**UNDERGRADUATE**

**ESD.01j Transportation Systems Modeling**  
(Same subject as 1.041j)  
Prereq: 1.00 or 1.000; 1.010  
U (Spring)  
3-1-8  
See description under subject 1.041j.  
C. Osorio

**ESD.03j System Safety**  
(Same subject as 16.63j)  
Prereq: None  
U (Spring)  
3-0-9 REST  
Introduces the concepts of system safety and how to analyze and design safer systems. Topics include the causes of accidents in general, and recent major accidents in particular; hazard analysis, safety-driven design techniques; design of human-automation interaction; integrating safety into the system engineering process; and managing and operating safety-critical systems.  
N. Leveson

**ESD.035j Engineering Design and Rapid Prototyping**  
(Same subject as 16.810j)  
Prereq: 16.01, 16.02 or 2.001, 2.002 or permission of instructor  
U (IAP)  
2-4-0  
See description under subject 16.810j.  
O. de Weck

**ESD.046j Global Environmental Science and Negotiations**  
(Same subject as 12.346j)  
Subject meets with 12.846j, ESD.110j  
Prereq: Permission of instructor  
U (Fall)  
3-0-6  
Practical introduction to the international environmental political arena, particularly designed for science and engineering students whose work is potentially relevant to global environmental issues. Covers basic issues in international politics, such as negotiations, North-South conflict, implementation and compliance, and trade. Emphasizes the roles and responsibilities of experts providing scientific assessment reports and in technical advisory bodies. Term projects focus on organizing and presenting scientific information in ways relevant for ongoing global policymaking. Students taking graduate version complete additional assignments.  
N. Selin

**ESD.05 Engineering Leadership Lab**  
(Subject meets with ESD.050)  
Prereq: None. Coreq: ESD.054 or permission of instructor  
U (Fall, Spring)  
0-2-1  
Can be repeated for credit  
Exposes students to engineering frameworks, models, and cases in an interactive, experience-based environment, and hones leadership skills. Students participate in guided reflection on successes and discover opportunities for improvement in a controlled setting. Activities include design-implent activities, role-playing, simulations, case study analysis, and performance assessment by and of other students. Content throughout the term is frequently student-driven. First-year GEL Program students register for ESD.05. Second-year GEL Program students register for ESD.050. Preference to first-year students in the Bernard M. Gordon-MIT Engineering Leadership Program.  
L. McGonagle, J. Magarian

**ESD.051j Engineering Innovation and Design**  
(Same subject as 2.723j, 6.902j)  
Prereq: None  
U (Fall, Spring)  
4-0-5  
Project-based seminar in innovative design thinking develops students’ ability to conceive, implement, and evaluate successful projects in any engineering discipline. Lectures focus on the iterative design process and techniques to enhance creative analysis. Students use this process to design and implement robust voice recognition applications using a simple web-based system. They also give presentations and receive feedback to sharpen their communication skills. Guest lectures illustrate multidisciplinary approaches to design thinking. Limited to 60.  
B. Kotelly

**ESD.052 Project Engineering**  
Prereq: ESD.05 or permission of instructor  
U (Spring)  
3-2-1  
Credit cannot also be received for 1.401, ESD.018  
Students attend a four day off-site workshop during IAP where an introduction to basic principles, methods, and tools for project management in a realistic context are covered. Over remainder of term, progresses to an introduction to project management, with emphasis on finance, evaluation, and organization. In teams, students create a plan for a project of their choice; past projects include Debris Removal in Haiti and Food Preparation Robot for Restaurants. Develops skills applicable to the management of complex development projects. Topics include cost-benefit analysis, resource and cost estimation, and project control and delivery. Case studies highlight projects in both hardware/construction and software. Preference to students in the Bernard M. Gordon-MIT Engineering Leadership Program.  
O. de Weck
ESD.054 Engineering Leadership
Prereq: None. Coreq: ESD.05 or permission of instructor
U (Fall, Spring)
1-0-2
Can be repeated for credit once with permission of instructor

Exposes students to the models and methods of engineering leadership within the contexts of conceiving, designing, implementing and operating products, processes and systems. Introduces models and theories, such as the Four Capabilities Framework and the Capabilities of Effective Engineering Leaders. Discusses the appropriate times and reasons to use particular models to deliver engineering success. Includes guest speakers and team projects that change from term to term. Preference to first-year students in the Gordon Engineering Leadership Program.

