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Industrial Engineering and Operations Research

Bachelor of Science (BS)

The Bachelor of Science (BS) degree in Industrial Engineering and Operations Research (IEOR) is designed to prepare students for technical careers in production or service industries. It provides a strong foundation for those headed for engineering management positions or for those intending to go on to specialized graduate study in operations research, industrial engineering, or business administration.

Students interested in Industrial Engineering and Operations Research may also be interested in the Operations Research and Management Science major in the College of Letters and Science. For further information on this program, please see the Operations Research and Management Science page (http://guide.berkeley.edu/archive/2014-15/ undergraduate/degree-programs/operations-research-managementscience) in this Bulletin.

Course of Study Overview

The core of the program includes: basic science mathematics, including probability and statistics engineering optimization and stochastic models. This forms the methodological foundation for upper division IEOR electives involving the analysis and design of production and service systems, information systems, and human work systems and organization, among others.

Accreditation

This program is accredited by the Engineering Accreditation Commission of ABET (http://www.abet.org) .

Admission to the Major

Prospective undergraduates to the College of Engineering will apply for admission to a specific program in the College. For further information, please see the College of Engineering's website (http://coe.berkeley.edu/students/prospective-students/admissions.html).

Admission to Engineering via a Change of College application for current UC Berkeley students is highly unlikely and very competitive as there few, if any, spaces that open in the College each year to students admitted to other colleges at UC Berkeley. For further information regarding a Change of College to Engineering, please see the College's website (http://coe.berkeley.edu/students/current-undergraduates/change-of-college).

Minor Program

The Department offers a minor in IEOR. In order to be eligible for the minor, students must have a minimum overall grade point average (GPA) of 3.0 and a minimum 3.0 grade point average (GPA) in the minor's prerequisite courses in order to be considered for departmental acceptance.

For the minor to be added to the transcript, students must file the Confirmation of Completion of Minor form with the Office of Undergraduate Advising in 4145 Etcheverry Hall during the last semester in which they complete their last class for the minor.

In addition to the University, campus, and college requirements, listed on the College Requirements tab, students must fulfill the below requirements specific to their major program.

General Guidelines

- 1. All technical courses (courses in engineering, mathematics, chemistry, physics, statistics, biological sciences, and computer science) must be taken for a letter grade.
- No more than one upper-division course may be used to simultaneously fulfill requirements for a student's major and minor programs.
- 3. A minimum overall grade point average (GPA) of 2.0 is required for all work undertaken at UC Berkeley.
- 4. A minimum GPA of 2.0 is required for all technical courses taken in satisfaction of major requirements.

For information regarding residence requirements and unit requirements, please see the College Requirements tab.

For a detailed plan of study by year and semester, please see the Plan of Study tab.

Lower-division Requirements

M	ATH 1A	Calculus	4
M	ATH 1B	Calculus	4
M	ATH 53	Multivariable Calculus	4
M	ATH 54	Linear Algebra and Differential Equations	4
CI	HEM 1A	General Chemistry	4
8	& 1AL	and General Chemistry Laboratory ¹	
or	CHEM 4A	General Chemistry and Quantitative Analysis	
Pł	HYSICS 7A	Physics for Scientists and Engineers	4
Pł	HYSICS 7B	Physics for Scientists and Engineers	4
E1	NGIN 7	Introduction to Computer Programming for Scientists and Engineers	4
Pr	ogramming: Se	lect one of the following:	
	COMPSCI 9C	C for Programmers	
	COMPSCI 9F	C++ for Programmers	
	COMPSCI 9G	JAVA for Programmers	
	COMPSCI 61A	The Structure and Interpretation of Computer Programs	
Er fol	ngineering Bread Ilowing:	dth Electives: Select at least 9 units from the	
	BIO ENG 102	Biomechanics: Analysis and Design	
	CIV ENG 11	Engineered Systems and Sustainability	
	CIV ENG C30	Introduction to Solid Mechanics	
	CIV ENG 60	Structure and Properties of Civil Engineering Materials	
	CIV ENG 70	Engineering Geology	
	CIV ENG 155	Transportation Systems Engineering	
	EL ENG 40	Introduction to Microelectronic Circuits	
	ENGIN 10	Engineering Design and Analysis	

ENGIN 15	Design Methodology
ENGIN 25	Visualization for Design
ENGIN 26	Three-Dimensional Modeling for Design
ENGIN 27	Introduction to Manufacturing and Tolerancing
ENGIN 28	Basic Engineering Design Graphics
ENGIN 45	Properties of Materials
ENGIN 115	Engineering Thermodynamics
MAT SCI 111	Properties of Electronic Materials
MEC ENG 40	Thermodynamics
MEC ENG C8	5 Introduction to Solid Mechanics
MEC ENG 132	2 Dynamic Systems and Feedback

CHEM 4A is intended for students major in chemistry or a closelyrelated field.

