ENGINEERING MANAGEMENT AND SYSTEMS ENGINEERING (EMSE)

Explanation of Course Numbers

- Courses in the 1000s are primarily introductory undergraduate courses
- Those in the 2000s to 4000s are upper-division undergraduate courses that also may be taken for graduate credit with permission and additional work assigned
- Those in the 6000s and 8000s are for master's, doctoral, and professional-level students
- The 6000s are open to advanced undergraduate students with approval of the instructor and the dean or advising office

EMSE 1001. Introduction to Systems Engineering. 1 Credit.
Core concepts in systems engineering; processes of system decomposition and integration; upfront conceptual design, rapid prototyping, structured testing, balanced work, lean processes, and design for manufacturability. Restricted to undergraduate systems engineering majors or with the permission of the instructor. (Fall, Every year)

EMSE 1099. Variable Topics. 1 Credit.

EMSE 2705. Mathematics of Operations Research. 3 Credits.
Systems of linear equations, applications of linear models, matrix algebra, vector spaces, determinants, eigenvalues and eigenvectors, orthogonality and least squares, symmetric matrices, quadratic forms, singular value decomposition. Prerequisites: MATH 1231. Credit cannot be earned for this course and MATH 2184. (Spring, Every year)

EMSE 2801. Fundamentals of Systems Engineering. 3 Credits.
The systems approach to designing, building, and operating complex engineering systems. Restricted to undergraduate students majoring in systems engineering or with the permission of the instructor. (Fall and spring, Every year)

EMSE 3740W. Systems Thinking and Policy Modeling. 3 Credits.
Introduction to systems thinking and system dynamics approach to policy analysis; applications to business management and public policy; key principles of systems; causal-loop and stock and flow models of business growth, technology adoption, and marketing. Includes a significant engagement in writing as a form of critical inquiry and scholarly expression to satisfy the WID requirement. Restricted to undergraduate students majoring in systems engineering or with the permission of the instructor. Prerequisites: CSCI 1111 or CSCI 1121 or CSCI 1131. (Fall, Every year)

EMSE 3741. Systems Thinking and Policy Modeling Recitation. 3 Credits.
The practical use of the simulation software. Individually and in groups, students review class material, work on in-class practice problems, enhancing their semester long projects, and prepare for the midterm and final examinations. Corequisites: EMSE 3740W.

EMSE 3760. Discrete Systems Simulation. 3 Credits.
Modeling of the operation of service systems using the discrete event simulation paradigm; theoretical topics including random variable sampling, input distribution fitting, model verification and validation, and aleatory and epistemic uncertainty in the simulation output analysis context. Restricted to undergraduate students majoring in systems engineering or with the permission of the instructor. Prerequisite: EMSE 3740W. (Fall, Every year)

EMSE 3815. Requirements Analysis and Elicitation. 3 Credits.
The process of translating and decomposing systems engineering objectives into measurable and tractable requirements. Restricted to undergraduate students majoring in systems engineering or with the permission of the instructor. Prerequisites: EMSE 3801. (Spring, Every year)

EMSE 3820. Project Management for Engineering Systems. 3 Credits.
Introduction to project management concepts, processes, tools, and techniques; activity planning, budgeting, scheduling, analyzing risk, monitoring and controlling, evaluation and terminating; challenges of uncertainty, risk, and behavioral factors. Restricted to undergraduate students in the systems engineering program or with the permission of the instructor. Prerequisites: APSC 3115. (Spring, Every year)

EMSE 3850. Quantitative Models in Systems Engineering. 3 Credits.
Introduction to analytical models used in systems engineering to support decision making in business and government; applications to, for example, production planning, workforce scheduling, and network problems; formulating and solving models using spreadsheets. Corequisite: APSC 3115. Restricted to undergraduate students majoring in systems engineering or with the permission of the instructor. Prerequisite: EMSE 2705. (Fall, Every year)

EMSE 3855W. Critical Infrastructure Systems. 3 Credits.
Topics in engineered infrastructure systems; asset management, environmental impact analysis, input–output life cycle analysis and inoperability modeling, infrastructure risk and reliability analysis, resilience and resistance to natural hazards or service disruptions, and development of infrastructure sustainability metrics. Includes a significant engagement in writing as a form of critical inquiry and scholarly expression to satisfy the WID requirement. Restricted to undergraduate students majoring in systems engineering or with the permission of the instructor. Prerequisite: UW 1020. (Spring, Every year)

EMSE 4190. Senior Project in Systems Engineering I. 3 Credits.
First of a two-semester senior project to identify real world problems and assess applicable systems engineering methodologies. Project focus varies, but may include Washington, DC, area problems in public infrastructure or the private sector, including transportation, energy, environment, health care, telecommunications. Restricted to undergraduate students majoring in systems engineering. Prerequisites: EMSE 3820 and EMSE 4765. (Fall, Every year)

EMSE 4191. Senior Project in Systems Engineering II. 3 Credits.
Second phase of a two-semester senior project. Field experience and systems engineering project completion in a team context. Each small group confronts an actual problem, conducts an analysis and formulates a solution using systems engineering methods and models. Oral and written reports demonstrate project management, effective teamwork, and the mastering of applied systems engineering concepts. Restricted to undergraduate students majoring in systems engineering. Prerequisite: EMSE 4190. (Spring, Every year)

EMSE 4197. Special Topics. 3 Credits.
Topics vary by semester. May be repeated for credit provided topic differs. Consult the Schedule of Classes for more details. Instructor's permission required prior to registration. (Spring and fall, Every year)

EMSE 4198. Research. 1-3 Credits.
Applied research and experimentation projects, as arranged. Prerequisite: junior or senior status.

