

# Industrial Engineering and Operations Research

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The Department of Industrial Engineering and Operations Research (IEOR) offers four graduate programs: a Master of Engineering (MEng), a Master of Science (MS), a Master of Analytics (MAnalytics), 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 and is currently a lock-step, two-semester 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.

## Master of Analytics (MAnalytics)

The 11-month in-person Master of Analytics program trains students in data-driven analytical methods and tools for optimization, statistics, simulation, and risk management with relevant industry context so that the graduates are not only highly skilled in the latest tools and fluent with working with large data sets, but also are able to raise the right questions to develop innovative models and find creative solutions to rapidly changing business and industry challenges, and communicate and implement their solutions.

## 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 but are not limited to 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

### Applying for Graduate Admission

Thank you for considering UC Berkeley for graduate study! UC Berkeley offers more than 120 graduate programs representing the breadth and depth of interdisciplinary scholarship. A complete list of graduate academic departments, degrees offered, and application deadlines can be found on the Graduate Division website (<http://grad.berkeley.edu/programs/list/>).

Prospective students must submit an online application to be considered for admission, in addition to any supplemental materials specific to the program for which they are applying. The online application can be found on the Graduate Division website (<http://grad.berkeley.edu/admissions/>).

### Admission Requirements

The minimum graduate admission requirements are:

1. A bachelor's degree or recognized equivalent from an accredited institution;
2. A satisfactory scholastic average, usually a minimum grade-point average (GPA) of 3.0 (B) on a 4.0 scale; and
3. Enough undergraduate training to do graduate work in your chosen field.

For a list of requirements to complete your graduate application, please see the Graduate Division's Admissions Requirements page (<https://grad.berkeley.edu/admissions/steps-to-apply/requirements/>). It is also important to check with the program or department of interest, as they may have additional requirements specific to their program of study and degree. Department contact information can be found here (<http://guide.berkeley.edu/graduate/degree-programs/>).

### 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 one and a half 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 4-5 years or 8-11 semesters.

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## Before Advancement to Candidacy

### 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. Doctoral students who do not pass the entrance exam are subject to dismissal from the IEOR PhD program.

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 and maintained a 3.5 GPA, the College of Engineering's expectation of distinguished scholarship, will be permitted to take the exam.

Students who enter in the fall are expected to take the exam at the end of the spring semester in the same academic year.

The entrance examination will consist of two written exams, in optimization and in stochastics, taken on separate days, and three oral examinations in the areas of optimization, stochastics, and modeling. Each student will be examined by two faculty members in each of the three areas. In optimization and stochastics, each student will be examined on topics related to the two courses taken in the area (in case the student took three or more courses in optimization or stochastics, they should state a preference as to which course will be considered the second). For modeling, the students will be provided with a case study approximately two weeks prior to the exam. Each student is expected to address the case study using applied operations research techniques and present their analysis at the modeling oral exam.

### 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 the IEOR department, but to a very limited extent, courses taken in other departments 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 nine courses in the major. Both minors should be selected to strengthen the student's background in his or her research area, and minors are subject to the approval of the head graduate adviser.

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 222 Financial Engineering Systems I [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]	
Group C: Modeling and Applied Operations Research: Select a minimum of two of the following: <sup>1</sup>		6
	IND ENG 220 Economics and Dynamics of Production [3]	
	IND ENG 221 Introduction to Financial Engineering [3]	
	IND ENG 223 Financial Engineering Systems II [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 255	Frontiers in Revenue Management [3]

<sup>1</sup> In addition to the courses listed here, many occasionally-offered 290 series courses fit into this category; check with the head graduate advisor about specific courses which may be approved. Effective Fall 2022, the department requires one of the Group C courses be one of INDENG 250, 251, 253, 254, or 255.