Upper-division Requirements

ENGIN 120	Principles of Engineering Economics	3
IND ENG 172	Probability and Risk Analysis for Engineers	3
or STAT 134	Concepts of Probability	
IND ENG 131	Discrete Event Simulation	3
IND ENG 160	Operations Research I	3
IND ENG 161	Operations Research II	3
IND ENG 162	Linear Programming	3
IND ENG 165	Engineering Statistics, Quality Control, and Forcasting	3
IND ENG 180	Senior Project	4
IEOR Electives: S	Select 6 units from the following courses:	
IND ENG 115	Industrial and Commercial Data Systems	
IND ENG 130	Methods of Manufacturing Improvement	
IND ENG 150	Production Systems Analysis	
IND ENG 151	Service Operations Design and Analysis	
IND ENG 153	Logistics Network Design and Supply Chain Management	
IND ENG 166	Decision Analysis	
IND ENG 170	Industrial Design and Human Factors	
IND ENG 171	Technology Firm Leadership	

Minor programs are areas of concentration requiring fewer courses than an undergraduate major. These programs are optional but can provide depth and breadth to a UC Berkeley education. The College of Engineering does not offer additional time to complete a minor, but it is usually possible to finish within the allotted time with careful course planning. Students are encouraged to meet with their ESS Adviser to discuss the feasibility of completing a minor program.

All the engineering departments offer minors. Students may also consider pursuing a minor in another school or college.

General Guidelines

- 1. All courses taken to fulfill the minor requirements must be taken for graded credit.
- 2. A minimum overall grade point average (GPA) of 3.0 and a minimum GPA of 3.0 in the prerequisite courses is required for acceptance into the minor program.

- 3. A minimum grade point average (GPA) of 2.0 is required for courses used to fulfill the minor requirements.
- No more than one upper-division course may be used to simultaneously fulfill requirements for a student's major and minor programs.
- 5. Completion of the minor program cannot delay a student's graduation.

Requirements

Prerequisites		
IND ENG 165	Engineering Statistics, Quality Control, and Forcasting	3
or STAT 135	Concepts of Statistics	
IND ENG 172	Probability and Risk Analysis for Engineers	3
or STAT 134	Concepts of Probability	
IND ENG 160	Operations Research I	3
or IND ENG 162	Linear Programming	
Upper-division R	equirements	
IND ENG 160	Operations Research I	3
or IND ENG 162	Linear Programming	
IND ENG 131	Discrete Event Simulation	3
or IND ENG 161	Operations Research II	
or IND ENG 166	Decision Analysis	
Select two from th	e following:	
IND ENG 115	Industrial and Commercial Data Systems	
IND ENG 130	Methods of Manufacturing Improvement	
IND ENG 150	Production Systems Analysis	
IND ENG 151	Service Operations Design and Analysis	
IND ENG 153	Logistics Network Design and Supply Chain Management	
IND ENG 170	Industrial Design and Human Factors	
IND ENG 171	Technology Firm Leadership	

Students in the College of Engineering must complete 120 semester units with the following provisions:

1. Completion of the requirements of one Engineering major program (http://coe.berkeley.edu/students/guide/departments) of study.

2. A minimum overall grade point average of 2.000 (C average) and a minimum 2.000 grade point average in upper division technical course work required of the major.

3. The final 30 units must be completed in residence in the College of Engineering on the Berkeley campus in two consecutive semesters.

4. All technical courses (math, science & engineering), required of the major or not, must be taken on a letter graded basis (unless they are only offered P/NP).

5. Entering freshman are allowed a maximum of eight semesters to complete their degree requirements. Entering junior transfers are allowed a maximum of four semesters to complete their degree requirements. Summer terms are optional and do not count toward the maximum.

Freehman

Students are responsible for planning and satisfactorily completing all graduation requirements within the maximum allowable semesters.

Humanities and Social Science Requirement

To promote a rich and varied educational experience outside of the technical requirements for each major, the College of Engineering has a Humanities and Social Sciences breadth requirement, which must be completed to graduate. This requirement is built into all the Engineering programs of study. The requirement includes two approved reading and composition courses and four additional approved courses, within which a number of specific conditions must be satisfied.

1. Complete a minimum of six courses (3 units or more) from the approved Humanities/Social Sciences (H/SS) lists (http:// coe.berkeley.edu/hssreq) .

2. Two of the six courses must fulfill the Reading and Composition Requirement. These courses must be taken for a letter grade (C- or better required), and MUST be completed by no later than the end of the sophomore year (4th semester of enrollment). The first half of R&C, the "A" course, must be completed by the end of the freshman year; the second half of R&C, the "B "course, by no later than the end of the sophomore year. For detailed lists of courses that fulfill Reading and Composition requirements, please see the Reading and Composition page (http://guide.berkeley.edu/archive/2014-15/undergraduate/collegesschools/engineering/reading-composition-requirement) in this bulletin.

3. The four additional courses must be chosen from the H/SS comprehensive list. These courses may be taken on a Pass/Not Passed Basis (P/NP).

4. At least two of the six courses must be upper division (courses numbered 100-196).

5. At least two courses must be from the same department and at least one of the two must be upper division. This is called the *Series requirement. AP tests can be combined with a course to complete the series requirement. For example, AP History (any) combined with an upper division History course would satisfy the series requirement

6. One of the six courses must satisfy the campus American Cultures Requirement. For detailed lists of courses that fulfill American Cultures requirements, please see the American Cultures page (http:// guide.berkeley.edu/archive/2014-15/undergraduate/colleges-schools/ engineering/american-cultures-requirement) in this bulletin.

