MANAGEMENT SCIENCE AND ENGINEERING

Emeriti: (Professors) James L. Adams, Kenneth J. Arrow, Richard W. Cottle, Donald A. Dunn, B. Curtis Eaves, Frederick S. Hillier, Donald L. Iglehart, James V. Jucker, Michael M. May, Robert V. Oakford, Henry E. Riggs, David A. Thompson

Chair: M. Elisabeth Paté-Cornell

Professors: Nicholas Bambos, Stephen R. Barley, Margaret L. Brandeau, Robert C. Carlson, Kathleen M. Eisenhardt, Peter W. Glynn, Warren H. Hausman, Ronald A. Howard, David G. Luenberger, M. Elisabeth Paté-Cornell, William J. Perry, Robert I. Sutton, James L. Sweeney, Arthur F. Veinott, Jr., Yinyu Ye

Associate Professors: Samuel S. Chiu, Ashish Goel, Pamela J. Hinds, Ross D. Shachter, Edison T. S. Tse, Benjamin Van Roy

Assistant Professors: Diane E. Bailey, Feryal Erhun, Kay Giesecke, Ramesh Johari, Riitta Katila, Ozalp Ozer, James A. Primbs, Amin Saberi, Thomas A. Weber

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

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

Courtesy Professors: Anat Admati, Walter Powell

Courtesy Assistant Professor: Timothy Roughgarden

Lecturers: Steve Blank, Barchi Gillai, Gregory Hamm, Hill Huntington, Ferdo Ivanek, Mary Morrison, Andrew Nelson, Donna Novitsky, Lena Ramfelt, Tina Seelig, Rosanne Siino, Lynda Kate Smith

Consulting Professors: Gerd Infanger, Thomas Kosnik, James E. Matheson, Robert R. Maxfield, D. Warner North, Burke Robinson, Sam L. Savage, Behnam Tabrizi

Consulting Associate Professors: Adam Borison, Peter Haas, Samuel Holtzman, Randy Komisar, Michael Lyons, Audrey MacLean, Adam Seiver, F. Victor Stanton

Consulting Assistant Professors: Blake E. Johnson, Hervé Kieffel, Jan Pietzsch

Visiting Professor: Olivier de La Grandville

Visiting Associate Professors: Charles Feinstein, Yee-Tien Fu

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Courses given in Management Science and Engineering have the subject code MS&E. For a complete list of subject codes, see Appendix.

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; and (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.

CAREERS IN MS&E

MS&E helps students prepare for a variety of professional careers in business, government, industry, non-profit institutions, and universities. Graduates have pursued successful 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.

UNDERGRADUATE PROGRAM

BACHELOR OF SCIENCE

The program leading to the B.S. degree in Management Science and Engineering (MS&E) is stated earlier under the "School of Engineering" section of this bulletin, and 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:

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

In particular, the department wants to help students develop:

1. an ability to apply knowledge of math, science, and engineering.
2. an ability to design and conduct experiments.
3. an ability to design a system or components to meet desired needs.
4. an ability to identify, formulate, and solve engineering problems.
5. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
6. an ability to function on multidisciplinary teams.

7. an ability to communicate effectively.
8. a recognition of the need for and an ability to engage in life-long learning.
9. background necessary for admission to top professional graduate engineering or business programs.
10. an understanding of professional and ethical responsibility.
11. the broad education necessary to understand the impact of engineering solutions in a global and societal context.
12. a knowledge of contemporary issues pertinent to the field of management science and engineering.

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

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.

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, decision analysis, economics, finance, investment science, and stochastic models.
2. *Operations Research:* provides a more mathematical program, based on algorithms, theory, and applications in economics and operations.
3. *Organization, Technology, and Entrepreneurship:* focuses on understanding and design of organizations, particularly technology-based issues. It features courses on innovation, product development, entrepreneurship, work and manufacturing systems, information systems, and human-computer interaction.
4. *Production and Operations Management:* focuses on the design and analysis of manufacturing, production, and service systems.
5. *Policy and Strategy*: focuses on the design and analysis of public policies and corporate strategies, especially those with technology-based issues. It features a core in microeconomics and modeling approaches, and policy-focused courses in topics such as national security, energy and environment, and health care, and strategy-focused courses in topics such as entrepreneurship, innovation, and product development.

For information about an MS&E minor, see the "School of Engineering" section of this bulletin.

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.

GRADUATE PROGRAMS

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 http://registrar.stanford.edu/shared/publications.htm#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 is January 8 for doctoral and master's applicants.

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.

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

MASTER OF SCIENCE

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.

MANAGEMENT SCIENCE AND ENGINEERING

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 Courses—M.S. students must take at least five courses out of the following ten options:

MS&E 201. Dynamic Systems *or* MS&E 251. Stochastic Decision Models
MS&E 211. Linear and Nonlinear Optimization
MS&E 221. Introduction to Stochastic Modeling *or* MS&E 223. Simulation
MS&E 240. Industrial Accounting *or* MS&E 242. Investment Science
MS&E 241. Economic Analysis
MS&E 252. Decision Analysis *or* MS&E 250A. Risk Analysis
MS&E 261. Production Systems
MS&E 270. Strategy in Technology-Based Companies
MS&E 271. Global Entrepreneurial Marketing
MS&E 280. Organizational Behavior and Management

Students may not waive core courses. They may, however, petition to substitute an approved, more advanced course in the same area. Courses used to satisfy the core requirement must be taken for a letter grade, must be taken for a minimum of three units each, and may not also be used to satisfy the concentration requirement.

Courses in an Area of Concentration—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.

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 letter grade, must be taken for a minimum of three units, and may also be used to satisfy the core or concentration requirement.

Additional requirements are:

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, and a maximum of one unit of MS&E 208A, B, or 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.

Please see the student services office or department web site for complete listing of project, integrated project and approved concentrations.

ENERGY AND ENVIRONMENT

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/energyenvironment.html.

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.

The Dual Degree Program—This dual degree program enables a small set 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.

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 deadline of January 8, 2008.

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 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.

DOCTOR OF PHILOSOPHY

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 certain 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

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 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. The list of courses satisfying the breadth requirement is available from the MS&E student services office.

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.

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 faculty meeting at the end of May or beginning of June. Ph.D. qualification decisions are made at that time and individual feedback is provided.

The Ph.D. qualification requirements comprise these elements:

1. *Grade Point Average:* a student must maintain a GPA of at least 3.4 in the four courses chosen to satisfy the breadth requirements, and a GPA of at least 3.4 in the set of all courses taken by the student within the department. In both cases, the GPA is 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, either to be completed before the Spring Quarter of the student's second year. The first option involves one paper supervised by a primary faculty adviser and a faculty consultant. 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 adviser(s)/consultant with the faculty members' consent.

   A student may register for up to 3 units per tutorial and up to 6 units for a paper. These paper or tutorial units do not count towards the 54 course units required for the Ph.D., and letter grades are not given.
3. *Area Qualification:* in addition, during the second year, a student must pass an examination in one of the eight areas of the MS&E department or the Systems Program which is a combination of several areas, which is of the student's choice. This area examination is written, oral, or both at the discretion of the area faculty administering the exam.
4. *Area Course Requirement:* students must complete the depth requirements of one of the eight fields of study of the MS&E department or the Systems Program which is a combination of several areas. Courses used to satisfy depth requirements must be taken for a letter grade. The Ph.D. requirements for the eight areas of the MS&E department are available from the MS&E student services office.

