 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Computing technology has advanced to the point that commonly available tools can be used to solve practical decision problems and optimize real-world systems quickly and efficiently. This course will focus on the understanding and use of such tools, to model and solve complex real-world business problems, to analyze the impact of changing data and relaxing assumptions on these decisions, and to understand the risks associated with particular decisions and outcomes.

Optimization Analytics: Read More [+]

Rules & Requirements

Prerequisites: Basic analysis and linear algebra, and basic computer skills and experience

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of laboratory per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Optimization Analytics: Read Less [-]

IND ENG 241 Risk Modeling, Simulation, and Data Analysis 3 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

This is a Masters of Engineering course, in which students will develop a fundamental understanding of how randomness and uncertainty are root causes of risk in modern enterprises. The technical material will be presented in the context of engineering team system design and operations decisions.

Risk Modeling, Simulation, and Data Analysis: Read More [+]

Rules & Requirements

Prerequisites: Basic notions of probability, statistics, and some programming and spreadsheet analysis experience

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of laboratory per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Risk Modeling, Simulation, and Data Analysis: Read Less [-]

IND ENG 242 Applications in Data Analysis 3 Units

Terms offered: Fall 2022, Spring 2022, Fall 2021

This course applies foundational concepts in programming, databases, machine learning, and statistical modeling to answer questions from business and social science. The goal is for students to develop the experience and intuition to gather and build new datasets and answer substantive questions.

Applications in Data Analysis: Read More [+]

Rules & Requirements

Prerequisites: Prerequisites include working knowledge of a programming language (preferably Python), database language (preferably SQL), a statistical package (preferably R), and an understanding of basic linear and non-linear statistical models. Prior exposure to machine learning is helpful, though this will be covered in the predictive analytics and theory course

Credit Restrictions: Ind Eng 242 shares a fair amount of overlapping content with Ind Eng 142. Students taking Ind Eng 242 cannot receive credit for Ind Eng 142.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Fleming

Applications in Data Analysis: Read Less [-]

IND ENG 243 Analytics Lab 4 Units

Terms offered: Spring 2022

A project course to provide hands-on experience in end-to-end analytics development from exploratory analytics to systems analytics in an industry context, including communication of recommendations. Students will work in teams on projects and build solutions to business/industry challenges using Python packages such as Pandas, NumPy, Matplotlib, scikit-learn, Bokeh, and relevant optimization and simulation software.

Analytics Lab: Read More [+]

Objectives & Outcomes

Student Learning Outcomes: Learning goals include technical communication and project presentation.

Rules & Requirements

Prerequisites: IEOR 240 Optimization Analytics, IEOR 241 Risk Modeling & Simulation Analytics, IEOR 242 Applications in Data Analysis. Familiarity with the Python programming language is also expected

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructors: Aswani, Grigas

Analytics Lab: Read Less [-]

IND ENG 248 Supply Chain Innovation, Strategy, and Analytics 3 Units

Terms offered: Fall 2013

This course introduces you to the field of supply chain management through a series of lectures and case studies that emphasize innovative concepts in supply chain management that have proven to be beneficial for a good number of adopters. Innovations that we will discuss include collaborative forecasting, social media, online procurement, and technologies such as RFID.

Supply Chain Innovation, Strategy, and Analytics: Read More [+]

Rules & Requirements

Prerequisites: Introductory course on Production and Inventory Control or Operations Management

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Supply Chain Innovation, Strategy, and Analytics: Read Less [-]

IND ENG 250 Introduction to Production Planning and Logistics Models 3 Units

Terms offered: Fall 2022, Fall 2021, Fall 2020

This will be an introductory first-year graduate course covering fundamental models in production planning and logistics. Models, algorithms, and analytical techniques for inventory control, production scheduling, production planning, facility location and logistics network design, vehicle routing, and demand forecasting will be discussed. Introduction to Production Planning and Logistics Models: Read More [+]

