Management Science and Engineering

Courses offered by the Department of Management Science and Engineering are listed under the subject code MS&E on the Stanford Bulletin’s ExploreCourses web site.

The Department of Management Science and Engineering leads at the interface of engineering, business, and public policy. The department’s mission is, through education and research, to advance the design, management, operation, and interaction of technological, economic, and social systems. The department’s engineering research strength is integrated with its educational program at the undergraduate, master’s, and doctoral levels. Graduates of the program are trained as engineers and future leaders in technology, policy, and industry. Research and teaching activities are complemented by an outreach program that encourages the transfer of ideas to the environment of Silicon Valley and beyond.

Management Science and Engineering (MS&E) provides programs of education and research by integrating three basic strengths:
1. depth in conceptual and analytical foundations
2. comprehensive coverage of functional areas of application
3. interaction with other Stanford departments, Silicon Valley industry, and organizations throughout the world.

The analytical and conceptual foundations include decision and risk analysis, dynamic systems, economics, optimization, organizational science, and stochastic systems. The functional areas of application include entrepreneurship, finance, information, marketing, organizational behavior, policy, production, and strategy. Close associations with other engineering departments and with industry enrich the programs by providing opportunities to apply MS&E methods to important problems and by motivating new theoretical developments from practical experience. MS&E programs also provide a basis for contributing to other areas such as biotechnology, defense policy, environmental policy, information systems, and telecommunications.

Mission of the Undergraduate Program in Management Science and Engineering

The mission of the undergraduate program in Management Science and Engineering is to provide students with the fundamentals of engineering systems analysis so that they are able to plan, design, and implement complex economic and technical management systems. The program builds on the foundational courses for engineering including calculus, engineering fundamentals, and physics or chemistry as well as management science. Students complete core courses in accounting, computer science, economics, ethics, organizational theory, mathematical modeling, optimization, probability, and statistics. To personalize their exploration, students select additional courses from different areas of the department, with greater emphasis in one of them. The major prepares students for a variety of career paths, including investment banking, management consulting, facilities and process management, or for graduate school in industrial engineering, operations research, business, economics, law, medicine, or public policy.

Learning Outcomes (Undergraduate)

The department expects undergraduate majors in the program to be able to demonstrate the following learning outcomes. These learning outcomes are used in evaluating students and the department’s undergraduate program. Students are expected to be able:
1. to apply the knowledge of mathematics, science, and engineering;
2. to design and conduct experiments;
3. to design a system or components to meet desired needs;
4. to identify, formulate, and solve engineering problems;
5. to use techniques, skills, and modern engineering tools necessary for engineering practice;
6. to function on multidisciplinary teams;
7. to communicate effectively;
8. to recognize the need for and demonstrate an ability to engage in lifelong learning;
9. to obtain the background necessary for admission to top professional graduate engineering or business programs;
10. to understand professional and ethical responsibility;
11. to obtain the broad education necessary to understand the impact of engineering solutions in a global and societal context; and
12. to obtain a knowledge of contemporary issues pertinent to the field of management science and engineering.

Graduate Programs in Management Science and Engineering

MS&E offers programs leading to the degrees of Master of Science and Doctor of Philosophy. The department also offers a coterminal B.S./M.S. degree, a dual master’s degree in cooperation with each of the other departments in the School of Engineering, and joint master’s degrees with the School of Law and the Public Policy Program.

For University coterminal degree program rules and University application forms, see the Registrar's coterminal degrees web site (http://studentaffairs.stanford.edu/Registrar/Publications/#Coterm).

Applicants for admission as graduate students in MS&E must submit the results of the verbal, quantitative, and analytical parts of the Graduate Record Examination. The deadline for application to the doctoral program is December 1, 2015, and the deadline for application to the master's program is January 12, 2016.

Except in unusual circumstances, admission is limited to the Autumn Quarter because courses are arranged sequentially with basic courses and prerequisites offered early in the academic year.

Assistantships and Fellowships

A limited number of fellowships and assistantships are awarded each year. Applicants admitted to the doctoral program, who have indicated on their application that they would like to be considered for financial aid, are automatically considered for these assistantships and fellowships. New and returning master's students may apply for course assistantships each quarter, but priority is given to MS&E doctoral students.

Information about loan programs and need-based aid for U.S. citizens and permanent residents can be obtained from the Financial Aid Office.

Learning Outcomes (Graduate)

The M.S. prepares engineers for a lifelong career addressing the critical technical and managerial needs of private and public organizations. The program emphasizes developing analytic abilities, making better decisions, developing and executing strategies while also leading people who innovate. Unlike an MBA, our master’s program addresses the technical as well as the behavioral challenges of running organizations and complex
systems. We emphasize quantitative analytic skills and an entrepreneurial spirit.

The Ph.D. is conferred upon candidates who have demonstrated substantial scholarship and the ability to conduct independent research. Through course work and guided research, the program prepares students to make original contributions in Management Science and Engineering and related fields.

**Careers in MS&E**

MS&E students are candidates for careers in consulting, product and project management, financial analysis, and work in policy arenas. A significant number join or found start-ups. Many have become leaders in technology-based businesses which have an increasing need for analytically oriented people who understand both business and technology. Other graduates make careers tackling the problems faced by local, national, and international governments by developing new healthcare systems, new energy systems and a more sustainable environment. The major problems of the day demand an ability to integrate the technical, social and economic ways of thinking. This is precisely what the department educates its students to do.

**Bachelor of Science in Management Science and Engineering**

The program leading to the B.S. degree in Management Science and Engineering (MS&E) is outlined in the School of Engineering section of this bulletin; more information is contained in the School of Engineering’s *Handbook for Undergraduate Engineering Programs*. Students are encouraged to plan their academic programs as early as possible, ideally in the freshman or sophomore year. Students should not wait until they are declaring a major to consult with the department’s student services staff. This is particularly important for students who would like to study overseas or pursue another major or minor.

The undergraduate curriculum in Management Science and Engineering provides students training in the fundamentals of engineering systems analysis to prepare them to plan, design, and implement complex economic and technological management systems where a scientific or engineering background is necessary or desirable. The major prepares students for a variety of career paths, including investment banking, management consulting, facilities and process management, or for graduate school in industrial engineering, operations research, business, economics, law, medicine, or public policy.

The educational objectives of the undergraduate degree program are:

- **Principles and Skills**—provide students with a basic understanding of management science and engineering principles, including analytical problem solving and communications skills.
- **Preparation for Practice**—prepare students for practice in a field that sees rapid changes in tools, problems, and opportunities.
- **Preparation for Continued Growth**—prepare students for graduate study and self development over an entire career.
- **Preparation for Service**—develop in students the awareness, background, and skills necessary to become responsible citizens, employees, and leaders.

See also the department's undergraduate Learning Outcomes (p. ) for additional learning objectives.

The program builds on the foundational courses for engineering, including calculus, mathematical modeling, probability, statistics, engineering fundamentals, and physics or chemistry.

Students interested in a minor should see the Minor tab in this section.

MS&E also participates with the departments of Computer Science, Mathematics, and Statistics in a program leading to a B.S. in Mathematical and Computational Science. See the “Mathematical and Computational Science” section of this bulletin.

**Core**

The department core, taken for all areas, includes courses in accounting, computer science, deterministic optimization, economics, organization theory, and a capstone senior project. Through the core, students in the program are exposed to the breadth of faculty interests, and are in a good position to choose an area during the junior year.

**Areas**

The major is designed to allow a student to explore all three areas of the department in greater depth.

1. **Finance and Decision** focuses on the design and analysis of financial and strategic plans.
2. **Operations and Analytics** focuses on algorithms, theory, and the design and analysis of manufacturing, production, and service systems.
3. **Organizations, Technology, and Policy** focuses on understanding, design, and analysis of organizations and public policy, particularly technology-based issues.

**Management Science and Engineering (MS&E)**

Completion of the undergraduate program in Management Science and Engineering leads to the conferral of the Bachelor of Science in Management Science and Engineering.

**Requirements**

<table>
<thead>
<tr>
<th>Mathematics and Science</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>All required; see SoE Basic Requirements 1 and 2</td>
<td>1</td>
</tr>
<tr>
<td>CME 100 Vector Calculus for Engineers</td>
<td>5</td>
</tr>
<tr>
<td>or MATH 51 Linear Algebra and Differential Calculus of Several Variables</td>
<td></td>
</tr>
<tr>
<td>CME 103 Introduction to Matrix Methods</td>
<td>5</td>
</tr>
<tr>
<td>MSE 120 Probabilistic Analysis</td>
<td>5</td>
</tr>
<tr>
<td>MSE 121 Introduction to Stochastic Modeling</td>
<td>4</td>
</tr>
<tr>
<td>MSE 125 Introduction to Applied Statistics</td>
<td>4</td>
</tr>
<tr>
<td>Select one of the following sequences:</td>
<td></td>
</tr>
<tr>
<td>CHEM 31B &amp; CHEM 33 Chemical Principles II and Structure and Reactivity</td>
<td>8</td>
</tr>
<tr>
<td>CHEM 31X Chemical Principles Accelerated &amp; CHEM 33 and Structure and Reactivity</td>
<td></td>
</tr>
<tr>
<td>PHYSICS 21 Mechanics Fluids and Heat &amp; PHYSICS 22 and Mechanics Fluids and Heat Laboratory</td>
<td>23</td>
</tr>
<tr>
<td>&amp; PHYSICS 23 and Electricity, Magnetism, and Optics</td>
<td></td>
</tr>
<tr>
<td>PHYSICS 41 Mechanics &amp; PHYSICS 43 and Electricity and Magnetism</td>
<td>13</td>
</tr>
<tr>
<td>Electives from SoE approved list or AP/IB credit</td>
<td></td>
</tr>
</tbody>
</table>

**Technology in Society**
Select one of the following; see SoE Basic Requirement 4

COMM 120W Digital Media in Society
COMM 169 Computers and Interfaces
CS 181 Computers, Ethics, and Public Policy
ENGR 129
ENGR 130 Science, Technology, and Contemporary Society
ENGR 131 Ethical Issues in Engineering
MSE 181 Issues in Technology and Work for a Postindustrial Economy
MSE 193 Technology and National Security (WIM)
MSE 197 Ethics, Technology, and Public Policy (WIM)
STS 1 The Public Life of Science and Technology

Engineering Fundamentals

Three courses; see SoE Basic Requirement 3

Select one of the following:

CS 106A Programming Methodology

Select one of the following (or ENGR 25, ENGR 40, or ENGR 80 if not used above):

ENGR 25B Biotechnology
or ENGR 25E Energy: Chemical Transformations for Production, Storage, and Use
ENGR 40 Introductory Electronics
or ENGR 40A Introductory Electronics
or ENGR 40M An Intro to Making: What is EE
or ENGR 40P Physics of Electrical Engineering
ENGR 80 Introduction to Bioengineering (Engineering Living Matter)

Engineering Depth

Core Courses (all six required)

CS 103 Mathematical Foundations of Computing
or CS 106B Programming Abstractions
or CS 106X Programming Abstractions (Accelerated)
ECON 50 Economic Analysis I
MSE 108 Senior Project
MSE 111 Introduction to Optimization
MSE 140 Accounting for Managers and Entrepreneurs
or MSE 140X Financial Accounting Concepts and Analysis
MSE 180 Organizations: Theory and Management

Area Courses (see below)

Choose four or five courses (minimum 15 units) from a primary area and two courses (minimum 6 units) from each of the other two areas.

Depth Areas

Finance and Decision Area

Students choosing F&D as their primary area must take at least two of ECON 51, MS&E 145, and MS&E 152

Introductory (appropriate for freshmen and sophomores)
MSE 152 Introduction to Decision Analysis (WIM)
Intermediate (appropriate for juniors and seniors)
MSE 145 Introductory Financial Analysis
MSE 146 Corporate Financial Management
MSE 245G Finance for Non-MBAs
MSE 252 Decision Analysis I: Foundations of Decision Analysis
Advanced (intended primarily for graduate students)
MSE 245A Investment Science
MSE 246 Financial Risk Analytics
MSE 250A Engineering Risk Analysis
MSE 250B Project Course in Engineering Risk Analysis
MSE 245B Advanced Investment Science

Operations and Analytics Area

Students choosing O&A as their primary area may also include CS 161, CS 229, and STATS 202 in their selections

Introductory (no prerequisites)
MSE 107 Interactive Management Science Methods
MSE 112 Mathematical Programming and Combinatorial Optimization
MSE 135 Networks
MSE 223 Simulation
MSE 226 "Small" Data
MSE 231 Introduction to Computational Social Science
MSE 251 Stochastic Control Applications
MSE 130 Information Networks and Services
MSE 233 Networked Markets
MSE 235 Analytics in Action
MSE 260 Introduction to Operations Management
MSE 262 Supply Chain Management
MSE 263 Healthcare Operations Management
MSE 264 Sustainable Product Development and Manufacturing
MSE 268 Operations Strategy

Organizations, Technology, and Policy Area

Students choosing OT&P as their primary area must take at least two of ENGR 145, MS&E 175, MS&E 181, MS&E 185, PSYCH 70, and SOC 114 (but not both PSYCH 70 and SOC 114)

Introductory (no prerequisites)
ENGR 131 Ethical Issues in Engineering
MSE 178 The Spirit of Entrepreneurship
MSE 189 Social Networks - Theory, Methods, and Applications
MSE 190 Methods and Models for Policy and Strategy Analysis
MSE 193 Technology and National Security (WIM)
MSE 197 Ethics, Technology, and Public Policy (WIM)
Advanced (has prerequisites and/or appropriate for juniors and seniors)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 145</td>
<td>Technology Entrepreneurship</td>
<td></td>
</tr>
<tr>
<td>MSE 175</td>
<td>Innovation, Creativity, and Change</td>
<td></td>
</tr>
<tr>
<td>MSE 177</td>
<td>Creativity Rules</td>
<td></td>
</tr>
<tr>
<td>MSE 181</td>
<td>Issues in Technology and Work for a Postindustrial</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Economy</td>
<td>4</td>
</tr>
<tr>
<td>MSE 183</td>
<td>Leadership in Action</td>
<td></td>
</tr>
<tr>
<td>MSE 185</td>
<td>Global Work</td>
<td></td>
</tr>
<tr>
<td>MSE 243</td>
<td>Energy and Environmental Policy Analysis</td>
<td></td>
</tr>
<tr>
<td>MSE 292</td>
<td>Health Policy Modeling</td>
<td></td>
</tr>
<tr>
<td>MSE 294</td>
<td>Climate Policy Analysis</td>
<td></td>
</tr>
<tr>
<td>MSE 295</td>
<td>Energy Policy Analysis</td>
<td></td>
</tr>
</tbody>
</table>

1 Math and Science must total a minimum of 44 units. Electives must come from the School of Engineering approved list, or, PSYCH 50 Introduction to Cognitive Neuroscience, or PSYCH 70 Introduction to Social Psychology, and may not repeat material from any other requirement. AP/IB credit for Chemistry, Mathematics, and Physics may be used.

2 Engineering fundamentals plus engineering depth must total a minimum of 60 units.

3 Students may petition to place out of CS 106A Programming Methodology.

4 Courses used to satisfy the Math, Science, Technology in Society, or Engineering Fundamental requirement may not also be used to satisfy an engineering depth requirement.

For additional information and sample programs see the Handbook for Undergraduate Engineering Programs (UGHB) (http://ughb.stanford.edu).

Management Science and Engineering (MS&E) Minor

The following courses are required to fulfill the minor requirements:

**Background requirements (two courses)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CME 100</td>
<td>Vector Calculus for Engineers</td>
<td>5</td>
</tr>
<tr>
<td>or MATH 51</td>
<td>Linear Algebra and Differential Calculus of Several</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Variables</td>
<td></td>
</tr>
<tr>
<td>CS 106A</td>
<td>Programming Methodology</td>
<td>5</td>
</tr>
</tbody>
</table>

**Minor requirements (seven courses, letter-graded)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 111</td>
<td>Introduction to Optimization</td>
<td>4</td>
</tr>
<tr>
<td>MSE 120</td>
<td>Probabilistic Analysis</td>
<td>5</td>
</tr>
<tr>
<td>MSE 121</td>
<td>Introduction to Stochastic Modeling</td>
<td>4</td>
</tr>
<tr>
<td>MSE 125</td>
<td>Introduction to Applied Statistics</td>
<td>4</td>
</tr>
<tr>
<td>MSE 180</td>
<td>Organizations: Theory and Management</td>
<td>4</td>
</tr>
<tr>
<td>Electives</td>
<td>Any two 100- or 200-level MS&amp;E courses</td>
<td>6</td>
</tr>
</tbody>
</table>

**Recommended courses**

In addition to the required background and minor courses, it is recommended that students also take the following courses.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 50</td>
<td>Economic Analysis I</td>
<td>5</td>
</tr>
<tr>
<td>MSE 140</td>
<td>Accounting for Managers and Entrepreneurs (may be used as one of the required electives above)</td>
<td>2-4</td>
</tr>
<tr>
<td>or MSE 140X</td>
<td>Financial Accounting Concepts and Analysis</td>
<td></td>
</tr>
</tbody>
</table>

Coterminal Program in Management Science and Engineering

This program allows Stanford undergraduates an opportunity to work simultaneously toward a B.S. in Management Science and Engineering or another quantitative major, and an M.S. in Management Science and Engineering.