PH.D. MINOR

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 ten MS&E M.S. 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.

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 30 semester (45 quarter) hours of approved courses may be counted toward both degrees. In the case of a J.D./Ph.D. program, no more than 36 semester (54 quarter) hours of approved courses may be counted toward both degrees. In either case, no more than 24 semester (36 quarter) hours 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) 12 semester (18 quarter) hours 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.

COURSES

WIM indicates that the course satisfies the Writing in the Major requirements. (AU) indicates that the course is subject to the University Activity Unit limitations for undergraduates (8 units maximum).

UNDERGRADUATE

MS&E 41. Financial Literacy—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.

1 unit, Win, Spr (Morrison, M)

MS&E 76. Pre-field Course for Alternative Spring Break—Preparation course for the Alternative Spring Break program, administered through the Haas Center for Public Service. Readings and guest speakers focus on discovering social entrepreneurship as a technique for large-scale social change, focusing on innovative individuals and organizations in the Bay Area. Emphasis is on developing an entrepreneurial approach to social-sector problems.

1 unit, Win (Seelig, T)

MS&E 92Q. International Environmental Policy—Stanford Introductory Seminar. 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.

4 units, Win (Weyant, J)

MS&E 93Q. Nuclear Weapons, Terrorism, and Energy—Stanford Introductory Seminar. Preference to sophomores. What are nuclear weapons and what do they do? Why do some nations want them? What are the risks of nuclear terrorism? What is radioactivity? What role does nuclear power play? Can it help with global warming? Emphasis is on policy options in the light of changes in the world. Recommended: a course in international relations, engineering, or physical science. GER:DB-EngrAppSci

3 units, Spr (Hecker, S)

MS&E 94Q. The Public Use and Misuse of Mathematics: How to Interpret Numbers as Used by Media and Politicians—Stanford Introductory Seminar. Preference to sophomores. How to unearth and interpret relevant math to illuminate underlying political and economic issues. How to interpret public budgets, whether jury pool selection is biased, estimate pollution risks, and when to believe poll results and statistical relationships; how to deal with rare but high-consequence eventualities such as terrorism, a nuclear meltdown, or a possible pandemic. How to determine how much to pay to reduce carbon emissions, when a medicine should be withdrawn, and what is a useful forecast.

3 units, Spr (May, M)

MS&E 101. Undergraduate Directed Study—Subject of mutual interest to student and faculty member. Prerequisite: faculty sponsor.

1-15 units, Aut, Win, Spr, Sum (Staff)

MS&E 107. Interactive Management Science—(Graduate students register for 207.) 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. GER:DB-EngrAppSci

3 units, Aut (Savage, S)

MS&E 108. Senior Project—Restricted to MS&E 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.

5 units, Win (Brandeau, M; Hecker, S; Shachter, R; Tse, E)

MS&E 111. Introduction to Optimization—(Same as ENGR 62.) 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: MATH 51. GER:DB-EngrAppSci

4 units, Aut (Goel, A), Spr (Van Roy, B)

MS&E 112. Mathematical Programming and Combinatorial Optimization—(Graduate students register for 212; same as CME 208.) Combinatorial and mathematical programming (integer and nonlinear) 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: CS 106A or X; ENGR 62 or MATH 103. GER:DB-EngrAppSci

3 units, Win (Saberi, A)

MS&E 120. Probabilistic Analysis—Concepts and tools for the analysis of problems under uncertainty, focusing on model building and communication: 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: MATH 51. Recommended: knowledge of spreadsheets. GER:DB-EngrAppSci

5 units, Aut (Shachter, R)

MS&E 121. Introduction to Stochastic Modeling—Stochastic processes and models in operations research. Discrete and continuous time parameter Markov chains. Queuing theory, inventory theory, simulation. Prerequisite: 120 or Statistics 116. GER:DB-EngrAppSci

4 units, Win (Glynn, P)

MS&E 130. Information Systems and Networks—Technical, social, and economic issues in modern information networks. Introduction to Internet architectures and search technologies. Network economics and the pricing of digital goods. Advertising and marketing models for the Internet. Social interaction in the networked society emphasizing how information systems have altered work and the workplace. Recommendation systems, reputation systems, and information markets. Prequisite: CS 106B or X.

3 units, Spr (Barley, S)

MS&E 134. Organizations and Information Systems—(Graduate students register for 234.) How information systems impact organizations and how organizations take control of information technology (IT) to gain a competitive edge. Topics include: IT components, architecture, and transformation; the effect of IT on competition; real-time enterprise; leadership; and outsourcing. Student teams perform field studies based on situations in which information technology is creating a significant management problem or business opportunity. Enrollment limited. Prerequisites: CS 106A, 180, or equivalents.

4 units, Win (Tabrizi, B)

MS&E 140. Industrial Accounting—(Graduate students register for 240.) 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.

3-4 units, Win, Sum (Stanton, F)

MS&E 142. Investment Science—(Graduate students register for 242.) Theory and application of modern quantitative investment analysis from an engineering perspective. How investment concepts are used to evaluate and manage opportunities, portfolios, and investment products including stocks, bonds, mortgages, and annuities. Topics: deterministic cash flows (term structure of interest rates, bond portfolio immunization, project optimization); mean-variance theory (Markowitz model, capital asset pricing); and arbitrage pricing theory. Group project. Prerequisites: 120, ENGR 60, MATH 51, or equivalents. Recommended: 140, ENGR 62, knowledge of spreadsheets.

3 units, Aut (Primbs, J)

MS&E 152. Introduction to Decision Analysis—(Same as 152W.) 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 actional 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. GER:DB-EngrAppSci

3-4 units, Spr (Shachter, R)

MS&E 152W. Introduction to Decision Analysis—(Same as 152.) For students seeking to fulfill the Writing in the Major requirement. GER:DB-EngrAppSci, WIM

3-4 units, Spr (Shachter, R)

MS&E 153. Introduction to Decision Making in Organizations—Experienced management consultants share lessons and war stories. Case studies, disguised examples from real engagements, and movie clips illustrate theories and concepts of decision analysis. Student teams critique decisions made in actual organizations. Topics include what makes a good decision, how decisions can be made better, framing and structuring techniques, modeling and analysis tools, biases and probability assessment, evaluation and appraisal methods, decision mindsets, creativity, leadership, and effective presentation styles.

3 units, Sum (Holtzman, S; Robinson, B)

MS&E 154. Business Strategy and Public Policy Decision Making—Comparative study of how decision makers should formulate, evaluate, and implement strategy or policy in organizations of all sizes. Student teams apply qualitative and quantitative methods to private sector strategies, such as Internet company growth, entrepreneurial start-up, or corporate R&D portfolio, and public sector policies, such as nuclear nonproliferation, flu pandemic mitigation, and terrorist attack prevention. Topics: right people doing the right thing in the right way; framing key issues and challenges; crafting doable strategies and policies; capturing uncertainties; resolving value dilemmas; analyzing consequences; testing sensitivities; gathering additional information; and committing to action.

3 units, Sum (Robinson, B)

MS&E 160. Analysis of Production and Operating Systems—(Graduate students register for 260; see 260.)

4 units, Aut (Ozer, A)

MS&E 169. Quality Control and Management—(Graduate students register for 269; see 269.)

3-4 units (Staff) not given this year

MS&E 175. Innovation, Creativity, and Change—Problem solving in organizations; creativity and innovation skills; thinking tools; creative organizations, teams, individuals, and communities.