Rules & Requirements

Prerequisites: 262A and 263A taken concurrently

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Kaminsky

Introduction to Production Planning and Logistics Models: Read Less [-]

IND ENG 251 Facilities Design and Logistics 3 Units

Terms offered: Fall 2012, Spring 2005, Spring 2004

Design and analysis of models and algorithms for facility location, vehicle routing, and facility layout problems. Emphasis will be placed on both the use of computers and the theoretical analysis of models and algorithms. Facilities Design and Logistics: Read More [+]

Rules & Requirements

Prerequisites: 262A, and either 172 or Statistics 134

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Kaminsky

Facilities Design and Logistics: Read Less [-]

IND ENG 252 Service Operations Management 3 Units

Terms offered: Spring 2021, Spring 2014, Spring 2013

This course focuses on the design of service businesses such as commercial banks, hospitals, airline companies, call centers, restaurants, Internet auction websites, and information providers. The material covered in the course includes internet auctions, procurement, service facility location, service quality management, capacity planning, airline ticket pricing, financial plan design, pricing of digital goods, call center management, service competition, revenue management in queueing systems, information intermediaries, and health care. The goal of the instructors is to equip the students with sufficient technical background to be able to do research in this area.

Service Operations Management: Read More [+]

Rules & Requirements

Prerequisites: Students who have not advanced to M.S., M.S./Ph.D., or Ph.D. levels or are not in the Industrial Engineering and Operations Research Department must consult with the instructor before taking this course for credit

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructors: Shen, Chen

Service Operations Management: Read Less [-]

IND ENG 253 Supply Chain Operation and Management 3 Units

Terms offered: Spring 2013, Spring 2012, Spring 2011

Supply chain analysis is the study of quantitative models that characterize various economic trade-offs in the supply chain. The field has made significant strides on both theoretical and practical fronts. On the theoretical front, supply chain analysis inspires new research ventures that blend operations research, game theory, and microeconomics. These ventures result in an unprecedented amalgamation of prescriptive, descriptive, and predictive models characteristic of each subfield. On the practical front, supply chain analysis offers solid foundations for strategic positioning, policy setting, and decision making.

Supply Chain Operation and Management: Read More [+]

Rules & Requirements

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Shen

Supply Chain Operation and Management: Read Less [-]

IND ENG C253 Supply Chain and Logistics Management 3 Units

Terms offered: Spring 2022, Spring 2021, Fall 2020, Spring 2020

Supply chain analysis is the study of quantitative models that characterize various economic trade-offs in the supply chain. The field has made significant strides on both theoretical and practical fronts. On the theoretical front, supply chain analysis inspires new research ventures that blend operations research, game theory, and microeconomics. These ventures result in an unprecedented amalgamation of prescriptive, descriptive, and predictive models characteristic of each subfield. On the practical front, supply chain analysis offers solid foundations for strategic positioning, policy setting, and decision making.

Supply Chain and Logistics Management: Read More [+]

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Shen

Also listed as: CIV ENG C258

Supply Chain and Logistics Management: Read Less [-]

IND ENG 254 Production and Inventory Systems 3 Units

Terms offered: Spring 2014, Fall 2011, Fall 2009

Mathematical and computer methods for design, planning, scheduling, and control in manufacturing and distribution systems.

Production and Inventory Systems: Read More [+]

Rules & Requirements

Prerequisites: 262A or 150; 263A or 173 recommended

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Production and Inventory Systems: Read Less [-]

IND ENG 255 Frontiers in Revenue Management 3 Units

Terms offered: Spring 2022

This course is targeted at understanding RM problems in the booming environment of online platforms and marketplaces with applications ranging from online advertising to ride-sharing markets. The main focus is on design and analysis of models and algorithms for matching, pricing, incentivizing, and personalizing on such platforms. Sample topics include, but are not limited to, resource allocation and pricing under uncertain sequential demand, mechanism design, discrete choice models, static and dynamic assortment optimization, real-time recommendations, spatial supply response and supply re-balancing in bike/ride sharing systems.