J. Schindall, L. McGonagle, R. Schuhmann

ESD.07] Statistical Thinking and Data Analysis
(Same subject as 15.075J)
Prereq: 6.041
U (Fall)
4-0-8
See description under subject 15.075J.
C. Rudin

ESD.082] Science, Technology, and Public Policy
(Same subject as 17.309J, STS.082J)
(Subject meets with 17.310J, ESD.103J, STS.482J)
Prereq: None
U (Fall)
4-0-8 HASS-S; CI-H
See description under subject 17.309J.
K. Oye

ESD.103] Science, Technology, and Public Policy
(Same subject as 17.310J, STS.482J)
(Subject meets with 17.309J, ESD.082J, STS.082J)
Prereq: Permission of instructor
G (Fall)
4-0-8 H-LEVEL Grad Credit

See description under subject 17.310J.
K. Oye

ESD.110] Global Environmental Science and Negotiations
(Same subject as 12.846J)
(Subject meets with 12.346J, ESD.046J)
Prereq: None
G (Fall)
3-0-6

Practical introduction to the international environmental political arena, particularly designed for science and engineering students whose work is potentially relevant to global environmental issues. Covers basic issues in international politics, such as negotiations, North-South conflict, implementation and compliance, and trade. Emphasizes the roles and responsibilities of experts providing scientific assessment reports and in technical advisory bodies. Term projects focus on organizing and presenting scientific information in ways relevant for ongoing global policymaking. Students taking graduate version complete additional assignments.
N. Selin

ESD.120] Sustainability Science and Engineering
(Same subject as 12.845J)
Prereq: None. Coreq: ESD.83 or permission of instructor
Acad Year 2014–2015: Not offered
Acad Year 2015–2016: G (Fall)
3-0-6 H-LEVEL Grad Credit

Introduces and develops core ideas and concepts in the field of sustainability science and engineering from an engineering systems perspective. Takes an interdisciplinary approach to discuss case studies of sustainability systems research. Exposes students to techniques for sustainability research across engineering, natural and social science disciplines. Term projects focus on applying techniques.
N. Selin

ESD.124 Energy Systems and Climate Change Mitigation
Prereq: Permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit

Explores the contributions of energy systems to global greenhouse gas emissions and the potential levers for reducing emissions. Lectures and projects focus on decomposing contributions to greenhouse gas emissions, with emphasis on technology related variables such as per unit cost and carbon intensity of energy. Reviews other performance attributes of energy technologies. Student projects explore pathways for realizing emissions reduction scenarios.
J. Trancik

ESD.125 Mapping and Evaluating New Energy Technologies
Prereq: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit

Project-based seminar covers recent developments in energy conversion and storage technologies. Merits of alternative technologies are debated based on their environmental performance and cost, and their potential improvement and scalability. Project teams develop quantitative models and interactive visualization tools to inform the future development of these technologies. Models may probe how the impact of a technology depends on assumptions about future advancements in materials or device design. Other projects may develop models for rational design choices (the selection of a particular material or processing technique) based on economic and environmental performance and physical constraints.
J. Trancik

(Same subject as 12.848J, 15.023J)
(Subject meets with 12.348J, 15.026J)
Prereq: Calculus II (GIR); 5.60; 14.01 or 15.010; or permission of instructor
Acad Year 2014–2015: Not offered
Acad Year 2015–2016: G (Spring)
3-0-6

See description under subject 15.023J.
R. G. Prinn

GRADUATE

ESD.101 Concepts and Research in Technology and Policy
Prereq: ESD.103, permission of instructor
G (Spring)
2-0-4 H-LEVEL Grad Credit

Focusing on technology and policy, explores the nature of engineering knowledge (as distinct from scientific knowledge), as well as the role of engineering systems in framing of problems. Considers implications of these concepts in the framing of research questions. Exercises aim to prepare students to apply these concepts in the framing of their thesis research. Preference to first-year students in the Technology and Policy Program.
F. Field
ESD.129J Space Policy Seminar
(Same subject as 16.891J)
Prereq: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit
See description under subject 16.891J.
Staff