7. A maximum of two exams (Advanced Placement, International Baccalaureate, or A-Level) may be used toward completion of the H/SS requirement. Visit this link (http://coe.berkeley.edu/exams)

8. No courses offered by an Engineering department (IEOR, CE, etc.) other than BIOE 100, CS C79, ENGIN 125, ENGIN 130AC, 157AC, ME 191K and ME 191AC may be used to complete H/SS requirements.

9. Courses may fulfill multiple categories. For example, if you complete City and Regional Planning 115 and 118AC that would satisfy the series requirement, the two upper division courses requirement and the American Cultures Requirement.

10. The College of Engineering (COE) uses modified versions of five of the College of Letters and Science (L&S) breadth requirements lists to provide options to our students for completing the Humanities and Social Science requirement. Our requirement is different than that of L & S, so

the guidelines posted on the top of each L & S breadth list do NOT apply to COE students.

11. Foreign language courses MAY be used to complete H/SS requirements. L & S does not allow students to use many language courses, so their lists will not include all options open to Engineering students. For a list of language options, visit http://coe.berkeley.edu/FL

*NOTE: for the Series Requirement: The purpose of the series requirement is to provide depth of knowledge in a certain area. Therefore, a two-course sequence not in the same department may be approved by petition, in cases in which there is a clear and logical connection between the courses involved.

For more detailed information regarding the courses listed below (e.g., elective information, GPA requirements, etc.), please see the Major Requirements tab.

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	Fall	Units	Spring	Units
Chemistry: CHEM 1A & CHEM 1AL, or CHEM 4		4	MATH 1B	4
MATH 1A		4	ENGIN 7	4
Reading and Composition course from List A		4	Reading & Composition course from List B	4
Optional Freshman Seminar or ENGIN 92		0-1	PHYSICS 7A	4
Engineering Breadth course		3		
		15-16		16
				Sophomore
	Fall	Units	Spring	Units
MATH 53		4	ENGIN 120	3
PHYSICS 7B		4	MATH 54	4
Engineering Breadth course		3	Programming course	2
Humanities/Social Sciences course		3-4	Engineering Breadth course	3
			Humanities/ Social Sciences course	3-4
		14-15		15-16
				Junior
	Fall	Units	Spring	Units
IND ENG 160		3	IND ENG 161	3
IEOR Elective		3	IND ENG 165	3
Humanities/Social Sciences course		3-4	IEOR Electives	6
IND ENG 162		3	Humanities/ Social Sciences course	3-4
IND ENG 172 or STAT 134		3		
		15-16		15-16
				Senior
	Fall	Units	Spring	Units
IEOR Electives		6	IND ENG 131	3
Free Electives		9	IND ENG 180	4
			IEOR Elective	3

Free Elective	3
15	13

Total Units: 118-123

Learning Goals for the Major

The IEOR Department has five general objectives for its Bachelor of Science (BS) degree program. It aims for BS degree graduates to become highly skilled in:

- Quantitative modeling and analysis of a broad array of systemslevel decision problems concerned with economic efficiency, productivity and quality
- 2. Development and creative use of analytical and computational methods for solving these problems
- 3. Collection of and analysis of data, and the use of database and decision-support tools
- 4. Comprehension and analysis of uncertainty
- 5. In addition, the Department expect their graduates to obtain the broader skills, background, and knowledge necessary to be an effective professional in a rapidly changing global economy.

All Berkeley engineering graduates acquire the following skills and knowledge:

- 1. Ability to apply knowledge of mathematics, science and engineering
- 2. Ability to design and conduct experiments, analyze and interpret data
- 3. Ability to design a system, component or process to meet desired needs
- 4. Ability to function on multi-disciplinary teams
- 5. Ability to identify, formulate and solve engineering problems
- 6. Understanding of professional and ethical responsibility
- 7. Ability to communicate effectively
- 8. Understand impact of engineering solutions in a global and societal context
- 9. Recognition of need for and ability to engage in life-long learning
- 10.Knowledge of contemporary issues
- 11 Ability to use techniques, skills and modern engineering tools for engineering practice

More specific outcomes of the IEOR BS degree program are as follows:

- 1. Identify, analyze and evaluate alternative or candidate solutions for decision problems
- 2. Identify appropriate models and methods for solving decision problems
- 3. Formulate mathematical optimization models for real-life decision problems
- 4. Understand methods for solving deterministic optimization problems and utilize optimization software for solving such problems
- 5. Formulate analytical models and develop computer simulations to predict and optimize systems under uncertainty
- 6. Develop models and utilize analytical tools and software to evaluate decisions under uncertainty
- 7. Understand performance measurement
- 8. Understand important concepts in manufacturing and service operations

- 9. Design and apply analytical models for manufacturing and service operations
- 10.Critique and reorganize business and industrial process flows and information flows
- 11.Structure data to support decisions related to the aforementioned topics
- 12.Understand organizational design and management issues

Advising Values

Student Success: Above all, the Department is dedicated to maximizing student potential and to helping students succeed in their University experiences. The Department encourages students to explore their minds and their hearts, challenges them to do their best work, and helps them realize their talents and passions and achieve their goals.