**University Coterminal Requirements**

Coterminal master’s degree candidates are expected to complete all master’s degree requirements as described in this bulletin. University requirements for the coterminal master’s degree are described in the “Coterminal Master’s Program (http://exploredegrees.stanford.edu/cotermdegrees)” section. University requirements for the master’s degree are described in the “Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees/#masterstext)” section of this bulletin.

After accepting admission to this coterminal master’s degree program, students may request transfer of courses from the undergraduate to the graduate career to satisfy requirements for the master’s degree. Transfer of courses to the graduate career requires review and approval of both the undergraduate and graduate programs on a case by case basis.

In this master’s program, courses taken during or after the first quarter of the sophomore year are eligible for consideration for transfer to the graduate career; the timing of the first graduate quarter is not a factor. No courses taken prior to the first quarter of the sophomore year may be used to meet master’s degree requirements.

Course transfers are not possible after the bachelor’s degree has been conferred.

The University requires that the graduate adviser be assigned in the student’s first graduate quarter even though the undergraduate career may still be open. The University also requires that the Master’s Degree Program Proposal be completed by the student and approved by the department by the end of the student’s first graduate quarter.

Master of Science in Management Science and Engineering

The M.S. degree programs require a minimum of 45 units beyond the equivalent of a B.S. degree at Stanford. All programs represent substantial progress in the major field beyond the bachelor’s degree.

University requirements for the master’s degree are described in the “Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)” section of this bulletin.

The master’s in Management Science and Engineer prepares engineers for a lifelong career addressing the technical and managerial needs of private and public organizations. The program emphasizes developing analytic abilities, making better decisions, and developing and executing strategies while also leading people who innovate. Unlike an M.B.A., the department’s master’s program addresses the technical as well as the behavioral challenges of running organizations and complex systems, emphasizing quantitative analytic skills and an entrepreneurial spirit.

MS&E students know math, engineering, as well as behavioral science. They can conduct experiments to design better systems, organizations and work processes. They understand how to analyze data to solve real world problems. They can develop mathematical and computational models to inform action. They know how to surface and examine unarticulated...
assumptions and root causes. These students can communicate effectively in the team environments found in so many contemporary organizations.

MS&E master’s students have breadth as well as depth. All are required to develop competence in optimization and analytics, organizations and decisions, and probability. In addition every student pursues a specialty in one of six areas:

1. **Financial Analytics**: Students who concentrate in Financial Analytics are prepared for careers requiring analytical rigor and the ability to innovate around market challenges. Example career paths include financial services, risk management, investment management, financial technology and data processing, financial regulation and policy, exchanges and clearing houses, and auditing and compliance. The concentration combines the in-depth study of quantitative techniques with practical, hands-on business problem solving. Students learn to use mathematical models and quantitative tools to solve complex problems in finance practice. The concentration exploits the intellectual ties between finance, operations research, computer science, and engineering. It offers a high level of flexibility and a range of elective courses that allow students to tailor the program to their specific career goals. Required courses immerse students in quantitative methods and deepen their understanding of finance fundamentals. Projects courses feature practical, data-driven team projects and case studies, fostering group learning and interaction with peers.

2. **Operations and Analytics**: Students following the Operations and Analytics track become prepared in the fundamentals and applications that are critical to careers in a fields ranging from operations management in the service, health care, production, manufacturing, computer, telecommunications, banking, industries to modern Silicon Valley information technology and data analytics. The program emphasizes a balance between the technical rigor of methodologies with lasting value and insightful modern applications and design challenges in a variety of established and emerging industries and operations environments. It offers a portfolio of courses in probabilistic modeling, optimization, simulation, algorithms, data science, networks, markets, and corresponding applications.

3. **Technology and Engineering Management** -- Students who concentrate in Technology and Engineering Management are prepared for careers including product and project management, management consulting, and entrepreneurship. They acquire skills to manage technical organizations, foster innovation, and deal with rapidly evolving technologies and dynamic markets. Specialized coursework is flexible, allowing students to explore and gain depth, understanding technical organizations to develop a culture of successful innovation and entrepreneurship, along with methods for decision making under uncertainty, financial analysis, and strategic planning.

4. **Decision and Risk Analysis**: Students who specialize in Decision and Risk Analysis are prepared for careers including management consulting, policy analysis, and risk management, applying engineering systems analysis to tackle complex economic and technical management problems in the private and public sectors. They acquire the skills to identify and develop opportunities in uncertain situations while recognizing and hedging the downside risks. Specialized course work includes the mathematical foundations for modeling in dynamic uncertain environments to value and manage uncertain opportunities and risks, applications to public policy, and an opportunity to work on a client project under faculty guidance.

5. **Energy and Environment**: The Energy and Environment track is designed for students interested in energy and environmental issues from the perspectives of public policy, nongovernmental organizations, or corporations. This track includes core courses; courses in economic analysis, energy resources, and energy/environmental policy analysis; and an individually designed concentration, typically emphasizing policy, strategy, or technology. Seminars provide insights into current corporate strategy, public policy, and research community developments. Energy/environmental project courses give practice in applying methodologies and concepts.

6. **Health Systems Modeling**: The Health Systems Modeling track is designed for students interested in healthcare operations and policy. The courses in this track emphasize the application of mathematical and economic analysis to problems in public health policy and the design and operation of healthcare services.

The master’s degree is designed to be a terminal degree program with a professional focus. The M.S. degree can be earned in one academic year (three academic quarters) of full-time work, although most students choose to complete the program in five academic quarters, or eighteen months, and work as an intern in the Summer Quarter.

**Background Requirements**

Students are expected to have completed both MATH 51 Linear Algebra and Differential Calculus of Several Variables, or an equivalent multivariable differential calculus course, and CS 106A Programming Methodology, or an equivalent general programming course, before beginning graduate study. These courses do not count toward degree requirements.

**Degree Requirements**

Students must take a minimum of 45 course units as follows:

- Three core courses (9-12 units)
- A primary or specialized concentration (12-24 units)
- One project course or two integrated project courses (0-8 units)
- Elective courses (1-24 units; see restrictions below)

**Core Courses (three courses required)**

### Optimization and Analytics (select one)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 211</td>
<td>Linear and Nonlinear Optimization</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 226</td>
<td>&quot;Small&quot; Data</td>
<td>3</td>
</tr>
</tbody>
</table>

Relevant 200 or 300 level MS&E course in optimization or analytics if a comparable introductory course in optimization or analytics has already been completed.

### Organizations and Decisions (select one)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 252</td>
<td>Decision Analysis I: Foundations of Decision Analysis</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 280</td>
<td>Organizational Behavior: Evidence in Action</td>
<td>3-4</td>
</tr>
</tbody>
</table>

Relevant 200 or 300 level MS&E course in organizations or decisions if a comparable introductory course in organizations or decisions has already been completed.

### Probability (select one)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 220</td>
<td>Probabilistic Analysis</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 221</td>
<td>Stochastic Modeling</td>
<td>3</td>
</tr>
</tbody>
</table>

Relevant 200 or 300 level MS&E course in probability or stochastics if a comparable introductory course in probability or stochastics has already been completed.
### Primary Concentrations

#### Financial Analytics Concentration (five courses required)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 245A</td>
<td>Investment Science</td>
<td>3</td>
</tr>
<tr>
<td>MSE 245B</td>
<td>Advanced Investment Science</td>
<td>3</td>
</tr>
<tr>
<td>MSE 246</td>
<td>Financial Risk Analytics</td>
<td>3</td>
</tr>
<tr>
<td>MSE 247</td>
<td>Quantitative Methods (two required):</td>
<td></td>
</tr>
<tr>
<td>MSE 250A</td>
<td>Linear and Nonlinear Optimization</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 251</td>
<td>&quot;Small&quot; Data</td>
<td>3</td>
</tr>
</tbody>
</table>

Select one:

- MSE 322 Stochastic Calculus and Control | 3
- STATS 207 Introduction to Time Series Analysis | 3
- STATS 240 Statistical Methods in Finance | 3-4
- STATS 241 Data-driven Financial and Risk Econometrics | 3-4

#### Financial Applications (select two):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CME 243</td>
<td>Financial Models and Statistical Methods in Active Risk Management</td>
<td>2-4</td>
</tr>
<tr>
<td>MATH 237</td>
<td>Default and Systemic Risk</td>
<td>3</td>
</tr>
<tr>
<td>MSE 347</td>
<td>Credit Risk: Modeling and Management</td>
<td>3</td>
</tr>
<tr>
<td>MSE 348</td>
<td>Optimization of Uncertainty and Applications in Finance</td>
<td>3</td>
</tr>
<tr>
<td>MSE 445</td>
<td>Projects in Wealth Management</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 447</td>
<td>Systemic and Market Risk: Notes on Recent History, Practice, and Policy</td>
<td>3</td>
</tr>
<tr>
<td>MSE 448</td>
<td>Big Financial Data and Algorithmic Trading</td>
<td>3</td>
</tr>
<tr>
<td>STATS 237</td>
<td>Theory of Investment Portfolios and Derivative Securities</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Operations and Analytics Concentration (four courses required)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 211</td>
<td>Linear and Nonlinear Optimization (whichever course wasn't taken for core)</td>
<td>3-4</td>
</tr>
<tr>
<td>or MSE 226</td>
<td>&quot;Small&quot; Data</td>
<td>3</td>
</tr>
<tr>
<td>MSE 221</td>
<td>Stochastic Modeling (or a more advanced course in probability (i.e. MS&amp;E 223 Simulation) if a student has taken an equivalent class in stochastic modeling)</td>
<td>3</td>
</tr>
<tr>
<td>MSE 235</td>
<td>Analytics in Action</td>
<td>3</td>
</tr>
<tr>
<td>or MSE 251</td>
<td>Stochastic Control</td>
<td>3</td>
</tr>
<tr>
<td>MSE 260</td>
<td>Introduction to Operations Management</td>
<td>3</td>
</tr>
<tr>
<td>or MSE 261</td>
<td>Inventory Control and Production Systems</td>
<td>3</td>
</tr>
<tr>
<td>or MSE 263</td>
<td>Healthcare Operations Management</td>
<td>3</td>
</tr>
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</table>

#### Recommended Elective Courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>MSE 223</td>
<td>Simulation</td>
<td>3</td>
</tr>
<tr>
<td>MSE 231</td>
<td>Introduction to Computational Social Science</td>
<td>3</td>
</tr>
<tr>
<td>MSE 233</td>
<td>Networked Markets</td>
<td>3</td>
</tr>
<tr>
<td>MSE 255</td>
<td>Analytics in Action</td>
<td>3</td>
</tr>
<tr>
<td>MSE 243</td>
<td>Energy and Environmental Policy Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MSE 245A</td>
<td>Investment Science</td>
<td>3</td>
</tr>
<tr>
<td>MSE 250A</td>
<td>Engineering Risk Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MSE 251</td>
<td>Stochastic Control</td>
<td>3</td>
</tr>
<tr>
<td>MSE 252</td>
<td>Decision Analysis I: Foundations of Decision Analysis</td>
<td>3-4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 260</td>
<td>Introduction to Operations Management</td>
<td>3</td>
</tr>
<tr>
<td>MSE 261</td>
<td>Inventory Control and Production Systems</td>
<td>3</td>
</tr>
<tr>
<td>MSE 262</td>
<td>Supply Chain Management</td>
<td>3</td>
</tr>
<tr>
<td>MSE 263</td>
<td>Healthcare Operations Management</td>
<td>3</td>
</tr>
<tr>
<td>MSE 264</td>
<td>Sustainable Product Development and Manufacturing</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 268</td>
<td>Operations Strategy</td>
<td>3</td>
</tr>
<tr>
<td>MSE 270</td>
<td>Strategy in Technology-Based Companies</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 292</td>
<td>Health Policy Modeling</td>
<td>3</td>
</tr>
<tr>
<td>MSE 467</td>
<td>Strategic Operations Consulting</td>
<td>3</td>
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</tbody>
</table>

#### Technology and Engineering Management Concentration (five courses required)

The course used to satisfy the Organizations and Decisions Core may also be counted here.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 270</td>
<td>Strategy in Technology-Based Companies</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 274</td>
<td>Dynamic Entrepreneurial Strategy</td>
<td>3</td>
</tr>
<tr>
<td>MSE 278</td>
<td>Patent Law and Strategy for Innovators and Entrepreneurs</td>
<td>2-3</td>
</tr>
<tr>
<td>MSE 280</td>
<td>Organizational Behavior: Evidence in Action</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 282</td>
<td>Transformational Leadership</td>
<td>3</td>
</tr>
<tr>
<td>MSE 284</td>
<td>Designing Modern Work Organizations</td>
<td>3</td>
</tr>
<tr>
<td>MSE 270</td>
<td>Strategy in Technology-Based Companies</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 271</td>
<td>Global Entrepreneurial Marketing</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 272</td>
<td>Startup Boards</td>
<td>3</td>
</tr>
<tr>
<td>MSE 273</td>
<td>Technology Venture Formation</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 275</td>
<td>Foundations for Large-Scale Entrepreneurship</td>
<td>3</td>
</tr>
<tr>
<td>MSE 276</td>
<td>Entrepreneurial Management and Finance</td>
<td>3</td>
</tr>
<tr>
<td>MSE 277</td>
<td>Creativity and Innovation</td>
<td>3-4</td>
</tr>
<tr>
<td>ENGR 245</td>
<td>The Lean LaunchPad: Getting Your Lean Startup Off the Ground</td>
<td>3-4</td>
</tr>
</tbody>
</table>

#### Organizations and Strategy (select at least one):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 270</td>
<td>Strategy in Technology-Based Companies</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 277</td>
<td>Global Entrepreneurial Marketing</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 272</td>
<td>Startup Boards</td>
<td>3</td>
</tr>
<tr>
<td>MSE 273</td>
<td>Technology Venture Formation</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 275</td>
<td>Foundations for Large-Scale Entrepreneurship</td>
<td>3</td>
</tr>
<tr>
<td>MSE 276</td>
<td>Entrepreneurial Management and Finance</td>
<td>3</td>
</tr>
<tr>
<td>MSE 277</td>
<td>Creativity and Innovation</td>
<td>3-4</td>
</tr>
<tr>
<td>ENGR 245</td>
<td>The Lean LaunchPad: Getting Your Lean Startup Off the Ground</td>
<td>3-4</td>
</tr>
</tbody>
</table>

#### Finance and Decisions (select at least one):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 240</td>
<td>Accounting for Managers and Entrepreneurs</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 245A</td>
<td>Investment Science</td>
<td>3</td>
</tr>
<tr>
<td>MSE 245G</td>
<td>Finance for Non-MBAs</td>
<td>3</td>
</tr>
<tr>
<td>MSE 250A</td>
<td>Engineering Risk Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MSE 252</td>
<td>Decision Analysis I: Foundations of Decision Analysis</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 352</td>
<td>Decision Analysis II: Professional Decision Analysis</td>
<td>3-4</td>
</tr>
</tbody>
</table>

#### Specialized Concentrations (must have approval of the academic advisor)

#### Decision and Risk Analysis Concentration (four courses required)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 211</td>
<td>Linear and Nonlinear Optimization</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 221</td>
<td>Stochastic Modeling</td>
<td>3</td>
</tr>
<tr>
<td>MSE 252</td>
<td>Decision Analysis I: Foundations of Decision Analysis</td>
<td>3-4</td>
</tr>
</tbody>
</table>

#### Required Courses (select two):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 245A</td>
<td>Investment Science</td>
<td>3</td>
</tr>
<tr>
<td>MSE 246</td>
<td>Financial Risk Analytics</td>
<td>3</td>
</tr>
<tr>
<td>MSE 247</td>
<td>Quantitative Methods (two required):</td>
<td></td>
</tr>
<tr>
<td>MSE 250A</td>
<td>Engineering Risk Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MSE 251</td>
<td>Stochastic Control</td>
<td>3</td>
</tr>
<tr>
<td>MSE 252</td>
<td>Decision Analysis I: Foundations of Decision Analysis</td>
<td>3-4</td>
</tr>
</tbody>
</table>
### Energy and Environment Concentration

**Units**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 241</td>
<td>Economic Analysis</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 250A</td>
<td>Engineering Risk Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MSE 352</td>
<td>Decision Analysis II: Professional Decision Analysis</td>
<td>3-4</td>
</tr>
</tbody>
</table>

#### Policy Course (select one):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 243</td>
<td>Energy and Environmental Policy Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MSE 292</td>
<td>Health Policy Modeling</td>
<td>3</td>
</tr>
<tr>
<td>MSE 293</td>
<td>Technology and National Security</td>
<td>3</td>
</tr>
<tr>
<td>MSE 294</td>
<td>Climate Policy Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MSE 295</td>
<td>Energy Policy Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Project Course (select one):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 250B</td>
<td>Project Course in Engineering Risk Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MSE 452</td>
<td>Decision Analysis Projects: Helping Real Leaders Make Real Decisions</td>
<td>3</td>
</tr>
</tbody>
</table>

### Health Systems Modeling Concentration

**Units**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 207A</td>
<td>Understanding Energy</td>
<td>3</td>
</tr>
<tr>
<td>MSE 241</td>
<td>Economic Analysis</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 243</td>
<td>Energy and Environmental Policy Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

Three additional courses from energy, policy, or strategy areas below.