ESD.132 Law, Technology, and Public Policy
Prereq: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit
Examination of the relationship between law and technological change, and the ways in which law, economics, and technological change shape public policy. Areas addressed include how law can be used to influence and guide technological change; responses of the legal system to environmental, safety, social and ethical problems created by new or existing technology; how law and markets interact to limit or encourage technological development; and how law can affect the distribution of wealth and social justice. Topics covered include climate change; genetic engineering; telecommunications; industrial automation; the effect of health, safety, and environmental regulation on technological innovation; the impacts of intellectual property law on innovation and equity; pharmaceuticals; nanotechnology; cost/benefit analysis as a decision tool; public participation in governmental decisions affecting science and technology; corporate influence on technology; and law and economics as competing paradigms to encourage sustainability. Permission of instructor required for freshmen and sophomores.
N. Ashford, C. Caldart

ESD.133J Environmental Law, Policy, and Economics: Pollution Prevention and Control
(Same subject as 1.811J, 11.630J)
(Subject meets with 1.801J, 11.021J, 17.393J)
Prereq: Permission of instructor for undergraduates
G (Fall)
3-0-9 H-LEVEL Grad Credit
See description under subject 1.811J.
N. Ashford, C. Caldart

ESD.134J Regulation of Chemicals, Radiation, and Biotechnology
(Same subject as 1.812J, 11.631J)
(Subject meets with 1.802J, 10.805J, 11.022J, ESD.136J)
Prereq: 1.811 or permission of instructor
G (Spring)
Not offered regularly; consult department
3-0-9 H-LEVEL Grad Credit
See description under subject 1.812J.
N. Ashford, C. Caldart

ESD.136J Technology, Law, and the Working Environment
(Same subject as 10.805J)
(Subject meets with 1.802J, 1.812J, 11.022J, 11.631J, ESD.134J)
Prereq: Permission of instructor
G (Spring)
Not offered regularly; consult department
3-0-6 H-LEVEL Grad Credit
See description under subject 10.805J.
N. A. Ashford, C. C. Caldart

ESD.137J Technology, Globalization, and Sustainable Development
(Same subject as 1.813J, 11.466J, 15.657J)
Prereq: Permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit
Investigates sustainable development, taking a broad view to include not only a healthy economic base, but also a sound environment, stable employment, adequate purchasing power, distributional equity, national self-reliance, and maintenance of cultural integrity. Explores national, multinational, and international political and legal mechanisms to further sustainable development through transformation of the industrial state. Addresses the importance of technological innovation and the financial crisis of 2008.
N. Ashford

ESD.151J Chemicals in the Environment: Fate and Transport
(Same subject as 1.725J)
Prereq: Permission of instructor
G (Fall)
3-0-9
See description under subject 1.725J.
H. Hemond

ESD.162J Engineering, Economics and Regulation of the Electric Power Sector
(Same subject as 6.695J, 15.032J)
Prereq: Permission of instructor
G (Spring)
3-2-7 H-LEVEL Grad Credit
Provides an in-depth and interdisciplinary look at electric power systems, focusing on regulation as the link among engineering, economic, legal, and environmental viewpoints. Topics include electricity markets, incentive regulation of network issues, retail competition, tariff design, distributed generation, rural electrification, multinational electricity markets, environmental impacts, future of utilities and strategic sustainability issues under both traditional and competitive regulatory frameworks. Background in policy, microeconomics, or engineering required.
I. Perez-Arriaga, C. Knittel

ESD.163J Managing Nuclear Technology
(Same subject as 22.812J)
Prereq: Permission of instructor
Acad Year 2014–2015: G (Fall)
Acad Year 2015–2016: Not offered
3-0-9 H-LEVEL Grad Credit
See description under subject 22.812J.
R. K. Lester

ESD.166J Sustainable Energy
(Same subject as 1.818J, 2.65J, 10.391J, 11.371J, 22.811J)
(Subject meets with 2.650J, 10.291J, 22.081J)
Prereq: Permission of instructor
G (Fall)
3-1-8 H-LEVEL Grad Credit
See description under subject 22.811J.
M. W. Golay