3-4 units (Katila, R) alternate years, given next year

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

4 units, Aut (Siino, R), Spr (Eisenhardt, K)

MS&E 181. Issues in Technology and Work for a Post-Industrial Economy—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.

3 units, Spr (Nelson, A)

MS&E 184. Technology and Work—Interplay between technology and work, emphasizing technological change and its impact on workers at all levels. Technologies include the assembly line, computer and information systems, cardiac surgery techniques, and advanced computational software. Motivations for and consequences of change, including rationalization, deskilling, reskilling, offshoring, and increasing abstraction of work.

3 units, Aut (Bailey, D)

MS&E 185. Global Work—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.

4 units (Hinds, P) not given this year

MS&E 190. Methods and Models for Policy and Strategy Analysis—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.

3 units, Spr (Eisenhardt, K)

MS&E 193. Technology and National Security—(Graduate students register for 293; same as 193W.) 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. Students seeking to fulfill the WIM requirement should register for 193W.

3 units, Aut (Perry, W; Hecker, S)

MS&E 193W. Technology and National Security—(Same as 193/293.) For students seeking to fulfill the Writing in the Major requirement. WIM

3 units, Aut (Perry, W; Hecker, S)

MS&E 196. Transportation Systems and Urban Development—(Graduate students register for 296.) Transportation systems and planning, and their roles in society. Analytical tools at a conceptual level to examine issues and evaluate alternatives. Policy implications and system effectiveness analysis of transportation in an urban context. Topics: economic analysis of transportation, supply and demand equilibrium analysis, urban transportation networks, congestion management, short and long term transportation planning, the impact of technology on transportation systems, land use and transportation, case studies of current transportation news items. Prerequisite: MATH 41.

3 units, Win (Chiu, S)

MS&E 197. Ethics and Public Policy—(Same as PUBLPOL 103B, STS 110.) 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. GER:DB-Hum, EC-EthicReas, WIM

5 units, Win (McGinn, R)

MS&E 198. Applied Modeling of Energy and Environmental Markets—Economic principles in models of energy and environmental markets. Spreadsheet examples for developing insights and communicating with decision makers. Market-clearing conditions, controlling emissions through fees, diffusion of new technologies, resource depletion, cartel behavior, and model evaluation. Prerequisites: ECON 50 and spreadsheets, or consent of instructor.

1 unit, Aut (Huntington, H)

COGNATE COURSES (UNDERGRADUATE)

See respective department listings for course descriptions and General Education Requirements (GER) information. See degree requirements above or the department's student services office for applicability of these courses to a major or minor program.

ENGR 60. Engineering Economy

3 units, Aut (Chiu, S), Win, Sum (Weber, T)

ENGR 145. High Technology Entrepreneurship

4 units, Aut (Gould, A; Kosnik, T), Win (Byers, T; Komisar, R, Kosnik, T)

POLISCI 114S. International Security in a Changing World—(Same as IPS 241.)

5 units, Win (Sagan, S; Blacker, C)

PRIMARILY FOR GRADUATE STUDENTS

GENERAL AND SYSTEMS ANALYSIS METHODS

MS&E 201. Dynamic Systems—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: MATH 103 or equivalent.

3-4 units, Spr (Tse, E)

MS&E 206. Art of Mathematical Modeling—Practicum. Students build mathematical models of real-life, ill-framed problems. Emphasis is on framing the issues, articulating modeling components logically (drawing from student's mathematical background), and analyzing the resulting model. Hands-on modeling. Project work in small groups. Prerequisites: basic analysis, calculus and algebra, and probability theory. Recommended: decision analysis, optimization and dynamic systems.

3-4 units, Spr (Kieffel, H)

MS&E 207. Interactive Management Science—(Undergraduates register for 107; see 107.)

3 units, Aut (Savage, S)

MS&E 208A,B,C. Practical Training—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 one-page statement showing relevance to degree program along with offer letter 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. Master's students are limited to one quarter of practical training. B.S. and Ph.D. students may take each of A, B, and C once.

1 unit, Aut, Win, Spr, Sum (Staff)

OPTIMIZATION

MS&E 211. Linear and Nonlinear Optimization—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: MATH 51.

3-4 units, Aut (Ye, Y)

MS&E 212. Mathematical Programming and Combinatorial Optimization—(Undergraduates register for 112; see 112; same as CME 208.)

3 units, Win (Saberi, A)

PROBABILITY AND STOCHASTIC SYSTEMS

MS&E 220. Probabilistic Analysis—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: MATH 51. Recommended: knowledge of spreadsheets.

3-4 units, Aut (Chiu, S)

MS&E 221. Stochastic Modeling—Focus is on time-dependent random phenomena. Topics: discrete and continuous time Markov chains, renewal processes, queueing theory, and applications. Emphasis is on building a framework to formulate and analyze probabilistic systems. Prerequisite: 220 or consent of instructor.

3 units, Win (Johari, R)

MS&E 223. Simulation—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, or FORTRAN; probability; and statistical methods.

3 units, Spr (Haas, P)

INFORMATION SCIENCE AND TECHNOLOGY

MS&E 234. Organizations and Information Systems—(Undergraduates register for 134; see 134.)

4 units, Win (Tabrizi, B)

MS&E 235. Internet Commerce—The technology, mathematics, and economics of Internet commerce. Topics include: models of Internet commerce; online advertising; product recommendation systems and personalized marketing; pricing and delivery of digital media; web tools; piracy, copyright, and peer-to-peer networks; rating and reviewing of online businesses; and co-evolution of Internet technology and commerce. Hands-on exercises; group project. Prerequisites: 111 or 211, and CS 106B or X.

3 units, Win (Goel, A)

MS&E 237. Progress in Worldwide Telecommunications—Interdisciplinary. Guest speakers from industry, government and academia. Topics include networks and services, market-driven competition, policy, regulation and deregulation, technology, standardization, and the needs of underserved parts of the world. Focus is on wireless communications, broadband user access, the Internet, and globalization. Individual or team case study and verbal presentation. May be repeated for credit. Limited enrollment.

3 units, Sum (Ivanek, F; Chiu, S)

MS&E 238. Network Structures and Analysis—The role of networks in social, technological, and economic systems. The impact of network structures on systems such as social networks including LinkedIn and Facebook; web pages and hyperlinks; buyers and sellers connected through a market; and towns connected by roads or airplane routes. Topics: graph and network analysis; epidemics on networks, the spread of fads, and tipping points; six degrees of separation and the small world phenomenon; power laws and their emergence; and network effects and externalities. Prerequisites: 220 and MATH 51.

3 units, Spr (Johari, R), alternate years, not given next year

ECONOMICS, FINANCE, AND INVESTMENT

MS&E 240. Industrial Accounting—(Undergraduates register for 140; see 140.)

3-4 units, Win, Sum (Stanton, F)

MS&E 241. Economic Analysis—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. See 341 for continuation of 241. Recommended: 211, ECON 50.

3-4 units, Win (Weber, T)

MS&E 242. Investment Science—(Undergraduates register for 142.) Theory and application of modern quantitative investment analysis from an engineering perspective. How investment concepts are used to evaluate and manage opportunities, portfolios, and investment products including stocks, bonds, mortgages, and annuities. Topics: deterministic cash flows (term structure of interest rates, bond portfolio immunization, project optimization); mean-variance theory (Markowitz model, capital asset pricing); and arbitrage pricing theory. Group project. Limited enrollment. Prerequisites: 120, ENGR 60, MATH 51, or equivalents. Recommended: 140, ENGR 62, knowledge of spreadsheets.