Equity & Inclusion: The Department is committed to creating an inclusive environment in which any individual or group can be and feel welcomed, respected, supported and valued. It aspires to provide fair treatment, access, opportunity, and advancement for all students and to identify and eliminate barriers that prevent the full participation of all.

Health & Well-Being: The Department collaborates with campus partners to keep the IEOR community healthy by helping students balance the physical, intellectual, emotional, social, occupational, spiritual and environmental aspects of life.

Advising Excellence: In all that it does, the Department strives to deliver personalized advising services of the highest quality. It seeks to continuously educate itself on developments in the field and to evaluate, improve, and streamline its services to support students in obtaining the best education and experience possible.

Advising Staff and Advising Hours

Academic Advising College of Engineering Undergraduate Adviser Jane Paris jparis@berkeley.edu

Department Student Services Anayancy Paz anayancy@berkeley.edu 4145 Etcheverry Hall 510-642-5485

Fall, Spring, and Summer: Monday-Wednesday & Friday: 9:00am - 12:00pm and 1:00pm - 4:00pm; and Thursdays: 1:00pm - 4:00pm.

Student Groups and Organizations

The Industrial Engineering and Operations Research (IEOR) Department is very proud that its students not only excel in academics but also in social organization. The Department hosts three professional student organizations that engage in activities such as advising, recruiting and graduate schools information, alumni relations, academic conference organization, and social events. For information regarding student groups, please see the following websites:

IEOR Alumni (http://ieor.berkeley.edu/Alumni)

Alpha Pi Mu (http://apm.ieor.berkeley.edu) (Industrial Engineering Honor Society)

IIE Student Chapter (http://iie.berkeley.edu) (Institute of Industrial Engineers)

INFORMS Student Chapter (http://www.ieor.berkeley.edu/~informs) (Institute for Operations Research and Management Science)

Study Abroad

The College of Engineering encourages all undergraduates in the College to study abroad. Whether students are interested in fulfilling general education requirements, taking courses related to their major/career, or simply living and studying in a country that is of interest to them, the Department will work with students to make it happen. For information about Study Abroad programs, please see the Berkeley Study Abroad website (http://studyabroad.berkeley.edu).

Career Services

The Career Center offers personalized career counseling and a wide variety of professional development workshops on topics such as networking as a job search strategy, getting results from the internet job search, internship search and success strategies, and applying for graduate school. For further information, please see the Career Services website (https://career.berkeley.edu).

Industrial Engineering and Operations Research

IND ENG 24 Freshman Seminars 1 Unit

The Berkeley Seminar Program has been designed to provide new students with the opportunity to explore an intellectual topic with a faculty member in a small-seminar setting. Berkeley Seminars are offered in all campus departments, and topics vary from department to department and semester to semester.

Rules & Requirements

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

Hours & Format

Fall and/or spring: 15 weeks - 1 hour of seminar per week

Additional Details

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

Grading/Final exam status: The grading option will be decided by the instructor when the class is offered. Final exam required.

IND ENG 98 Supervised Group Study and Research 1 - 3 Units Supervised group study and research by lower division students. **Rules & Requirements**

Prerequisites: Consent of instructor

Credit Restrictions: Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.

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

Hours & Format

Fall and/or spring: 15 weeks - 1-3 hours of directed group study per week

Additional Details

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

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

IND ENG 99 Supervised Independent Study and Research 1 - 4 Units Supervised independent study for lower division students. Rules & Requirements

Prerequisites: Freshman or sophomore standing and consent of instructor

Credit Restrictions: Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.

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

Hours & Format

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

Summer:

8 weeks - 1.5-7.5 hours of independent study per week 10 weeks - 1.5-6 hours of independent study per week

Additional Details

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

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

IND ENG 115 Industrial and Commercial Data Systems 3 Units Design and implementation of databases, with an emphasis on industrial and commercial applications. Relational algebra, SQL, normalization. Students work in teams with local companies on a database design project. WWW design and queries.

Rules & Requirements

Prerequisites: Upper division standing

Hours & Format

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

Additional Details

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

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Goldberg

IND ENG 130 Methods of Manufacturing Improvement 3 Units Analytical techniques for the improvement of manufacturing performance along the dimensions of productivity, quality, customer service, and throughput. Techniques for yield analysis, process control, inspection sampling, equipment efficiency analysis, cycle time reduction, and ontime delivery improvement. Applications on semiconductor manufacturing or other industrial settings.

Rules & Requirements

Prerequisites: 172, Mathematics 54, or Statistics 134 (may be 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/ Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Leachman

IND ENG 131 Discrete Event Simulation 3 Units

Introductory course on design, programming, and statistical analysis of a simulation study. Topics include the types of problems that can be solved by such methods. Programming material includes the theory behind random variable generation for a variety of common variables. Techniques to reduce the variance of the resultant estimator and statistical analysis are considered. Final project required. **Rules & Requirements**

Prerequisites: 161, 165; 172 or Statistics 134

Hours & Format

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

Summer:

6 weeks - 5 hours of lecture and 1.5 hours of discussion per week 8 weeks - 4.5 hours of lecture and 1.5 hours of discussion per week 10 weeks - 3 hours of lecture and 1.5 hours of discussion per week

Additional Details

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

Grading/Final exam status: Letter grade. Final exam not required.