ESD.191J Urban and Regional Economics
(Same subject as 1.283J, 11.410J, 14.573J)
(Subject meets with 14.51)
Prereq: 14.04, 14.32
Acad Year 2014–2015: Not offered
Acad Year 2015–2016: G (Spring)
3-0-9 H-LEVEL Grad Credit
See description under subject 14.573J.
Consult W. Wheaton
ESD.192J Analyzing and Accounting for Regional Economic Change
(Same subject as 1.284J, 11.481J)
Prereq: 14.03, 14.04
Acad Year 2014–2015: Not offered
Acad Year 2015–2016: G (Spring)
3-0-9 H-LEVEL Grad Credit
See description under subject 11.481J.
K. R. Polenske

ESD.193J Regional Socioeconomic Impact Analyses and Modeling
(Same subject as 1.285J, 11.482J)
Prereq: 11.481J or permission of instructor
Acad Year 2014–2015: Not offered
Acad Year 2015–2016: G (Fall)
2-1-9 H-LEVEL Grad Credit
See description under subject 11.482J.
K. R. Polenske

ESD.210J Transportation Systems Analysis: Performance and Optimization
(Same subject as 1.200J, 11.544J)
Prereq: 1.010J, permission of instructor
G (Fall)
3-1-8 H-LEVEL Grad Credit
See description under subject 1.200J.
C. Barnhart, A. R. Odoni, C. Osorio

ESD.211J Logistical and Transportation Planning Methods
(Same subject as 1.203J, 6.281J, 15.073J, 16.76J)
Prereq: 6.041
G (Fall)
3-0-9 H-LEVEL Grad Credit
See description under subject 1.203J.
R. C. Larson, A. R. Odoni, A. I. Barnett

ESD.217J The Airline Industry
(Same subject as 1.232J, 15.054J, 16.71J)
Prereq: None
G (Fall)
3-0-9
See description under subject 16.71J.
P. P. Belobaba, A. I. Barnett, C. Barnhart,
R. J. Hansman, T. A. Kochan, A. R. Odoni

ESD.218J Business Writing for Supply Chain Management
(Same subject as 21W.800J)
Prereq: None
G (Fall)
1-0-2
See description under subject 21W.800J.

ESD.219J Advanced Demand Modeling
(Same subject as 1.205J)
Prereq: 1.202 or permission of instructor
Acad Year 2014–2015: Not offered
Acad Year 2015–2016: G (Fall)
3-0-9 H-LEVEL Grad Credit
See description under subject 1.205J.
M. E. Ben-Akiva

ESD.220J Geographical Techniques for Urban Planning
(Same subject as 1.207J, 16.711J)
Prereq: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit
See description under subject 1.207J.

ESD.221J The Environment and Livable Communities
(Same subject as 1.233J, 11.542J, 16.712J)
Prereq: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit
See description under subject 1.233J.

ESD.222J Urban Transportation Planning
(Same subject as 1.250J, 11.543J)
Prereq: Permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit
See description under subject 1.250J.
K. R. Polenske

ESD.224J Planning and Design of Airport Systems
(Same subject as 1.231J, 16.781J)
Prereq: Permission of instructor
Acad Year 2014–2015: Not offered
Acad Year 2015–2016: G (Fall)
3-0-9 H-LEVEL Grad Credit
See description under subject 1.231J.
R. de Neufville, A. R. Odoni

ESD.250J Analytical Methods for Supply Chain Management
Prereq: None
G (Fall; partial term)
3-0-3
Covers the primary methods of analysis required for supply chain management planning. The class solves various practical problems using simulation, linear programming, integer programming, regression, and other techniques. The work is primarily team based with a final exam. Restricted to students in the SCM program.
B. Arntzen, J. Goentzel, C. Caplice, E. Blanco

ESD.251 Supply Chain Finance
Prereq: None. Coreq: ESD.260 or permission of instructor
G (Fall; first half of term)
2-0-4 H-LEVEL Grad Credit
Explores the linkages between supply chain management and corporate finance. Emphasizes how the supply chain creates value for both the shareholders of the company and for the stakeholders affected by the company’s operations. Sessions combine lectures and data-rich cases from the manufacturer, distributor, and retailer perspective. Topics include accounting fundamentals, financial analysis, activity-based costing, working capital management, cash flow projections, capital budgeting, and sustainability.
J. Goentzel, J. Rice