3 units, Aut (Primbs, J)

MS&E 242H. Investment Science Honors—Concepts of modern quantitative finance and investments. Basic concepts under certainty including arbitrage, term structure of interest rates, and bond portfolio immunization. A situation of uncertainty in one period. Topics: arbitrage; theorems of asset pricing; pricing measures; derivative securities; applications and estimating of financial risk measures; mean-variance portfolio analysis; and equilibrium and the capital asset pricing model. Group projects involving financial market data. Prerequisites: basic probability, statistics, and economics such as MS&E 120, 121, MATH 51, ENGR 60, or equivalents. No prior knowledge of finance required.

3 units, Aut (Giesecke, K)

MS&E 242S. Investment Science—Emphasis is on a cash flow approach. Topics include deterministic cash flow analysis (time value of money, present value, internal rate of return, taxes, inflation), fixed income securities, duration and bond portfolio immunization, term structure of interest rates (spot rates, discount factors, forward rates), Fisher-Weill duration and immunization, capital budgeting, dynamic optimization problems, investments under uncertainty, mean-variance portfolio theory, capital asset pricing, and basic options theory. Goal is to create a link between engineering analysis and business decision making.

3 units, Sum (Feinstein, C)

MS&E 243. Energy and Environmental Policy Analysis—(Same as IPER 243.) 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: 241 or ECON 50, 51.

3 units, Spr (Sweeney, J)

MS&E 245G. Finance for Non-MBAs—(Same as ECON 135, FINANCE 221.) 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: 51, or ENGR 60, or equivalent; ability to use spreadsheets, and basic probability and statistics concepts including random variables, expected value, variance, covariance, and simple estimation and regression.

4 units, Aut (Admati, A)

MS&E 246. Game Theory with Engineering Applications—Strategic interactions among multiple decision makers emphasizing applications to engineering systems. Topics: efficiency and fairness; collective decision making and cooperative games; static and dynamic noncooperative games; and complete and incomplete information models. Competition: Bertrand, Cournot, and Stackelberg models. Mechanism design: auctions, contracts. Examples from engineering problems. Prerequisites: MATH 51 and exposure to probability such as 120 or EE 178. Recommended: 211, concurrent enrollment in 241 or ECON 202.

3 units, Win (Erhun Oguz, F)

MS&E 247S. International Investments—International financial markets, their comparative behavior and interrelations. Focus is on assets traded in liquid markets: currencies, equities, bonds, swaps, and derivatives. Topics: institutional arrangements, taxation and regulation, international arbitrage and parity conditions, valuation of target firms for cross-border acquisitions, direct foreign investment, international diversification and portfolio management, derivative instruments and dynamic investment strategies, international performance analysis, international capital flows and financial crises, and topics of current relevance and importance. Prerequisite: basic finance theory (equivalent to 242 or 245G).

3 units, Sum (Fu, Y)

MS&E 248. Economics of Natural Resources—Intertemporal economic analysis of natural resource use, particularly energy, and including air, water, and other depletable mineral and biological resources. Emphasis is on an integrating theory for depletable and renewable resources. Stock-flow relationships; optimal choices over time; short- and long-run equilibrium conditions; depletion/extinction conditions; market failure mechanisms (common-property, public goods, discount rate distortions, rule-of-capture); policy options. Prerequisite: 241 or ECON 51.

3-4 units, Aut (Sweeney, J)

MS&E 249. Growth and Development—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 financial crises in E. Asia and Argentina; 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.

3 units, Sum (De La Grandville, O)

DECISION AND RISK ANALYSIS

MS&E 250A. Engineering Risk Analysis—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: 120 or STATS 116, and ENGR 60, or equivalents.

2-3 units, Win (Paté-Cornell, E)

MS&E 250B. Project Course in Engineering Risk Analysis—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. Prerequisite: 250A, consent of instructor.

3 units, Spr (Paté-Cornell, E)

MS&E 251. Stochastic Decision Models—Efficient formulation and computational solution of sequential decision problems under uncertainty. Markov decision chains and stochastic programming. Maximum expected present value and rate of return. Optimality of simple policies: myopic, linear, index, acceptance limit, and (s,S). Optimal stationary and periodic infinite-horizon policies. Applications to investment, options, overbooking, inventory, production, purchasing, selling, quality, repair, sequencing, queues, capacity, transportation. MATLAB is used. Prerequisites: probability, linear programming.

3 units, Win (Veinott, A)

MS&E 252. Decision Analysis I: Foundations of Decision Analysis—Coherent approach to decision making, using the metaphor of developing a structured conversation having desirable properties, and producing actional 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.

3-4 units, Aut (Howard, R)

MS&E 254. The Ethical Analyst—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.

1-3 units, Spr (Howard, R)

MS&E 256. Technology Assessment and Regulation of Medical Devices—(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.

1-3 units, Spr (Pietzsch, J)

PRODUCTION OPERATIONS, SERVICES, AND MANUFACTURING

MS&E 260. Analysis of Production and Operating Systems—(Undergraduates register for 160.) Businesses add value through production and delivery of products and services; operations managers are responsible for designing, running, and improving systems and processes to meet demand for goods and services. Techniques to analyze an operating system. Topics include determination of optimal facility location, production lot sizing, optimal timing and sizing of capacity expansion, and inventory control. Prerequisites: probability and optimization.

4 units, Aut (Ozer, A)

MS&E 261. Inventory Control and Production Systems—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.

3 units, Win (Hausman, W)

MS&E 262. Supply Chain Management—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. Prerequisite: 260 or 261.

3 units, Spr (Hausman, W)

MS&E 263. Internet-Enabled Supply Chains—E-businesses have changed traditional supply chain interactions by creating a web-like structure and more flexible relationships, and it is no longer possible operationally or strategically to ignore the information-based virtual value chains for any business. How information technologies advanced supply chain integration; e-markets including auctions and exchanges; dynamic pricing; bundling; strategic implications of lock-in and switching costs; compatibility choices; and standardization efforts.

3 units (Erhun Oguz, F) not given this year

MS&E 263B. Demand and Supply Chain Analytics—Tools to efficiently manage supply and demand networks. Topics include service and inventory trade offs, stock allocation, pricing, and contracts and coordination. TImely product distribution to market while avoiding excess inventories; allocating adequate resources to the most profitable products. Selling the right product to the right customer at the right price at the right time.

3 units, Spr (Ozer, A)

MS&E 264. Manufacturing Systems Design—Multidisciplinary. The concepts and techniques of designing and improving performance and productivity in systems composed of and influenced by people, organizational factors, environmental factors, and technology. Emphasis is on the design of high-performance manufacturing systems. Use of simulation as a tool for design evaluation.

3-4 units, Aut (Erhun Oguz, F)

MS&E 265. Supply Chain Logistics—Student teams redesign the manufacturing and distribution system of a medium-sized manufacturer. Focus is on the transportation system, inventory policies for a regional warehouse, design of a national distribution system, improvements of work flow, and layout of the manufacturing plant. The redesign is at a detailed operational level consistent with a strategy of integrating the functions of manufacturing and distribution. Analytical and game software is used. Knowledge of inventory theory, linear/integer programming, economic analysis, and applied probability is required. Emphasis is on group learning. Limited enrollment. Prerequisites: senior or graduate standing, 160, ENGR 60 and 62, or consent of instructor.