Instructor: Schruben

IND ENG 150 Production Systems Analysis 3 Units Quantitative models for operational and tactical decision making in production systems, including production planning, inventory control, forecasting, and scheduling. **Rules & Requirements**

Prerequisites: 160, 161, 162, 165, and Engineering 120, or senior standing in manufacturing engineering

Hours & Format

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

Additional Details

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

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Yano

IND ENG 151 Service Operations Design and Analysis 3 Units This course is concerned with improving processes and designing facilities for service businesses such as banks, health care organizations, telephone call centers, restaurants, and transportation providers. Major topics in the course include design of service processes, layout and location of service facilities, demand forecasting, demand management, employee scheduling, service quality management, and capacity planning.

Rules & Requirements

Prerequisites: 161, 162, and a course in statistics

Hours & Format

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

Additional Details

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

Grading/Final exam status: Letter grade. Final exam required.

IND ENG 153 Logistics Network Design and Supply Chain Management 3 Units

We will focus primarily on both quantitative and qualitative issues which arise in the integrated design and management of the entire logistics network. Models and solution techniques for facility location and logistics network design will be considered. In addition, qualitative issues in distribution network structuring, centralized versus decentralized network control, variability in the supply chain, strategic partnerships, and product design for logistics will be considered through discussions and cases. **Rules & Requirements**

Prerequisites: 160, 162 or senior standing

Hours & Format

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

Additional Details

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

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Kaminsky

IND ENG 160 Operations Research I 3 Units

Deterministic methods and models in operations research. Unconstrained and constrained optimization. Equality, inequality, and integer constraints. Sequential decisions; dynamic programming. Resource allocation, equipment replacement, inventory control, production planning. **Rules & Requirements**

Prerequisites: Mathematics 53 and 54

Hours & Format

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

Additional Details

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

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Atamturk

IND ENG 161 Operations Research II 3 Units Probability review. Conditional expectation. The exponential distribution and Poisson process. Discrete and continuous-time Markov chains. Applications reliability, transportation, inventory, queueing, financial, and communications models.

Rules & Requirements

Prerequisites: Industrial Engineering 172 or Statistics 134

Hours & Format

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

Additional Details

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

Grading/Final exam status: Letter grade. Final exam required.

IND ENG 162 Linear Programming 3 Units

Formulation to linear programs. Optimal allocation and control problems in industry and environmental studies. Convex sets; properties of optimal solutions. The simplex method; theorems of duality; complementary slackness. Problems of post-optimization. Special structures; network problems. Digital computation. **Rules & Requirements**

Prerequisites: Mathematics 53 and 54

Hours & Format

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

Additional Details

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

Grading/Final exam status: Letter grade. Final exam required.

IND ENG S162 Linear Programming 3 Units

Formulation to linear programs. Optimal allocation and control problems in industry, environmental studies. Convex sets; properties of optimal solutions. The simplex method; theorems of duality; complementary slackness. Problems of post-optimization. Special structures; network problems. Digital computation.

Rules & Requirements

Prerequisites: Mathematics 50A

Hours & Format

Summer: 8 weeks - 4 hours of lecture and 2 hours of discussion per week

Additional Details

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

Grading/Final exam status: Letter grade. Final exam not required.

IND ENG 165 Engineering Statistics, Quality Control, and Forcasting 3 Units

This course will introduce students to basic statistical techniques such as parameter estimation, hypothesis testing, regression analysis, analysis of variance. Applications in forecasting and quality control.

Rules & Requirements

Prerequisites: Industrial Engineering 172 or Statistics 134 or an equivalent course in probability theory

Credit Restrictions: Students will receive no credit for Industrial Engineering 165 after taking Statistics 135.

Hours & Format

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

Summer: 6 weeks - 7.5 hours of lecture and 1 hour of discussion per week

Additional Details

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

Grading/Final exam status: Letter grade. Final exam required.

IND ENG 166 Decision Analysis 3 Units

Introductory course on the theory and applications of decision analysis. Elective course that provides a systematic evaluation of decision-making problems under uncertainty. Emphasis on the formulation, analysis, and use of decision-making techniques in engineering, operations research and systems analysis. Includes formulation of risk problems and probabilistic risk assessments. Graphical methods and computer software using event trees, decision trees, and influence diagrams that focus on model design.

Rules & Requirements

Prerequisites: 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/ Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Oren

IND ENG 170 Industrial Design and Human Factors 3 Units This course surveys topics related to the design of products and interfaces ranging from alarm clocks, cell phones, and dashboards to logos, presentations, and web sites. Design of such systems requires familiarity with human factors and ergonomics, including the physics and perception of color, sound, and touch, as well as familiarity with case studies and contemporary practices in interface design and usability testing. Students will solve a series of design problems individually and in teams.