ESD.259J Business Writing for Supply Chain Management (New)
(Same subject as 21W.800J)
Prereq: None
G (Fall)
1-0-2
Focuses on analyzing and tailoring content for specific audiences, developing argumentation and persuasion skills, and writing clear, concise and well-structured documents (business letters, memos, executive summaries, and briefings). Covers business writing techniques and strategies through lectures and exercises, individual writing assignments, and peer reviewed workshops. In preparation for the master’s thesis requirement, students create problem statements, as well as research, write and revise a literature review. Restricted to students in the SCM program.
L. Myka, B. Arntzen
ESD.260| Logistics Systems
(Same subject as 1.260J, 15.770J)
Prereq: Permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit
Provides an introduction to supply chain management from both analytical and practical perspectives. Taking a unified approach, students develop a framework for making intelligent decisions within the supply chain. Covers key logistics functions, such as demand planning, procurement, inventory theory and control, transportation planning and execution, reverse logistics, and flexible contracting. Explores concepts such as postponement, portfolio management, and dual sourcing. Emphasizes skills necessary to recognize and manage risk, analyze various tradeoffs, and model logistics systems.
Y. Sheffi, C. Caplice

ESD.261J| Case Studies in Logistics and Supply Chain Management
(Same subject as 1.261J, 15.771J)
Prereq: Permission of instructor
G (Spring)
2-0-6 H-LEVEL Grad Credit
A combination of lectures and cases covering the strategic, management, and operating issues in contemporary logistics and integrated supply chain management. Includes: logistics strategy; supply chain restructuring and change management; and distribution, customer service, and inventory policy.
J. Byrnes

ESD.262J| Supply Chain Leadership
(Same subject as 1.262J)
Prereq: ESD.260 or permission of instructor
G (IAP)
2-0-7
Reinforces supply chain concepts covered in prerequisite coursework and develops management and teamwork skills. Focuses on practical, rather than theoretical tools, methodologies, and approaches that students will use throughout their supply chain career. Includes guest lectures and a large-scale, team-based simulation game.
B. Arntzen, C. Caplice

ESD.263| Thesis Writing for Supply Chain Management
Prereq: None
G (Spring)
2-0-1 [P/D/F]
Instruction provided on writing a thesis, including technical writing and presentation skills.

ESD.264J| Database, Internet, and Systems Integration Technologies
(Same subject as 1.264J)
Prereq: Permission of instructor
G (Fall)
5-0-7 H-LEVEL Grad Credit
See description under subject 1.264J.
Staff

ESD.265J| Global Supply Chain Management
(Same subject as 1.265J, 2.965J, 15.765J)
Prereq: 1.260, 1.261, 15.761, 15.778, or permission of instructor
G (Spring)
2-0-4 H-LEVEL Grad Credit
See description under subject 2.965J.
B. Arntzen

ESD.266| Freight Transportation
Prereq: ESD.260
G (Spring; second half of term)
2-0-4 H-LEVEL Grad Credit
Provides an in-depth introduction to the fundamental concepts and techniques related to the design, procurement, and management of freight transportation. Examines freight transportation as a bridging function for a firm, considering the physical flow of raw materials and finished goods as well as connections to suppliers and customers. Also covers how freight transportation insulates a firm’s core operations from external disruptions and variability of supply and demand.
C. Caplice, Y. Sheffi

ESD.267J| Supply Chain Planning
(Same subject as 1.273J, 15.762J)
Prereq: 1.260J, 15.760, or 15.761
G (Spring)
2-0-4 H-LEVEL Grad Credit
See description under subject 15.762J.
Staff

ESD.268| Manufacturing System and Supply Chain Design
(Same subject as 1.274J, 15.763J)
Prereq: 1.260, 15.761, or 15.778
G (Spring)
2-0-4 H-LEVEL Grad Credit
See description under subject 15.763J.
S. C. Graves, D. Simchi-Levi