Frontiers in Revenue Management: Read More [+]

Rules & Requirements

Prerequisites: IndEng 262A and IndEng 263A (or equivalent coursework) IndEng 264 and IndEng 269 recommended but not required

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Udwani

Frontiers in Revenue Management: Read Less [-]

IND ENG 258 Control and Optimization for Power Systems 3 Units

Terms offered: Spring 2019, Spring 2017

One of the grand challenges of this century is the modernization of electrical power networks. This graduate-level course provides a fundamental understanding of the mathematics behind the operation of power grids.

Control and Optimization for Power Systems: Read More [+]

Objectives & Outcomes

Course Objectives:

Students will understand the operation of power networks from a control and optimization perspective. They will learn how mathematical tools and computational methods are used for the design, modeling, planning, and real-time operation of power grids. They will also learn about the interaction between operation and electricity market.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Lavaei

Control and Optimization for Power Systems: Read Less [-]

IND ENG 261 Experimenting with Simulated Systems 3 Units

Terms offered: Spring 2009, Spring 2007, Spring 2006

This course will introduce graduate and upper division undergraduate students to modern methods for simulating discrete event models of complex stochastic systems. About a third of the course will be devoted to system modeling, with the remaining two-thirds concentrating on simulation experimental design and analysis.

Experimenting with Simulated Systems: Read More [+]

Rules & Requirements

Prerequisites: 165 or equivalent statistics course, and some computer programming background

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructors: Ross, Schruben, Shanthikumar

Experimenting with Simulated Systems: Read Less [-]

IND ENG 262A Mathematical Programming I 4 Units

Terms offered: Fall 2022, Fall 2021, Fall 2020

Basic graduate course in linear programming and introduction to network flows and non-linear programming. Formulation and model building.

The simplex method and its variants. Duality theory. Sensitivity analysis, parametric programming, convergence (theoretical and practical).

Polynomial time algorithms. Introduction to network flows models.

Optimality conditions for non linear optimization problems.

Mathematical Programming I: Read More [+]

Rules & Requirements

Prerequisites: Mathematics 110

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructors: Adler, Oren

Mathematical Programming I: Read Less [-]

IND ENG 262B Mathematical Programming II 3 Units

Terms offered: Spring 2022, Spring 2021, Fall 2020

Basic first year graduate course in optimization of non-linear programs. Formulation and model building. Theory of optimization for constrained and unconstrained problems. Study of algorithms for non-linear optimization with emphasis on design considerations and performance evaluation.

Mathematical Programming II: Read More [+]

Rules & Requirements

Prerequisites: Math 110 or equivalent

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructors: Adler, Oren

Mathematical Programming II: Read Less [-]

IND ENG 263A Applied Stochastic Process I 4 Units

Terms offered: Fall 2022, Fall 2021, Fall 2020

Conditional Expectation. Poisson and general point process and renewal theory. Renewal reward processes with application to inventory, congestion, and replacement models. Discrete and continuous time Markov chains; with applications to various stochastic systems--such as queueing systems, inventory models and reliability systems.

Applied Stochastic Process I: Read More [+]

Rules & Requirements

Prerequisites: Industrial Engineering

172, or Statistics 134 or Statistics 200A. Probability background with Industrial Engineering 173 or equivalent is recommended

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Righter

Applied Stochastic Process I: Read Less [-]

IND ENG 263B Applied Stochastic Process II 3 Units

Terms offered: Spring 2022, Spring 2021, Spring 2020

Continuous time Markov chains. The reversed chain concept in continuous time Markov chains with applications of queueing theory. Semi-Markov processes with emphasis on application. Brownian Motion. Random walks with applications. Introduction to Martinjales.