#### Policy:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 251</td>
<td>Natural Resource and Energy Economics</td>
<td>2-5</td>
</tr>
<tr>
<td>ENERGY 158</td>
<td>Bringing New Energy Technologies to Market: Optimizing Technology Push and Market Pull</td>
<td>3</td>
</tr>
<tr>
<td>GSBGEN 336</td>
<td>Business Models for Sustainable Energy</td>
<td>3</td>
</tr>
<tr>
<td>LAW 455</td>
<td>Energy Law</td>
<td>3</td>
</tr>
<tr>
<td>MSE 293</td>
<td>Technology and National Security</td>
<td>3</td>
</tr>
<tr>
<td>MSE 294</td>
<td>Climate Policy Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MSE 295</td>
<td>Energy Policy Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Strategy:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>ECON 203N</td>
<td>Microeconomics II For Non-Economics PhDs</td>
<td>2-5</td>
</tr>
<tr>
<td>ENERGY 158</td>
<td>Bringing New Energy Technologies to Market: Optimizing Technology Push and Market Pull</td>
<td>3</td>
</tr>
<tr>
<td>GSBGEN 538</td>
<td>Energy Policy, Markets, and Climate Change</td>
<td>2</td>
</tr>
<tr>
<td>MSE 270</td>
<td>Strategy in Technology-Based Companies</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 271</td>
<td>Global Entrepreneurial Marketing</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 272</td>
<td>Startup Boards</td>
<td>3</td>
</tr>
<tr>
<td>MSE 273</td>
<td>Technology Venture Formation</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 274</td>
<td>Dynamic Entrepreneurial Strategy</td>
<td>3</td>
</tr>
<tr>
<td>MSE 275</td>
<td>Foundations for Large-Scale Entrepreneurship</td>
<td>3</td>
</tr>
<tr>
<td>MSE 276</td>
<td>Entrepreneurial Management and Finance</td>
<td>3</td>
</tr>
<tr>
<td>MSE 277</td>
<td>Creativity and Innovation</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 278</td>
<td>Patent Law and Strategy for Innovators and Entrepreneurs</td>
<td>2-3</td>
</tr>
</tbody>
</table>

#### Energy:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY 102</td>
<td>Renewable Energy Sources and Greener Energy Processes</td>
<td>3</td>
</tr>
<tr>
<td>ENERGY 104</td>
<td>Sustainable Energy for 9 Billion</td>
<td>3</td>
</tr>
<tr>
<td>ENERGY 158</td>
<td>Bringing New Energy Technologies to Market: Optimizing Technology Push and Market Pull</td>
<td>3</td>
</tr>
<tr>
<td>ME 370A</td>
<td>Energy Systems I: Thermodynamics</td>
<td>3</td>
</tr>
<tr>
<td>ME 370B</td>
<td>Energy Systems II: Modeling and Advanced Concepts</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 240</td>
<td>Introduction to the Physics of Energy</td>
<td>3</td>
</tr>
<tr>
<td>PHYSICS 241</td>
<td>Introduction to Nuclear Energy</td>
<td>3</td>
</tr>
</tbody>
</table>

### Projects

Select one project course or two integrated project courses; may double-count as part of the core or concentration.

#### Project Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 250B</td>
<td>Project Course in Engineering Risk Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MSE 348</td>
<td>Optimization of Uncertainty and Applications in Finance</td>
<td>3</td>
</tr>
<tr>
<td>MSE 403</td>
<td>Integrative Modeling</td>
<td>3</td>
</tr>
<tr>
<td>MSE 445</td>
<td>Projects in Wealth Management</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 447</td>
<td>Systemic and Market Risk : Notes on Recent History, Practice, and Policy</td>
<td>3</td>
</tr>
<tr>
<td>MSE 448</td>
<td>Big Financial Data and Algorithmic Trading</td>
<td>3</td>
</tr>
<tr>
<td>MSE 452</td>
<td>Decision Analysis Projects: Helping Real Leaders Make Real Decisions</td>
<td>3</td>
</tr>
<tr>
<td>MSE 464</td>
<td>Global Project Coordination</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 467</td>
<td>Strategic Operations Consulting</td>
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</tbody>
</table>

#### Integrated Project Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE 201</td>
<td>Dynamic Systems</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 211</td>
<td>Linear and Nonlinear Optimization</td>
<td>3-4</td>
</tr>
<tr>
<td>MSE 233</td>
<td>Networked Markets</td>
<td>3</td>
</tr>
</tbody>
</table>
Management Science and Engineering

Additional Requirements

1. At least 45 units must be in courses numbered 100 and above.
2. The degree program must be completed with a grade point average (GPA) of 3.0 or higher.
3. At least 27 units must be in courses numbered 200 and above in MS&E, taken for a letter grade and a minimum of two units each.
4. At least 36 letter-graded units must be in MS&E or closely related fields. Closely related fields include any department in the School of Engineering, mathematics, statistics, economics, sociology, psychology, or business.
5. All courses used to satisfy core, concentration, or project requirements must be taken for a letter grade.
6. A maximum of three units of 1-unit courses such as seminars, colloquia, workshops, in any department, including MS&E 208A, B, and C, Curricular Practical Training.
7. A maximum of 18 non-degree option (NDO) units through the Stanford Center for Professional Development (SCPD).
8. Courses in athletics, physical education, and recreation may not be applied toward the degree.

Professional Education

The Stanford Center for Professional Development (SCPD) provides opportunities for employees of some local and remote companies to take courses at Stanford.

The Honors Cooperative Program (HCP) provides opportunities for employees of SCPD member companies to earn an M.S. degree, over a longer period, by taking one or two courses per academic quarter. Some courses are only offered on campus; HCP students may attend those courses at Stanford to meet the degree requirements. It is possible to complete this program as a remote HCP student although the remote offerings are limited. Students must apply for a degree program through the standard application process, and must meet the standard application deadlines.

The non-degree option (NDO) allows employees of some local companies to take courses for credit from their company sites before being admitted to a degree program. Students apply to take NDO courses each quarter through the Stanford Center for Professional Development. Up to 18 units taken as an NDO student may be applied toward a degree program. For additional information about the NDO application process and deadlines, see the SCPD web site (http://scpd.stanford.edu), or contact SCPD at (650) 725-3000.

Certificate

The department offers a certificate program within the framework of the NDO program. A certificate can be obtained by completing three MS&E core courses, plus one MS&E elective course for a total of four courses. For further information, see http://scpd.stanford.edu/scpd/programs/certs/managementSci.htm.

Dual Master's Degree Program

The dual degree program enables a small group of graduate students to obtain two master’s degrees simultaneously. Students complete the course requirements for each department. A total of 90 units is required to complete the dual master’s degree.

Admission

For the dual degree, admission to two departments is required, but is coordinated by designated members of both admissions committees who make recommendations to the committees of their respective departments. Students may apply to only one department initially. After the first quarter at Stanford, students may apply to be admitted to the second department.

Advising

Every student in the dual degree program has one adviser in each department.

Joint MS&E and Law Degrees

The School of Law and the Department of Management Science and Engineering offer joint degree programs leading to a J.D. degree and an M.S. degree in MS&E, or to a J.D. and Ph.D. in MS&E. These programs are designed for students who wish to prepare themselves for careers in areas relating to both law and to the decision making, policy making, and problem solving knowledge and skills developed in the MS&E program. Students interested in either joint degree program must apply and gain admission separately to the School of Law and the Department of Management Science and Engineering and, as an additional step, must secure consent from both academic units to pursue degrees in those units as part of a joint degree program. Interest in either joint degree program should be noted on the student’s admission applications and may be considered by the admission committee of each program. Alternatively, an enrolled student in either the Law School or MS&E may apply for admission to the other program and for joint degree status in both academic units after commencing study in either program.

Joint degree students may elect to begin their course of study in either the School of Law or MS&E. Students are assigned to a joint program committee composed of at least one faculty member from Law and one from MS&E. This committee plans the student’s program jointly with the student. Students must be enrolled full time in the Law School for the first year of law studies, and it is recommended that students devote exclusively one Autumn Quarter to the MS&E M.S. program to initiate their MS&E work. After that time, enrollment may be in MS&E or Law, and students may choose courses from either program regardless of where enrolled. A candidate in the joint J.D./Ph.D. program should spend a substantial amount of full time residency in MS&E. Students must satisfy the requirements for both the J.D. and the M.S. or Ph.D. degrees as specified in this bulletin.
or by the School of Law. The Law School may approve courses from MS&E or courses in the student’s MS&E program from outside of the Department of Management Science and Engineering that may count toward the J.D. degree, and MS&E may approve courses from the Law School that may count toward the M.S. or Ph.D. degree in MS&E. In either case, approval may consist of a list applicable to all joint degree students or may be tailored to each individual student’s program. The lists may differ depending on whether the student is pursuing an M.S. or a Ph.D. in MS&E.

In the case of a J.D./M.S. program, no more than 45 units of approved courses may be counted toward both degrees. In the case of a J.D./Ph.D. program, no more than 54 units of approved courses may be counted toward both degrees. In either case, no more than 36 units of courses that originate outside the Law School may count toward the law degree. To the extent that courses under this joint degree program originate outside the Law School but count toward the law degree, the law credits permitted under Section 17(1) of the Law School Regulations are reduced on a unit-per-unit basis, but not below zero. The maximum number of law school credits that may be counted toward the M.S. in MS&E is the greater of: (a) 18 units in the case of the M.S., or (b) the maximum number of hours from courses outside the department that an M.S. candidate in MS&E is permitted to count toward the applicable degree under general departmental guidelines or under departmental rules that apply in the case of a particular student.

Tuition and financial aid arrangements are normally through the school in which the student is then enrolled.

Joint MS&E and Master of Public Policy Degree

MS MS&E students who wish to apply their analytical and management skills to the field of public policy can simultaneously pursue a master degree in MS&E and a master degree in Public Policy. The MPP is a two-year degree program, but MS MS&E students who pursue the joint program can earn both degrees in a minimum of two years, depending on prior preparation and elective choices, by counting up to 45 quarter units of course work toward both degrees. After admission to the Department of Management Science and Engineering, incoming or current MS students request that their application file be forwarded to the MPP program director for review.

Students in the joint program normally will spend most of their first year taking MS&E core courses. The second year is typically devoted to the MPP core, concentration, and practicum. The joint degree requires 90 quarter units. Tuition for the first year of study is paid at the Graduate Engineering rate, the remaining time at the graduate rate.

Doctor of Philosophy in Management Science and Engineering

University requirements for the Ph.D. degree are described in the “Graduate Degrees” section of this bulletin.

The Ph.D. degree in MS&E is intended for students primarily interested in a career of research and teaching, or high-level technical work in universities, industry, or government. The program requires three years of full-time graduate study, at least two years of which must be at Stanford. Typically, however, students take four to five years after entering the program to complete all Ph.D. requirements. The Ph.D. is organized around the expectation that the students acquire a certain breadth across all areas of the department, and depth in one of them. The current areas are:

- Decision analysis and risk analysis
- Economics and finance
- Information science and technology
- Organization, technology, and entrepreneurship
- Policy and strategy
- Probability and stochastic systems
- Production and operations management
- Systems modeling and optimization

Doctoral students are required to take a number of courses, both to pass a qualifying exam in one of these areas, or the Systems Program which is a combination of several areas, and to complete a dissertation based on research which must make an original contribution to knowledge.

Each student admitted to the Ph.D. program must satisfy a breadth requirement and pass a qualification procedure. The purpose of the qualification procedure is to assess the student’s command of the field and to evaluate his or her potential to complete a high-quality dissertation in a timely manner. The student must complete specified course work in one of the areas of the department (or the Systems Program which is a combination of several areas). The qualification decision is based on the student’s coursework and grade point average (GPA), on the one or two preliminary papers prepared by the student with close guidance from two faculty members, at least one of whom must be an MS&E faculty member, the student’s performance in an area examination or defense of the written paper(s), and an overall assessment by the faculty of the student’s ability to conduct high-quality Ph.D. research. Considering this evidence, the department faculty will vote on advancing the student to candidacy in the department at large. The Ph.D. requires a minimum of 135 units, up to 45 units of which may be transferred from another graduate program. All courses used to satisfy breadth and depth requirements must be taken for a letter grade, if the letter graded option is available. Prior to candidacy, at least 3 units of work must be taken with each of four Stanford faculty members. Finally, the student must pass a University oral examination and complete a Ph.D. dissertation. During the course of the Ph.D. program, students who do not have a master’s degree are strongly encouraged to complete one, either in MS&E or in another Stanford department.

Breadth Requirement

All first year students are required to attend and participate in MS&E 302 Fundamental Concepts in Management Science and Engineering, which will meet in the Autumn Quarter.

Each course session will be devoted to a specific MS&E PhD research area. At a given session several advanced PhD students in that area will make carefully prepared presentations designed for first-year doctoral students regardless of area. The presentations will be devoted to: (a) illuminating how people in the area being explored that day think about and approach problems, and (b) illustrating what can and cannot be done when addressing problems by deploying the knowledge, perspectives, and skills acquired by those who specialize in the area in question.

Faculty in the focal area of the week will comment on the student presentations. The rest of the session will be devoted to questions posed and comments made by the first year PhD students.

During the last two weeks of the quarter groups of first year students will make presentations on how they would approach a problem drawing on two or more of the perspectives to which they have been exposed earlier in the class.

Attendance is mandatory and performance will be assessed on the basis of the quality of the students’ presentations and class participation

Qualification Procedure Requirements

The qualification procedure is based on depth in an area of the student’s choice and preparation for dissertation research. The qualification process must be completed by the end of the month of May of the student’s second year of graduate study in the department. The performance of all doctoral students is reviewed every year at a department faculty meeting at the end
of May or beginning of June. Ph.D. qualification decisions will be made at that time and individual feedback will be provided.

The Ph.D. qualification requirements comprise these elements:

1. **Courses and GPA:** Students must complete the depth requirements of one of the areas of the MS&E department (or the Systems Program which is a combination of several areas). (The Ph.D. area course requirements are below). All courses used to satisfy depth requirements must be taken for a letter grade, if the letter graded option is available. Course substitutions may be approved by the doctoral program advisor or the MS&E dissertation advisor on the candidacy form or on a request for graduate course waiver/substitution form. A student must maintain a GPA of at least 3.4 in the set of all courses taken by the student within the department. The GPA will be computed on the basis of the nominal number of units for which each course is offered.

2. **Paper(s):** A student may choose between two options. The first option involves one paper supervised by a primary faculty adviser and a second faculty reader. This paper should be written in two quarters. The second option involves two shorter sequential tutorials, with two different faculty advisers. Each tutorial should be completed in one quarter. In both options, the student chooses the faculty advisor/reader with the faculty members’ consent. There must be two faculty members, at least one of whom must be an MS&E faculty member, supervising and evaluating this requirement for advancement to candidacy. The paper/tutorials must be completed before the Spring Quarter of the student’s second year of graduate study in the department if the student’s qualifying exam is during the Spring Quarter, and before the end of May of that year otherwise. A student may register for up to 3 units per tutorial and up to 6 units for a paper.