ESD.269| Supply Chain Risk Management
Prereq: None
G (Spring)
3-0-9
Ways to develop effective and innovative strategies for risk mitigation are introduced. Also covered are identifying methods for the enterprise to respond to disruptions that may affect it, its business eco-system and the larger economy. Teaches ways to apply the SCRM framework in industrial practice.
Y. Sheffi, J. Rice

ESD.270| Studies in Transportation
Prereq: Permission of instructor
G (Fall, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit
Individual advanced study of a topic in transportation systems, selected with the approval of the instructor.
Consult B. Arntzen

ESD.271| Research Seminar in Transportation
Prereq: Permission of instructor
G (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit
Discussion of current research at various stages of development, including problem definition, literature review, methodology, and evaluation of results. Intended for advanced doctoral students who have passed the general examination.
Consult B. Arntzen

ESD.274| The Theory of Operations Management
(Same subject as 1.271J, 15.764J)
Prereq: 15.081J or 6.251J, 6.436J; or permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit
See description under subject 15.764J.

ESD.278| Managing Sustainable Businesses for People and Profits
(Same subject as 11.383J, 15.662J)
Prereq: None
G (Spring)
3-6-3
See description under subject 15.662J.
T. Kochan
ESD.283 Humanitarian Logistics
(Subject meets with ESD.284)
Prereq: None
G (Spring)
2-0-4
Explores how logistics management principles apply in dynamic, resource-constrained contexts, ranging from humanitarian crisis response to international development. Class sessions combine interactive presentations, practical exercises, case discussions, and guest speakers from humanitarian organizations. Provides an introduction to supply chain concepts and the humanitarian context to accommodate students from various backgrounds.
J. Goentzel

ESD.284 Humanitarian Logistics Project
(Subject meets with ESD.283)
Prereq: None
G (Spring)
2-0-7
Explores how logistics management principles apply in dynamic, resource-constrained contexts, ranging from humanitarian crisis response to international development. Class sessions combine interactive presentations, practical exercises, case discussions, and guest speakers from humanitarian organizations. Provides an introduction to supply chain concepts and the humanitarian context to accommodate students from various backgrounds. Team projects utilize data and information from the UN, NGOs, government agencies, and the private sector.
J. Goentzel

ESD.30J Engineering Apollo: The Moon Project as a Complex System
(Same subject as 16.895J, STS.471J)
Prereq: Permission of instructor
Acad Year 2014–2015: G (Spring)
Acad Year 2015–2016: Not offered
4-0-8 H-LEVEL Grad Credit
See description under subject STS.471J.
D. Mindell

ESD.31 Probability and Statistics
Prereq: None
G (IAP)
1-0-3 [P/D/F]
A highly-condensed review of topics from basic probability through calculus-based statistical analysis. It assumes previous probability and statistics course work, and is designed to be an intensive review for incoming SDM students. Limited to SDM students except by permission of instructor.
J. Orloff

ESD.31J SDM Leadership: The Missing Link
Prereq: ESD.34, 15.905/15.965, participation in SDM IAP session, as well as SDM Spring and Summer business trips
G (Fall; partial term) 3-0-3
Hands-on experience blends theory and practice. Curriculum is integrated into the first year of the SDM program. Students reflect on prior leadership experiences and then apply concepts presented during seminars to further develop their leadership capabilities.
S. Saar

ESD.32J Product Design and Development
(Same subject as 2.739J, 15.783J)
Prereq: 2.009, 15.761, 15.778, 15.810, or permission of instructor
G (Spring)
3-3-6 H-LEVEL Grad Credit
Credit cannot also be received for 15.735, ESD.40
See description under subject 15.783J.
S. Eppinger, W. P. Seering

ESD.33 Systems Engineering
Prereq: Limited to SDM students except by permission of instructor
G (Summer)
4-0-5 H-LEVEL Grad Credit
Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem including operations, performance, test, manufacturing, cost, and schedule. This subject emphasizes the links of systems engineering to fundamentals of decision theory, statistics, and optimization. Also introduces the most current, commercially successful techniques for systems engineering.
Q. Hommes, P. Hale