EMSE 4410. Engineering Economic Analysis. 3 Credits.
How the concept of time value of money is used to make optimal engineering project investment choices in the face of competing alternatives; life-cycle financial analysis of engineering projects. Provides foundation knowledge for the National Council of Examiners for Engineering and Surveying Fundamentals of Engineering examination. Restricted to undergraduate SEAS students or with permission of the instructor. Prerequisites: ECON 1011 and MATH 1232. (Fall and spring, Every year)

EMSE 4571. Introduction to Programming for Analytics. 3 Credits.
Introduction to R with a comparison to Python: functions, packages, conditionals, loops, strings, coding style, file input/output, data structures, data wrangling, simple data visualization, reproducible reporting, and Monte Carlo methods. Restricted to Restricted to students pursuing a BS in Systems Engineering; others may be admitted with the permission of instructor on a space available basis. (Spring, Every year)

EMSE 4572. Exploratory Data Analysis. 3 Credits.
Introduction to exploratory data analysis using R: data types, centrality, variability, correlation, advanced data visualization, data cleaning, reproducible reporting, interactive charts, shiny apps, and communicating results. Restricted to students in the BS in systems engineering program or with the permission of the instructor on a space available basis. Prerequisites: EMSE 4574 or EMSE 6574 or permission of the instructor. Recommended background: completion of at least one introductory programming course prior to enrollment; experience with R is recommended but not essential.

EMSE 4574. Programming for Analytics. 3 Credits.
Introduction to programming for data analytics using the Python programming language. Prepares students for higher-level courses in data analytics. Restricted to SEAS students; other students may be admitted with permission of instructor on a space available basis. Prerequisites: APSC 3115 and EMSE 4571. Recommended background: Some prior experience with programming.

EMSE 4575. Applied Machine Learning for Analytics. 3 Credits.
Methods and techniques for discovering patterns and relationships in aggregated data, with practical focus on engineering problems. Tools, techniques, and methods explored in the context of their application. Restricted to SEAS students. Prerequisites: EMSE 2705 or MATH 2184; and EMSE 4574 and EMSE 4765. Recommended background: engineering students or those with advanced mathematics skills.

EMSE 4577. Data Driven Policy for Analytics. 3 Credits.
The application of data mining algorithms and other computational techniques to answer questions related to policy; problem formulation, tool selection, and interpretation of analysis results; volume, velocity, variety, veracity, and value. Restricted to SEAS students. Prerequisites: EMSE 4575. Recommended background: engineering students or those with more advanced mathematics preparation. (Spring, Every year)

EMSE 4710. Applied Optimization Modeling. 3 Credits.
Formulation and analysis of linear, network, and integer optimization models that arise in practice; optimization software to formulate and solve models. Linear optimization theory and algorithms: Simplex method, branch-and-bound, duality theory. Restricted to undergraduate students majoring in systems engineering or with the permission of the instructor. Prerequisites: EMSE 2705 and EMSE 3850. Credit cannot be earned for this course and EMSE 6710. (Fall, Every year)

EMSE 4755. Quality Control and Acceptance Sampling. 3 Credits.
Survey of techniques in quality control, including acceptance sampling, capability analysis, control charts, and design of experiments. Restricted to undergraduate students majoring in systems engineering or with the permission of the instructor. Prerequisite: EMSE 4765. (Fall, Every year)

EMSE 4765. Data Analysis for Engineers and Scientists. 3 Credits.
Inference methods in a single dimension: estimation, confidence intervals, hypothesis testing and goodness-of-fit testing; multivariate data analysis techniques using matrices and vectors: the Hotelling T-squared test, multiple linear regression and principle component analysis. Restricted to undergraduate students majoring in systems engineering or with the permission of the instructor. Prerequisite: APSC 3115. (Spring, Every year)

EMSE 4770. Techniques of Risk Analysis and Management. 3 Credits.
Topics and models in current risk analysis; use of quantitative and qualitative methods in risk analysis; modern applications of risk-based planning and risk management. Restricted to undergraduate students majoring in systems engineering or with the permission of the instructor. Prerequisite: EMSE 4755. (Spring, Every year)

EMSE 5099. Variable Topics. 1-99 Credits.

EMSE 6001. The Management of Technical Organizations. 3 Credits.
Introduction to management theory and practice for engineers advancing to leadership and engineering management roles. (Spring, Every year)

EMSE 6005. Organizational Behavior for the Engineering Manager. 3 Credits.
Individual and group behavior in the context of technical organizations, focused on relationships and interactions within an organization's operating activities. Individual and group development and motivation. Organizational structures and cultures. (Spring, Every year)

EMSE 6014. Management of Engineering Contracts. 3 Credits.
The total contracting process considered from the perspectives of the industrial and government buyer and the seller of technical materials and services. (Fall, Even years)

EMSE 6018. Engineering Law. 3 Credits.
Legal principles and procedures of interest to engineers. The American legal system, contracts and specifications, liability of professional engineers, product liability, agency relationships, patent and proprietary rights, special problems in research and development contracts. (Fall, Odd years)

