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.

In December 1999, the Board of Trustees authorized the creation of the Department of Management Science and Engineering from the Department of Industrial Engineering and Engineering Management and the Department of Engineering-Economic Systems and Operations Research. Its main objective is to be the leader 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’s 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 may select courses in computer science, information, organizational theory, mathematical modeling, optimization, probability, statistics and finance or production. To allow for greater in-depth exploration in a particular area, students then choose a concentration area. The major prepares students for a variety of career paths, including facilities exploration in a particular area, students then choose a concentration area. Statistics and finance or production. To allow for greater in-depth

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 life-long 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, in collaboration with other departments of the University, 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, and a dual master’s degree in cooperation with each of the other departments in the School of Engineering.

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 3, 2013, and the deadline for application to the master’s program is January 14, 2014.

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.

Learning Outcomes (Graduate)

The purpose of the master’s program is to provide students with the knowledge and skills necessary for a life-long career addressing critical technical and managerial needs in private and public decision-making. This is done through course work providing specialization in an area of the field as well as breadth across several of those areas. Specializations include decision and risk analysis, energy and environment, finance, information science and technology, operations research, operations management, policy/strategy, and organizations, technology and entrepreneurship. The master’s degree may be a terminal degree program with a professional focus, or a preparation for a more advanced graduate program.

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.

### 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.

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

### Careers in MS&E

MS&E helps students prepare for professional careers in business, government, industry, non-profit institutions, and universities. Graduates have pursued careers in consulting, enterprise management, financial analysis, government policy analysis, industrial research, line management, product development, project management, strategic planning, and university teaching and research. Some have founded companies specializing in financial services, high technology products, management and systems consulting, or software. Other graduates have helped establish new analytical capabilities in existing firms or government agencies.

Many graduates have become leaders in technology-based businesses, which have an increasing need for well-educated, analytically oriented people who understand both business and technology. The Department of MS&E is attractive to people with engineering, mathematical science, and physical science backgrounds as it complements their technical abilities with the conceptual frameworks needed to analyze problems of investment, management, marketing, operations, production, and strategic planning in a technical environment.

### 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 San Francisco 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 http://scpd.stanford.edu or contact SCPD at (650) 725-3000.

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.

### 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. Graduates are prepared for work in a variety of career paths, including facilities and process management, investment banking, management consulting, or graduate study in industrial engineering, operations research, economics, public policy, medicine, law, or business.

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 (http://exploredegrees.stanford.edu/archive/2013-14/schoolofengineering/managementscienceandengineering/#text-learoutcunde) for additional learning objectives.

The program builds on the foundational courses for engineering, including calculus, 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 (http://exploredegrees.stanford.edu/archive/2013-14/schoolofhumantiesandsciences/mathematicalandcomputationalscience/#bachelortext)” section of this bulletin.

### Core

The department core, taken for all concentrations, includes courses in computer science, deterministic optimization, information, organization theory, a senior project, and finance or production. Through the core, students in the program are exposed to the breadth of faculty interests, and are in a good position to choose a concentration during the junior year.

### Concentrations

The five concentrations are designed to allow a student to explore one area of the department in greater depth.

1. **Financial and Decision Engineering** focuses on the design and analysis of financial and strategic plans. It features accounting,
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

Mathematics (32-34)

- Seven courses and 32 units minimum; see Basic Requirement 1
- Select one of the following sequences:
  - MATH 41 Calculus 5
  - MATH 42 Calculus 5
  - MATH 51 Linear Algebra and Differential Calculus of Several Variables 5
  - CME 100 Vector Calculus for Engineers 5
  - MATH 53 Ordinary Differential Equations with Linear Algebra 5
  - CME 102 Ordinary Differential Equations for Engineers 5
  - MS&E 120 Probabilistic Analysis 5
  - MS&E 121 Introduction to Stochastic Modeling 4

Science (11-13)