Rules & Requirements

Prerequisites: Upper division standing

Hours & Format

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

Additional Details

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

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Goldberg

IND ENG 171 Technology Firm Leadership 3 Units

This course explores key management and leadership concepts relevant to the high-technology world. Topics include the firm's key operations, strategic issues, and managerial leadership including personal leadership and talent management. This course prepares technical and business minded students for careers focused on professional and management track careers in high technology. Students undertake intensive study of actual business situations through rigorous case-study analysis. **Rules & Requirements**

Prerequisites: Upper division standing

Credit Restrictions: Students will receive no credit for 171 after taking Undergraduate Business Administration 105.

Repeat rules: Students cannot receive credit for both 171 and Business Administration 105. Course may be repeated for credit when topic changes.

Hours & Format

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

Summer: 8 weeks - 6 hours of lecture per week

Additional Details

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

Grading/Final exam status: Letter grade. Final exam required.

IND ENG 172 Probability and Risk Analysis for Engineers 3 Units This is an introductory probability course for students in engineering. It focuses mostly on random variables and their applications. Applications will be given in such areas as reliability theory, risk theory, inventory theory, financial models, computer science, and others. Note: This course is a statistics course and cannot be used to fulfill any engineering unit or elective requirements.

Rules & Requirements

Prerequisites: Mathematics 1A-1B or 16A-16B

Credit Restrictions: Students will receive no credit for 172 after taking Statistics 134.

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

Hours & Format

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

Summer: 6 weeks - 5 hours of lecture and 2.5 hours of discussion per week

Additional Details

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

Grading/Final exam status: Letter grade. Final exam required.

IND ENG 180 Senior Project 4 Units

Application of systems analysis and industrial engineering to the analysis, planning, and/or design of industrial, service, and government systems. Consideration of technical and economic aspects of equipment and process design. Students work in teams under faculty supervision. Topics vary yearly.

Rules & Requirements

Prerequisites: 131, 160, 161, 162, 165, Engineering 120, and three other Industrial Engineering and Operations Research electives

Hours & Format

Fall and/or spring: 15 weeks - 1 hour of lecture, 1 hour of discussion, and 6 hours of fieldwork per week

Summer: 10 weeks - 1.5 hours of lecture, 1.5 hours of discussion, and 9 hours of fieldwork per week

Additional Details

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

Grading/Final exam status: Letter grade. Final exam not required.

IND ENG 185 Challenge Lab 4 Units

This course is meant for students in engineering and other disciplines who seek a challenging, interactive, team-based, and hands-on learning experience in entrepreneurship and technology. In this highly experiential course, students work in simulated start-up teams to create products or start-up ideas to address a broadly-defined need of an industry partner or social challenge.

Objectives & Outcomes

Course Objectives: 1) To catalyze learning through experiential entrepreneurship

2) To help students understand the entrepreneurial context, and how it can create better outcomes.

3) To help students identify the best role for themselves within an entrepreneurial organization.

Student Learning Outcomes: 1) Gain experience with effectively

refining ideas and pivoting based on feedback and external factors. 2) Gain experience building effective teams to develop and execute an idea

3) Become comfortable with failure and how to learn from failure.4) Become adept at succinctly communicating ideas in terms of value proposition and business viability.

Rules & Requirements

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

Hours & Format

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

Summer:

6 weeks - 10 hours of seminar per week 8 weeks - 7.5 hours of seminar per week 10 weeks - 6 hours of seminar per week

Additional Details

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

Grading/Final exam status: Letter grade. Alternative to final exam.

Instructors: Goldberg, Sidhu, Wroblewki, IEOR / CET Instructors

IND ENG 186 Product Management 3 Units

Too often we are enamored in our brilliant ideas, we skip the most important part: building products consumers will want and use. Precious time and effort is wasted on engineering perfect products only to launch to no users. This course teaches product management skills such as attributes of great product managers, reducing risk and cost while accelerating time to market, product life cycle, stakeholder management and effective development processes.

Objectives & Outcomes

Course Objectives: • Students will experience a live development of a product within the context of a product development process.

Students will learn common methods used in product management
Students will understand the difference between engineering design and product development as a process commonly used in new venture environments.

Student Learning Outcomes: • Students will actually develop a real world functioning product, to be described as Minimum Viable.
Students will be able to manage a product development process that leads to a product that is technically feasible as well as desired by customers.

• Students will gain experience needed to work as product managers in real life environments.

Hours & Format

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

Additional Details

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

Grading/Final exam status: Letter grade. Alternative to final exam.

Instructors: Shen, Sidhu, IEOR / CET Instructors

IND ENG 190A Advanced Topics in Industrial Engineering and Operations Research 1 - 4 Units The 190 series cannot be used to fulfill any engineering requirement (engineering units, courses, technical electives, or otherwise). **Rules & Requirements**

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

Hours & Format

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

Summer:

8 weeks - 1.5-7.5 hours of seminar per week 10 weeks - 1.5-6 hours of seminar per week

Additional Details

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

Grading/Final exam status: The grading option will be decided by the instructor when the class is offered. Final exam required.

IND ENG 190B Advanced Topics in Industrial Engineering and Operations Research: Entrepreneurial Marketing and Finance 1 - 4 Units The 190 series cannot be used to fulfill any engineering requirement (engineering units, courses, technical electives, or otherwise). **Rules & Requirements**

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

Hours & Format

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

Summer:

8 weeks - 1.5-7.5 hours of seminar per week 10 weeks - 1.5-6 hours of seminar per week

Additional Details

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

Grading/Final exam status: The grading option will be decided by the instructor when the class is offered. Final exam required.