Applied Stochastic Process II: Read More [+]

Rules & Requirements

Prerequisites: 263A

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Righter

Applied Stochastic Process II: Read Less [-]

IND ENG 264 Computational Optimization 3 Units

Terms offered: Spring 2017, Spring 2016, Spring 2015

This course is on computational methods for the solution of large-scale optimization problems. The focus is on converting the theory of optimization into effective computational techniques. Course topics include an introduction to polyhedral theory, cutting plane methods, relaxation, decomposition and heuristic approaches for large-scale optimization problems.

Computational Optimization: Read More [+]

Rules & Requirements

Prerequisites: 262A

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Atamturk

Computational Optimization: Read Less [-]

IND ENG 265 Learning and Optimization 3 Units

Terms offered: Spring 2022, Spring 2021, Spring 2020

This course will cover topics related to the interplay between optimization and statistical learning. The first part of the course will cover statistical modeling procedures that can be defined as the minimizer of a suitable optimization problem. The second part of the course will discuss the formulation and numerical implementation of learning-based model predictive control (LBMPC), which is a method for robust adaptive optimization that can use machine learning to provide the adaptation. The last part of the course will deal with inverse decision-making problems, which are problems where an agent's decisions are observed and used to infer properties about the agent.

Learning and Optimization: Read More [+]

Rules & Requirements

Prerequisites: Course on optimization (Industrial Engineering 162 or equivalent); course on statistics or stochastic processes (Industrial Engineering 165 or equivalent) Industrial Engin and Oper Research 165

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Aswani

Learning and Optimization: Read Less [-]

IND ENG 266 Network Flows and Graphs 3 Units

Terms offered: Fall 2022, Fall 2021, Fall 2020

Survey of solution techniques and problems that have formulations in terms of flows in networks. Max-flow min-cut theorem. Minimum cost flows. Multiterminal and multicommodity flows. Relationship with linear programming, transportation problems, electrical networks and critical path scheduling.

Network Flows and Graphs: Read More [+]

Rules & Requirements

Prerequisites: 262A (may be taken concurrently)

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructors: Adler, Hochbaum

Network Flows and Graphs: Read Less [-]

IND ENG 267 Queueing Theory 3 Units

Terms offered: Spring 2022, Spring 2016, Spring 2015

The result " $L = (\lambda) w$ " and other conservation laws. Elementary queueing models; comparing single- and multiple-server queues. PASTA. Work. Markovian queues; product form results. Overflow models. Embedded Markov chains. Random walks and the GI/G/1 queues. Work conservation; priorities. Bounds and approximations.

Queueing Theory: Read More [+]

Rules & Requirements

Prerequisites: IND ENG 263A

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Queueing Theory: Read Less [-]

IND ENG 268 Applied Dynamic Programming 3 Units

Terms offered: Fall 2021, Spring 2018, Spring 2017

Dynamic programming formulation of deterministic decision process problems, analytical and computational methods of solution, application to problems of equipment replacement, resource allocation, scheduling, search and routing. Brief introduction to decision making under risk and uncertainty.

Applied Dynamic Programming: Read More [+]

Rules & Requirements

Prerequisites: Mathematics 51

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Dreyfus

Applied Dynamic Programming: Read Less [-]

IND ENG 269 Integer Programming and Combinatorial Optimization 3 Units

Terms offered: Spring 2020, Spring 2010, Spring 2009

The course deals with discrete optimization problems and their complexity. These topics include complexity analysis of algorithms and its drawbacks; solving a system of linear integer equations and inequalities; strongly polynomial algorithms, network flow problems (including matching and branching); polyhedral optimization; branch and bound and lagrangean relaxation.