## 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 a Faculty Senate Member 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 must meet with the Head Graduate Advisor and provide the following: a list of topics which will form the basis of the exam (also known as a "syllabus"), a Program of Study that includes all major and minor courses taken or planned (whether or not they are included in the syllabus), a list of faculty members who have agreed to serve on the exam committee, a preliminary draft of the Qualifying Exam Report for the exam committee (also known as a "prospectus" or "technical report"), and approval from the student's advisor of the intended date and topics. The syllabus should include topics from major subject areas, equivalent to several courses, together with topics from one of the minor areas. The Program of Study must be approved by the Head Graduate Advisor before submitting the "Application for Qualifying Examination" via CalCentral to the Graduate Division.

Next the student needs to begin arranging the Qualifying Examination logistics with their Qualifying Exam Committee by determining a date and time when all committee members can attend. The student must also request a room in which the exam can be held. This exam is to be scheduled for three hours, at a time when all Committee members can attend.

At least four weeks prior to the exam and upon approval from the Head Graduate Advisor, the student must submit the "Application for Qualifying Examination" to the Graduate Division. To do so, the student must log in to CalCentral > Student Resources > Higher Degree Committees Form > select Qualifying Exam from the dropdown and enter all information. Students must remember to upload the syllabus and Qualifying Exam Report.

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.

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.

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.

Effective Fall 2022, students who do not pass the Qualifying Examination by their third semester after passing the Doctoral Entrance Examination are subject to progress probation through the Graduate Division and are responsible for payment of their own non-resident tuition.

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## 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. Students work as teaching assistants (Graduate Student Instructors, or GSIs), responsible for discussion or laboratory sections, and serve as readers assisting with grading but not conducting independent teaching.

### Workshops

At least once a year after passing the qualifying examination, the student is required to hold a dissertation workshop. 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." All Workshops, including the Final Workshop, will be open to, and announced to, the IEOR faculty and PhD and MS students.

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.

### Final Workshop

Once the candidate has completed his or her research and completely written the thesis, a final 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 final 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 12-unit 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.

All students must take at least one course from each of the following three categories (optimization, stochastics, modeling), as listed below.

### Optimization courses

IND ENG 160	Nonlinear and Discrete Optimization	3
IND ENG 162	Linear Programming and Network Flows	3
IND ENG 169	Integer Optimization	3
IND ENG 262A	Mathematical Programming I	4
	or IND ENG C227A Introduction to Convex Optimization	
	or EECS 227A Optimization Models in Engineering	
IND ENG 262B	Mathematical Programming II	3
	or IND ENG C2Convex Optimization and Approximation	
IND ENG 264	Computational Optimization	3
IND ENG 266	Network Flows and Graphs	3
IND ENG 268	Applied Dynamic Programming	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	3
IND ENG 174	Simulation for Enterprise-Scale Systems	3
IND ENG 222	Financial Engineering Systems I	3
IND ENG 231	Introduction to Data Modeling, Statistics, and System Simulation	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 267	Queueing Theory	3

### Modeling courses

IND ENG 145	Fundamentals of Revenue Management	3
IND ENG 150	Production Systems Analysis	3

IND ENG 153	Logistics Network Design and Supply Chain Management	3
IND ENG 156	Healthcare Analytics	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 223	Financial Engineering Systems II	3
IND ENG 230	Economics of Supply Chains	3
IND ENG 250	Introduction to Production Planning and Logistics Models	3
IND ENG 251	Facilities Design and Logistics	3
IND ENG 252	Service Operations Management	3
IND ENG 253	Supply Chain Operation and Management	3
IND ENG 254	Production and Inventory Systems	3
IND ENG 255	Frontiers in Revenue Management	3
IND ENG 256	Healthcare Analytics	3
IND ENG 290	Special Topics in Industrial Engineering and Operation Research (With approval of advisor)	2-3

- FinTech students must select **two** of the following: IND ENG 221, IND ENG 222, IND ENG 223, and IND ENG 224. Additionally, FinTech students must take IND ENG 290: Applications of Machine Learning to Electronic Markets.
- IP & Entrepreneurship Strategy students must take IND ENG 242A, one additional INDENG 200+ course from an approved list, and two business courses, ENGIN 273 and ENGIN 274.

#### Leadership Courses (must be taken for a letter grade):

- All students must complete 8 semester units of core leadership courses from an approved list.