Three courses and 11 units minimum; see Basic Requirement 2

- Select one of the following:
  - CHEM 31B Chemical Principles II and Structure and Reactivity
  - CHEM 31X Chemical Principles
  - CHEM 33 and Structure and Reactivity
  - PHYSICS 21 Mechanics and Heat
  - PHYSICS 22 and Mechanics and Heat Laboratory
  - PHYSICS 23 and Electricity and Optics
  - PHYSICS 24 and Electricity and Optics Laboratory
  - PHYSICS 41 Mechanics
  - PHYSICS 4 and Electricity and Magnetism

- Science Elective 3-5

Technology in Society (3-5)

Select one of the following; see Basic Requirement 4

- COMM 120W Digital Media in Society
- CS 181 Computers, Ethics, and Public Policy
- ENGR 131 Ethical Issues in Engineering

- MS&E 181 Issues in Technology and Work for a Postindustrial Economy
- MS&E 193 Technology and National Security (WIM)
- MS&E 197 Ethics and Public Policy (WIM)

Engineering Fundamentals (11-15)

Three courses; see Basic Requirement 3

- Select one of the following:
  - ENGR 25B Biotechnology
  - ENGR 40 Introductory Electronics
  - ENGR 50 Introduction to Materials Science, Nanotechnology Emphasis
  - ENGR 80 Introduction to Bioengineering

- Select one of the following (or E25, E40, or E80 if not used above):
  - ENGR 10 Introduction to Engineering Analysis
  - ENGR 14 Intro to Solid Mechanics
  - ENGR 15 Dynamics
  - ENGR 20 Introduction to Chemical Engineering
  - ENGR 30 Engineering Thermodynamics
  - ENGR 50 Introduction to Materials Science, Nanotechnology Emphasis
  - ENGR 60 Engineering Economy
  - ENGR 90 Environmental Science and Technology

Engineering Depth (core; six courses) (22-25)

- MS&E 108 Senior Project
- MS&E 111 Introduction to Optimization 5
- MS&E 180 Organizations: Theory and Management 4

Select one of the following:

- CS 103 Mathematical Foundations of Computing
- CS 106B Programming Abstractions 5
- CS 106X Programming Abstractions (Accelerated) 5

- Select one of the following:
  - MS&E 130 Information Networks and Services
  - MS&E 233 Networked Markets

Select one of the following:

- MS&E 142 Introductory Financial Analysis
- MS&E 260 Introduction to Operations Management 3

Engineering Depth (concentration; seven or eight courses) (21-30)

Concentration: choose one of the following 5 concentrations:

- Financial and Decision Engineering Concentration (25-29)
- ECON 50 Economic Analysis I 5
- ECON 51 Economic Analysis II 5
- MS&E 140 Accounting for Managers and Entrepreneurs 3-4
- MS&E 152 Introduction to Decision Analysis (WIM) 3-4
- MS&E 245G Finance for Non-MBAs 3

Select two of the following:

- ENGR 145 Technology Entrepreneurship
- MS&E 107 Interactive Management Science
- MS&E 146 Corporate Financial Management
### Operations Research Concentration (21-24)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 113</td>
<td>Linear Algebra and Matrix Theory</td>
<td>3</td>
</tr>
<tr>
<td>MATH 115</td>
<td>Functions of a Real Variable</td>
<td>3</td>
</tr>
<tr>
<td>MS&amp;E 152</td>
<td>Introduction to Decision Analysis (WIM)</td>
<td>3-4</td>
</tr>
<tr>
<td>MS&amp;E 241</td>
<td>Economic Analysis</td>
<td>3-4</td>
</tr>
<tr>
<td>MS&amp;E 251</td>
<td>Stochastic Control</td>
<td>3</td>
</tr>
<tr>
<td>STATS 202</td>
<td>Data Mining and Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

Select one of the following:

- MS&E 142 Introductory Financial Analysis
- MS&E 260 Introduction to Operations Management

### Organization, Technology, and Entrepreneurship Concentration (22-30)

Select one of the following:

- ECON 50 Economic Analysis I
- PSYCH 70 Introduction to Social Psychology
- SOC 114 Economic Sociology

Select two of the following:

- ENGR 145 Technology Entrepreneurship
- MS&E 175 Innovation, Creativity, and Change
- MS&E 181 Issues in Technology and Work for a Postindustrial Economy