IND ENG 190C Advanced Topics in Industrial Engineering and Operations Research 1 - 4 Units The 190 series cannot be used to fulfill any engineering requirement (engineering units, courses, technical electives, or otherwise). **Rules & Requirements**

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

Hours & Format

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

Summer: 8 weeks - 1.5-7.5 hours of seminar per week 10 weeks - 1.5-6 hours of seminar per week

Additional Details

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

Grading/Final exam status: The grading option will be decided by the instructor when the class is offered. Final exam required.

IND ENG 190D Advanced Topics in Industrial Engineering and Operations Research 1 - 4 Units

The 190 series cannot be used to fulfill any engineering requirement (engineering units, courses, technical electives, or otherwise). **Rules & Requirements**

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

Hours & Format

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

Summer: 8 weeks - 1.5-7.5 hours of seminar per week 10 weeks - 1.5-6 hours of seminar per week

Additional Details

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

Grading/Final exam status: The grading option will be decided by the instructor when the class is offered. Final exam required.

IND ENG 190E Advanced Topics in Industrial Engineering and Operations Research: Entrepreneurship & amp; Innovation 1 - 4 Units The 190 series cannot be used to fulfill any engineering requirement (engineering units, courses, technical electives, or otherwise). **Rules & Requirements**

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

Hours & Format

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

Summer:

6 weeks - 2.5-10 hours of seminar per week 8 weeks - 1.5-7.5 hours of seminar per week 10 weeks - 1.5-6 hours of seminar per week

Additional Details

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

Grading/Final exam status: Letter grade. Final exam required.

IND ENG 190F Advanced Topics in Industrial Engineering and Operations Research 1 - 4 Units

The 190 series cannot be used to fulfill any engineering requirement (engineering units, courses, technical electives, or otherwise). **Rules & Requirements**

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

Hours & Format

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

Summer:

8 weeks - 1.5-7.5 hours of seminar per week 10 weeks - 1.5-6 hours of seminar per week

Additional Details

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

Grading/Final exam status: The grading option will be decided by the instructor when the class is offered. Final exam required.

IND ENG 190G Advanced Topics in Industrial Engineering and Operations Research 1 - 4 Units

The 190 series cannot be used to fulfill any engineering requirement (engineering units, courses, technical electives, or otherwise). **Rules & Requirements**

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

Hours & Format

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

Summer:

8 weeks - 1.5-7.5 hours of seminar per week 10 weeks - 1.5-6 hours of seminar per week

Additional Details

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

Grading/Final exam status: The grading option will be decided by the instructor when the class is offered. Final exam required.

IND ENG 190H Cases in Global Innovation 1 Unit

This course is designed primarily for upper-level undergraduate and graduate students interested in examining the major challenges and success factors entrepreneurs and innovators face in globalizing a company, product, or service. Over the duration of this course, students will examines case studies of early, mid-stage, and large-scale enterprises as they seek to start a new venture, introduce a new product or service, or capitalize on global economic trends to enhance their existing business. The course content exposes students interested in internationally oriented careers to the strategic thinking involved in international engagement and expansion. Cases will include both U.S. companies seeking to enter emerging markets and emerging market companies looking to expand within their own nations or into markets in developed nations. The course is focused around intensive study of actual business situations through rigorous case-study analysis. **Rules & Requirements**

Prerequisites: Junior or Senior standing

Hours & Format

Fall and/or spring: 8 weeks - 2 hours of lecture per week

Additional Details

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

Grading/Final exam status: Letter grade. Final exam not required.

IND ENG 1901 Cases in Global Innovation: China 1 Unit This course is designed primarily for upper-level undergraduate and graduate students interested in examining the major challenges and success factors entrepreneurs and innovators face in globalizing a company product or service, with a focus on China. Over the duration of this course, students will examine case studies of foreign companies seeking to start a new venture, introduce a new product or service to the China market, or domestic Chinese companies seeking to adapt a U.S. or western business model to the China market. The course content exposes students interested in internationally oriented careers to the strategic thinking involved in international engagement and expansion and the particularities of the China market and their contrast with the U.S. market. The course is focused around intensive study of actual business situations through rigorous case-study analysis and the course size is limited to 30.

Rules & Requirements

Prerequisites: Junior or senior standing. Recommended, but not required to be taken after or along with Engineering 198

Hours & Format

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

Additional Details

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

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Sidhu

IND ENG 190K Cases in Global Innovation: South Asia 1 Unit This course is designed primarily for upper-level undergraduate and graduate students interested in examining the major challenges and success factors entrepreneurs and innovators face in conducting business, globalizing a company product or service, or investing in South Asia. Over the duration of this course, students will examine case studies of foreign companies seeking to start a new venture, introduce a new product or service to the South Asian market, or South Asian companies seeking to adapt a U.S or western business model. The course will put this into the larger context of the political, economic, and social climate in several South Asian countries and explore the constraints to doing business, as well as the policy changes that have allowed for a more conducive business environment.