#### Capstone Project Courses (must be taken for a letter grade):

- 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.

### Required Technical Courses

IND ENG 240	Optimization Analytics	3
IND ENG 241	Risk Modeling, Simulation, and Data Analysis	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 (Fall & Spring)	1
ENGIN 270K	Coaching for High Performance Teams	1

### Required Capstone Courses

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

### Comprehensive Technical Exam

Passing the departmental Comprehensive Technical Examination is a required milestone for all IEOR MEng students. The three-hour written exam is administered every year during RRR week of the Fall semester (the last instruction week of the semester). The exam is composed of two parts as follows:

**Optimization (90 minutes):** Based on INDENG 240 material, the exam questions focus on formulation (modeling) of optimization problems, covering linear, integer, and nonlinear programming problems.

**Stochastic Modeling (90 minutes):** Based on INDENG 241 material, the exam questions focus on basics of probability theory and stochastic processes, including random variables, conditional expectation, variance and covariance, and Poisson processes.

### Comprehensive Leadership Exam

The Fung Institute will administer the MEng Comprehensive Leadership Exam, which will be held early in the spring semester. The format will be an individual, oral exam related to the student's capstone leadership experience (e.g., teaming, stakeholder management, conflict resolution, and project scoping). The exam details and pass/fail assessment criteria

## 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. 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 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 PhD even 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.
- **Technical Electives:** Students must complete a minimum of 6 units of IND ENG 200-level technical electives from an approved list for letter grades.

will be shared on bCourses. Please contact Fung Institute staff for more details.

## Capstone Project

Students are required to complete a capstone project. The project enables the student to integrate the core leadership curriculum with the concentration and gain hands-on industry experience.

## Unit Requirements

Minimum number of units to complete degree: 29-semester units.

## Curriculum

### Python Boot camp

All students are encouraged to take a Python boot camp (50 hrs) in preparation for the technical coursework. The Python boot camp is a 0-unit course offered in July or August leading up to the program's start.

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

#### Core Analytical Methods Courses

IND ENG 215	Analysis and Design of Databases	3
IND ENG 240	Optimization Analytics	3
IND ENG 241	Risk Modeling, Simulation, and Data Analysis	3
IND ENG 242A	Machine Learning and Data Analytics	4
IND ENG 243	Analytics Lab	4

### Elective Specialty Courses (MUST BE TAKEN FOR A LETTER GRADE)

Students must complete a minimum of 9 units of IND ENG 200-level technical electives for letter grades from an approved list.

### SUMMER INTERNSHIP

All students must complete four units of the summer internship (individual study) course (200 hours, typically 20 hr/week over 10 weeks in May-August) during the final summer semester.

IND ENG 299	Individual Study or Research	1-12
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## Comprehensive Exam

Passing the departmental Comprehensive Examination is a required milestone for all IEOR MAnalytics students. The three-hour written exam is administered annually during the RRR week of the Fall semester (the last instruction week of the semester). The exam is composed of two parts as follows:

**Optimization (90 minutes):** Based on INDENG 240 material, the exam questions focus on the formulation (modeling) of optimization problems covering linear, integer, and nonlinear programming problems.

**Stochastic Modeling (90 minutes):** Based on INDENG 241 material, the exam questions focus on the basics of probability theory and stochastic processes, including random variables, conditional expectation, variance and covariance, and Poisson processes.

## Industrial Engineering and Operations Research

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

## IND ENG 210 Python for Analytics 3 Units

Terms offered: Prior to 2007

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 2024, Spring 2024, Fall 2023

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 2024, Spring 2024, Fall 2023

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: Spring 2024, Spring 2023, Fall 2022

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: Spring 2024, Spring 2023, Fall 2022

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: Spring 2024, Spring 2023

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 2023, Spring 2017, Spring 2015

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 2023, 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 2024, Fall 2023, Fall 2022

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 2024, Fall 2023, Fall 2022

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 242A Machine Learning and Data Analytics 4 Units

Terms offered: Fall 2024, Spring 2024

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.