3. **Area Qualification:** In addition, during the second year, a student must pass an examination in one of the areas of the MS&E department (or the Systems Program which is a combination of several areas), or defense of the written paper(s). The student chooses the area(s) in which to take the examination. This area examination is written, oral, or both, at the discretion of the area faculty administering the exam. Most areas offer the qualifying exam only once per year, which may be early in the second year.

**Degree Progress and Student Responsibility**

Each student’s progress will be reviewed annually by the MS&E faculty. Typically, this will occur at a faculty meeting at the end of Spring Quarter, and email notifications will be sent over the summer.

First year students should complete 30 units of breadth and depth courses, including MS&E 302, and develop relationships with faculty members who might serve as dissertation advisor and reading committee.

Second year students should complete most, if not all, of the required depth courses, work with two faculty members, at least one of whom must be an MS&E faculty member, on tutorials/research paper, and pass an area qualifying exam. Most areas offer the qualifying exam only once per year, which may be early in the second year. Students should continue to develop relationships with faculty members who might serve as dissertation advisors and reading committee, and select a dissertation advisor before the beginning of the third year.

Third year students should complete any remaining depth courses, select a dissertation topic, and make progress on the dissertation.

Fourth year students should select a reading committee, and complete, or nearly complete, the oral exam and dissertation.

It shall be the responsibility of the student to initiate each step in completing the Ph.D. program.

It is strongly recommended that each student, in the first year of graduate study at Stanford, make it a special point to become well acquainted with MS&E faculty members and to seek advice and counsel regarding possible Ph.D. candidacy. A faculty member will be more likely to accept the responsibility of supervising the research of a student whom he or she knows fairly well than a student whose abilities, initiative, and originality the faculty member knows less.

It is expected that advanced students will regularly report to their full Reading Committee on the progress of their dissertation. It is also expected that the student avail him/herself of the different expertise represented on the Committee continually. Each member of this Committee must certify approval of both the scope and quality of the dissertation.

The **Doctoral Dissertation Reading Committee** consists of the principal dissertation adviser and two other readers. At least one member must be from the student’s major department.

As administered in this department, the **University Oral Examination** is a defense of the dissertation; however, the candidate should be prepared to answer any question raised by any members of the Academic Council who choose to be present. Students should schedule three hours for the Oral Examination, which usually consists of a 45 minute public presentation, followed by closed-session questioning of the examinee by the committee, and committee deliberation. The University Oral examination may be scheduled after the Dissertation Reading Committee has given tentative approval to the dissertation. The student must be enrolled in the quarter of **their Oral Examination**.

The examining committee usually consists of the three members of the Reading Committee as well as a fourth faculty member and an Orals Chair. It is the responsibility of the student's advisor to find an appropriate Orals Chair. The Chair must be an Academic Council member and may not be affiliated with either the Department of Management Science and Engineering nor any department in which the student's advisor has a regular appointment. Emeriti Professors are eligible to serve as an Orals Chair. The student needs to reserve a room, and meet with the Student Services Manager to complete the Oral Examination Schedule and pick up other paper work. This paperwork, along with an abstract, needs to be delivered to the Orals Chair at least one week prior to the Oral Examination.

**Course Requirements**

**Decision Analysis and Risk Analysis**

**Prerequisites:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>CS 106A</td>
<td>Programming Methodology</td>
</tr>
<tr>
<td>CME 100</td>
<td>Vector Calculus for Engineers</td>
</tr>
<tr>
<td>CME 103</td>
<td>Introduction to Matrix Methods</td>
</tr>
</tbody>
</table>

**Required:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>MSE 201</td>
<td>Dynamic Systems</td>
</tr>
<tr>
<td>or EE 263</td>
<td>Introduction to Linear Dynamical Systems</td>
</tr>
<tr>
<td>MSE 211</td>
<td>Linear and Nonlinear Optimization</td>
</tr>
<tr>
<td>or MSE 311</td>
<td>Optimization</td>
</tr>
<tr>
<td>MSE 220</td>
<td>Probabilistic Analysis</td>
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<tr>
<td>MSE 221</td>
<td>Stochastic Modeling</td>
</tr>
<tr>
<td>or STATS 217</td>
<td>Introduction to Stochastic Processes</td>
</tr>
<tr>
<td>MSE 223</td>
<td>Simulation</td>
</tr>
<tr>
<td>MSE 241</td>
<td>Economic Analysis</td>
</tr>
<tr>
<td>MSE 250A</td>
<td>Engineering Risk Analysis</td>
</tr>
<tr>
<td>MSE 250B</td>
<td>Project Course in Engineering Risk Analysis</td>
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<tr>
<td>or MSE 452</td>
<td>Decision Analysis Projects: Helping Real Leaders Make Real Decisions</td>
</tr>
<tr>
<td>MSE 251</td>
<td>Stochastic Control</td>
</tr>
<tr>
<td>or MSE 351</td>
<td>Dynamic Programming and Stochastic Control</td>
</tr>
<tr>
<td>MSE 252</td>
<td>Decision Analysis I: Foundations of Decision Analysis</td>
</tr>
</tbody>
</table>

**University Oral Examination** is
MSE 352  Decision Analysis II: Professional Decision Analysis
MSE 353  Decision Analysis III: Frontiers of Decision Analysis
MSE 355  Influence Diagrams and Probabilistics Networks

Recommended:
MSE 207  Interactive Management Science
MSE 245A  Investment Science
MSE 254  The Ethical Analyst
MSE 270  Strategy in Technology-Based Companies
MSE 280  Organizational Behavior: Evidence in Action
MSE 299  Voluntary Social Systems
MSE 321  Stochastic Systems

or STATS 218  Introduction to Stochastic Processes
MSE 450  Lessons in Decision Making
or MSE 453  Decision Analysis Applications: Business Strategy and Public Policy
CS 228  Probabilistic Graphical Models: Principles and Techniques
CS 270  Modeling Biomedical Systems: Ontology, Terminology, Problem Solving
ECON 286  Game Theory and Economic Applications
ECON 290  Multiagent Decision Theory
MGT100  Analysis of Costs, Risks, and Benefits of Health Care
STATS 200  Introduction to Statistical Inference
or STATS 201  Design and Analysis of Experiments
or STATS 202  Data Mining and Analysis
or ECON 271  Intermediate Econometrics II

Economics and Finance

The economics and finance area emphasizes the use of economic and financial concepts, methods, and practice for problem solving, in areas including individual choice, financial engineering, economic policy analysis, and financial market analysis. A strong mathematical and systems analysis background is essential to the area. Students in this area are expected to develop a strong background in economics and finance and closely related disciplines and to obtain experience in addressing significant problem areas.

Required
MSE 201  Dynamic Systems
MSE 220  Probabilistic Analysis
MSE 241  Economic Analysis
MSE 245A  Investment Science
MSE 245B  Advanced Investment Science
MSE 311  Optimization

or MATH 115  Functions of a Real Variable
or MATH 171  Fundamental Concepts of Analysis

Select five of the following options:

General
MSE 314  Linear and Conic Optimization with Applications
EE 263  Introduction to Linear Dynamical Systems
STATS 310A  Theory of Probability
or MATH 205A  Real Analysis

Economics (two of Econ 280-290 may be used)
ECON 370  Econometrics Workshop
or ECON 271  Intermediate Econometrics II

or ECON 272  Intermediate Econometrics III
or ECON 273  Advanced Econometrics I
or ECON 274  Advanced Econometrics II
or ECON 275  Time Series Econometrics
or ECON 276  Limited Dependent Variables

ECON 282  Contracts, Information, and Incentives
or ECON 283  Theory and Practice of Auction Market Design
or ECON 285  Matching and Market Design
or ECON 286  Game Theory and Economic Applications
or ECON 288  Computational Economics
or ECON 289  Advanced Topics in Game Theory and Information Economics
or ECON 290  Multiperson Decision Theory

Finance

MSE 347  Credit Risk: Modeling and Management
MSE 348  Optimization of Uncertainty and Applications in Finance

MATH 136  Stochastic Processes

Students should consult with their dissertation advisors to select additional courses from any department to complete a PhD in their area.

Students should plan to complete most if not all required courses by the end of the first year of graduate study. The choice courses should be chosen to form a coherent program either in economics, finance or both. PhD students must also meet the department’s requirements for both an MS degree and a PhD degree.

Economics and Finance Qualifying Procedure

In addition to beginning an appropriate course program, students must pass two-quarters of tutorial and an oral examination to obtain qualification. The tutorials emphasize basic research skills. The oral examination emphasizes command of basic concepts as represented in the required courses as well as the modeling of practical situations.

Information Science and Technology

Select five classes from four different core areas.

Optimization and algorithms core:
MSE 212  Mathematical Programming and Combinatorial Optimization
MSE 310  Linear Programming
MSE 311  Optimization
MSE 312  Advanced Methods in Numerical Optimization
MSE 314  Linear and Conic Optimization with Applications
MSE 315  Numerical Optimization
MSE 316  Discrete Mathematics and Algorithms
MSE 317  Algorithms for Modern Data Models
MSE 318  Large-Scale Numerical Optimization
MSE 319  Approximation Algorithms
MSE 351  Dynamic Programming and Stochastic Control
CS 261  Optimization and Algorithmic Paradigms

Networks core:
MSE 235  Analytics in Action
MSE 238  Leading Trends in Information Technology
MSE 335  Queueing and Scheduling in Processing Networks
MSE 337

Economics and game theory core:
MSE 246  Financial Risk Analytics
MSE 336  Platform and Marketplace Design
Operations Research Qualifying Procedure

The student will do two quarter-length tutorials with IST faculty. At the end of these tutorials, the student must make a 45-minute presentation of one of their tutorials to a committee of three IST faculty members. The student can do both tutorials with the same faculty member, in which case the presentation can be of the two tutorials together, and another committee member must be kept informed of the student’s progress on a regular basis during the two quarters. The presentation should take place in the spring quarter of the student’s second year, or earlier. The presentation must include original research or promising directions towards original research. During this presentation, the student must also provide the name of their chosen focus area, and the list of courses that the student has completed and intends to complete in the core as well as in the chosen focus area. The committee will then make a recommendation to the IST area and the MS&E department regarding qualification of the student for the PhD program in IST.

Organization, Technology, and Entrepreneurship

Foundation in Organizational Behavior (five courses):

<table>
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<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>PSYCH 212</td>
<td>Social Psychology</td>
</tr>
<tr>
<td>SOC 363A</td>
<td>Seminar on Organizational Theory</td>
</tr>
</tbody>
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Plus three of the following:

<table>
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<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>MSE 371</td>
<td>Innovation and Strategic Theory</td>
</tr>
<tr>
<td>MSE 372</td>
<td>Entrepreneurship Doctoral Research Seminar</td>
</tr>
<tr>
<td>MSE 374</td>
<td>Dynamic Corporate Strategy</td>
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<tr>
<td>MSE 375</td>
<td>Research on Entrepreneurship</td>
</tr>
<tr>
<td>MSE 376</td>
<td>Strategy Doctoral Research Seminar</td>
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</tbody>
</table>
institutions, and in the private sector. Preparing doctoral students for careers at research universities, government and industry is the mission of the P&S Area to provide a first-class learning and research environment with the goal of enhancing the student's understanding of the specific application domains. The P&S Area's course requirements for Ph.D. students are designed to build a strong foundation in economics, strategy, and organizational theory through a variety of courses. Students can select from a wide range of courses in fields such as decision analysis, optimization, and econometrics.

The student must select a program of four or more electives including disciplinary depth courses that reflect his or her interests and this approved by the Policy and Strategy faculty. The following are a number of sample programs:

### Sample Program: Modeling Emphasis

#### Research Methods

- MSE 201 Dynamic Systems
- MSE 252 Decision Analysis I: Foundations of Decision Analysis
- MSE 311 Optimization
- MSE 321 Stochastic Systems

#### Domain Depth

- MSE 292 Health Policy Modeling
- HRP 392 Analysis of Costs, Risks, and Benefits of Health Care

Two of the following:

- MSE 263 Healthcare Operations Management
- MSE 463 Healthcare Systems Design
- HRP 256 Economics of Health and Medical Care
- HRP 263 Advanced Decision Science Methods and Modeling in Health

### Sample Program: Economics Emphasis

#### Research Methods

- ECON 282 Contracts, Information, and Incentives
- ECON 286 Game Theory and Economic Applications

#### Domain Depth

- ECON 257 Industrial Organization I
- ECON 285 Matching and Market Design

### Sample Program: Strategy Emphasis

#### Research Methods

- MSE 408 Directed Reading and Research (Methods Apprenticeship)
- SOC 369 Social Network Methods

#### Domain Depth

- MSE 371 Innovation and Strategic Change
- MSE 376 Strategy Doctoral Research Seminar
- SOC 314 Economic Sociology

### Sample Program: Risk Analysis Emphasis

#### Research Methods

- MSE 250A Engineering Risk Analysis
- MSE 251 Stochastic Control
- MSE 252 Decision Analysis I: Foundations of Decision Analysis
- MSE 355 Influence Diagrams and Probabilistics Networks

#### Domain Depth

- MSE 250B Project Course in Engineering Risk Analysis
or MSE 452 Decision Analysis Projects: Helping Real Leaders Make Real Decisions
MSE 353 Decision Analysis III: Frontiers of Decision Analysis

Students are expected to complete a yearly plan, of no more than two typed pages in length, detailing the student's plans for the next year in terms of education (e.g., courses and seminars), research (e.g., RAships), and teaching (e.g., TAships). This plan should be provided to the students' academic advisor for review no later than May 15 each calendar year.

Policy and Strategy Qualifying Procedure
Advancement to Ph.D. candidacy will be determined at the end of the student's second year of studies. It will be based on the following three components:

1. the student's overall grade point average in the program (a GPA of 3.5 or higher is required);
2. a second-year research paper that is written by the student under the supervision of a faculty member, and that is presented to examining faculty members in the second year;
3. a written and an oral qualifying examination taken by the student in the spring quarter of the second year.

Production and Operations Management
Foundation courses (may be waived based on prior coursework):

MSE 211 Linear and Nonlinear Optimization
MSE 241 Economic Analysis
or ECON 202N Microeconomics I For Non-Economics PhDs
MSE 260 Introduction to Operations Management
or MSE 261 Inventory Control and Production Systems

Methodology courses (all):

MSE 221 Stochastic Modeling
or STATS 217 Introduction to Stochastic Processes
MSE 223 Simulation
or STATS 362 Topic: Monte Carlo
MSE 251 Stochastic Control
or MSE 351 Dynamic Programming and Stochastic Control
MSE 311 Optimization
or EE 364A Convex Optimization I
MSE 321 Stochastic Systems
MSE 335 Queueing and Scheduling in Processing Networks
ECON 203N Microeconomics II For Non-Economics PhDs

OM research courses (any four):

MSE 336 Platform and Marketplace Design
MSE 365 Advanced Models in Operations Management
Faculty-approved GSB OIT Ph.D. courses (about six are offered every two years).

Ph.D. Minor in Management Science and Engineering

Students pursuing a Ph.D. in another department who wish to receive a Ph.D. minor in Management Science and Engineering should consult the MS&E student services office. A minor in MS&E may be obtained by completing 20 units of approved graduate-level MS&E courses, of which at least 6 units must be at the 300-level. Courses approved for the minor must form a coherent program, and must include one course from at least three of the eleven MS&E Master of Science core options. The program must include a minimum of 16 letter-graded units, and a minimum grade point average of 3.3 must be achieved in these courses.


Chair: Peter W. Glynn


Associate Professors: Samuel S. Chiu, Kay Giesecke, Ramesh Johari, Amin Saberi, Ross D. Shachter, Edison T. S. Tse

Assistant Professors: Itai Ashlagi, Charles E. Eesley, Sharad Goel, Markus Pelger, Johan Ugander, Melissa A. Valentine

Professors (Research): Siegfried S. Hecker, Walter Murray, Michael A. Saunders, John P. Weyant

Professors (Teaching): Thomas H. Byers, Robert E. McGinn

Professor of the Practice: Tina L. Seelig


Consulting Professors: Peter J. Haas, Gerd Infanger, Burke Robinson, James E. Matheson, Sam Savage, Behnam N. Tabrizi

Consulting Associate Professors: Steve Blank, Michael G. Lyons, Audrey MacLean, Jan B. Pietzsch, F. Victor Stanton, Peter Woehrmann

Consulting Assistant Professors: Blake Johnson

Visiting Professor: Olivier de la Grandville

Visiting Associate Professor: Irad Ben Gal

Director of the Industrial Affiliates Program: Yinyu Ye

Courses

MSE 20, Discrete Probability Concepts And Models. 4 Units.
Concepts and tools for the analysis of problems under uncertainty, focusing on structuring, model building, and analysis. Examples from legal, social, medical, and physical problems. Topics include axioms of probability, probability trees, belief networks, random variables, conditioning, and expectation.