EMSE 6020. Decision Making with Uncertainty. 3 Credits.
Problem formulation. Concepts and techniques used in analyzing complex decision problems. Modeling decision problems using decision trees, probability models, multi-objective models and utility theory. (Fall, Every year)

EMSE 6023. Technology Issue Analysis. 3 Credits.
Contextual background and intellectual basis for addressing technology issues in the public and private sectors. Technology impact assessment, forecasting, and innovation; principles and practices of technology transfer as elements of a systematic approach to making technology decisions. (Fall, Odd years)

EMSE 6025. Entrepreneurship and Technology. 3 Credits.
Concepts and methods associated with starting an entrepreneurial venture: organization design, team building, protection of intellectual property, strategies for developing and marketing a technology product; financial, legal, and market valuation issues and methods for a start-up venture. (Fall, Even years)

EMSE 6026. Technical Enterprises. 3 Credits.
Essential features of technology-based companies from the entrepreneur's point of view. Team preparation of a simulated business plan for a technology-based company. Recommended background: Designed for those working in technical firms and for government personnel who depend on technical firms as suppliers. (As arranged)

EMSE 6030. Technological Forecasting and Management. 3 Credits.
Concepts and methods for understanding the dynamics of technological change. Issues in technology assessment, technology transfer, and strategic management of technology. (Spring, Even years)

EMSE 6035. Marketing Analytics for Design Decisions. 3 Credits.
Analyzing data to inform design decisions in an uncertain, competitive, market, topics include consumer choice modeling, programming in R, survey design, conjoint analysis, optimization market simulation, and professional communication skills. Recommended background: This course requires prior exposure to probability theory, multivariable calculus, linear algebra, and regression; experience with the R programming language is beneficial but not essential. (Fall, Every year)

EMSE 6045. International Technology Commercialization. 3 Credits.
The process of moving ideas to commercial reality in an international setting. Interdisciplinary approach that weaves together study of international and organizational cultures and dynamics, with the disciplines of analytics, engineering management, entrepreneurship, marketing, and technology forecasting, to commercialize innovations in technology. (Spring, Every year)

EMSE 6070. Management of Research and Development. 3 Credits.
Seminar on readings and classic and contemporary case studies in the strategic management of innovation and technology.

EMSE 6099. Problems in Engineering Management and Systems Engineering. 3 Credits.
Capstone project providing the opportunity to apply concepts and tools previously studied to the solution of a real-world problem. Students work in small groups on a problem proposed by students and approved by the instructor. Restricted to master's candidates in the department, preferably during the last semester of their program. (Spring, Every year)

EMSE 6115. Uncertainty Analysis for Engineers. 3 Credits.
Basics of probability theory and statistics, with a focus on engineering applications, particularly in the realm of systems. Topics include simulation, uncertainty analysis, central limit theorem, and systems examination and analysis. Credit cannot be earned for this course and APSC 3115.

EMSE 6200. Policy Factors in Environmental and Energy Management. 3 Credits.
Exploration of the policy development process from several different but integrated perspectives. Focus on areas of environmental and energy management and use of current case studies to develop a framework of understanding to support decisions in a broad variety of management settings. (Spring, Odd years)

EMSE 6220. Environmental Management. 3 Credits.
Technical, economic, political, administrative, and social forces influencing the quality of the environment and the use of resources. Government and industrial programs to combat pollution of the air, soil, and water; existing and pending pertinent legislation; theoretical aspects of specific management problems. (Fall, Odd years)

EMSE 6225. Air Quality Management. 3 Credits.
The nature of critical local, regional, continental, and global problems associated with air pollution and the historical evolution of such problems. The complex regulatory and institutional framework controlling air quality management in the U.S. Current air quality management concepts and processes. (Spring, Odd years)

EMSE 6230. Hazardous Waste Management and Cleanup. 3 Credits.
Hazardous waste management and cleanup processes used in the U.S. and around the world. The roles of the relevant federal, state, and local government agencies; major hazardous waste laws and regulations. Planning, assessment, investigation, design, and construction phases of hazardous waste remediation projects. (Spring, Even years)

EMSE 6235. Water Quality Management. 3 Credits.
The nature of point and non-point sources of surface and ground water pollution and the statutory, regulatory, and institutional framework controlling water quality management activities in the U.S. Current approaches to water quality protection and enhancement. The role of engineered treatment processes in water quality management. (Spring, Even years)

EMSE 6240. Environmental Hazard Management. 3 Credits.
Causes and effects of extreme natural and technological hazards. Organizational responsibilities, management approaches, directed technologies, and social factors related to environmental hazard assessment. Cultural, institutional, and technical capacities bearing on environmental disaster management, national and international risk reduction, and mitigation measures. (Spring, Odd years)

EMSE 6245. Analytical Tools for Environmental Management. 3 Credits.
A survey course in environmental management, focusing on tools to assess the environment: quantitative risk assessment, environmental valuation methodologies, Congressional activities, and environmental laws. The regulatory process as it relates to environmental management. Risk assessment and modeling approaches to solving environmental problems. (Spring, Odd years)

EMSE 6260. Energy Management. 3 Credits.
Examination of the range of available energy resources, trends in their use, the programs and organizations that have developed and evolved to address problems associated with energy resource use. (Fall, Even years)