Integer Programming and Combinatorial Optimization: Read More [+]

Rules & Requirements

Prerequisites: 262A

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructor: Hochbaum

Integer Programming and Combinatorial Optimization: Read Less [-]

IND ENG 270 Current Readings in Innovation 3 Units

Terms offered: Fall 2015, Fall 2014

This seminar and discussion class aims to survey current and classic research on innovation and help doctoral students formulate their research designs. Readings are drawn from economics, organizations, and other social sciences, and engineering and in particular, data science research on analyzing large data sets. Students develop research designs and present each week and formally for their final. A written paper is also required. Authors join us, physically or virtually. Current Readings in Innovation: Read More [+]

Rules & Requirements

Prerequisites: Background: upper level standing or graduate student, any school

Repeat rules: Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of seminar per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Instructors: Fleming, Lee

Current Readings in Innovation: Read Less [-]

IND ENG 280 Systems Analysis and Design Project 3 Units

Terms offered: Spring 2011, Spring 2010, Spring 2009

A project course for students interested in applications of operations research and engineering methods. One or more systems, which may be public or in the private sector, will be selected for detailed analysis and re-designed by student groups.

Systems Analysis and Design Project: Read More [+]

Rules & Requirements

Prerequisites: 262A, 263A

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Systems Analysis and Design Project: Read Less [-]

IND ENG 288 Automation Science and Engineering 3 Units

Terms offered: Prior to 2007

Automation is a central aspect of contemporary industrial engineering that combines sensors, actuators, and computing to monitor and perform operations. It is applied to a broad range of applications from manufacturing to transportation to healthcare. This course provides an introduction to analysis, models, algorithms, research, and practical skills in the field and includes a laboratory component where students will learn and apply basic skills in computer programming and interfacing of sensors and motors that will culminate in a team design project.

Automation Science and Engineering: Read More [\[+\]](#)

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of lecture, 1 hour of discussion, and 1 hour of laboratory per week

Additional Details

Subject/Course Level: Industrial Engineering and Operations Research/Graduate

Grading: Letter grade.

Automation Science and Engineering: Read Less [\[-\]](#)

IND ENG 290 Special Topics in Industrial Engineering and Operations Research 2 - 3 Units

Terms offered: Fall 2022, Spring 2022, Fall 2021

Lectures and appropriate assignments on fundamental or applied topics of current interest in industrial engineering and operations research.

Special Topics in Industrial Engineering and Operations Research: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: Upper level standing or graduate student

Repeat rules: Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 2-3 hours of lecture per week

Summer:

6 weeks - 5-7.5 hours of lecture per week

10 weeks - 3-4.5 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engineering and Operations Research/Graduate

Grading: Letter grade.

Special Topics in Industrial Engineering and Operations Research: Read Less [\[-\]](#)

IND ENG 290A Dynamic Production Theory and Planning Models 3 Units

Terms offered: Spring 2014, Fall 2008, Spring 2008

Development of dynamic activity analysis models for production planning and scheduling. Relationship to theory of production, inventory theory and hierarchical organization of production management.

Dynamic Production Theory and Planning Models: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: 220 and 254

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engineering and Operations Research/Graduate

Grading: Letter grade.

Dynamic Production Theory and Planning Models: Read Less [\[-\]](#)

IND ENG 290G Advanced Mathematical Programming 3 Units

Terms offered: Spring 2017, Spring 2014, Spring 2011

Selected topics in mathematical programming. The actual subjects covered may include: Convex analysis, duality theory, complementary pivot theory, fixed point theory, optimization by vector space methods, advanced topics in nonlinear algorithms, complexity of mathematical programming algorithms (including linear programming).

Advanced Mathematical Programming: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: 262A

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engineering and Operations Research/Graduate

Grading: Letter grade.

Advanced Mathematical Programming: Read Less [\[-\]](#)

IND ENG 290R Topics in Risk Theory 3 Units

Terms offered: Spring 2016, Spring 2015, Spring 2014

Seminar on selected topics from financial and technological risk theory, such as risk modeling, attitudes towards risk and utility theory, portfolio management, gambling and speculation, insurance and other risk-sharing arrangements, stochastic models of risk generation and run off, risk reserves, Bayesian forecasting and credibility approximations, influence diagrams, decision trees. Topics will vary from year to year.

Topics in Risk Theory: Read More [+]

Rules & Requirements

Prerequisites: IND ENG 263A

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Letter grade.