MSE 22Q, The Flaw of Averages. 3 Units.
Uncertain assumptions in business and public policy are often replaced with single iquest;best guessiquest; or average numbers. This leads to a fallacy as fundamental as the belief that the earth is flat, which I call the Flaw of Averages. It states, in effect, that plans based on average assumptions are wrong on average. This class will discuss mitigations of the flaw of averages using simulation and other methods from probability management.

MSE 41, Financial Literacy. 1 Unit.
Practical knowledge about personal finance and money management including budgeting, pay checks, credit cards, banking, insurance, taxes, and saving. Class especially appropriate for those soon to be self-supporting. Limited enrollment. Admission by order of enrollment in Axess.
MSE 52. Introduction to Decision Making. 3 Units.
How to ensure focus, discipline, and passion when making important decisions. Comprehensive examples illustrate Decision Analysis fundamentals. Consulting case studies highlight practical solutions for real decisions. Student teams present insights from their analyses of decisions for current organizations. Topics: declaring when and how to make a decision, framing and structuring the decision basis, defining values and preferences, creating alternative strategies, assessing unbiased probabilistic judgments, developing appropriate risk/reward and portfolio models, evaluating double strategies across the range of uncertain future scenarios, analyzing relevant sensitivities, determining the value of additional information, and addressing the qualitative aspects of communication and commitment to implementation. Not intended for MS&E majors.

MSE 92Q. International Environmental Policy. 3 Units.
Preference to sophomores. Science, economics, and politics of international environmental policy. Current negotiations on global climate change, including actors and potential solutions. Sources include briefing materials used in international negotiations and the U.S. Congress.

MSE 93Q. Nuclear Weapons, Energy, Proliferation, and Terrorism. 3 Units.
Preference to sophomores. At least 20 countries have built or considered building nuclear weapons. However, the paths these countries took in realizing their nuclear ambitions vary immensely. Why is this the case? How do the histories, cultures, national identities, and leadership of these countries affect the trajectory and success of their nuclear programs? This seminar will address these and other questions about nuclear weapons and their proliferation. Students will learn the fundamentals of nuclear technology, including nuclear weapons and nuclear energy, and be expected to use this knowledge in individual research projects on the nuclear weapons programs of individual countries. Case studies will include France, UK, China, India, Israel, Pakistan, North Korea, South Africa, Libya, Iraq, and Iran, among others. Please note any language skills in your application. Recommended: 193 or 293.

MSE 101. Undergraduate Directed Study. 1-15 Unit.
Subject of mutual interest to student and faculty member. Prerequisite: faculty sponsor.

MSE 101A. Undergraduate Directed Study. 1-4 Unit.
Subject of mutual interest to student and mentor.

MSE 107. Interactive Management Science. 3 Units.
Analytical techniques such as linear and integer programming, Monte Carlo simulation, forecasting, decision analysis, and Markov chains in the environment of the spreadsheet. Probability management. Materials include spreadsheet add-ins for implementing these and other techniques. Emphasis is on building intuition through interactive modeling, and extending the applicability of this type of analysis through integration with existing business data structures. Same as: MSE 207

MSE 108. Senior Project. 5 Units.
Restricted to MS&EE majors in their senior year. Students carry out a major project in groups of four, applying techniques and concepts learned in the major. Project work includes problem identification and definition, data collection and synthesis, modeling, development of feasible solutions, and presentation of results. Service Learning Course (certified by Haas Center).

MSE 111. Introduction to Optimization. 4 Units.
Formulation and analysis of linear optimization problems. Solution using Excel solver. Polyhedral geometry and duality theory. Applications to contingent claims analysis, production scheduling, pattern recognition, two-player zero-sum games, and network flows. Prerequisite: CME 100 or MATH 51.
Same as: ENGR 62

MSE 112. Mathematical Programming and Combinatorial Optimization. 3 Units.
Combinatorial and mathematical programming (integer and non-linear) techniques for optimization. Topics: linear program duality and LP solvers; integer programming; combinatorial optimization problems on networks including minimum spanning trees, shortest paths, and network flows; matching and assignment problems; dynamic programming; linear approximations to convex programs; NP-completeness. Hands-on exercises. Prerequisites: 111 or MATH 103, CS 106A or X.
Same as: MSE 212

MSE 120. Probabilistic Analysis. 5 Units.
Concepts and tools for the analysis of problems under uncertainty, focusing on focusing on structuring, model building, and analysis. Examples from legal, social, medical, and physical problems. Topics include axioms of probability, probability trees, random variables, distributions, conditioning, expectation, change of variables, and limit theorems. Prerequisite: CME 100 or MATH 51.

MSE 121. Introduction to Stochastic Modeling. 4 Units.
Stochastic processes and models in operations research. Discrete and continuous time parameter Markov chains. Queuing theory, inventory theory, simulation. Prerequisite: 120, 125, or equivalents.

MSE 125. Introduction to Applied Statistics. 4 Units.
An increasing amount of data is now generated in a variety of disciplines, ranging from finance and economics, to the natural and social sciences. Making use of this information, however, requires both statistical tools and an understanding of how the substantive scientific questions should drive the analysis. In this hands-on course, we learn to explore and analyze real-world datasets. We cover techniques for summarizing and describing data, methods for statistical inference, and principles for effectively communicating results. Prerequisite: 120, CS 106A, or equivalents.

MSE 130. Information Networks and Services. 3 Units.

MSE 135. Networks. 3 Units.
This course provides an introduction to how networks underly our social, technological, and natural worlds, with an emphasis on developing intuitions for broadly applicable concepts in network analysis. The course will include: an introduction to graph theory and graph concepts; social networks; information networks; the aggregate behavior of markets and crowds; network dynamics; information diffusion; the implications of popular concepts such as "six degrees of separation", the "friendship paradox", and the "wisdom of crowds".

MSE 140. Accounting for Managers and Entrepreneurs. 3-4 Units.
Non-majors and minors who have taken or are taking elementary accounting should not enroll. Introduction to accounting concepts and the operating characteristics of accounting systems. The principles of financial and cost accounting; design of accounting systems, techniques of analysis, and cost control. Interpretation and use of accounting information for decision making. Designed for the user of accounting information and not as an introduction to a professional accounting career. Enrollment limited. Admission by order of enrollment. Same as: MSE 240
MSE 140X. Financial Accounting Concepts and Analysis. 2 Units.
Introduction course in financial accounting. Accounting is referred to as the language of business. Developing students ability to read, understand, and use business financial statements. Understanding the mapping between the underlying economic events and financial statements, and how this mapping can affect inferences about future firm profitability. Introduction to measuring and reporting of the operating cycle; the process of preparing and presenting primary financial statements; the judgment involved and discretion allowed in making accounting choices; the effects of accounting discretion on the quality of the reported financial information; and the fundamentals of financial statement analysis. Class time will be allocated to a combination of lectures, cases and discussions of cases. Capstone project analyzing a company's financials at the end of the quarter. Enrollment limited. Admission by order of enrollment.

MSE 145. Introductory Financial Analysis. 3 Units.
Formerly MS&E 142. Evaluation and management of money, complicated by temporary distributions and uncertainty. The "time-value of money" and its impact on economic decisions (both personal and corporate) with the introduction of interest rate (constant or varying over time); several approaches critically examined and made consistent as suitable metrics of comparison. The concept of investment diversification in the presence of uncertainty; portfolio selection and efficient frontier analysis leading to the formulation of the Capital Asset Pricing Model; practical implementation of the concepts, including comparison of loan (e.g., house and auto) terms, credit card financial terms, interest rate term structure and its relationship to rate-of-return analysis, and graphical presentation of uncertain investment alternatives; and current economic news of interest. Critical thinking, discussion, and interaction, using group and computer labs assignments. Prerequisites: 111, 120, CME 100 or MATH 51, or equivalents.

MSE 146. Corporate Financial Management. 4 Units.
Key functions of finance in both large and small companies, and the core concepts and key analytic tools that provide their foundation. Making financing decisions, evaluating investments, and managing cashflow, profitability and risk. Designing performance metrics to effectively measure and align the activities of functional groups and individuals within the firm. Structuring relationships with key customers, partners and suppliers. Prerequisite: 145, 245A, 245G or equivalent.

MSE 152. Introduction to Decision Analysis. 3-4 Units.
How to make good decisions in a complex, dynamic, and uncertain world. People often make decisions that on close examination they regard as wrong. Decision analysis uses a structured conversation based on actionable thought to obtain clarity of action in a wide variety of domains. Topics: distinctions, possibilities and probabilities, relevance, value of information and experimentation, relevance and decision diagrams, risk attitude. Students seeking to fulfill the Writing in the Major requirement should register for MS&E 152W.

MSE 152W. Introduction to Decision Analysis. 3-4 Units.
How to make good decisions in a complex, dynamic, and uncertain world. People often make decisions that on close examination they regard as wrong. Decision analysis uses a structured conversation based on actionable thought to obtain clarity of action in a wide variety of domains. Topics: distinctions, possibilities and probabilities, relevance, value of information and experimentation, relevance and decision diagrams, risk attitude. Students seeking to fulfill the Writing in the Major requirement should register for MS&E 152W.

MSE 174. Social Entrepreneurship Collaboratory. 4 Units.
Interdisciplinary student teams create and develop U.S. and international social entrepreneurship initiatives. Proposed initiatives may be new entities, or innovative projects, partnerships, and/or strategies impacting existing organizations and social issues in the U.S. and internationally. Focus is on each team's research and on planning documents to further project development. Project development varies with the quarter and the skill set of each team, but should include: issue and needs identification; market research; design and development of an innovative and feasible solution; and drafting of planning documents. In advanced cases, solicitation of funding and implementation of a pilot project. Enrollment limited to 20. May be repeated for credit. Prerequisites: 131 and 132, or consent of instructor. 

MSE 175. Innovation, Creativity, and Change. 3-4 Units.
Problem solving in organizations; creativity and innovation skills; thinking tools; creative organizations, teams, individuals, and communities. Limited enrollment. (Katila).

MSE 177. Creativity Rules. 4 Units.
This experiential course explores a wide array of tools that are used to enhance innovation and how those tools are applied across engineering disciplines. Using workshops, demonstrations, and field trips, students will learn how creative problem solving is deployed across engineering fields and, in partnership with the Stanford Virtual Human Interaction Lab, expand their own creative problem solving skills with virtual reality experiences that stretch their imagination. Limited enrollment. Admission by application.

MSE 178. The Spirit of Entrepreneurship. 3 Units.
Is there more to entrepreneurship than inventing the better mouse trap? This course uses the speakers from the Entrepreneurial Thought Leader seminar (MS&E472) to drive research and discussion about what makes an entrepreneur successful. Topics include venture financing, business models, and interpersonal dynamics in the startup environment. Students meet before and after MS&E 472 to prepare for and debrief after the sessions. Enrollment limited to 50 students. Please submit Autumn course application at http://goo.gl/forms/0O61GT11nY by 6pm on Monday, September 21, 2015.

MSE 180. Organizations: Theory and Management. 4 Units.
For undergraduates only; preference to MS&E majors. Classical and contemporary organization theory; the behavior of individuals, groups, and organizations. Limited enrollment. Admission by application. Students must attend first session.

MSE 181. Issues in Technology and Work for a Postindustrial Economy. 3 Units.
How changes in technology and organization are altering work and lives. Approaches to studying and designing work. How understanding work and work practices can assist engineers in designing better technologies and organizations. Topics include job design, distributed and virtual organizations, the blurring of boundaries between work and family life, computer supported cooperative work, trends in skill requirements and occupational structures, monitoring and surveillance in the workplace, downsizing and its effects on work systems, project work and project-based lifestyles, the growth of contingent employment, telecommuting, electronic commerce, and the changing nature of labor relations. Enrollment limited to 50 students. Preference to MS&E, STS, and CEE seniors, followed by MS&E, STS, and CEE juniors.

MSE 183. Leadership in Action. 3 Units.
Leadership in action is designed with a significant lab component in which students will be working on leadership projects throughout the quarter. The projects will provide students with hands on experience trying out new leadership behaviors in a variety of situations, along with the opportunity to reflect on these experiences and, in turn, expand their leadership skills. Limited enrollment. Please submit course application at http://goo.gl/forms/0O61GT11nY by 6pm on Monday, September 21, 2015.
MSE 185. Global Work. 4 Units.
Issues, challenges, and opportunities facing workers, teams, and organizations working across national boundaries. Topics include geographic distance, time zones, language and cultural differences, technologies to support distant collaboration, team dynamics, and corporate strategy. Limited enrollment. Admission by application. Recommended: 180.

MSE 189. Social Networks - Theory, Methods, and Applications. 3 Units.
Introduces students to the theoretical, substantive, and methodological foundations of social networks. The social network paradigm seeks to explain how social relations facilitate and constrain an actor's opportunities, behaviors, and cognitions. Topics include: network concepts and principles; network data collection, measurement, and analysis; and applications in management, engineering, and related disciplines.

MSE 190. Methods and Models for Policy and Strategy Analysis. 3 Units.
Guest lectures by departmental practitioners. Emphasis is on links among theory, application, and observation. Environmental, national security, and health policy; marketing, new technology, and new business strategy analyses. Comparisons between domains and methods.

MSE 193. Technology and National Security. 3 Units.
The interaction of technology and national security policy from the perspective of history to implications for the new security imperative, homeland defense. Key technologies in nuclear and biological weapons, military platforms, and intelligence gathering. Policy issues from the point of view of U.S. and other nations. The impact of terrorist threat. Guest lecturers include key participants in the development of technology and/or policy.
Same as: MSE 293

MSE 197. Ethics, Technology, and Public Policy. 5 Units.
Ethical issues in science- and technology-related public policy conflicts. Focus is on complex, value-laden policy disputes. Topics: the nature of ethics and morality; rationales for liberty, justice, and human rights; and the use and abuse of these concepts in policy disputes. Case studies from biomedicine, environmental affairs, technical professions, communications, and international relations.

MSE 201. Dynamic Systems. 3-4 Units.
Goal is to think dynamically in decision making, and recognize and analyze dynamic phenomena in diverse situations. Concepts: formulation and analysis; state-space formulation; solutions of linear dynamic systems, equilibria, dynamic diagrams; eigenvalues and eigenvectors of linear systems, the concept of feedback; nonlinear dynamics, phase plane analysis, linearized analysis, Liapunov functions, catastrophe theory. Examples: grabber-holder dynamics, technology innovation dynamics, creation of new game dynamics in business competition, ecosystem dynamics, social dynamics, and stochastic exchange dynamics. Prerequisite: CME 100 or MATH 51 or equivalent.

MSE 207. Interactive Management Science. 3 Units.
Analytical techniques such as linear and integer programming, Monte Carlo simulation, forecasting, decision analysis, and Markov chains in the environment of the spreadsheet. Probability management. Materials include spreadsheet add-ins for implementing these and other techniques. Emphasis is on building intuition through interactive modeling, and extending the applicability of this type of analysis through integration with existing business data structures.
Same as: MSE 107

MSE 208A. Practical Training. 1 Unit.
MS&E students obtain employment in a relevant industrial or research activity to enhance professional experience, consistent with the degree program they are pursuing. Students submit a statement showing relevance to degree program along with offer letter to the Student Services Office before the start of the quarter, and a 2-3 page final report documenting the work done and relevance to degree program at the conclusion of the quarter. Students may take each of A, B, and C once.

MSE 208B. Practical Training. 1 Unit.
MS&E students obtain employment in a relevant industrial or research activity to enhance professional experience, consistent with the degree program they are pursuing. Students submit a statement showing relevance to degree program along with offer letter to the Student Services office before the start of the quarter, and a 2-3 page final report documenting the work done and relevance to degree program at the conclusion of the quarter. Students may take each of A, B, and C once.

MSE 208C. Practical Training. 1 Unit.
MS&E students obtain employment in a relevant industrial or research activity to enhance professional experience, consistent with the degree program they are pursuing. Students submit a statement showing relevance to degree program along with offer letter to the Student Services office before the start of the quarter, and a 2-3 page final report documenting the work done and relevance to degree program at the conclusion of the quarter. Students may take each of A, B, and C once, and may petition to take D.

MSE 211. Linear and Nonlinear Optimization. 3-4 Units.
Optimization theory and modeling. The role of prices, duality, optimality conditions, and algorithms in finding and recognizing solutions. Perspectives: problem formulation, analytical theory, computational methods, and recent applications in engineering, finance, and economics. Theories: finite dimensional derivatives, convexity, optimality, duality, and sensitivity. Methods: simplex and interior-point, gradient, Newton, and barrier. Prerequisite: CME 100 or MATH 51.