Select at least four of the following courses (may also include E145, MS&E 175, or MS&E 260, if not used above):

- CS 147 Introduction to Human-Computer Interaction Design
- ENGR 130 Science, Technology, and Contemporary Society
- MS&E 140 Accounting for Managers and Entrepreneurs
- MS&E 178 The Spirit of Entrepreneurship
- MS&E 185 Global Work
- MS&E 189 Social Networks - Theory, Methods, and Applications
- MS&E 266 Management of New Product Development

### Policy and Strategy Concentration (25-30)

Select at least four of the following courses, including at least one course in policy and at least one course in strategy:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS&amp;E 193</td>
<td>Technology and National Security (WIM)</td>
</tr>
<tr>
<td>MS&amp;E 197</td>
<td>Ethics and Public Policy (WIM)</td>
</tr>
<tr>
<td>MS&amp;E 243</td>
<td>Energy and Environmental Policy Analysis</td>
</tr>
<tr>
<td>MS&amp;E 248</td>
<td>Economics of Natural Resources</td>
</tr>
<tr>
<td>MS&amp;E 292</td>
<td>Health Policy Modeling</td>
</tr>
<tr>
<td>ENGR 145</td>
<td>Technology Entrepreneurship</td>
</tr>
<tr>
<td>MS&amp;E 175</td>
<td>Innovation, Creativity, and Change</td>
</tr>
<tr>
<td>MS&amp;E 266</td>
<td>Management of New Product Development</td>
</tr>
</tbody>
</table>

### Production and Operations Management Concentration (25-29)

Select three of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 50</td>
<td>Economic Analysis I</td>
</tr>
<tr>
<td>ECON 51</td>
<td>Economic Analysis II</td>
</tr>
<tr>
<td>MS&amp;E 140</td>
<td>Accounting for Managers and Entrepreneurs</td>
</tr>
<tr>
<td>MS&amp;E 152</td>
<td>Introduction to Decision Analysis (WIM)</td>
</tr>
</tbody>
</table>

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:

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

### Minor requirements (seven courses) (26-27)

Select from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS&amp;E 111</td>
<td>Introduction to Optimization</td>
</tr>
<tr>
<td>MS&amp;E 120</td>
<td>Probabilistic Analysis</td>
</tr>
<tr>
<td>MS&amp;E 121</td>
<td>Introduction to Stochastic Modeling</td>
</tr>
<tr>
<td>MS&amp;E 180</td>
<td>Organizations: Theory and Management</td>
</tr>
<tr>
<td>MS&amp;E 130</td>
<td>Information Networks and Services</td>
</tr>
<tr>
<td>or MS&amp;E 233</td>
<td>Networked Markets</td>
</tr>
<tr>
<td>MS&amp;E 142</td>
<td>Introductory Financial Analysis</td>
</tr>
<tr>
<td>or MS&amp;E 260</td>
<td>Introduction to Operations Management</td>
</tr>
</tbody>
</table>

Elective (select any 100- or 200-level MS&E course) 3-4
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” section of this bulletin.

The M.S. program in Management Science and Engineering (MS&E) prepares individuals for a lifelong career addressing critical technical and managerial needs in private and public decision making. Department requirements for the M.S. degree provide breadth across some of the areas of the department, and flexibility for meeting individual objectives of depth in a particular area of concentration. The master’s degree may be a terminal degree program with a professional focus, or a preparation for a more advanced graduate program. The M.S. degree can normally be earned in one academic year (three academic quarters) of full-time work, although students may choose to continue their education by taking additional MS&E courses beyond that year. Background requirements, taken in addition to degree requirements, must be met by students who have had insufficient course work in mathematical sciences, computer science, engineering and/or natural sciences.

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

1. At least five core courses
2. At least three other courses in an area of concentration of their choice
3. A course in probability, unless a college-level course in probability has already been passed
4. A project course requirement
5. The remaining units in elective courses.