ESD.341J Architecting and Engineering Software Systems
(Same subject as 1.125J)
Prereq: 1.00, 1.124J, or permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit
Software architecting and design of software-intensive systems. Targeted at future CTOs who must understand both the business and technical issues involved in architecting enterprise-scale systems. Student teams confront technically challenging problems. Lectures and readings cover core database, XML, web server components and browser issues in a distributed web service environment. Enrollment limited.
J. Williams, A. Sanchez

ESD.344 Real Options for Product and Systems Design
Prereq: None
G (Spring; second half of term) 3-0-3
Studies the theory and practice of implementing flexibility (real options) in the design of products and systems. Topics include recognition of uncertainty, identification of best opportunities for flexibility, and valuation of these options and their effective implementation. Enables effective and efficient adaptation to future changes. Students apply the concepts by working in teams on an ongoing product development project. Final product is an advanced, dynamic business plan for design and deployment of products.
R. de Neufville

ESD.351J Air Transportation Systems Architecting
(Same subject as 16.886J)
Prereq: Permission of instructor
G (Fall)
3-2-7 H-LEVEL Grad Credit
See description under subject 16.886J.
R. J. Hansman

ESD.352J Space Systems Engineering
(Subject meets with ESD.284)
Prereq: 16.851, 16.892, or permission of instructor
Acad Year 2014–2015: Not offered
Acad Year 2015–2016: G (Spring)
4-2-6 H-LEVEL Grad Credit
See description under subject 16.892J.
J. A. Hoffman

ESD.355J Concepts in the Engineering of Software
(Subject meets with ESD.355J)
Prereq: Permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit
See description under subject 16.355J.
N. G. Leveson
ESD.379 Systems Engineering Taxonomy and Semantics in Commercial Domains
Prereq: None
G (Fall, Spring)
1-0-3 [P/D/F]

The application of systems engineering practices is increasing in commercial enterprises, but the semantics and process frameworks for ‘commercial systems engineering’ often appear to be quite different from the process and taxonomy developed in defense and aerospace, arguably the birthplace of modern systems engineering. Examines how systems engineering practices are employed in commercial industries, including product and service development and delivery. Special project. Limited to 5.

P. Hole

ESD.38J Systems Architecting Applied to Enterprises
(Same subject as 16.855J)
Prereq: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit

Principles and practices used in systems architecting are presented, adapted and extended to design a future architecture for an enterprise undergoing change. Uses case-based exercises and examples. Team projects investigate a real-world enterprise from multiple perspectives and apply architecting and design techniques. Topics include theories, frameworks, and methods for generating and evaluating alternative architectures, selecting a preferred future state architecture, and developing implementation strategies.

D. Nightingale, D. Rhodes

ESD.39 Systems, Leadership, and Management Lab (SLaM-Lab)
Prereq: ESD.34, 15.905; or permission of instructor
G (Fall)
3-3-3 [P/D/F] H-LEVEL Grad Credit

Focuses on the practical means for integrating leadership and systems and engineering approaches to solve real-world problems. In addition to classroom learning and exercises, students work one day a week with the top management of a high-tech business on a relevant systems and management challenge. The host company sets the project focus. Project teams of four to six students help to solve a problem that is of concern to the host company. Limited to SDM fellows.

M. Davies

ESD.40 Product-System Design
Prereq: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Modern tools and methods for product design and development. Teams conceive, design, and prototype a physical product. Cases and exercises reinforce key ideas. Topics include product planning, identifying customer needs, concept generation/selection, product architecture, industrial design, concept design, and design-for-manufacturing. Preference to SDM students.

M. Yang, P. Hale

ESD.411 Foundations of System Design and Management (New)
Prereq: Permission of instructor
G (Fall, IAP, Spring)
Units arranged H-LEVEL Grad Credit

Presents the foundations of systems architecture, systems engineering and project management in an integrated format, through a synchronized combination of in-class discussion, industrial guest speakers, team projects, and individual assignments. Topics include stakeholder analysis, project planning and monitoring, requirements definition, concept generation and selection, complexity management, system integration, verification and validation, cost modeling, systems safety, organizational design and effective teamwork, risk management, and leadership styles. Restricted to students in the SDM program.