4 units (Staff) alternate years, not given this year

MS&E 266. Management of New Product Development—Techniques of managing or leading the process of new product development that have been found effective. Emphasis is placed on how much control is desirable and how that control can be exercised in a setting where creativity has traditionally played a larger role than discipline. Topics: design for manufacturability, assessing the market, imposing discipline on the new product development process, selecting the appropriate portfolio of new product development projects, disruptive technology, product development at internet speed, uncertainty in product development, role of experimentation in new product development, creating an effective development organization, and developing products to hit cost targets.

3-4 units, Win (Staff)

MS&E 267. Innovations in Manufacturing—Major innovations including mass production, quality movement, lean manufacturing, outsourcing, and sustainable manufacturing; underlying changes in how products are made, who makes them, and why they are designed and marketed as they are; and key metrics such as cost, quality, speed of delivery, product variety, and social or environmental responsibility. Economic, social, and political factors influencing product, process, and organizational changes.

3-4 units, Aut (Bailey, D)

MS&E 268. Operations Strategy—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.

3 units (Carlson, R) given next year

MS&E 269. Quality Control and Management—(Undergraduates register for 169.) Topics include the cost of quality, inspection, sampling plans, statistical process control, uncertainty in the supply process, Bayesian decision methods, reliability, robust quality, quality function deployment, quality in services, and approaches to quality management. Case studies. Class project involving local industry required for fourth unit. Prerequisites: 120 and STATS 110.

3-4 units (Staff) not given this year

STRATEGY, ENTREPRENEURSHIP, AND MARKETING

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

3-4 units, Win (Katila, R)

MS&E 271. Global Entrepreneurial Marketing—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.

4 units, Win, Spr (Kosnik, T; Novitsky, D; Ramfelt, L; Smith, L)

MS&E 272. Entrepreneurial Finance—Primarily for graduate engineering students. Introduction to the concepts in and around the financing of entrepreneurial companies. Focus is on teaching future general managers how to use financial perspective to make better decisions in entrepreneurial settings, including selecting financial partners, evaluating financing vehicles, and financing companies through all growth stages, from startup through initial public offering. Limited enrollment. Prerequisites: 140 and ENGR 60, or equivalents. Recommended: 242 or 245G.

3 units, Spr (Staff)

MS&E 273. Technology Venture Formation—Open to graduate students interested in high-technology entrepreneurship.The process of starting venture scale high-tech businesses. Assessing opportunities, sizing markets, evaluating sales channels, developing R&D and operations plans, raising venture capital, managing legal issues, and building a team. Teaching team includes entrepreneurs, venture capitalists, and guest speakers. Student teams write a business plan and make a formal presentation to a group of first tier venture capitalists. Enrollment limited. Recommended: 140, 270, 271, 272, or equivalent.

3-4 units, Aut (Lyons, M; MacLean, A; Blank, S)

MS&E 274. Dynamic Entrepreneurial Strategy—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.

3 units, Win (Tse, E)

MS&E 277. Creativity and Innovation—Factors that promote and inhibit creativity of individuals, teams, and organizations. Creativity tools, assessment metrics, and exercises; workshops, field trips, and case studies. Each student completes an individual creativity portfolio and participates in a long-term team project. Enrollment limited to 32. See http://creativity.stanford.edu.

4 units, Spr (Seelig, T)

ORGANIZATIONAL BEHAVIOR, MANAGEMENT, AND WORK

MS&E 280. Organizational Behavior: Evidence in Action—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.

3-4 units, Win (Sutton, R), Spr (Siino, R)

MS&E 281. Management and Organization of Research and Development—The organization of R&D in industry and the problems of the technical labor force. Relevant theoretical perspectives from sociology, anthropology, and management theory on the social and pragmatic issues that surround technical innovation and the employment of scientists and engineers. Possible topics: organization of scientific and technical communities, industrialization of research, the nature of scientific and technical work, strategies for fostering innovation, careers of scientists and engineers, and managerial problems characteristic of R&D settings.

3 units, Aut (Nelson, A)

MS&E 282. Innovation and Implementation in Complex Organizations—The difficulty of moving new ideas through large organizations. Executives from large companies describe cases; student teams analyze the cases and provide recommendations. Final project. Enrollment limited to 12. Prerequisites: master's standing and consent of instructors.

3 units, Win (Sutton, R; Dearing, M)

MS&E 282B. Creative Product Marketing—Continuation of 282; project-based. Implementation of new product designs in complex organizations and markets. Design projects in online publishing and advertising and the home and personal care businesses. Prerequisite: 282.

3 units, Spr (Sutton, R; Dearing, M)

MS&E 285. Negotiation—(Same as CEE 151/251, ME 207.) Negotiation styles and processes to help students conduct and review negotiations. Workshop format integrating intellectual and experiential learning. Exercises, live and field examples, individual and small group reviews. Application required before first day of class; see http://www.stanford.edu/class/msande285/. Enrollment limited to 50.

3 units, Spr (Christensen, S)

MS&E 286. Interpersonal Influence and Leadership—(Same as IPER 286, GSBGEN 374, LAW 628.) How one's actions affect and influence others and the ability to work with them. Foundational skills such as the ability to work through difficult issues, give and receive feedback, and work in groups. How to work with different people. The art of learning from experience. Prerequisiste: consent of instructor.

3-4 units, Win (Robin, C)

MS&E 288. Creating Infectious Action—Offered by the d.school. Teams of master's students from disciplines including engineering, design, business, behavioral sciences, and education attempt to spread positive behavior through projects that include spreading the adoption of the Firefox web browser, applying methods from hip hop to fuel the spread of fads, and spreading financially responsible individual behavior. Industry experts and academics provide guidance.

3-4 units, Spr (Sutton, R)

MS&E 289. Clicks and Bricks: Creating Customer Experiences—Project-based; offered by the d.school. Interdisciplinary student teams develop and build prototype solutions to improve offline and online customer service experiences.

3 units (Sutton, R) not given this year

PUBLIC POLICY ANALYSIS

MS&E 292. Health Policy Modeling—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.

3 units, Win (Brandeau, M)

MS&E 293. Technology and National Security—(Undergraduates register for 193; see 193; same as 193W.)
3 units, Aut (Perry, W; Hecker, S)

MS&E 294. Climate Policy Analysis—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. Recommended: background in economics, optimization, and decision analysis.
3 units, Win (Weyant, J), alternate years, not given next year

MS&E 296. Transportation Systems and Urban Development—(Undergraduates register for 196; see 196.)
3 units, Win (Chiu, S)

MS&E 299. Designing A Free Society—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.
1-3 units, Win (Howard, R)

PRIMARILY FOR DOCTORAL STUDENTS

GENERAL AND SYSTEMS ANALYSIS METHODS

MS&E 300. Ph.D. Qualifying Tutorial or Paper—Restricted to Ph.D. students assigned tutorials as part of the MS&E Ph.D. qualifying process. Enrollment optional.
1-3 units, Aut, Win, Spr, Sum (Staff)

MS&E 301. Dissertation Research—Prerequisite: doctoral candidacy.
1-15 units, Aut, Win, Spr, Sum (Staff)

OPTIMIZATION

MS&E 310. Linear Programming—Formulation 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 conic linear programs. Applications include game equilibrium facility location. Prerequisite: MATH 113 or consent of instructor.
3 units, Aut (Ye, Y)