EMSE 6285. Analytical Tools for Energy Management. 3 Credits.
Analytical tools needed to manage energy resources at the facility level. Energy technologies: instrumentation, measurement, and control. Energy auditing; conservation techniques, financial and economic analysis, and maintenance of energy budgets. Functions of an energy management office of a large organization. (Fall, Even years)

EMSE 6290. Climate Change: Policy, Impacts, and Response. 3 Credits.
The known and unknown in climate change science; strategies and technologies for mitigation of and adaptation to the impact of climate change; international issues related to avoidance, challenges posed by as yet undefined effects, and responsibilities mandated by existing and proposed laws, executive orders, regulations, and court rulings. (Fall, Odd years)

EMSE 6291. Greenhouse Gas Measurement and Reporting. 3 Credits.
Study of existing methodologies and standards for measuring and reporting greenhouse gas (GHG) emissions with particular emphasis on accepted environmental accounting frameworks for the business sector and regulatory schemes. (Fall and spring, Every year)

EMSE 6292. Greenhouse Gas Mitigation. 3 Credits.
Conducting mitigation analyses, identifying, and analyzing projects to reduce greenhouse gas emissions with a focus on energy efficiency and renewable energy; monitoring and reporting emission reductions using accepted methodologies; use of carbon markets as a tool for cost-effective mitigation. This course is taught online. (Fall and spring, Every year)

EMSE 6293. Greenhouse Gas Management Assurance and Information Systems Design. 3 Credits.
Design of information systems for management of greenhouse gas emissions. Assurance of greenhouse gas emissions assertions. This course is taught online. (Fall and spring, Every year)

EMSE 6295. Environmental Secuity. 3 Credits.
Overview of potential terrorist attack vectors on government-owned and private sector assets most directly tied to environmental health and safety. Homeland security requirements for environmental infrastructure, water supplies, energy sources, nuclear waste, and other programs vulnerable to targeting. Courses of action designed to prevent attacks. (Fall)

EMSE 6296. Beyond Compliance: Next Generation Environmental Governance. 3 Credits.
Organizational environmental and energy self-governance, including the implementation of voluntary systems based on the ISO 14000 (environmental management) and 50000 (energy management) series standards. (Fall, Every year)

EMSE 6300. Homeland Security: The National Challenge. 3 Credits.
Evolution of homeland security as a concept, legal framework, and redirection of national policies and priorities. Issues and problems of implementation. Evolution of terrorist threat and U.S. response. Fundamental policy legislation and documents. (Spring, Every year)

EMSE 6305. Crisis and Emergency Management. 3 Credits.
Defining crises, emergencies, and disasters; developing crisis, business continuity, and incident management plans within robust emergency management programs; National Response Framework and National Incident Management System; organizing for response, managing the response organization, managing in a turbulent environment, and crisis decision making and communication. (Fall, Every year)

EMSE 6310. Information Technology in Crisis and Emergency Management. 3 Credits.
The role of information in crisis and response management, determining disaster and crisis information requirements; information technologies applied to crisis, disaster, and emergency management; causes and effects of information breakdowns. (Spring, Even years)

EMSE 6315. Risk Management, Hazard Analysis, and Risk-Based Decision Making. 3 Credits.
Risk management as an iterative process for risk identification, context setting, risk assessment and analysis, threat analysis, risk-informed decision making, risk communication, and risk program evaluation. Restricted to SEAS and GWSB graduate students or with the permission of the instructor. Recommended background: some prior coursework in management. (Fall, Odd years)

EMSE 6320. International Disaster Management. 3 Credits.
Guiding principles, key institutions, operational requirements, policy issues, and broad fundamentals associated with international disaster risk reduction and humanitarian response to natural and man-made disasters and complex emergencies. (Fall)

EMSE 6325. Medical and Public Health Emergency Management. 3 Credits.
Medical and public health management issues encountered in crises, emergencies, and disasters for non-medical emergency managers. The spectrum of medical, public health, psychological and behavioral problems; incident management organization and processes that address these concerns and integrate medical and public health assets into the response. (Spring)

EMSE 6330. Management of Terrorism Preparedness and Response. 3 Credits.
Terrorism, terrorist methods, and human/infrastructure vulnerability. Current preparedness and response programs. Mitigation, preparedness, and response requirements to manage mass terrorism incidents within the context of all-hazard emergency management. Case studies. (Fall)

EMSE 6345. Building the Resilient Organization: Continuity, Crisis and Disaster Recovery Management. 3 Credits.
Organizational leadership and operational resilience by managing business continuity, continuity of operations and business recovery from threat and hazard impacts, supply chain disruptions, technological failures, reputational crises, and more. Restricted to SEAS and GWSB graduate students or with the permission of the instructor. Recommended background: some prior coursework in management.