Machine Learning and Data Analytics: [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:** Students will receive no credit for IND ENG 242A after completing 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:** Grigas

**Formerly known as:** Industrial Engin and Oper Research 242

Machine Learning and Data Analytics: [Read Less](#) [-]

## IND ENG 242B Machine Learning and Data Analytics II 4 Units

Terms offered: Spring 2024

Following IEOR 142A/242A, this course further introduces students to essential

methodologies and recent trends in machine learning and data analytics. The

course will bridge theoretical foundations with applied data analytics by using

examples and real datasets from domains such as e-commerce, social media, finance,

and more. Students will gain experience with various data analytics packages in

Python and will deliver a comprehensive team project. Topics include: deep

learning, time series and survival analysis, end-to-end learning, causal inference,

reinforcement learning, and ethics, fairness and safety in artificial intelligence.

Machine Learning and Data Analytics II: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** IndEng 142A or IndEng 242A or equivalent introductory machine learning class. Familiarity with the Python programming language

**Credit Restrictions:** Students will receive no credit for IND ENG 242B after completing IND ENG 142B.

### 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.

Machine Learning and Data Analytics II: [Read Less](#) [-]

## IND ENG 243 Analytics Lab 4 Units

Terms offered: Spring 2024, Spring 2023, 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 245 Fundamentals of Revenue Management 3 Units

Terms offered: Fall 2024, Fall 2023

This course will introduce students to the science of engineering demand given a fixed supply of various goods and services when the customer base is heterogeneous and uncertain (a.k.a. Revenue Management). This requires an understanding of customer choice behaviour, different pricing and allocation strategies, and mechanisms for customer and seller interaction. The course will focus on introducing students to (i) Models that capture the key dynamics of these problems and (ii) Algorithmic ideas that turn these models into actionable decisions. The broad usefulness of concepts covered will be demonstrated through several applications such as in airline reservation systems, retail, advertising, e-commerce as well as non-profit applications. Fundamentals of Revenue Management: Read More [+]

### Rules & Requirements

**Prerequisites:** INDENG 240 and INDENG 241 or equivalent

**Credit Restrictions:** Students will receive no credit for IND ENG 245 after completing IND ENG 145.

### 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

Fundamentals of Revenue Management: 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 2024, Fall 2023, Fall 2022

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 2024, Spring 2023, Spring 2022, Spring 2021

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 2024, Spring 2023, 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:** Udmani

Frontiers in Revenue Management: Read Less [-]

## IND ENG 256 Healthcare Analytics 3 Units

Terms offered: Spring 2024

With the growing complexity of providing healthcare, it is increasingly important to design and manage health systems using engineering and analytics perspectives. This course will cover topics related to healthcare analytics, including: optimizing chronic disease management, designing matching markets for health systems, developing predictive analytics models, and managing resource utilization.

Healthcare Analytics: Read More [+]

### Rules & Requirements

**Prerequisites:** Courses in mathematical modeling (such as IND ENG 160 and IND ENG 172) and computer programming (such as CS C8 or CS 61A) are recommended

**Credit Restrictions:** Students will receive no credit for IND ENG 256 after completing IND ENG 156.

### 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

Healthcare Analytics: 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 2024, Fall 2023, Fall 2022

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 2024, Spring 2023, Spring 2022

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 2024, Fall 2023, Fall 2022

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 2024, Spring 2023, Spring 2022

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, Fall 2021, Spring 2021

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 2024, Spring 2024, Fall 2022

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 2024, Fall 2021, Spring 2018

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 [+]

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 Engin and Oper Research/Graduate

**Grading:** Letter grade.

Automation Science and Engineering: Read Less [-]

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

Terms offered: Spring 2024, Fall 2023, Spring 2023

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

Special Topics in Industrial Engineering and Operation 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 Engin and Oper Research/Graduate

**Grading:** Letter grade.

Special Topics in Industrial Engineering and Operation 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 Engin and Oper 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 Engin and Oper 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 2024, Spring 2024, Fall 2023

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 2024, Summer 2024 Second 6 Week Session, Fall 2023

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 2024, Fall 2023, Fall 2022

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](#) [-]