Background Requirements

Students must have had or must take the following (or equivalent) courses before the M.S. degree is conferred: MATH 41, 42, 51, Calculus, 15 units; CS 106A, Programming Methodology, 5 units, and an additional 15 units of engineering, mathematical sciences, or natural sciences. These courses do not count toward the 45 units of the M.S. degree. Courses taken to meet MS&E background requirements may be at either the undergraduate or graduate level, and may be taken as credit/no credit. These additional background requirements would typically be met by students who have a bachelor’s degree in engineering, or mathematical or natural sciences.

Core (Breadth) Courses

M.S. students must take five courses out of the following eleven areas. No more than one course may be taken from each of the eleven areas.

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic Systems or Stochastic Decision Models</td>
<td>3-4</td>
</tr>
<tr>
<td>MS&amp;E 201</td>
<td>Dynamic Systems</td>
</tr>
<tr>
<td>Optimization</td>
<td>3-4</td>
</tr>
<tr>
<td>MS&amp;E 251</td>
<td>Stochastic Control</td>
</tr>
<tr>
<td>MS&amp;E 211</td>
<td>Linear and Nonlinear Optimization</td>
</tr>
<tr>
<td>Probability</td>
<td>3-4</td>
</tr>
<tr>
<td>MS&amp;E 220</td>
<td>Probabilistic Analysis</td>
</tr>
<tr>
<td>Stochastic Modeling or Simulation</td>
<td>3</td>
</tr>
<tr>
<td>MS&amp;E 221</td>
<td>Stochastic Modeling</td>
</tr>
<tr>
<td>MS&amp;E 223</td>
<td>Simulation</td>
</tr>
<tr>
<td>Financial Analysis</td>
<td>3-4</td>
</tr>
<tr>
<td>MS&amp;E 240</td>
<td>Accounting for Managers and Entrepreneurs</td>
</tr>
</tbody>
</table>

Courses in an Area of Concentration (Depth)

Students must complete a departmentally approved set of three or more letter-graded courses taken for a minimum of three units each, in an area of concentration of one of the following types:

1. An area of concentration in the MS&E department
2. An area of concentration in one of the seven other departments of the School of Engineering
3. In exceptional cases, a coherent area of concentration designed by the student. Petitions for student-designed concentrations must list the three proposed courses (taken for three units or more and at the 200-level or above) and include a brief justification. The petition must be submitted to student services no later than the fifth week of the quarter prior to graduation.

Decision and Risk Analysis Pre-Approved Concentration Courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS&amp;E 250A</td>
<td>Engineering Risk Analysis</td>
</tr>
<tr>
<td>MS&amp;E 250B</td>
<td>Project Course in Engineering Risk Analysis</td>
</tr>
<tr>
<td>MS&amp;E 251</td>
<td>Stochastic Control</td>
</tr>
<tr>
<td>MS&amp;E 252</td>
<td>Decision Analysis I: Foundations of Decision Analysis</td>
</tr>
<tr>
<td>MS&amp;E 254</td>
<td>The Ethical Analyst</td>
</tr>
<tr>
<td>MS&amp;E 256</td>
<td>Technology Assessment and Regulation of Medical Devices</td>
</tr>
<tr>
<td>MS&amp;E 351</td>
<td>Dynamic Programming and Stochastic Control</td>
</tr>
<tr>
<td>MS&amp;E 352</td>
<td>Decision Analysis II: Professional Decision Analysis</td>
</tr>
<tr>
<td>MS&amp;E 353</td>
<td>Decision Analysis III: Frontiers of Decision Analysis</td>
</tr>
<tr>
<td>MS&amp;E 355</td>
<td>Influence Diagrams and Probabilistics Networks</td>
</tr>
<tr>
<td>MS&amp;E 452</td>
<td>Decision Analysis Projects: Helping Real Leaders Make Real Decisions</td>
</tr>
</tbody>
</table>

Stanford University
Economics and Finance Pre-Approved Concentration Courses:

- MS&E 241 Economic Analysis * 3-4
- MS&E 242 Investment Science * 3
- MS&E 242H Investment Science Honors * 3
- MS&E 243 Energy and Environmental Policy Analysis 3
- MS&E 245G Finance for Non-MBAs 3
- MS&E 247S International Investments 3
- MS&E 248 Economics of Natural Resources 3
- MS&E 249 Economic Growth and Development 3
- MS&E 342 Advanced Investment Science 3
- MS&E 347 Credit Risk: Modeling and Management 3
- MS&E 348 Optimization of Uncertainty and Applications in Finance 3
- MS&E 349 Capital Deployment 3
- MS&E 444 Investment Practice 3-4
- MS&E 445 Projects in Wealth Management 3-4