EMSE 6350. Managing Disaster Resilience Through Hazard and Threat Mitigation. 3 Credits.
Disaster resilience through planned and executed risk reduction actions for organizations, communities, and governmental agencies. Organized approach to identifying, planning, and managing physical and functional risk interventions. Recommended background: some prior coursework in management. (Fall, Every year)

EMSE 6410. Survey of Finance and Engineering Economics. 3 Credits.
Survey of material relevant to financial decision making for engineering activity; traditional engineering economy topics; fundamentals of accounting; financial planning, budgeting, and estimating applicable to management of technical organizations. (Fall, Every year)

EMSE 6420. Uncertainty Analysis in Cost Engineering. 3 Credits.
Basic skills for building probability models to perform meaningful engineering economic studies, financial feasibility assessments, and cost uncertainty analysis in the planning phase of engineering projects. Prerequisites: EMSE 6410. (Spring, Even years)

EMSE 6430. Financial Management for Engineers. 3 Credits.
Management of existing resources, including the use of financial statements and ratio analysis to assess a company's financial health, its strengths, weaknesses, recent performance, and future prospects. Prerequisites: EMSE 6410. (Fall, Every year)

EMSE 6450. Quantitative Methods in Investment Engineering. 3 Credits.
Cash flow streams and the basic theory of interest; bond pricing and immunization of bond portfolios, the term structure of interest rates, mean-variance portfolio theory and the capital asset pricing model; value at risk. Recommended background: Technical background at the level of a bachelor's degree in engineering, mathematics, or science, and working knowledge of Microsoft Excel. (Spring, Odd years)

EMSE 6505. Knowledge Management I. 3 Credits.
The foundations of knowledge management, including cultural issues, technology applications, organizational concepts and processes, management aspects, and decision support systems. Case studies. (Fall)

EMSE 6506. Knowledge Management II. 3 Credits.
A capstone course. Students work in teams, applying principles and processes of systems thinking, systems engineering, and integrative management in the design and implementation of a knowledge management system. Prerequisite: EMSE 6505.

EMSE 6507. Advanced Knowledge Management. 3 Credits.
Advanced study of contemporary knowledge management: cost estimating methods, development of enterprise-level strategies, structure of strategic leadership in managing intellectual capital and competitive intelligence. (Fall, spring, and summer, Every year)

EMSE 6510. Decision Support Systems and Models. 3 Credits.
Theory of decision making—a cognitive view. Modeling decision maker heuristics and processes. Design, implementation, and evaluation of state-of-the-art DSS (hands-on). Assess impact of behavioral, situational, and organizational variables. (Fall)

EMSE 6537. Information Operations. 3 Credits.
National security concerns of governments and business about attacks across national borders and through physical protective mechanisms. The emergence of information technologies, from casual to full-fledged operational scale, to advance causes. Specific examples (e.g., attacks on Estonia, Palestinian conflict). (On demand)

EMSE 6540. Management of Information and Systems Security. 3 Credits.
Information and information security defense techniques and countermeasures with defense fundamentals; critical infrastructure protection; network defense techniques such as designing firewall systems and IDS, VPNs, cryptographic solutions, Internet security protocols, and cyber security and information assurance tenants such as confidentiality, Integrity, availability, authentication and non-repudiation. (Fall, Every year)

EMSE 6542. Cybersecurity Risk Management and Compliance. 3 Credits.
Cybersecurity threats and other risks to an organization's core business; risk-based planning and risk management of cybersecurity at the enterprise level; risk assessment and modeling approaches to cybersecurity issues related to security structures, sustaining healthy cybersecurity posture, and satisfying compliance with risk frameworks. Prerequisite: EMSE 6540. (Fall, spring, and summer, Every year)

EMSE 6543. Managing the Protection of Information Assets and Systems. 3 Credits.
Advanced topics in protection of information assets and systems, including authentication, asset control, security models and kernels, physical security, personnel security, operational security, administrative security, security configuration management, and resource control. Prerequisite: EMSE 6540.

EMSE 6544. Auditing, Monitoring, and Intrusion Detection for Information Security Managers. 3 Credits.
Methods for detecting problems with unauthorized activity in information systems and management challenges associated with those activities.

EMSE 6545. Internet and Online Law for Security Managers. 3 Credits.
Legal issues regarding control of behavior, information security mechanisms, and information systems engineering in connected enterprises. Specific laws and regulations governing Internet and online activity, jurisdictional challenges associated with networked computing, and business law in cyberspace. (Fall and spring, Every year)

EMSE 6546. Cybercrime for Information Security Managers. 3 Credits.
Information security actions related to and in response to criminal activity, including industrial espionage, back-hacking, cracking, and cyberterrorism. Transnational issues, cybercrime treaties and conventions, and cyberwar issues. (Fall, spring, and summer, Every year)

EMSE 6547. Cyber Resilience. 3 Credits.
Resilience planning for cybersecurity; assessment and modeling approaches to limit system failure toward creating a cyber-resilient organization; recognition, resistance, recovery, reinstatement from the perspectives of information technologists and engineering managers; existing cybersecurity reliance frameworks; potential policies to sustain a healthy and robust security posture. (Fall, spring, and summer, Every year)

EMSE 6549. Business and Competitive Intelligence. 3 Credits.
Discovery and analysis of competitive information from open-source intelligence. Sources and methods for data collection; legal issues and constraints; analysis processes; longitudinal aspects; inference. (Spring)

EMSE 6560. Open-source Intelligence Analysis. 3 Credits.
Data analytics tools and develop decision support frameworks to identify threats, evaluate capability of actors to exploit vulnerabilities, and evaluate the risk of damage. Overview of strategies for mining/aggregating data across multiple sources. Restricted to SEAS online students.