MS&E 311. Optimization—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.
3 units, Win (Ye, Y)

MS&E 312. Advanced Methods in Numerical Optimization—(Same as CME 334.) 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.
3 units, Aut (Murray, W)

MS&E 313. Vector Space Optimization—Optimization theory from the unified framework of vector space theory: treating together problems of mathematical programming, calculus of variations, optimal control, estimation, and other optimization problems. Emphasis is on geometric interpretation. Duality theory. Topics: vector spaces including function spaces; Hilbert space and the projection theorem; dual spaces and the separating hyperplane theorem; linear operators and adjoints; optimization of functionals, including theory of necessary conditions in general spaces, and convex optimization theory; constrained optimization including Fenchel duality theory. Prerequisite: MATH 115.
3 units (Luenberger, D) alternate years, not given this year

MS&E 314. Linear and Conic Optimization with Applications—(Same as CME 336.) 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.
3 units (Ye, Y) alternate years, not given this year

MS&E 315. Numerical Optimization—(Same as CME 304.) 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.
3 units, Win (Murray, W)

MS&E 316. Discrete Mathematics and Algorithms—(Same as CME 305.) Topics: enumeration such as Cayley's theorem and Prufer codes, SDR, flows and cuts (deterministic and randomized algorithms), probabilistic methods and random graphs, asymptotics (NP-hardness and approximation algorithms). Topics illustrated with EE, CS, and bioinformatics applications. Prerequisites: MATH 51 or 103 or equivalents.
3 units, Win (Saberi, A)

MS&E 318. Large-Scale Numerical Optimization—(Same as CME 338.) 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. Interior methods. The simplex method. Factorization and updates. The reduced-gradient, augmented Lagrangian, and SQP methods. Recommended: MS&E 310, 311, 312, 314, or 315; CME 108 or 302.
3 units, Spr (Saunders, M)

MS&E 319. Approximation Algorithms—Combinatorial and mathematical programming techniques to derive approximation algorithms for NP-hard optimization problems. Prossible 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.
3 units (Saberi, A) alternate years, not given this year

PROBABILITY AND STOCHASTIC SYSTEMS

MS&E 321. Stochastic Systems—Topics in stochastic processes, emphasizing applications. Markov chains in discrete and continuous time; Markov processes in general state space; Lyapunov functions; regenerative 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.
3 units, Spr (Glynn, P)

MS&E 322. Stochastic Calculus and Control—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.

3 units, Win (Glynn, P), alternate years, not given next year

MS&E 323. Stochastic Simulation—Emphasis is on the theoretical foundations of simulation methodology. Generation of uniform and non-uniform random variables. Discrete-event simulation and generalized semi-Markov processes. Output analysis (autoregressive, regenerative, spectral, and stationary times series methods). Variance reduction techniques (antithetic variables, common random numbers, control variables, discrete-time, conversion, importance sampling). Stochastic optimization (likelihood ratio method, perturbation analysis, stochastic approximation). Simulation in a parallel environment. Prerequisite: MS&E 221 or equivalent.

3 units (Glynn, P) alternate years, not given this year

INFORMATION SCIENCE AND TECHNOLOGY

MS&E 332. Security and Risk in Computer Networks—Risk management of large scale computing and networking systems with respect to security, data integrity, performance collapse, and service disruption. Qualitative and analytical basis for assessment, modeling, control, and mitigation of network risks. Stochastic risk models. Contact process. Random fields on networks. Virus and worm propagation dynamics and containment. Denial of service attacks. Intruder detection technologies. Distributed network attacks and countermeasures. Disaster recovery networks. Network protection services and resource placement. Autonomic self-defending networks. Economics of risk management. Emphasis is on analytics and quantitative methods.

3 units, Spr (Bambos, N)

MS&E 335. Queuing Systems and Processing Networks—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.

3 units, Aut (Bambos, N)

MS&E 336. Topics in Game Theory with Engineering Applications—Seminar. Recent research applying economic methods to engineering problems. Recent topics include: incentives in networked systems; mechanism design in engineered systems; and dynamics and learning in games. Prerequisites: mathematics at the level of MATH 115; game theory at the level of 246 or ECON 203; probability at the level of 220; optimization at the level of 211. May be repeated for credit.

3 units, Spr (Johari, R)

MS&E 337. Information Networks—(Same as CME 337.) Network structure of the Internet and the web. Modeling, scale-free graphs, small-world phenomenon. Algorithmic implications in searching and inter-domain routing; the effect of structure on performance. Game theoretic issues, routing games, and network creation games. Security issues, vulnerability, and robustness. Prerequisite: basic probability and graph theory.

3 units, Aut (Saberi, A), alternate years, not given next year

MS&E 338. Advanced Topics in Information Science and Technology—Prerequisite: consent of instructor.

3 units (Van Roy, B) not given this year

MS&E 339. Approximate Dynamic Programming—Approximation algorithms for large-scale dynamic programming. Real-time dynamic programming and reinforcement learning algorithms. Generalizations of value iteration, policy iteration, and linear programming approaches. Recent research topics. Prerequisite: 251, 351, CS 221, CS 228, or CS 229.

3 units (Van Roy, B) not given this year

ECONOMICS, FINANCE, AND INVESTMENT

MS&E 341. Advanced Economic Analysis—Builds on 241 concepts. Market structure and industrial organization (oligopoly, strategic behavior of firms, game theoretic models); economics of uncertainty; general equilibrium theory and economic efficiency (formulation, Walras' Law, existence, uniqueness, duality between efficiency and general equilibrium; trade); intertemporal equilibrium and asset markets; public goods, externalities. Background for advanced economics. Prerequisite: 241.

3 units, Spr (Weber, T)

MS&E 342. Advanced Investment Science—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: 242.

3 units, Win (Luenberger, D)

MS&E 344. Applied Information Economics—The strategic acquisition, pricing, transfer, and use of information. Theoretical findings applied to real-world settings. Topics: optimal risk bearing, adverse selection, signaling, screening, nonlinear and state-contingent pricing, design of contests, incentives and organizations, strategic information transmission, long-run relationships, negative information value, research and invention, leakage and espionage, imperfect competition, information sharing, search and advertising, learning, and real-option exercise games. Prerequisites: 211, 220, 241. Recommended: 341.

3 units (Weber, T) not given this year

MS&E 345. Advanced Topics in Financial Engineering—Derivative pricing theory from an engineering perspective. Underlying principles that apply to all derivative securities; general frameworks to model and price derivative securities on equities, interest rates, and credit. Topics in hedging and risk management. Prerequisites: derivative pricing and stochastic differential equations; and 220, 221, 242, 342, or consent of instructor. Recommended: Matlab.

3 units, Win (Primbs, J)

MS&E 347. Credit Risk: Modeling and Management—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. Prerequisites: stochastic processes at the level of MSE 321, 322 or equivalent, and financial engineering at the level of MSE 342, MATH 180, MATH 240, FINANCE 622 or equivalent.

3 units, Spr (Giesecke, K)

MS&E 348. Optimization of Uncertainty and Applications in Finance—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.

3 units, Win (Infanger, G)

MS&E 349. Capital Deployment—Methods for efficiently allocating capital among alternatives, constructing business plans, determining the value of risky projects, and creating alternatives that enhance value. Prerequisites: 242, 342.