Energy and Environment Pre-Approved Concentration Courses:

- MS&E 243 Energy and Environmental Policy Analysis 3
- MS&E 248 Economics of Natural Resources 3
- MS&E 264 Sustainable Product Development and Manufacturing 3-4
- MS&E 294 Climate Policy Analysis 3
- MS&E 295 Energy Policy Analysis 3
- MS&E 491 Clean Energy Development 3
- CEE 207A Energy Resources 3-5
- EARTHYSYS 275 California Coast: Science, Policy, and Law 3-4
- EE 293A Solar Cells, Fuel Cells, and Batteries: Materials for the Energy Solution 3-4
- EE 293B Fundamentals of Energy Processes 3
- LAW 603 Environmental Law and Policy 3
- MATSCI 302 Solar Cells 3
- ME 260 Fuel Cell Science and Technology 3
- ME 370A Energy Systems I: Thermodynamics 3
- ME 370B Energy Systems II: Modeling and Advanced Concepts 4

Information Science and Technology Pre-Approved Concentration Courses:

- MS&E 233 Networked Markets 3
- MS&E 238 Leading Trends in Information Technology 3
- MS&E 239 Computational Advertising 3
- MS&E 335 Queueing and Scheduling in Processing Networks 3
- MS&E 336 Topics in Game Theory with Engineering Applications 3
- MS&E 337 Information Networks 3
- MS&E 338 Advanced Topics in Information Science and Technology 3
- CS 364A Algorithmic Game Theory 3
- EE 284 Introduction to Computer Networks 3
- EE 384S Performance Engineering of Computer Systems & Networks 3

Operations Research Pre-Approved Concentration Courses:

- MS&E 211 Linear and Nonlinear Optimization * 3-4
- MS&E 221 Stochastic Modeling * 3
- MS&E 223 Simulation * 3
- MS&E 251 Stochastic Control * 3
- MS&E 310 Linear Programming 3
- MS&E 311 Optimization 3
- MS&E 312 Advanced Methods in Numerical Optimization 3
- MS&E 313 Vector Space Optimization 3
- MS&E 314 Linear and Conic Optimization with Applications 3
- MS&E 315 Numerical Optimization 3
- MS&E 316 Discrete Mathematics and Algorithms 3
- MS&E 317 Algorithms for Modern Data Models 3
- MS&E 318 Large-Scale Numerical Optimization 3
- MS&E 319 Approximation Algorithms 3
- MS&E 321 Stochastic Systems 3
- MS&E 322 Stochastic Calculus and Control 3
- MS&E 335 Queueing and Scheduling in Processing Networks 3
- MS&E 336 Topics in Game Theory with Engineering Applications 3
- MS&E 337 Information Networks 3
- MS&E 338 Advanced Topics in Information Science and Technology 3
- MS&E 348 Optimization of Uncertainty and Applications in Finance 3
- MS&E 351 Dynamic Programming and Stochastic Control 3
- MS&E 355 Influence Diagrams and Probabilistics Networks 3
- EE 384S Performance Engineering of Computer Systems & Networks 3

Organization, Technology, and Entrepreneurship Pre-Approved Concentration Courses:

- MS&E 271 Global Entrepreneurial Marketing * 3-4
- MS&E 272 Startup Boards 3
- MS&E 273 Technology Venture Formation 3-4
- MS&E 274 Dynamic Entrepreneurial Strategy 3
- MS&E 276 Entrepreneurial Management and Finance 3
- MS&E 277 Creativity and Innovation 4
- MS&E 278 Patent Law and Strategy for Innovators and Entrepreneurs 2-3
- MS&E 279 The Founder’s Dilemmas 3
- MS&E 280 Organizational Behavior: Evidence in Action * 3-4
- MS&E 282 Transformational Leadership 3
- MS&E 283 Scaling up Excellence in Organizations 4
- MS&E 284 Work Design in Modern Organizations 3
- MS&E 289 Designing for Sustainable Abundance 3-4
- MS&E 464 Global Project Coordination 3-4