MSE 212. Mathematical Programming and Combinatorial Optimization. 3 Units.
Combinatorial and mathematical programming (integer and non-linear) techniques for optimization. Topics: linear program duality and LP solvers; integer programming; combinatorial optimization problems on networks including minimum spanning trees, shortest paths, and network flows; matching and assignment problems; dynamic programming; linear approximations to convex programs; NP-completeness. Hands-on exercises. Prerequisites: 111 or MATH 103, CS 106A or X. Same as: MSE 112

MSE 220. Probabilistic Analysis. 3-4 Units.
Concepts and tools for the analysis of problems under uncertainty, focusing on model building and communication: the structuring, processing, and presentation of probabilistic information. Examples from legal, social, medical, and physical problems. Spreadsheets illustrate and solve problems as a complement to analytical closed-form solutions. Topics: axioms of probability, probability trees, random variables, distributions, conditioning, expectation, change of variables, and limit theorems. Prerequisite: CME 100 or MATH 51. Recommended: knowledge of spreadsheets.

MSE 221. Stochastic Modeling. 3 Units.
Focus is on time-dependent random phenomena. Topics: discrete and continuous time Markov chains, renewal processes, queuing theory, and applications. Emphasis is on building a framework to formulate and analyze probabilistic systems. Prerequisite: 220 or consent of instructor.
MSE 223. Simulation. 3 Units.
Discrete-event systems, generation of uniform and non-uniform random numbers, Monte Carlo methods, programming techniques for simulation, statistical analysis of simulation output, efficiency-improvement techniques, decision making using simulation, applications to systems in computer science, engineering, finance, and operations research. Prerequisites: working knowledge of a programming language such as C, C++, Java, Python, or FORTRAN; calculus-base probability; and basic statistical methods.

MSE 226. "Small" Data. 3 Units.
This course is about understanding "small data": these are datasets that allow interaction, visualization, exploration, and analysis on a local machine. The material provides an introduction to applied data analysis, with an emphasis on providing a conceptual framework for thinking about data from both statistical and machine learning perspectives. Topics will be drawn from the following list, depending on time constraints and class interest: approaches to data analysis: statistics (frequentist, Bayesian) and machine learning; binary classification; regression; bootstrapping; causal inference and experimental design; time series modeling. Class lectures will be supplemented by data-driven problem sets and a project. Prerequisites: CME 100 or MATH 51; 120, 220 or STATS 116; experience with R at the level of CME/STATS 195 or equivalent.

MSE 231. Introduction to Computational Social Science. 3 Units.
With a vast amount of data now collected on our online and offline actions -- from what we buy, to where we travel, to who we interact with -- we have an unprecedented opportunity to study complex social systems. This opportunity, however, comes with scientific, engineering, and ethical challenges. In this hands-on course, we develop ideas from computer science and statistics to address problems in sociology, economics, political science, and beyond. We cover techniques for collecting and parsing data, methods for large-scale machine learning, and principles for effectively communicating results. To see how these techniques are applied in practice, we discuss recent research findings in a variety of areas. Prerequisites: introductory course in applied statistics, and experience coding in R, Python, or another high-level language.
Same as: SOC 329

MSE 233. Networked Markets. 3 Units.
An introduction to economic analysis for modern online services and systems. Topics include: Examples of networked markets. Online advertising. Recommendation and reputation systems. Pricing digital media. Network effects and network externalities. Social learning and herd behavior. Markets and information. Prerequisites: CME 100 or MATH 51, and probability at the level of MS&E 220 or equivalent. No prior economics background will be assumed; requisite concepts will be introduced as needed.

MSE 235. Analytics in Action. 3 Units.
Examines the role of analytics in real-world solutions across different industries. Provides a short introduction on the main concepts of analytics, and addresses common modeling approaches for both supervised (e.g., regression and classification) and unsupervised techniques (e.g., clustering, anomaly detection and pattern recognition), using platforms such as Hadoop and R. Discussion of implementations of these models in various industries, such as manufacturing, retail, banking, marketing, telecom and security. Teams of students will be required to prepare and present an analytics use case, covering aspects related to data collection, pre-processing, modeling, analyses, visualization, recommendations, implementation, business value and ROI. Students will be expected to come prepared to class, ready to discuss the case at hand, and offer their thoughts and insights. Cases will be presented in the context of leading a data science team, much as a Chief Analytics Officer (CAO) would be expected to do. Prerequisite: 226, CME 195, or equivalents.

MSE 237. Spectral Graph Theory and Algorithmic Applications. 3 Units.
Brings students to the forefront of a very active area of research. Reviews classic results relating graph expansion and spectra, random walks, random spanning trees, and their electrical network representation. Covers recent progress on graph sparsification, Kadison-Singer problem and approximation algorithms for traveling salesman problems.
Same as: CME 337

MSE 238. Leading Trends in Information Technology. 3 Units.
Focuses on new trends and disruptive technologies in IT. Emphasis on the way technologies create a competitive edge and generate business value. Broad range of views presented by guest speakers, including top level executives of technology companies, and IT executives (e.g. CIOs) of Fortune 1000 companies. Special emphasis in technologies such as Virtualization, Cloud Computing, Security, Mobility and Unified Communications.

MSE 238A. Leading Trends in Information Technology. 1 Unit.
Focuses on new trends and disruptive technologies in IT. Emphasis on the way technologies create a competitive edge and generate business value. Broad range of views presented by guest speakers, including top level executives of technology companies, and IT executives (e.g. CIOs) of Fortune 1000 companies. Special emphasis in technologies such as Virtualization, Cloud Computing, Security, Mobility and Unified Communications.

MSE 240. Accounting for Managers and Entrepreneurs. 3-4 Units.
Non-majors and minors who have taken or are taking elementary accounting should not enroll. Introduction to accounting concepts and the operating characteristics of accounting systems. The principles of financial and cost accounting, design of accounting systems, techniques of analysis, and cost control. Interpretation and use of accounting information for decision making. Designed for the user of accounting information and not as an introduction to a professional accounting career. Enrollment limited. Admission by order of enrollment.
Same as: MSE 140

MSE 241. Economic Analysis. 3-4 Units.
Principal methods of economic analysis of the production activities of firms, including production technologies, cost and profit, and perfect and imperfect competition; individual choice, including preferences and demand; and the market-based system, including price formation, efficiency, and welfare. Practical applications of the methods presented. Recommended: 211, ECON 50.

MSE 243. Energy and Environmental Policy Analysis. 3 Units.
Concepts, methods, and applications. Energy/environmental policy issues such as automobile fuel economy regulation, global climate change, research and development policy, and environmental benefit assessment. Group project. Prerequisite: MS&E 241 or ECON 50, 51.

MSE 244. Economic Growth and Development. 3 Units.
Formerly 249. What generates economic growth. Emphasis is on theory accompanied by intuition, illustrated with country cases. Topics: the equation of motion of an economy; optimal growth theory; calculus of variations and optimal control approaches; deriving the Euler and Pontriaguine equations from economic reasoning. Applications: former planned economies in Russia and E. Europe; the present global crisis: causes and consequences; a comparative study of India and China. The links between economic growth and civilization; the causes of the rise and decline of civilizations; lessons for the future. Intended for graduate students. Prerequisite: multivariate calculus and permission of instructor. To receive permission, submit an application at http://web.stanford.edu/~lcottle/forms/244app.fb.
MSE 245A. Investment Science. 3 Units.
Formerly MS&E 242. Introduction to the basic concepts of modern quantitative finance and investments. Focus is on basic principles and how they are applied in practice. Topics: basic interest rates; evaluating investments: present value and internal rate of return; fixed-income markets: bonds, yield, duration, portfolio immunization; term structure of interest rates; measuring risk: volatility and value at risk; designing optimal security portfolios; the capital asset pricing model. Group projects involving financial market data. No prior knowledge of finance required. Appropriate for engineering or science students wishing to apply their quantitative skills to develop a basic understanding of financial modeling and markets. Prerequisite: basic preparation in probability, statistics, and optimization.

MSE 245B. Advanced Investment Science. 3 Units.
Formerly MS&E 342. Topics: forwards and futures contracts, continuous and discrete time models of stock price behavior, geometric Brownian motion, Ito's lemma, basic options theory, Black-Scholes equation, advanced options techniques, models and applications of stochastic interest rate processes, and optimal portfolio growth. Computational issues and general theory. Teams work on independent projects. Prerequisite: 245A.

MSE 245G. Finance for Non-MBAs. 3 Units.
For graduate students and advanced undergraduates. The foundations of finance; applications in corporate finance and investment management. Financial decisions made by corporate managers and investors with focus on process valuation. Topics include criteria for investment decisions, valuation of financial assets and liabilities, relationships between risk and return, market efficiency, and the valuation of derivative securities. Corporate financial instruments including debt, equity, and convertible securities. Equivalent to core MBA finance course, FINANCE 220. Prerequisites: ECON 50, ECON 102A, or equivalents; ability to use spreadsheets, and basic probability and statistics concepts including random variables, expected value, variance, covariance, and simple estimation and regression.
Same as: ECON 135

MSE 246. Financial Risk Analytics. 3 Units.
Practical introduction to financial risk analytics, focusing on data-driven modeling, computation, and statistical estimation of credit and market risks. Case studies based on real data will be emphasized. Topics include mortgage risk, asset-backed securities, commercial lending, consumer delinquencies, crowd funding, transactions analytics, derivatives risk. Tools from machine learning and statistics will be developed. Data sources will be discussed. Intended to enable students to design and implement risk analytics tools in practice. Prerequisite: 245A or similar, some background in probability and statistics, working knowledge of R, Matlab, or similar computational/statistical package.

MSE 250A. Engineering Risk Analysis. 3 Units.
The techniques of analysis of engineering systems for risk management decisions involving trade-offs (technical, human, environmental aspects). Elements of decision analysis; probabilistic risk analysis (fault trees, event trees, systems dynamics); economic analysis of failure consequences (human safety and long-term economic discounting); and case studies such as space systems, nuclear power plants, and medical systems. Public and private sectors. Prerequisites: probability, decision analysis, stochastic processes, and convex optimization.

MSE 250B. Project Course in Engineering Risk Analysis. 3 Units.
Students, individually or in groups, choose, define, formulate, and resolve a real risk management problem, preferably from a local firm or institution. Oral presentation and report required. Scope of the project is adapted to the number of students involved. Three phases: risk assessment, communication, and management. Emphasis is on the use of probability for the treatment of uncertainties and sensitivity to problem boundaries. Limited enrollment. Prerequisites: MS&E 250A and consent of instructor.

MSE 251. Stochastic Control. 3 Units.
Introduction to stochastic control, with applications taken from a variety of areas including supply-chain optimization, advertising, finance, dynamic resource allocation, caching, and traditional automatic control. Markov decision processes, optimal policy with full state information for finite-horizon case, infinite-horizon discounted, and average stage cost problems. Bellman value function, value iteration, and policy iteration. Approximate dynamic programming. Linear quadratic stochastic control. Formerly EE365. Prerequisites: EE 263, EE 178 or equivalent.
Same as: EE 266

MSE 252. Decision Analysis I: Foundations of Decision Analysis. 3-4 Units.
Coherent approach to decision making, using the metaphor of developing a structured conversation having desirable properties, and producing actionable thought that leads to clarity of action. Socratic instruction; computational problem sessions. Emphasis is on creation of distinctions, representation of uncertainty by probability, development of alternatives, specification of preference, and the role of these elements in creating a normative approach to decisions. Information gathering opportunities in terms of a value measure. Relevance and decision diagrams to represent inference and decision. Principles are applied to decisions in business, technology, law, and medicine. See 352 for continuation.

MSE 254. The Ethical Analyst. 1-3 Unit.
The ethical responsibility for consequences of professional analysts who use technical knowledge in support of any individual, organization, or government. The means to form ethical judgments; questioning the desirability of physical coercion and deception as a means to reach any end. Human action and relations in society in the light of previous thought, and research on the desired form of social interactions. Attitudes toward ethical dilemmas through an explicit personal code.

MSE 256. Technology Assessment and Regulation of Medical Devices. 3 Units.
(Formerly 475.) Regulatory approval and reimbursement for new medical technologies as a key component of product commercialization. The regulatory and payer environment in the U.S. and abroad, and common methods of health technology assessment. Framework to identify factors relevant to adoption of new medical devices, and the management of those factors in the design and development phases. Case studies; guest speakers from government (FDA) and industry.

MSE 256A. Technology Assessment and Regulation of Medical Devices. 1 Unit.
Regulatory approval and reimbursement for new medical technologies as a key component of product commercialization. The regulatory and payer environment in the U.S. and abroad, and common methods of health technology assessment. Framework to identify factors relevant to adoption of new medical devices, and the management of those factors in the design and development phases. Case studies; guest speakers from government (FDA) and industry.

MSE 257. Healthcare Reforms and Value-Based Biomedical Technology Innovation. 3 Units.
A fundamental transformation of the healthcare system is underway in which policymakers, payers and administrators are intensely focused on new policy mechanisms designed to constrain healthcare costs while promoting quality, outcomes and value. This class evaluates healthcare reforms in the U.S. and abroad with specific focus on examining their impact on the biomedical technology innovation process. Lectures and case studies, guest speakers from health plans, providers, and the medical technology industry perspectives. Students investigate real-world technology innovations in projects.
MSE 260. Introduction to Operations Management. 3 Units.
Operations management focuses on the effective planning, scheduling, and control of manufacturing and service entities. This course introduces students to a broad range of key issues in operations management. Topics include determination of optimal facility location, production planning, optimal timing and sizing of capacity expansion, and inventory control. Prerequisites: basic knowledge of Excel spreadsheets, probability, and optimization.

MSE 261. Inventory Control and Production Systems. 3 Units.
Topics in the planning and control of manufacturing systems. The functions of inventory, determination of order quantities and safety stocks, alternative inventory replenishment systems, item forecasting, production-inventory systems, materials requirements planning (MRP), just-in-time systems, master and operations scheduling, supply chain management, and service operations. Limited enrollment. Prerequisite: 120, or STATS 116, or equivalent.

MSE 262. Supply Chain Management. 3 Units.
Definition of a supply chain; coordination difficulties; pitfalls and opportunities in supply chain management; inventory/service tradeoffs; performance measurement and incentives. Global supply chain management; mass customization; supplier management. Design and redesign of products and processes for supply chain management; tools for analysis; industrial applications; current industry initiatives. Enrollment limited to 50. Admission determined in the first class meeting. Prerequisite: 260 or 261.

MSE 263. Healthcare Operations Management. 3 Units.
With healthcare spending in the US exceeding 17% of GDP and growing, improvements in the quality and efficiency of healthcare services are urgently needed. This class focuses on the use of analytical tools to support efficient and effective delivery of health care. Topics include quality control and management, capacity planning, resource allocation, management of patient flows, and scheduling. Prerequisites: basic knowledge of Excel spreadsheets, probability, and optimization.

MSE 264. Sustainable Product Development and Manufacturing. 3-4 Units.
For SCPD students only in 2014; not offered on-campus. Strategies and techniques for development of sustainable products and manufacturing processes. Topics: strategic decisions in new product development when environmental and resource externalities are accounted for; effect of regulatory requirements on ability of a firm to achieve its business objectives; contributions of sustainable products/processes to the firm's competitive advantage and operational efficiency and to enabling entrepreneurial opportunities; industrial ecology and life cycle analysis techniques in integrating traditional product development requirements with those of the environment and society. May be repeatable for credit once.

MSE 268. Operations Strategy. 3 Units.
The development and implementation of the operations functional strategy. The integration of operations strategy with business and corporate strategies of a manufacturing-based firm. Topics: types and characteristics of manufacturing technologies, quality management, capacity planning and facilities choice, organization and control of operations, and operations' role in corporate strategy. Prerequisites: 260 or 261, or equivalent experience.

MSE 270. Strategy in Technology-Based Companies. 3-4 Units.
For graduate students only. Introduction to the basic concepts of strategy, with emphasis on high technology firms. Topics: competitive positioning, resource-based perspectives, co-creation and standards setting, and complexity/evolutionary perspectives. Limited enrollment.

MSE 271. Global Entrepreneurial Marketing. 3-4 Units.
Skills needed to market new technology-based products to customers around the world. Case method discussions. Cases include startups and global high tech firms. Course themes: marketing toolkit, targeting markets and customers, product marketing and management, partners and distribution, sales and negotiation, and outbound marketing. Team-based take-home final exam. Limited enrollment. Admission by application.