EMSE 6570. Information Management and Information Systems. 3 Credits.
The use of information in organizations, the management of the information resource; the impact of information and communication technology. (Spring)

EMSE 6573. Managing E-Commerce Technologies. 3 Credits.
Principles of good e-business management. Methods of conducting e-commerce—major opportunities, limitations, issues, and risks. Popular technologies for building e-businesses, security authentication, privacy, acceptable use policies, and legal limits. (Fall, Odd years)

EMSE 6574. Programming for Analytics. 3 Credits.
Introduction to programming for data analytics using the Python programming language. Prepares students for higher-level courses in data analytics. Recommended background: Some prior experience with programming. (Fall, Every year)

EMSE 6575. Applied Machine Learning for Analytics. 3 Credits.
Methods and techniques for discovering patterns and relationships in aggregated data, with practical focus on engineering problems. Tools, techniques, and methods explored in the context of their application. Students are expected to have completed coursework in linear algebra and probability and statistics prior to enrollment. Prerequisite: EMSE 6574. (Spring, Every year)

EMSE 6577. Data-Driven Policy. 3 Credits.
The application of data mining algorithms and other computational techniques to answer questions related to policy. May serve as a capstone course in the data analytics sequence. Prerequisites: EMSE 6575 and EMSE 6765. (Fall, Every year)

EMSE 6579. Applied Data Mining in Engineering Management. 3 Credits.
Methods and techniques for discovering patterns and relationships in aggregated data, with practical focus on engineering problems. Tools, techniques, and methods explored in the context of their application. Prerequisite: EMSE 6020, EMSE 6586.

EMSE 6580. Information and Software Engineering. 3 Credits.
Introduction to analysis and design of information systems including requirements analysis, project management, and software architectures. Introduction to CASE tools. Prerequisite: EMSE 6570 or permission of instructor.

EMSE 6582. Object-Oriented Analysis and Design. 3 Credits.
The object-relationship model and the object-behavior model. Managing complexity with views and high-level modeling in object-oriented systems analysis. The concepts, the method, and applications, including object-based and object-oriented languages. Prerequisite: EMSE 6580.

EMSE 6584. Fundamentals of Artificial Intelligence. 3 Credits.
History of AI, expert systems, knowledge representation, search and control techniques, natural language processing, computer vision, computer speech, knowledge-based systems, and evidential reasoning. Hands-on experience with a knowledge-based shell. (Spring)

EMSE 6586. Data Management Systems for Data Analytics. 3 Credits.
Study and design of database and data management systems for big data and data analytics. Prerequisites: EMSE 6574. (Spring, Every year)

EMSE 6588. Software Project Development with CASE. 3 Credits.
Evaluation and selection of CASE tools, use of CASE tools in software design/project. Graphical user interface and re-engineering tools. Open only to master's candidates in the department during the last semester of their program. Prerequisite: EMSE 6580.

EMSE 6589. Data Communications and Networks. 3 Credits.
Technical and managerial aspects of data communications, with emphasis on communication networks. Methodologies used in data communications, communication networks, and distributed data processing. (On demand)

EMSE 6701. Operations Research Methods. 3 Credits.
Mathematical and algorithmic aspects of linear, network, integer, and nonlinear optimization. Prerequisites: EMSE 6705 and EMSE 6710; or permission of instructor. (Spring, Every year)

EMSE 6705. Mathematics in Operations Research. 3 Credits.
Systems of linear equations, applications of linear models, matrix algebra, vector spaces, determinants, eigenvalues and eigenvectors, orthogonality and least squares, symmetric matrices, quadratic forms, singular value decomposition. Prerequisites: MATH 1231. (Spring, Every year)

EMSE 6710. Optimization Models and Algorithms. 3 Credits.
Formulation and analysis of linear, network, and integer optimization models that arise in practice; use of optimization software to formulate and solve models. Linear optimization theory and algorithms. Prerequisites: EMSE 6705 or permission of the instructor. Recommended background: coursework in linear algebra. (Fall, Every year)

EMSE 6715. Theory of Games. 3 Credits.
Mathematical models of conflict and cooperation with applications in economics, business, defense, transportation, and societal issues (voting schemes, fair division, auctions). Concept and computation of equilibrium in n-person games. Prerequisite: MATH 2233 or permission of instructor.

EMSE 6720. Topics in Optimization. 3 Credits.
Selected topics from the fields of linear programming, nonlinear programming, dynamic programming, heuristics, and constraint programming. May be repeated for credit provided the topic differs. Prerequisite: EMSE 6701 or permission of instructor.

EMSE 6730. Integer and Network Programming. 3 Credits.
Combinatorial optimization problems: algorithms and applications. Network problems: minimum spanning tree, shortest path, maximum flows, minimum cost flows, optimal matchings, routing problems. Complexity theory. Enumeration and cutting plane methods for solving integer programs. Prerequisite: EMSE 6701 or permission of instructor.

EMSE 6740. Systems Thinking and Policy Modeling I. 3 Credits.
Introduction to systems thinking and the system dynamics approach to policy analysis, with applications to business management and public policy. Causal-loop and stock and flow models of business growth, technology adoption, and marketing. Use of role-based games to explain key principles of systems. Use of simulation software to model problems and case studies.

EMSE 6745. Systems Thinking and Policy Modeling II. 3 Credits.
Case studies in dynamic policy analysis. Use of microcomputers in simulation. The class collectively models and simulates a social system to explore policy options. Prerequisite: EMSE 6740.

EMSE 6750. Stochastic Foundations of Operations Research. 3 Credits.
Topics in probability theory, stochastic processes, and statistical inference. Foundations of probability, conditional probability and expectation, Poisson processes, Markov chains, and Brownian motion. Prerequisite: APSC 3116 or permission of instructor.