Policy and Strategy Pre-Approved Concentration Courses:

- MS&E 271 Global Entrepreneurial Marketing * 3-4
- MS&E 272 Startup Boards 3
- MS&E 273 Technology Venture Formation 3-4
MS&E 274  Dynamic Entrepreneurial Strategy  3
MS&E 276  Entrepreneurial Management and Finance  3
MS&E 277  Creativity and Innovation  4
MS&E 278  Patent Law and Strategy for Innovators and Entrepreneurs  2-3
MS&E 279  The Founder’s Dilemmas  3
MS&E 292  Health Policy Modeling  3
MS&E 293  Technology and National Security  3
MS&E 294  Climate Policy Analysis  3
MS&E 295  Energy Policy Analysis  3
MS&E 299  Voluntary Social Systems  3
MS&E 464  Global Project Coordination  3-4

Production and Operations Management Pre-Approved Concentration Courses:
MS&E 260  Introduction to Operations Management  3-4
MS&E 261  Inventory Control and Production Systems  3
MS&E 262  Supply Chain Management  3
MS&E 263  Healthcare Operations Management  3
MS&E 264  Sustainable Product Development and Manufacturing  3-4
MS&E 266  Management of New Product Development  3
MS&E 268  Operations Strategy  3
MS&E 464  Global Project Coordination  3-4

* These courses are also listed as core courses. You may use them to satisfy either the core or the concentration requirement, but not both.

Project Course Requirement
Students must take either a designated project course or two designated integrated project courses. The project course(s) must be taken for a letter grade, must be taken for a minimum of three units, and may also be used to satisfy the core or concentration requirement.

Project Courses
MS&E 250B  Project Course in Engineering Risk Analysis  3
MS&E 348  Optimization of Uncertainty and Applications in Finance  3
MS&E 444  Investment Practice  3-4
MS&E 445  Projects in Wealth Management  3-4
MS&E 452  Decision Analysis Projects: Helping Real Leaders Make Real Decisions  3
MS&E 464  Global Project Coordination  3-4
MS&E 491  Clean Energy Development  3

Integrated Project Courses
MS&E 201  Dynamic Systems  3-4
MS&E 206  Art of Mathematical Modeling  3
MS&E 211  Linear and Nonlinear Optimization  3-4
MS&E 242  Investment Science  3
MS&E 242H  Investment Science Honors  3
MS&E 243  Energy and Environmental Policy Analysis  3
MS&E 248  Economics of Natural Resources  3
MS&E 256  Technology Assessment and Regulation of Medical Devices  3
MS&E 262  Supply Chain Management  3
MS&E 264  Sustainable Product Development and Manufacturing  3-4
MS&E 266  Management of New Product Development  3
MS&E 270  Strategy in Technology-Based Companies  3-4

MS&E 271  Global Entrepreneurial Marketing  3-4
MS&E 273  Technology Venture Formation  3-4
MS&E 274  Dynamic Entrepreneurial Strategy  3
MS&E 277  Creativity and Innovation  3-4
MS&E 280  Organizational Behavior: Evidence in Action  3-4
MS&E 294  Climate Policy Analysis  3
MS&E 295  Energy Policy Analysis  3
MS&E 311  Optimization  3
MS&E 315  Numerical Optimization  3
MS&E 337  Information Networks  3
MS&E 347  Credit Risk: Modeling and Management  3
MS&E 349  Capital Deployment  3
MS&E 355  Influence Diagrams and Probabilities  3

Additional Requirements
1. At least 45 units must be in courses numbered 100 and above.
2. 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, and 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.
3. The degree program must be completed with a grade point average (GPA) of 3.0 or higher.
4. A maximum of three units of language courses (numbered 100 and above).
5. 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.
6. A maximum of 18 non-degree option (NDO) units through the Stanford Center for Professional Development (SCPD).
7. Courses in athletics may not be applied toward the degree.