Topics in Risk Theory: Read Less [-]

IND ENG 298 Group Studies, Seminars, or Group Research 1 - 4 Units

Terms offered: Fall 2022, Spring 2022, Fall 2021

Advanced seminars in industrial engineering and operations research.

Group Studies, Seminars, or Group Research: Read More [+]

Rules & Requirements

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

Fall and/or spring: 15 weeks - 1-4 hours of colloquium per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: The grading option will be decided by the instructor when the class is offered.

Group Studies, Seminars, or Group Research: Read Less [-]

IND ENG 299 Individual Study or Research 1 - 12 Units

Terms offered: Fall 2019, Fall 2016, Spring 2016

Individual investigation of advanced industrial engineering problems.

Individual Study or Research: Read More [+]

Rules & Requirements

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

Fall and/or spring: 15 weeks - 3-36 hours of independent study per week

Summer:

6 weeks - 7.5-40 hours of independent study per week

8 weeks - 6-40 hours of independent study per week

10 weeks - 4.5-40 hours of independent study per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate

Grading: Offered for satisfactory/unsatisfactory grade only.

Individual Study or Research: Read Less [-]

IND ENG 375 GSI Proseminar on Teaching Engineering 2 Units

Terms offered: Fall 2022, Fall 2021, Fall 2020

This course provides basic training for graduate student instructors (GSIs). Discussion, practice, and review of fundamentals, issues, and best practices in teaching for any engineering course. Topics include: preparing a syllabus; public speaking and coping with language barriers; creating effective slides and exams; differing student learning styles; grading; encouraging diversity, equity, and inclusion; ethics; dealing with conflict and misconduct; and other topics relevant to serving as an effective teaching assistant.

GSI Proseminar on Teaching Engineering: Read More [\[+\]](#)

Objectives & Outcomes

Course Objectives: 2. Organize concepts and objectives covered in an engineering course.

3. Design activities and discussions to promote learning and provide practice in course concepts and objectives.

4. Integrate verbal and visual methods of conveying engineering concepts and practices in the classroom and in discussions.

5. Practice fair and helpful evaluation of student work.

After completion of the course, GSIs will be able to perform the following course-related tasks:

1. Understand the University policies and procedures on academic integrity and ethics.

Rules & Requirements

Prerequisites: Graduate Standing or ASE (Academic Student Employee) Status

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of seminar per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Professional course for teachers or prospective teachers

Grading: Offered for satisfactory/unsatisfactory grade only.

Instructor: Goldberg

GSI Proseminar on Teaching Engineering: Read Less [\[-\]](#)

IND ENG 601 Individual Study for Master's Students 1 - 12 Units

Terms offered: Fall 2010, Fall 2008, Spring 2008

Individual study for the comprehensive in consultation with the field adviser. Units may not be used to meet either unit or residence requirements for a master's degree.

Individual Study for Master's Students: Read More [\[+\]](#)

Rules & Requirements

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Summer: 8 weeks - 6-68 hours of independent study per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate examination preparation

Grading: Offered for satisfactory/unsatisfactory grade only.

Individual Study for Master's Students: Read Less [\[-\]](#)

IND ENG 602 Individual Study for Doctoral Students 1 - 12 Units

Terms offered: Fall 2010, Spring 2008, Fall 2007

Individual study in consultation with the major field adviser, intended to provide an opportunity for qualified students to prepare themselves for the various examinations required of candidates for the Ph.D. (and other doctoral degrees). May not be used for unit or residence requirements for the doctoral degree.

Individual Study for Doctoral Students: Read More [\[+\]](#)

Rules & Requirements

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Summer: 8 weeks - 6-68 hours of independent study per week

Additional Details

Subject/Course Level: Industrial Engin and Oper Research/Graduate examination preparation

Grading: Offered for satisfactory/unsatisfactory grade only.

Individual Study for Doctoral Students: Read Less [\[-\]](#)