EMSE 6755. Quality Control and Acceptance Sampling. 3 Credits.
Statistical approaches to quality assurance. Single and multivariate control charts, acceptance sampling by attributes and variables, process capability and design of experiments. Prerequisite: APSC 3115 or permission of instructor.

EMSE 6760. Discrete Systems Simulation. 3 Credits.
Analytical methods for the solution of problems in engineering using concepts from probability and statistics: probability modeling, random variables and their distributions, mathematical expectation, sampling, point and confidence interval estimation, hypothesis testing, correlation, regression, and engineering applications. Restricted to SEAS graduate students. Prerequisites: One of the following: CSCI 1121, CSCI 1041, CSCI 1111, or permission of instructor. (Spring, Every year)

EMSE 6765. Data Analysis for Engineers and Scientists. 3 Credits.
Design of experiments and data collection. Regression, correlation, and prediction. Multivariate analysis, data pooling, data compression. Model validation. Prerequisites: APSC 3115 or permission of instructor.

EMSE 6767. Applied Data Analytics. 3 Credits.
Applied and practical data analytics. High-level theory, with primary focus on practical application of a broad set of statistical techniques needed to support an empirical foundation for systems engineering and engineering management. A variety of practical visualization and statistical analysis techniques. Leveraging Minitab and Excel to examine raw data to arrive at insightful conclusions. (Fall, spring, and summer, Every year)

EMSE 6769. Applied Machine Learning for Engineers. 3 Credits.
Theory and practice of machine learning, leveraging open source frameworks to explore the ideas, algorithms, and techniques. Restricted to graduate students.

EMSE 6770. Techniques of Risk Analysis and Management. 3 Credits.
Topics and models in current risk analysis; modern applications of risk-based planning and risk management; use of quantitative methods in risk analysis. (Spring)

EMSE 6790. Logistics Planning. 3 Credits.
Quantitative methods in model building for logistics systems, including organization, procurement, transportation, inventory, maintenance, and their interrelationships. Stresses applications. Prerequisite: APSC 3115, MATH 1232.

EMSE 6801. Systems Engineering I. 3 Credits.
Systems approach to the architecting and engineering of large-scale systems.

EMSE 6805. Systems Engineering II. 3 Credits.
Application of systems engineering tools to provide hands-on experience with essential elements of practice. Processes of requirements engineering, functional analysis and allocation, risk management, architecting; architectural heuristics, axiomatic design, analytical assessment of alternative architectures. Prerequisite: EMSE 6801.

EMSE 6807. Advanced Systems Engineering. 3 Credits.
Analysis of advanced systems engineering topics; system lifecycle models, INCOSE Vision 2025, requirements types and processes, architectural design processes and frameworks, DoDAF artifacts, enterprise architecture and enterprise systems engineering, complex adaptive systems (CAS), modeling languages and SysML, and Model Based Systems Engineering (MBSE). Applications of systems engineering tools and techniques. (Spring, Every year)

EMSE 6810. Systems Analysis and Management. 3 Credits.
The systems or holistic approach as a methodology for making decisions and allocating resources. Analysis by means of objectives, alternatives, models, criteria, and feedback. (Fall, spring, Summer)

EMSE 6815. Requirements Engineering. 3 Credits.
Requirements in systems engineering, including requirement types, quality factors, elicitation methods, analysis, derivation of implicit requirements, management, traceability, verification, cross-requirement assessments, and validation. Focus on writing and managing quality requirements in complex systems. Prerequisite: EMSE 6801.

EMSE 6817. Model-Based Systems Engineering. 3 Credits.
Model-based systems engineering and its derivative, evidence-based systems engineering, as techniques with potential for improving the technical integrity of complex systems. The foundation to these model- and research-based techniques for system definition and analysis as applied to life-cycle systems engineering. Prerequisites: EMSE 6805 or permission of the instructor. (Fall, spring, and summer, Every year)

EMSE 6820. Program and Project Management. 3 Credits.
Problems in managing projects; project management as planning, organizing, directing, and monitoring; project and corporate organizations; duties and responsibilities; the project plan; schedule, cost, earned-value and situation analysis; leadership; team building; conflict management; meetings, presentations, and proposals. (Fall)

EMSE 6825. Project Cost and Quality Management. 3 Credits.
Developing project cost and resource estimates during the planning stages. Monitoring, forecasting, and controlling cost throughout the project life cycle. Project quality planning, assurance, and control. Relationships among project scope, time, cost, quality, human resources, communications, procurement, and risk. Preparation for the Project Management Professional examination. Prerequisite: EMSE 6820.