MSE 272. Startup Boards. 3 Units.
Accelerate your startup through hands-on guidance from your own "board of directors" comprised of venture capitalists and experienced entrepreneurs. Like real startup boards, your board will help you identify critical milestones, assist in achieving them, and hold your team accountable through regular board meetings. Learn how to avoid common mistakes that lead to ineffective board meetings, fired CEOs, and startup failures. Experience the other side of the table as a board member for another startup and learn the principles of effective board services. Topics include building boards, managing board meetings, making strategic decisions, executing board responsibilities, and replacing CEOs. Limited enrollment. Admission by application. Preference given to teams with demonstrated commitment to a viable startup business.

MSE 273. Technology Venture Formation. 3-4 Units.
Open to graduate students interested in technology driven start-ups. Provides the experience of an early-stage entrepreneur seeking initial investment, including: team building, opportunity assessment, customer development, go-to-market strategy, and IP. Teaching team includes serial entrepreneurs and venture capitalists. Student teams validate the business model using R&D plans and financial projections, and define milestones for raising and using venture capital. Final exam is an investment pitch delivered to a panel of top tier VC partners. In addition to lectures, teams interact with mentors and teaching team weekly. Enroll by application: http://www.stanford.edu/class/msande273. Recommended: 270, 271, or equivalent.

MSE 274. Dynamic Entrepreneurial Strategy. 3 Units.
Primarily for graduate students. How entrepreneurial strategy focuses on creating structural change or responding to change induced externally. Grabber-holder dynamics as an analytical framework for developing entrepreneurial strategy to increase success in creating and shaping the diffusion of new technology or product innovation dynamics. Topics: First mover versus follower advantage in an emerging market; latecomer advantage and strategy in a mature market; strategy to break through stagnation; and strategy to turn danger into opportunity. Modeling, case studies, and term project.

MSE 275. Foundations for Large-Scale Entrepreneurship. 3 Units.
Explore the foundational and strategic elements needed for startups to be designed for “venture scale” at inception. Themes include controversial and disruptive insights, competitive analysis, network effects, organizational design, and capital deployment. Case studies, expert guests, and experiential learning projects will be used. Primarily for graduate students. Limited enrollment. Recommended: basic accounting.
MSE 276. Entrepreneurial Management and Finance. 3 Units.
For graduate students only, with a preference for engineering and science majors. Emphasis on managing high-growth, early-stage enterprises, especially those with innovation-based products and services. Students work in teams to develop skills and approaches necessary to becoming effective entrepreneurial leaders and managers. Topics include assessing risk, understanding business models, analyzing key operational metrics, modeling cash flow and capital requirements, evaluating sources of financing, structuring and negotiating investments, managing organizational culture and incentives, managing the interplay between ownership and growth, and handling adversity and failure. Limited enrollment. Admission by application. Recommended: basic accounting.

MSE 277. Creativity and Innovation. 3-4 Units.
Experiential course explores factors that promote and inhibit creativity and innovation in individuals, teams, and organizations. Teaches creativity tools using workshops, case studies, field trips, expert guests, and team design challenges. Enrollment limited to 40. Admission by application. See http://stvp.stanford.edu/classes.

MSE 278. Patent Law and Strategy for Innovators and Entrepreneurs. 2-3 Units.
Inventors and entrepreneurs have four concerns related to patent law: protecting their inventions in the very early stages of product development, determining the patentability of their invention, avoiding infringement of a competitor's patent, and leveraging their patent as a business asset. This course will address each of these concerns through the application of law cases and business cases to an invention of the Studentacirc;quest;iqest;s choice. Although listed as a ME/MSE course, the course is not specific to any discipline or technology. Same as: ME 208

MSE 279A. Entrepreneurial Leadership. 1 Unit.
This seminar explores a wide range of topics related to entrepreneurial leadership through class discussions, case studies, field trips, and guest speakers. It is part of the DFJ Entrepreneurial Leaders Fellowship, which requires an application during Fall quarter. Details can be found at: http://stvp.stanford.edu/dfj/.

MSE 279B. Entrepreneurial Leadership. 1 Unit.
This seminar explores a wide range of topics related to entrepreneurial leadership through class discussions, case studies, field trips, and guest speakers. It is part of the DFJ Entrepreneurial Leaders Fellowship, which requires an application during Fall quarter. Details can be found at: http://stvp.stanford.edu/dfj/.

MSE 280. Organizational Behavior: Evidence in Action. 3-4 Units.
Organization theory; concepts and functions of management; behavior of the individual, work group, and organization. Emphasis is on cases and related discussion. Enrollment limited; priority to MS&E students. Please submit Autumn course application at http://goo.gl/forms/FO61GT1INnY by 6pm on Monday, September 21, 2015.

MSE 282. Transformational Leadership. 3 Units.
The personal, team-based and organizational skills needed to become a transformative leader. Case method discussions and lectures. Themes include: personal transformation; the inside-out effect; group transformation; cross-functional teams; re-engineering; rapid - non-profit and for profit - organizational transformation; and social transformation. Course includes a group project that is defined and approved during the first two weeks of class. Limited enrollment. Graduate students only. Admission by application. Prerequisite: 180 or 200.

MSE 284. Designing Modern Work Organizations. 3 Units.
This practice-based experiential lab course is geared toward MS&E masters students. Students will master the concepts of organizational design, with an emphasis on applying them to modern challenges (technology, growth, globalization, and the modern workforce). Students will also gain mastery of skills necessary for success in today’s workplace (working in teams, communicating verbally, presenting project work). Guest speakers from industry will present real-world challenges related to class concepts. Students will complete a quarter-long project designing and managing an actual online organization. Limited to 25. Admission by application.

MSE 292. Health Policy Modeling. 3 Units.
Primarily for master's students; also open to undergraduates and doctoral students. The application of mathematical, statistical, economic, and systems models to problems in health policy. Areas include: disease screening, prevention, and treatment; assessment of new technologies; bioterrorism response; and drug control policies.

MSE 293. Technology and National Security. 3 Units.
The interaction of technology and national security policy from the perspective of history to implications for the new security imperative, homeland defense. Key technologies in nuclear and biological weapons, military platforms, and intelligence gathering. Policy issues from the point of view of U.S. and other nations. The impact of terrorist threat. Guest lecturers include key participants in the development of technology and/or policy. Same as: MSE 193

MSE 294. Climate Policy Analysis. 3 Units.
Design and application of formal analytical methods in climate policy development. Issues include instrument design, technology development, resource management, multiparty negotiation, and dealing with complexity and uncertainty. Links among art, theory, and practice. Emphasis is on integrated use of modeling tools from diverse methodologies and requirements for policy making application. Prerequisites: ECON 50, MS&E 211, MS&E 252, or equivalents, or permission of instructor.

MSE 295. Energy Policy Analysis. 3 Units.
Design and application of formal analytical methods for policy and technology assessments of energy efficiency and renewable energy options. Emphasis is on integrated use of modeling tools from diverse methodologies and requirements for policy and corporate strategy development. Prerequisites: ECON 50, MS&E 211, MS&E 252, or equivalents, or permission of instructor.

MSE 297. The Lean LaunchPad for Business to Government. 3-4 Units.
Student teams design technology solutions to real government technology requirements, or needs, while applying the Lean LaunchPad methodology. Intended for students interested in understanding how to sell and scale dual-use technology into the business-to-government, or B2G, market. Customer discovery and validation followed by product discovery and validation are conducted in collaboration with sponsoring government agencies. Students learn government acquisition channels, technology needs, and how to locate and access non-dilutive government funding. Students also gain exposure to Silicon Valley venture investors familiar with funding dual-use technologies. Topics introduced are relevant to academic technology researchers, founders of technology companies, and future employees of startups pursuing dual-use technologies.

MSE 299. Voluntary Social Systems. 1-3 Unit.
Ethical theory, feasibility, and desirability of a social order in which coercion by individuals and government is minimized and people pursue ends on a voluntary basis. Topics: efficacy and ethics; use rights for property; contracts and torts; spontaneous order and free markets; crime and punishment based on restitution; guardian-ward theory for dealing with incompetents; the effects of state action-hypothesis of reverse results; applications to help the needy, armed intervention, victimless crimes, and environmental protection; transition strategies to a voluntary society.
MSE 300. Ph.D. Qualifying Tutorial or Paper. 1-3 Units.
Restricted to Ph.D. students assigned tutorials as part of the MS&E Ph.D. qualifying process. Enrollment optional.

MSE 301. Dissertation Research. 1-15 Unit.
Prerequisite: doctoral candidacy.

MSE 302. Fundamental Concepts in Management Science and Engineering. 1 Unit.
Each course session will be devoted to a specific MS&E PhD research area. Advanced students will make presentations designed for first-year doctoral students regardless of area. The presentations will be devoted to: illuminating how people in the area are being explored that day think about and approach problems, and illustrating what can and cannot be done when addressing problems by deploying the knowledge, perspectives, and skills acquired by those who specialize in the area in question. Area faculty will attend and participate. During the last two weeks of the quarter groups of first year students will make presentations on how they would approach a problem drawing on two or more of the perspectives to which they have been exposed earlier in the class. Attendance is mandatory and performance will be assessed on the basis of the quality of the students' presentation and class participation. Restricted to first year MS&E PhD students.

MSE 310. Linear Programming. 3 Units.
Formulations of standard linear programming models. Theory of polyhedral convex sets, linear inequalities, alternative theorems, and duality. Variants of the simplex method and the state of art interior-point algorithms. Sensitivity analyses, economic interpretations, and primal-dual methods. Relaxations of harder optimization problems and recent convex cone linear programs. Applications include game equilibrium facility location. Prerequisite: MATH 113 or consent of instructor.

MSE 311. Optimization. 3 Units.
Applications, theories, and algorithms for finite-dimensional linear and nonlinear optimization problems with continuous variables. Elements of convex analysis, first- and second-order optimality conditions, sensitivity and duality. Algorithms for unconstrained optimization, and linearly and nonlinearly constrained problems. Modern applications in communication, game theory, auction, and economics. Prerequisites: MATH 113, 115, or equivalent.

MSE 312. Advanced Methods in Numerical Optimization. 3 Units.
Topics include interior-point methods, relaxation methods for nonlinear discrete optimization, sequential quadratic programming methods, optimal control and decomposition methods. Topic chosen in first class; different topics for individuals or groups possible. Individual or team projects. May be repeated for credit.
Same as: CME 334

MSE 314. Linear and Conic Optimization with Applications. 3 Units.
Linear, semidefinite, conic, and convex nonlinear optimization problems as generalizations of classical linear programming. Algorithms include the interior-point, barrier function, and cutting plane methods. Related convex analysis, including the separating hyperplane theorem, Farkas lemma, dual cones, optimality conditions, and conic inequalities. Complexity and/or computation efficiency analysis. Applications to combinatorial optimization, sensor network localization, support vector machine, and graph realization. Prerequisite: MS&E 211 or equivalent.
Same as: CME 336

MSE 315. Numerical Optimization. 3 Units.
Solution of nonlinear equations; unconstrained optimization; linear programming; quadratic programming; global optimization; general linearly and nonlinearly constrained optimization. Theory and algorithms to solve these problems. Prerequisite: background in analysis and numerical linear algebra.
Same as: CME 304

MSE 316. Discrete Mathematics and Algorithms. 3 Units.
Topics: Basic Algebraic Graph Theory, Matroids and Minimum Spanning Trees, Submodularity and Maximum Flow, NP-Hardness, Approximation Algorithms, Randomized Algorithms, The Probabilistic Method, and Spectral Sparserization using Effective Resistances. Topics will be illustrated with applications from Distributed Computing, Machine Learning, and large-scale Optimization. Prerequisites: CS 261 is highly recommended, although not required.
Same as: CME 305

MSE 317. Algorithms for Modern Data Models. 3 Units.
We traditionally think of algorithms as running on data available in a single location, typically main memory. In many modern applications including web analytics, search and data mining, computational biology, finance, and scientific computing, the data is often too large to reside in a single location, is arriving incrementally over time, is noisy/uncertain, or all of the above. Paradigms such as map-reduce, streaming, sketching, Distributed Hash Tables, Bulk Synchronous Processing, and random walks have proved useful for these applications. This course will provide an introduction to the design and analysis of algorithms for these modern data models. Prerequisite: Algorithms at the level of CS 261.
Same as: CS 263

MSE 318. Large-Scale Numerical Optimization. 3 Units.
The main algorithms and software for constrained optimization emphasizing the sparse-matrix methods needed for their implementation. Iterative methods for linear equations and least squares. The simplex method. Basis factorization and updates. Interior methods. The reduced-gradient method, augmented Lagrangian methods, and SQP methods. Prerequisites: Basic numerical linear algebra, including LU, QR, and SVD factorizations, and an interest in MATLAB, sparse-matrix methods, and gradient-based algorithms for constrained optimization. Recommended: MS&E 310, 311, 312, 314, or 315; CME 108, 200, 302, 304, 334, or 335.
Same as: CME 338

MSE 319. Approximation Algorithms. 3 Units.
Combinatorial and mathematical programming techniques to derive approximation algorithms for NP-hard optimization problems. Possible topics include: greedy algorithms for vertex/set cover; rounding LP relaxations of integer programs; primal-dual algorithms; semidefinite relaxations. May be repeated for credit. Prerequisites: 112 or CS 161.

MSE 321. Stochastic Systems. 3 Units.
Topics in stochastic processes, emphasizing applications. Markov chains in discrete and continuous time; Markov processes in general state space; Lyapunov functions; regeneration process theory; renewal theory; martingales, Brownian motion, and diffusion processes. Application to queueing theory, storage theory, reliability, and finance. Prerequisites: 221 or STATS 217; MATH 113, 115. (Glynn).

MSE 322. Stochastic Calculus and Control. 3 Units.
Ito integral, existence and uniqueness of solutions of stochastic differential equations (SDEs), diffusion approximations, numerical solutions of SDEs, controlled diffusions and the Hamilton-Jacobi-Bellman equation, and statistical inference of SDEs. Applications to finance and queueing theory. Prerequisites: 221 or STATS 217; MATH 113, 115.

MSE 332. Topics in Social Algorithms. 3 Units.
In depth discussion of selected research topics in social algorithms, including networked markets, collective decision making, recommendation and reputation systems, prediction markets, social computing, and social choice theory. The class will include a theoretical project and a paper presentation. Prerequisites: CS 261 or equivalent; understanding of basic game theory.

MSE 333. Social Algorithms. 1 Unit.
This seminar will introduce students to research in the field of social algorithms, including networked markets, collective decision making, recommendation and reputation systems, prediction markets, social choice theory, and models of influence and contagion.
MSE 334. The Structure of Social Data. 3 Units.
This course provides a survey of recent research in the study of social networks and large-scale social and behavioral data. Topics will include network models based on random graphs and their properties; centrality and ranking on graphs; ranking from comparisons; heavy-tailed statistical distributions for social data; the wisdom of crowds; homophily and social influence; experimentation and causal inference on networks. Prerequisites: 221, 226, CS161.

MSE 335. Queueing and Scheduling in Processing Networks. 3 Units.
Advanced stochastic modeling and control of systems involving queueing and scheduling operations. Stability analysis of queueing systems. Key results on single queues and queueing networks. Controlled queueing systems. Dynamic routing and scheduling in processing networks. Applications to modeling, analysis and performance engineering of computing systems, communication networks, flexible manufacturing, and service systems. Prerequisite: 221 or equivalent.

MSE 336. Platform and Marketplace Design. 3 Units.
The last decade has witnessed a meteoric rise in the number of online markets and platforms competing with traditional mechanisms of trade. Examples of such markets include online marketplaces for goods, such as eBay; online dating markets; markets for shared resources, such as Lyft, Uber, and Airbnb; and online labor markets. We will review recent research that aims to both understand and design such markets. Emphasis on mathematical modeling and methodology, with a view towards preparing Ph.D. students for research in this area. Prerequisites: Mathematical maturity; 300-level background in optimization and probability; prior exposure to game theory.

MSE 338. Advanced Topics in Information Science and Technology. 3 Units.
Advanced material in this area is sometimes taught for the first time as a topics course. Prerequisite: consent of instructor.

MSE 347. Credit Risk: Modeling and Management. 3 Units.
Credit risk modeling, valuation, and hedging emphasizing underlying economic, probabilistic, and statistical concepts. Point processes and their compensators. Structural, incomplete information and reduced form approaches. Single name products: corporate bonds, equity, equity options, credit and equity default swaps, forwards and swaptions. Multiname modeling: index and tranche swaps and options, collateralized debt obligations. Implementation, calibration and testing of models. Industry and market practice. Data and implementation driven group projects that focus on problems in the financial industry.