Rules & Requirements

Prerequisites: Junior or senior standing. Recommended but not required to be taken after or along with Engineering 198

Hours & Format

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

Additional Details

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

Grading/Final exam status: Letter grade. Final exam not required.

Instructor: Sidhu

IND ENG 191 Technology Entrepreneurship 3 Units

This course explores key entrepreneurial concepts relevant to the hightechnology world. Topics include the entrepreneurial perspective, start-up strategies, business idea evaluation, business plan writing, introduction to entrepreneurial finance and venture capital, managing growth, and delivering innovative products. This course prepares technical and business minded students for careers focused on entrepreneurship, intrapreneurship, and high technology. Students undertake intensive study of actual business situations through rigorous case-study analysis. This course can not be used to fulfill any engineering requirement (engineering units, courses, technical electives, or otherwise). **Rules & Requirements**

Prerequisites: Junior or senior standing

Credit Restrictions: Students will receive no credit for 191 after taking 190A prior to fall 2009.

Hours & Format

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

Additional Details

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

Grading/Final exam status: Letter grade. Final exam not required.

Instructor: Sidhu

IND ENG 192 Berkeley Method of Entrepreneurship Bootcamp 1 Unit This course offers the opportunity to understand the Berkeley Method of Entrepreneurship (BME) in an intensive format. The BME curriculum conveys the latest approaches for training global technology entrepreneurs. This method leverages insights on strategy, tactics, culture, and psychology with an accompanying entrepreneurial infrastructure. The curriculum is structured to provide an optimal global entrepreneurship experience from real life experiences. **Objectives & Outcomes**

Course Objectives: * To understand and make use of the value of diversity in idea generation and new venture creation. Student should become aware of the infrastructure available through UC Berkeley that an support them in developing new ventures. To understand common tactics in starting new ventures including a lean learning cycle.

To understand the mindset of an entrepreneur, including the soft skills, behaviors, and psychological factors most likely to be needed to develop a new venture.

Student Learning Outcomes: Students should be able to consider a greater number of ideas for global entrepreneurship by observing the effect of background diversity in the class.

Students should be able to follow a process of idea generation, rapid prototyping / venture story development, attraction of stakeholders, data collection, and hypothesis testing and regeneration.

Students should become aware of the mindset and behaviour required for entreprenurship and be able to reinforce some of these behavious (eg rejection tolerance, comfort with failing or being wrong, inductive learning, venture story telling/communication abilities) through excercizes in the program.

Hours & Format

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

Additional Details

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

Grading/Final exam status: Letter grade. Alternative to final exam.

Instructor: IEOR / CET Instructors

IND ENG H196A Operations Research and Management Science Honors Thesis 3 Units

Individual study and research for at least one academic year on a special problem approved by a member of the faculty; preparation of the thesis on broader aspects of this work.

Rules & Requirements

Prerequisites: Open only to students in the honors program

Credit Restrictions: Course may be repeated for credit with consent of instructor.

Repeat rules: Course may be repeated for credit with consent of instructor. Course may be repeated for credit when topic changes.

Hours & Format

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

Additional Details

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

Grading/Final exam status: Offered for pass/not pass grade only. Final exam required.

IND ENG H196B Operations Research and Management Science Honors Thesis 3 Units

Individual study and research for at least one academic year on a special problem approved by a member of the faculty; preparation of the thesis on broader aspects of this work.

Rules & Requirements

Prerequisites: Open only to students in the honors program

Repeat rules: Course may be repeated for credit with consent of instructor. Course may be repeated for credit when topic changes.

Hours & Format

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

Additional Details

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

Grading/Final exam status: Offered for pass/not pass grade only. Final exam required.

IND ENG 197 Undergraduate Field Research in Industrial Engineering 1 - 12 Units

Students work on a field project under the supervision of a faculty member. Course does not satisfy unit or residence requirements for bachelor's degree.

Rules & Requirements

Prerequisites: Completion of two semesters of coursework

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

Hours & Format

Fall and/or spring: 15 weeks - 1-12 hours of fieldwork per week

Summer:

6 weeks - 2.5-30 hours of fieldwork per week 8 weeks - 1.5-22.5 hours of fieldwork per week 10 weeks - 1.5-18 hours of fieldwork per week

Additional Details

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

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

IND ENG 198 Directed Group Studies for Advanced Undergraduates 1 - 4 Units

Group studies of selected topics. Semester course unit value and contact hours will have a one-to-one ratio. Rules & Requirements

Prerequisites: Senior standing in Engineering

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

Hours & Format

Fall and/or spring: 15 weeks - 1-4 hours of directed group study per week

Additional Details

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

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

IND ENG 199 Supervised Independent Study 1 - 4 Units Supervised independent study. Enrollment restrictions apply. **Rules & Requirements**

Prerequisites: Consent of instructor and major adviser

Credit Restrictions: Course may be repeated for a maximum of four units per semester.

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

Hours & Format

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

Summer:

6 weeks - 2.5-10 hours of independent study per week 8 weeks - 2-7.5 hours of independent study per week 10 weeks - 1.5-6 hours of independent study per week

Additional Details

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

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.