EMSE 6830. Human Factors Engineering. 3 Credits.
Study of the human–machine interface applied to system design, job design, and technology management. Human sensory–motor, perceptual, and cognitive functions; task analysis and allocation; contextual aspects of human factors engineering. Modeling, design, and evaluation methodologies. Applications to user-centered industrial and information systems. (As required)

EMSE 6840. Applied Enterprise Systems Engineering. 3 Credits.
Applications of systems engineering in the U.S. Department of Defense and other federal government entities as well as commercial sectors; architectural frameworks and enterprise architecting concepts and practices, including JCIDS/DODAF, federal enterprise architecture framework, and Zachman Framework; enterprise architecting and advanced modeling tools. Prerequisite: EMSE 6801. (Fall, spring, and summer, Every year)

EMSE 6845. Lean and Agile Systems Engineering. 3 Credits.
Lean and agile methods as applied to the engineering design and development of systems; review of contemporary implementation frameworks, methodologies, and the tools used to support them. Implications for traditional systems engineering; fundamental changes to the requirements processes; implications for engineering management. Prerequisite: EMSE 6805. (Spring, Every year)

EMSE 6848. Systems of Systems. 3 Credits.
Complex systems engineering in terms of systems of systems (SoS); theoretical and practical instances of SoS; application of lifecycle systems engineering processes; various types of SoS and the challenges to be faced to ensure their acquisition and technical integrity. Prerequisite: EMSE 6805. (Spring, Every year)

EMSE 6850. Quantitative Models in Systems Engineering. 3 Credits.
Quantitative modeling techniques and their application to decision making in systems engineering. Linear, integer, and nonlinear optimization models. Stochastic models: inventory control, queuing systems, and regression analysis. Elements of Monte Carlo and discrete event system simulation. Prerequisite: APSC 3115 or EMSE 6020.

EMSE 6855. Reliability Analysis and Infrastructure Systems. 3 Credits.
Modeling basic variables and defining the limit-state surface. Computing the reliability index of an infrastructure system by approximating the limit-state surface—FORM and SORM. Modeling an infrastructure system. Reliability analysis using branch and bound, failure paths and failure modes, identification of dominant failure paths. Case studies. (Fall)

EMSE 6991. Project for Professional Degree. 3 Credits.
Limited to students in the Applied Scientist or Engineer degree program.

EMSE 6992. Special Topics. 3 Credits.
Selected topics in engineering management and systems engineering, as arranged. May be repeated for credit. Permission of the instructor required prior to enrollment. (Fall and spring, Every year)

EMSE 6995. Research. 1-12 Credits.
Basic or applied research in engineering management or systems engineering. Open to master's degree candidates in the department. May be repeated for credit.

EMSE 6997. Advanced Topics in Operations Research. 3 Credits.
Advanced topics from the literature of operations research for analysis, presentation, and discussion. Reading assignments from professional journals selected by the instructor and the student. May be repeated for credit. Prerequisite: permission of instructor.

EMSE 6998. Thesis Research. 3 Credits.

EMSE 6999. Thesis Research. 3 Credits.

EMSE 8000. Research Formulation in Engineering Management and Systems Engineering. 3 Credits.
First in a two-course sequence of doctoral seminars designed to give students their first exposure to the process of formulating and executing empirical research. Class format includes discussion, field experiments, data analysis, and theorizing. Study of core concepts in building theory from empirical data and classic works in technically-oriented management theory. Participants design and execute a research project. Restricted to EMSE PhD students. (Spring, Every year)

EMSE 8001. Research Methods for Engineering Management and Systems Engineering. 3 Credits.
Second in a two-course sequence introducing doctoral students to the fundamentals of research design and methods. Introduction to a range of research methods relevant to the study of engineering management and systems engineering, reading, writing, and critiquing the elements of a research proposal. Restricted to EMSE PhD students. Prerequisite: EMSE 8000. (Fall, Every year)

EMSE 8010. Advanced Topics in Optimization. 3 Credits.
May be repeated for credit provided the topic differs. Prerequisite: EMSE 6701, EMSE 6705 or permission of instructor.

EMSE 8020. Advanced Stochastic Models in Operations Research. 3 Credits.
Applied probability models, including the Poisson process, continuous-time, denumerable-state Markov processes, renewal theory, semi-Markov regenerative processes. Applications to queues, inventories, and other operations research systems. Prerequisite: permission of instructor.

EMSE 8030. Risk Management Process for the Engineering Manager. 3 Credits.
Risk management process; individual and collaborative responsibilities of program and engineering managers; practical applications of risk-based planning and risk management tools essential to success of any program; communicating the process and its value in avoiding catastrophic outcomes. Case studies. (Fall, spring, and summer, Every year)

EMSE 8099. Survey of Research Formulation for Engineering Management. 3 Credits.
Researching the praxis paper. Introduces the design of research studies in applied engineering management settings from a practical perspective. Fundamentals of applied research, formulating research questions/hypotheses and research designs from empirical data. Restricted to students in the DEng in the field of engineering management program. (Fall, spring, and summer, Every year)

EMSE 8100. The Praxis Proposal. 3 Credits.
Overview of research methods; aims and purposes of the praxis; development of praxis research strategies; formulation and defense of a praxis proposal. Praxis proposal defense must be passed before the student is admitted to degree candidacy to undertake praxis work. Restricted to students who have completed all required coursework for the DEng in the field of engineering management degree. (Fall, spring, and summer, Every year)

EMSE 8199. Praxis Research. 1-12 Credits.
Independent applied research in engineering management culminating in the final praxis report and final examination for the degree of doctor of engineering. May be repeated for credit. Restricted to students in the DEng in the field of engineering management program who have passed the praxis proposal defense. Prerequisite: EMSE 8100. (Fall, spring, and summer, Every year)

EMSE 8998. Advanced Reading and Research. 1-12 Credits.
May be repeated for credit. Restricted to doctoral candidates. (Fall and spring, Every year)

EMSE 8999. Dissertation Research. 1-12 Credits.
May be repeated for credit. Restricted to doctoral candidates. (Fall and spring, Every year)