See the student services office or department web site for complete listing of approved concentrations.

Energy and Environment Track
The Energy and Environment M.S. 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 that provide the conceptual background in economics, decisions, strategy, investment, and organizational behavior; courses in energy resources, natural resource economics, and energy/environmental policy analysis; and an individually designed concentration emphasizing policy, strategy, and/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. Students can complete the program in one year or may extend the program up to two years, taking additional courses for greater depth and breadth. For additional information, see http://www.stanford.edu/dept/MSandE/academics/energy/environment.html.

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, 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 about four to five years after entering the program to complete all Ph.D. requirements. The Ph.D. is generally organized around the requirement that the students acquire a breadth across some of the eight areas of the department, and depth in one of them. These fields of study 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

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 eight areas of the department, or the Systems Program which is a combination of several areas. The qualification decision is based on the student’s grade point average (GPA), on the one or two preliminary papers prepared by the student, and on the student’s performance in an area examination. Considering this evidence, the department faculty votes on advancing the student to candidacy in the department at large. The Ph.D. requires a minimum of 135 units, at least 54 of which must be in courses of 3 units or more. At least 48 course units in courses of 3 units or more must be taken for a letter grade. 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

1. The breadth requirement is to be satisfied by a choice of four courses spanning four out of the above mentioned eight areas of the department.
2. The Ph.D. candidacy form must contain four courses that satisfy the breadth requirement.
3. Courses chosen to satisfy the breadth requirement must be taken for letter grades.
4. At least one of the four courses chosen to satisfy the breadth requirement must be at the 300 level.

Courses Satisfying the Breadth Requirement:

Choose at least one course from four different areas. Courses used to satisfy the breadth requirement may also be used to satisfy the depth requirement.

- **Systems Modeling and Optimization:**
  - MS&E 201 Dynamic Systems 3-4
  - MS&E 211 Linear and Nonlinear Optimization 3-4
  - MS&E 310 Linear Programming 3
  - MS&E 311 Optimization 3
  - MS&E 312 Advanced Methods in Numerical Optimization 3
  - MS&E 313 Vector Space Optimization 3
  - MS&E 314 Linear and Conic Optimization with Applications 3
  - MS&E 315 Numerical Optimization 3
  - MS&E 316 Discrete Mathematics and Algorithms 3
  - MS&E 317 Algorithms for Modern Data Models 3
  - MS&E 318 Large-Scale Numerical Optimization 3
  - MS&E 319 Approximation Algorithms 3

- **Probability and Stochastic Systems:**
  - MS&E 220 Probabilistic Analysis 3-4
  - MS&E 221 Stochastic Modeling 3
  - MS&E 223 Simulation 3
  - MS&E 321 Stochastic Systems 3
  - MS&E 322 Stochastic Calculus and Control 3
  - MS&E 335 Queueing and Scheduling in Processing Networks 3
  - MS&E 336 Topics in Game Theory with Engineering Applications 3
  - MS&E 337 Information Networks 3
  - MS&E 338 Advanced Topics in Information Science and Technology 3

- **Information Science and Technology:**
  - MS&E 233 Networked Markets 3
  - MS&E 239 Computational Advertising 3
  - MS&E 335 Queueing and Scheduling in Processing Networks 3
  - MS&E 336 Topics in Game Theory with Engineering Applications 3
  - MS&E 337 Information Networks 3
  - MS&E 338 Advanced Topics in Information Science and Technology 3

- **Economics and Finance:**
  - MS&E 241 Economic Analysis 3-4
  - MS&E 242 Investment Science 3
  - MS&E 242H Investment Science Honors 3
  - MS&E 242S Investment Science 3
  - MS&E 248 Economics of Natural Resources 3
  - MS&E 342 Advanced Investment Science 3
  - MS&E 347 Credit Risk: Modeling and Management 3
  - MS&E 348 Optimization of Uncertainty and Applications in Finance 3
  - MS&E 349 Capital Deployment 3

Qualification Procedure Requirements

The qualification procedure is based both on breadth across the department’s disciplines and depth in an area of the student’s choice. 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.
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.

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