3 units, Spr (Luenberger, D), alternate years, not given next year

DECISION AND RISK ANALYSIS

MS&E 351. Dynamic Programming and Stochastic Control—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.

3 units, Spr (Veinott, A)

MS&E 352. Decision Analysis II: Professional Decision Analysis—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.

3-4 units, Win (Howard, R)

MS&E 353. Decision Analysis III: Frontiers of Decision Analysis—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.

3 units, Spr (Howard, R)

MS&E 355. Influence Diagrams and Probabilistics Networks—Network representations for reasoning under uncertainty: influence diagrams, belief networks, and Markov networks. Structuring and assessment of decision problems under uncertainty. Learning from evidence. Conditional independence and requisite information. Node reductions. Belief propagation and revision. Simulation. Linear-quadratic-Gaussian decision models and Kalman filters. Dynamic processes. Bayesian meta-analysis. Prerequisites: 220, 252, or equivalents, or consent of instructor.

3 units, Win (Shachter, R), alternate years, not given next year

PRODUCTION OPERATIONS, SERVICES, AND MANUFACTURING

MS&E 361. Supply Chain Optimization—Characterization and computation of optimal and nearly optimal multiperiod supply chain policies with known or uncertain demands using dynamic, lattice, network, and convex and concave programming. Cooperation: sharing benefits of alliances. Competition. Leontief-substitution and network-flow models. Lattice programming: comparison of optima; existence and comparison of equilibria of non-cooperative games. Stochastic comparison. Invariant properties of optimal flows: graphical optimization of supply chains. Optimality of myopic policies. Prerequisites: MATH 115, optimization theory, probability.

3 units (Veinott, A) alternate years, not given this year

MS&E 362. Advanced Models in Production and Operations—The design and operation of production-inventory systems. Topics include production scheduling, capacity planning, sequencing, assembly-line balancing, dynamic scheduling, and multigoal optimizations. Readings primarily from journal articles. Prerequisite: 260.

3 units (Carlson, R) alternate years, not given this year

MS&E 363. Advanced Models in Management Science—Primarily for doctoral students. Content varies. Topics based on recent literature and working papers. See http://www.stanford.edu/~ozalp/ for information. May be repeated for credit. Prerequisite: consent of instructor.

3 units (Ozer, A) not given this year

MS&E 364. Multi-echelon Inventory Models—Theoretical treatment of control problems arising in inventory management, production, and distribution systems. Inventory control for single and multi-location systems. Emphasis is on operating characteristics, performance measures, and optimal operating and control policies. Dynamic programming and applications in inventory control. Prerequisite: STATS 217 or equivalent, linear programming.

3 units, Spr (Ozer, A), alternate years, not given next year

MS&E 365B. Game Theoretic Models in Operations Management—Formal analysis of strategic interactions among decision makers such as suppliers, manufacturers, retailers, and consumers; the resulting dynamics in a market environment. Game theory as the main tool of analysis. Readings primarily from journal articles. May be repeated for credit. Prerequisite: 246 or equivalent.

3 units, Win (Erhun Oguz, F), alternate years, not given next year

MS&E 366. Advanced Models in Supply Chain Management—Primarily for doctoral students. Content varies. Topics based on recent literature and working papers. May be repeated for credit. Prerequisite: consent of instructor.

3 units (Hausman, W) alternate years, not given this year

MS&E 369. Supply Chain Risk and Flexibility Management—Methods and analytic tools for quantifying and managing the impact of uncertainty in supply and demand on the operating and financial performance of firms and networks of firms. Design and delivery of products and services to provide competitive differentiation by enabling cost, value, risk and flexibility to be balanced and managed across supply networks. Case study applications by leading companies to procurement, manufacturing, outsourcing, and sales relationships. Tools, processes, and internal crossfunctional coordination required to operationalize approaches in core planning and execution systems and processes. Prerequisite: 262.

3-4 units, Spr (Johnson, B)

STRATEGY, ENTREPRENEURSHIP, AND MARKETING

MS&E 371. Innovation and Strategic Change—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.

2-3 units, Win (Katila, R), alternate years, not given next year

MS&E 374. Dynamic Corporate Strategy—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.

3 units (Tse, E) alternate years, not given this year

MS&E 376. Strategy and Organization Doctoral Research Seminar—Current research at the interface of strategy policy and organization theory. Topics vary annually. Limited enrollment. Prerequisites: SOC 360 or equivalent, and consent of instructor.

3 units, Spr (Eisenhardt, K)

ORGANIZATIONAL BEHAVIOR, MANAGEMENT, AND WORK

MS&E 380. Doctoral Research Seminar in Organizations—Limited to Ph.D. students. Topics from current published literature and working papers. Content varies. Prerequisite: consent of instructor.

3 units, Win (Sutton, R)

MS&E 381A. Doctoral Research Seminar in Work, Technology, and Organization: Theoretical Underpinnings—Enrollment limited to Ph.D. students. Topics from current published literature and working papers. Content varies. Prerequisite: consent of instructor.

2-3 units (Barley, S) alternate years, not given this year

MS&E 381B. Doctoral Research Seminar in Work, Technology, and Organization: The Study of Work—Enrollment limited to Ph.D. students. Topics from current published literature and working papers. Prerequisite: consent of instructor.

2-3 units (Bailey, D) alternate years, not given this year

MS&E 381C. Doctoral Research Seminar in Work, Technology, and Organization: The Study of Technology—Enrollment limited to Ph.D. students. Topics from current literature and working papers. Prerequisite: consent of instructor.

2-3 units, Aut (Bailey, D), alternate years, not given next year

MS&E 383. Doctoral Seminar on Ethnographic Research—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.

5-6 units (Barley, S) not given this year

MS&E 384. Groups and Teams—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.

3 units, Win (Hinds, P), alternate years, not given next year

MS&E 386. Behavioral Aspects of Computer Supported Cooperative Work—For Ph.D. students. Research on behavioral aspects of computer supported cooperative work. Topics include knowledge management, awareness and awareness systems, group decision support, cooperation and collaboration, effects of computer mediated communications on interpersonal relationships, and geographically distributed work.

3 units (Hinds, P) not given this year

PROJECT COURSES, SEMINARS, AND WORKSHOPS

MS&E 406. Mathematical Modeling Seminar—Mathematical modeling issues in participants' current research. Topics such as modularity, variable endogenization, parameter estimation, and orders of effect. Students share their models for discussion. Limited enrollment. Recommended: 206.

1 unit, Aut (Kieffel, H), alternate years, not given next year

MS&E 408. Directed Reading and Research—Directed study and research on a subject of mutual interest to student and faculty member. Prerequisite: faculty sponsor.

1-15 units, Aut, Win, Spr, Sum (Staff)

MS&E 430. Tools for Experience Design—Interdisciplinary, project-based, studio course to create innovative tools for designers and for future d.school use. Focus is on empathy with the experience of designers. Field visits, guest speakers, case studies.

3-4 units (Hinds, P) not given this year

MS&E 444. Investment Practice—Theory of real options, soft derivatives, and related ideas. Problems from financial engineering and risk management. Examples from industry. Small group projects formulate and design solutions to actual industry problems. Enrollment limited to 30.

3-4 units, Spr (Giesecke, K)

MS&E 446. Policy and Economics Research Roundtable (PERR)—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.

1 unit, Aut, Win, Spr (Sweeney, J)

MS&E 450. Lessons in Decision Making—Entrepreneurs, senior management consultants, and executives from Fortune 500 companies share real-world stories and insights from their experience in decision making.