MSE 348. Optimization of Uncertainty and Applications in Finance. 3 Units.
How to make optimal decisions in the presence of uncertainty, solution techniques for large-scale systems resulting from decision problems under uncertainty, and applications in finance. Decision trees, utility, two-stage and multi-stage decision problems, approaches to stochastic programming, model formulation; large-scale systems, Benders and Dantzig-Wolfe decomposition, Monte Carlo sampling and variance reduction techniques, risk management, portfolio optimization, asset-liability management, mortgage finance. Projects involving the practical application of optimization under uncertainty to financial planning.

MSE 351. Dynamic Programming and Stochastic Control. 3 Units.
Markov population decision chains in discrete and continuous time. Risk posture. Present value and Cesaro overtaking optimality. Optimal stopping. Successive approximation, policy improvement, and linear programming methods. Team decisions and stochastic programs; quadratic costs and certainty equivalents. Maximum principle. Controlled diffusions. Examples from inventory, overbooking, options, investment, queues, reliability, quality, capacity, transportation. MATLAB. Prerequisites: MATH 113, 115; Markov chains; linear programming.

MSE 352. Decision Analysis II: Professional Decision Analysis. 3-4 Units.
How to organize the decision conversation, the role of the decision analysis cycle and the model sequence, assessing the quality of decisions, framing decisions, the decision hierarchy, strategy tables for alternative development, creating spare and effective decision diagrams, biases in assessment, knowledge maps, uncertainty about probability. Sensitivity analysis, approximations, value of revelation, joint information, options, flexibility, bidding, assessing and using corporate risk attitude, risk sharing and scaling, and decisions involving health and safety. See 353 for continuation. Prerequisite: 252.

MSE 353. Decision Analysis III: Frontiers of Decision Analysis. 3 Units.
The concept of decision composite; probabilistic insurance and other challenges to the normative approach; the relationship of decision analysis to classical inference and data analysis procedures; the likelihood and exchangeability principles; inference, decision, and experimentation using conjugate distributions; developing a risk attitude based on general properties; alternative decision aiding practices such as analytic hierarchy and fuzzy approaches. Student presentations on current research. Goal is to prepare doctoral students for research. Prerequisite: 352.

MSE 355. Influence Diagrams and Probabilistic Networks. 3 Units.

MSE 356. Advanced Models in Operations Management. 3 Units.
Primarily for doctoral students. Focus on quantitative models dealing with sustainability and related to operations management. Prerequisite: consent of instructor. May be repeated for credit.

MSE 371. Innovation and Strategic Change. 2-3 Units.
Doctoral research seminar, limited to Ph.D. students. Current research on innovation strategy. Topics: scientific discovery, innovation search, organizational learning, evolutionary approaches, and incremental and radical change. Topics change yearly. Recommended: course in statistics or research methods.

MSE 372. Entrepreneurship Doctoral Research Seminar. 1-3 Unit.
Classic and current research on entrepreneurship. Limited enrollment, restricted to PhD students. Prerequisites: SOC 363 or equivalent, and permission of instructor.

MSE 374. Dynamic Corporate Strategy. 3 Units.
Restricted to Ph.D. students. Research on the creation and shaping of disruptive industry dynamics and how companies can formulate and implement strategies to excel in such changing environments. Dynamic system model approach; case studies. Prerequisites: 201 or equivalent, 274.

MSE 375. Research on Entrepreneurship. 3 Units.
Restricted to Ph.D. students. Organization theory, economics, and strategy perspectives. Limited enrollment. Prerequisites: SOC 360 or equivalent, and consent of instructor.

MSE 376. Strategy Doctoral Research Seminar. 3 Units.
Classic and current research on business and corporate strategy. Limited enrollment, restricted to PhD students. Prerequisites: SOC 363 or equivalent, and permission of instructor. Course may be repeated for credit.

MSE 380. Doctoral Research Seminar in Organizations. 3 Units.
Limited to Ph.D. students. Topics from current published literature and working papers. Content varies. Prerequisite: consent of instructor.
MSE 381. Doctoral Research Seminar in Work, Technology, and Organization. 2-3 Units.
Enrollment limited to Ph.D. students. Topics from current published literature and working papers. Content varies. Prerequisite: consent of instructor.

MSE 383. Doctoral Seminar on Ethnographic Research. 3 Units.
For graduate students; upper-level undergraduates with consent of instructor. Ethnosemantic interviewing and participant observation. Techniques for taking, managing, and analyzing field notes and other qualitative data. 15 hours per week outside class collecting and analyzing own data. Methods texts and ethnographies offer examples of how to analyze and communicate ethnographic data. Prerequisite: consent of instructor. (Barley).

MSE 384. Groups and Teams. 3 Units.
Research on groups and teams in organizations from the perspective of organizational behavior and social psychology. Topics include group effectiveness, norms, group composition, diversity, conflict, group dynamics, temporal issues in groups, geographically distributed teams, and intergroup relations.

MSE 387. Design of Field Research Methods. 3 Units.
Field research involves collecting original data (qualitative and/or quantitative) in field sites. This course combines informal lecture and discussion with practical exercises to build specific skills for conducting field research in organizations. Readings include books and papers about research methodology and articles that provide exemplars of field research. Specific topics covered include: the role of theory in field research, variance versus process models, collecting and analyzing different kinds of data (observation, interview, survey), levels of analysis, construct development and validity, blending qualitative and quantitative data (in a paper, a study, or a career), and writing up field research for publication. Students will develop intuition about the contingent relationship between the nature of the research question and the field research methods used to answer it as a foundation for conducting original field research.

MSE 388. Themes in Contemporary Meso-level Field Research. 3 Units.
Doctoral research seminar, limited to Ph.D. students. Current meso-level field research on organizational behavior, especially work and coordination. Topics: work design, job design, roles, teams, organizational change and learning, knowledge management, performance. Focus on understanding theory development and research design in contemporary field research. Topics change yearly. Recommended: course in statistics or research methods.

MSE 389. Seminar on Organizational Theory. 5 Units.
The social science literature on organizations assessed through consideration of the major theoretical traditions and lines of research predominant in the field.
Same as: EDUC 375A, SOC 363A

MSE 390. Doctoral Research Seminar in Health Systems Modeling. 1-3 Unit.
Restricted to PhD students, or by consent of instructor. Doctoral research seminar covering current topics in health policy, health systems modeling, and health innovation. May be repeated for credit.

MSE 391. Doctoral Research Seminar in Energy-Environmental Systems Modeling and Analysis. 1-3 Unit.
Restricted to PhD students, or by consent of instructor. Doctoral research seminar covering current topics in energy and environmental modeling and analysis. Current emphasis on approaches to incorporation of uncertainty and technology dynamics into complex systems models. May be repeated for credit.

MSE 403. Integrative Modeling. 3 Units.
Modeling approaches for examining real life problems: how to get started. Critical thinking in framing and problem formulation leading to actionable solutions and communication of results to decision makers. Models to identify and evaluate multiple objectives/metrics. Models examined include both deterministic and probabilistic components. Overview of optimization and probability, decomposition principles to model large scale problems, appropriate integration of uncertainties into model formulations. Primarily team-project based assignments, with three to four group projects. Project topics drawn from applications with real data. Sample project topics include: optimizing group phone plans for large corporations, life insurance business models, making sense of the health care debate, logistic decision problems. Project teams will critically grade other teams' projects; project reports using provided guidelines. Project presentations throughout the quarter. Prerequisites: 211, 220.

MSE 408. Directed Reading and Research. 1-15 Unit.
Directed study and research on a subject of mutual interest to student and faculty member. Prerequisite: faculty sponsor.

MSE 408A. Directed Reading and Research. 1-4 Unit.
Directed study and research on a subject of mutual interest to student and mentor.

MSE 431. Projects in Computational Social Science. 3-4 Units.
Students work in interdisciplinary teams to complete a project of their choice in computational social science. Groups present their progress throughout the term, receiving regular feedback on their own projects and providing feedback on other students' projects. Students learn how to deal with the computational and statistical challenges of working with large, real-world datasets in the context of a motivating, substantive problem in the social sciences. Lectures and discussions are tailored to the specific topics that the groups pursue. Enrollment is by application only; details will be posted in the fall quarter. Prerequisite: MSE 231 or similar.

MSE 441. Policy and Economics Research Roundtable. 1 Unit.
Research in progress or contemplated in policy and economics areas. Emphasis depends on research interests of participants, but is likely to include energy, environment, transportation, or technology policy and analysis. May be repeated for credit. Same as: PERR

MSE 445. Projects in Wealth Management. 3-4 Units.
Recent theory and standard practice in portfolio design for institutions, individuals, and funds. Student projects and case studies derived from the financial industry.

MSE 447. Systemic and Market Risk : Notes on Recent History, Practice, and Policy. 3 Units.
The global financial crisis of 2007-8 threw into sharp relief the ongoing challenges of understanding risk, the financial system, links with the global economy, and interactions with policy. We will explore elements of the crisis, a few other key events, and ongoing debates about systemic risk. Group projects will explore in more detail past events and current topics in systemic risk. Supplements a rigorous technical curriculum in modern finance with select aspects relevant to understanding the practice and broader context of modern financial activities such as derivatives, financial engineering, and risk management.
MSE 448. Big Financial Data and Algorithmic Trading. 3 Units.
Project course emphasizing the connection between data, models, and reality. Vast amounts of high volume, high frequency observations of financial quotes, orders and transactions are now available, and poses a unique set of challenges. This type of data will be used as the empirical basis for modeling and testing various ideas within the umbrella of algorithmic trading and quantitative modeling related to the dynamics and micro-structure of financial markets. Due to the fact that it is near impossible to perform experiments in finance, there is a need for empirical inference and intuition, any model should also be justified in terms of plausibility that goes beyond pure econometric and data mining approaches. Introductory lectures, followed by real-world type projects to get a hands-on experience with realistic challenges and hone skills needed in the workplace. Work in groups on selected projects that will entail obtaining and cleaning the raw data and becoming familiar with techniques and challenges in handling big data sets. Develop a framework for modeling and testing (in computer languages such as Python, C++, Matlab and R) and prepare presentations to present to the class. Example projects include optimal order execution, developing a market making algorithm, design of an intra-day trading strategy, and modeling the dynamics of the bid and ask. Prerequisites: MSE 211, 242, 342, or equivalents, some exposure to statistics and programming. Enrollment limited. Admission by application; details at first class.

MSE 450. Lessons in Decision Making. 1 Unit.
Entrepreneurs, senior management consultants, and executives from Fortune 500 companies share real-world stories and insights from their experience in decision making.

MSE 452. Decision Analysis Projects: Helping Real Leaders Make Real Decisions. 3 Units.
A virtual consulting firm directed by professional decision analysts who offer advice and guidance as student teams help local organizations make a current business strategy or public policy decision. Projects for businesses, governments, or other institutions typically include start-up venture funding, R&D portfolio planning, new product or market entry, acquisition or partnering, cost reduction, program design, or regulatory policy decisions. Emphasis is on developing clarity of action and delivering insights to clients. Satisfies MS&E project course requirement. Prerequisite: 252. Recommended: 352.

MSE 453. Decision Analysis Applications: Business Strategy and Public Policy. 2-3 Units.
What are the most essential, efficient, and effective ways that important decisions are being made in the real world? Experienced practitioners provide insights from technically challenging and organizationally complex decisions that they helped analyze for decision makers in businesses, nonprofits, and governments. Both the process and content of such decisions are discussed. Process includes disciplined qualitative and quantitative approaches for framing, structuring, modeling, assessing, evaluating, appraising, and communicating decisions. Content broadly covers business and corporate strategy, venture capital investing, financial derivatives and hedging, R&D portfolio management, new product design, technology manufacturing alternatives, business renewal, real estate investment and development, intellectual property litigation risk, interplanetary contamination risk, energy economics and policies, electric power production, nuclear waste disposal, environmental cleanup of mines, marine fisheries and resource protection, medical diagnosis and treatment options, health insurance plans, hospital risk management, pharmaceutical drug trials and backups, behavioral economics lessons, effective interaction techniques, and implications of social psychology for improved organizational decision making. Prerequisite: 252.

MSE 454. Decision Analysis Seminar. 1 Unit.
Current research and related topics presented by doctoral students and invited speakers. May be repeated for credit. Prerequisite: 252.

MSE 463. Healthcare Systems Design. 3 Units.
Students work on projects to analyze and design various aspects of healthcare including hospital patient flow, physician networks, clinical outcomes, reimbursement incentives, and community health. Students work in small teams under the supervision of the course instructor and partners at the Lucille Packard Children's Hospital, the Stanford Hospital, and other regional healthcare providers. Prerequisite: 263.

MSE 464. Global Project Coordination. 3-4 Units.
Students engage in projects that are global in nature and related to the planning, design, and operations of supply chains, marketing, manufacturing, and product development processes. Stanford students work with students from an overseas university in teams of 6-8, using email, teleconferencing, and videoconferencing to meet on a regular basis. As part of the course, students travel to Hong Kong during Stanford's spring break. Applications due by November 15. Information session on October 29. Please see https://stanford.qualtrics.com/SE/?SID=SV_3aKZBx2NWB8p73T for more information.

MSE 467. Strategic Operations Consulting. 3 Units.
Restricted to MS&E masters students. Guided by industry practitioners, students work in teams to conduct an in-depth consulting project for a sponsoring company, assessing operational challenges and developing effective solutions. Projects range from the planning, design, and operation of supply chains to manufacturing to new product introduction. Emphasis is on developing diagnostic skills and designing effective and actionable solutions that provide new insights to clients. Students will be taught and coached on business writing and presentation skills. Projects culminate with a comprehensive presentation of findings and recommended actions to the sponsor. Satisfies MS&E project course requirement. Prerequisites: 260 or 261. Admission by application, limited enrollment.

MSE 472. Entrepreneurial Thought Leaders' Seminar. 1 Unit.
Entrepreneurial leaders share lessons from real-world experiences across entrepreneurial settings. ETL speakers include entrepreneurs, leaders from global technology companies, venture capitalists, and best-selling authors. Half-hour talks followed by half hour of class interaction. Required web discussion. May be repeated for credit.

MSE 476. Entrepreneurship Through the Lens of Venture Capital: Venture Capital From Past to Present. 2 Units.
Explores changes in the venture capital industry: rise of Silicon Valley and Sand Hill Road, investing in the dot-com bubble, incubators and accelerators, equity crowd funding platform, and different models of venture capital. Explores how companies are funded, grown, and scaled by meeting with individuals who have been at the forefront of this change. See www.lensofvc.com.

MSE 478. The Spirit of Entrepreneurship. 2 Units.
This course uses the speakers from the Entrepreneurial Thought Leader seminar (MS&E472) to drive research and discussion about what makes an entrepreneur successful. Students meet before and after MS&E 472 to prepare for and debrief after the sessions. It is part of the DfJ Entrepreneurial Leaders Fellowship, which requires an application during Fall quarter. Details can be found at: http://stvp.stanford.edu/djf/.

MSE 487. D.ORG: PROTOTYPING ORGANIZATIONAL CHANGE. 2-4 Units.
d.org will send outstanding, proven design thinkers into organizations to jump-start iquest; organizational R&Dquest; experiments. Students will work directly with senior leaders to prototype ways to reinforce culture through policies, rituals, and behavioral norms.
MSE 488. Prototyping and Rapid Experiment Lab. 4 Units.
Gain a deeper understanding of the prototyping and user feedback parts of the design thinking process with a focus on rapid experimentation. Explore prototyping and user feedback that happens in later stages of iteration when design ideas are somewhat gelled, but designers are still uncertain about whether the design will meet the need and evoke the response intended. Introduce and generate creative ways to discover what users will do in the real world with the designs we envision. For seasoned students who thoroughly understand the design thinking process or, more broadly, human-centered design and now want to focus on one later stage aspect of it in more depth. An application process will happen in Fall Quarter. Please contact the d.school for more details.

MSE 489. d.Leadership: Design Leadership in Context. 1-3 Unit.
d.Leadership is a course that teaches the coaching and leadership skills needed to drive good design process in groups. d.leaders will work on real projects driving design projects within organizations and gain real world skills as they experiment with their leadership style. Take this course if you are inspired by past design classes and want skills to lead design projects beyond Stanford. Preference given to students who have taken other Design Group or d.school classes. Admission by application. See dschool.stanford.edu/classes for more information. Same as: ME 368

MSE 494. The Energy Seminar. 1 Unit.
Interdisciplinary exploration of current energy challenges and opportunities, with talks by faculty, visitors, and students. May be repeated for credit. Same as: CEE 301, ENERGY 301

MSE 802. TGR Dissertation. 0 Units.