1 unit, Spr (Howard, R)

MS&E 451. Decision Systems I: Professional Secrets and Tricks of the Trade—Professional tricks for designing decision systems that help in facing decisions such as buying a car, bidding on the Internet, hiring NFL players, making charitable donations, or choosing medical treatment. Demonstrations; small project. Topics: automatic decision diagram formulation, decision-class analysis, and dynamic sensitivity analysis. No programming required.

2-3 units, Win (Holtzman, S)

MS&E 452. Decision Systems II: Business, Consumer, and Medical Applications—Students design a system to help business, consumer, medical, or other decision makers. Previous student teams have designed systems for auction bidding, cancer treatment, sailing tactics, automobile purchasing, network design, Mars exploration, flu treatment, platoon tactics, high-tech manufacturing, and oil-and-gas exploration. No programming required. Satisfies MS&E project course requirement. Prerequisite: 252 or equivalent. Recommended: 451.

3 units, Spr (Holtzman, S)

MS&E 453A. Medical Decision Making Seminar—Decision making models and methods to address complex, uncertain medical decisions. Experts present best practices and research on current topics such as mathematical modeling of bioterrorism, HIV screening and prevention, flu pandemic interventions, personal medical procedure decisions, and decision support for cancer care delivery.

1 unit, Aut (Robinson, B)

MS&E 453B. Energy Decision Making Seminar—Decision making models and methods to address complex, uncertain energy decisions. Experts present best practices and research on current topics such as traditional versus alternative energy supply, global demand forecasts, mathematical modeling of energy economics, energy policy and consumer behavior, and geopolitical energy considerations.

1 unit, Win (Robinson, B)

MS&E 453C. Environmental Decision Making Seminar—Decision making models and methods to address complex, uncertain environmental decisions. Experts present best practices and research on current topics such as climate change science and policy, mathematical modeling of environmental strategy consequences, marine resource preservation, groundwater contamination, and international agricultural crop decisions.

1 unit, Spr (Robinson, B)

MS&E 454. Decision Analysis Seminar—Current research and related topics presented by doctoral students and invited speakers. May be repeated for credit. Prerequisite: 252.

1 unit, Aut, Win, Spr (Howard, R)

MS&E 455. Decision Making in Organizations: Avoiding Traps, Motivating People, and Improving Process—Lectures and war stories from management consultants experienced in applying decision analysis. Student teams critique decisions from news articles, case studies, and

interviews with leaders of local organizations. Topics: roles people play, normative versus descriptive approaches, avoiding traps and failure modes, decision process and content quality, biases, expert judgments, economic analysis, creativity, organizational behavior, leadership styles, decision psychology, mutual learning models, advocacy and inquiry, new venture investing, and portfolio evaluation.

2 units, Aut (Robinson, B)

MS&E 456. Decision Analysis Applications: Making Business Strategy and Public Policy Decisions—How decision analysis models and methods are applied to make technically and organizationally complex decisions for private and public sector organizations. Student teams model, assess, and analyze real examples. Cases include C5 Corvette design, global competition for HDTV market, DRAM manufacturing, movie studio portfolios, pharmaceutical drug development, oil and gas exploration and production, financial derivatives, litigation strategy, electric power regulation, and marine resource preservation. Guest consultants.

2 units, Win (Robinson, B)

MS&E 457. Decision Analysis Projects: Helping Real Leaders Make Real Decisions—A virtual consulting firm directed by decision analysts. Student teams help local businesses, governments, or other institutions make a current strategy or policy decision. Projects typically include start-up venture funding, R&D portfolio planning, new product/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 or equivalent.

3 units, Spr (Robinson, B)

MS&E 458. Professional Decision Consulting: Marketing Services, Delivering Results, and Balancing Lifestyle—Management consultants share lessons about professional services marketing, pricing to value, leading and managing consulting projects, communicating with diverse audiences, and delivering insights that exceed client expectations. What it looks like from inside a consulting firm, the client's view, and the consulting industry perspective. Student teams develop answers to frequently asked questions, prepare marketing materials, and present proposals for consulting services to decision makers in local organizations.

2 units, Aut (Robinson, B)

MS&E 464. Global Project Coordination—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. Project teams from Stanford and an overseas university work on common projects using telephones, faxes, email, Internet, video conferences, and face-to-face meetings. As part of the project, students travel to Hong Kong. Applications due in November. See http://www.stanford.edu/class/msande464/.

3-4 units, Win (Gillai, B)

MS&E 472. Entrepreneurial Thought Leaders' Seminar—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.

1 unit, Aut, Win, Spr (Byers, T; Kosnik, T; Seelig, T)

MS&E 474. Business and Environmental Issues—(Same as GSBGEN 547.) Overlap and synergies between business and environmental fields. Guest speakers from for-profit and nonprofit sectors. Past speakers have included business executives, alternative energy experts, environmental consultants, and professors. Group assignments.

2 units, Spr (Plambeck, E, Matson, P, Sweeney, J)

MS&E 485. Crosscultural Design—Project-based. The design of products and services for a global world. How to design products or services to be used across cultures, how to design for a culture other than one's own, and how the process of design is approached in different cultures.

3-4 units (Hinds, P) not given this year

MS&E 491. Real-World Clean Energy Project Development—Student teams prepare and present a development plan for a clean energy project of their choice, specifying the resource, technology, market, end-use, and policy and regulatory factors. Management plan and financial and economic evaluation. Readings and presentations on topics in clean energy. Guest speakers involved in project development.

3 units, Spr (Borison, A; Hamm, G)

COGNATE COURSES (GRADUATE)

See respective department listings for course descriptions. See degree requirements above or the department's student services office for applicability of these courses to a major or minor program.

AA 253. Aerospace Product and Systems Development

3 units, Spr (Weiss, S)

CS 364A. Game Theory in the Internet

3 units, not given this year

EE 284. Introduction to Computer Networks

3-4 units, Aut (Tobagi, F)

EE 384S. Network Architectures and Performance Engineering

3 units, Spr (Bambos, N)

EE 402A. Topics in International Technology Management

1 unit, Aut (Dasher, R)

EE 402T. Entrepreneurship in Asian High Tech Industries

1 unit, Spr (Dasher, R)

LAW 206. Core Legal Concepts: Thinking Like a Lawyer—(Same as GSBGEN 382.)

3 units, Aut (Kelman, M; Kramer, L)

LAW 611. International Conflict Resolution Colloquium—(Same as POLISCI 403, PSYCH 283.)

2-5 units, Win (Weiner, A)

STATS 252. Data Mining and Electronic Business

3 units, Sum (Staff)

STS 279. Technology, Policy, and Management in Newly-Industrializing Countries

2-4 units, Spr (Forbes, N), offered occasionally

OVERSEAS STUDIES

Courses approved for the Management Science and Engineering major and taught overseas can be found in the "Overseas Studies" section of this bulletin, in the Overseas Studies office, 126 Sweet Hall, or at http://osp.stanford.edu.

BEIJING

OSPBEIJ 33. Designing Products for the Chinese Context

4 units, Aut (Hinds, P)

OSPBEIJ 36. Globally Distributed Work

4 units, Aut (Hinds, P)

OXFORD

OSPOXFRD 28. Technology and Work

3 units, Win (Barley, S)

OSPOXFRD 29. Issues in Technology and Work for a Post-Industrial Economy

3 units, Aut (Barley, S)