O. de Weck

ESD.51J Software and Computation for Simulation
(Same subject as 1.124J, 2.091J)
Prereq: 1.00 or permission of instructor
Acad Year 2014–2015: Not offered
Acad Year 2015–2016: G (Fall)
3-0-9 H-LEVEL Grad Credit

See description under subject 1.124J.

J. R. Williams

ESD.53J Globalization and the Built Environment
(Same subject as 1.463J, 11.342J)
Prereq: Permission of instructor
G (Fall)
2-0-4 H-LEVEL Grad Credit

See description under subject 1.463J.

F. Moavenzadeh, D. Wolff

ESD.565J Digital Evolution: Managing Web 3.0
(Same subject as 15.565J)
Prereq: Permission of instructor
G (Spring)
3-0-6 H-LEVEL Grad Credit

See description under subject 15.565J.

S. Madnick
### COURSE ESD

#### ESD.65J Aerospace Biomedical and Life Support Engineering
*Prereq: 16.423J, HST.515J*
- Acad Year 2014–2015: G (Spring)
- Acad Year 2015–2016: Not offered

#### ESD.69J Seminar on Health Care Systems Innovation
*Prereq: Permission of instructor*
- Acad Year 2014–2015: Not offered
- Acad Year 2015–2016: G (Fall)

#### ESD.69J Principles and Practice of Drug Development
*Prereq: 7.547J, 10.547J, 15.136J, HST.920J*

#### ESD.70J Engineering Economy Module
*Prereq: None*
- Acad Year 2014–2015: Not offered
- Acad Year 2015–2016: G (Fall; partial term)

#### ESD.71J Engineering Systems Analysis for Design Engineering School-Wide Elective Subject
*Prereq: 1.146J, 16.861J, ESD.710*

#### ESD.710 Risk and Decision Analysis
*Prereq: 1.146J, 16.861J, ESD.710*

#### ESD.712J Tools for Analysis: Design for Real Estate and Infrastructure Development
*Prereq: None*
- G (Spring; second half of term)

#### ESD.73J Materials Selection, Design, and Economics
*Prereq: Permission of instructor*

#### ESD.74J System Dynamics for Engineers
*Prereq: Permission of instructor*
- 3-0-9 H-LEVEL Grad Credit

#### ESD.750J System Optimization and Analysis for Operations
*Prereq: Calculus II (GIR)*
- G (Summer)

#### ESD.751J Engineering Probability and Statistics
*Prereq: Calculus II (GIR)*
- G (Summer)

#### ESD.753J Statistical Learning and Data Mining
*Prereq: 6.431, 15.085, or 18.440; 18.06 or 18.700*
- G (Spring)

#### ESD.754J Data Mining: Finding the Data and Information
*Prereq: Calculus II (GIR)*
- G (Summer)

#### ESD.755J Predictive Data Analytics and Statistical Modeling
*Prereq: 6.431, 15.060, or permission of instructor*
- G (Spring)
- 4-0-5 H-LEVEL Grad Credit
From aerospace, mechanical, civil engineering and system architecture.
O. de Weck, K. E. Willcox

EDS.773J Human Factors Engineering
(Same subject as 16.453J)
Prereq: 6.041 or permission of instructor
G (Fall)
3-1-8 H-LEVEL Grad Credit
See description under subject 16.453J.
L. A. Stirling

EDS.774J Human Supervisory Control of Automated Systems
(Same subject as 16.422J)
Prereq: Permission of instructor
Acad Year 2014–2015: Not offered
Acad Year 2015–2016: G (Fall)
3-1-H LEVEL Grad Credit
See description under subject 16.422J.
J. A. Shah

EDS.775J Human-Computer Interface Design Colloquium
(Same subject as 16.475J)
Prereq: None
G (Spring)
2-0-1 H-LEVEL Grad Credit
See description under subject 16.475J.

EDS.778J Network Optimization
(Same subject as 15.082J)
Prereq: 18.085 or permission of instructor
G (Spring)
3-0-3 H-LEVEL Grad Credit
See description under subject 16.475J.

EDS.80 Seminar in Technology Policy Research
Prereq: ESD.10
G (Spring)
2-0-1 H-LEVEL Grad Credit
Presentations by students, faculty and guest speakers of ongoing research related to current issues in technology and policy. Specific topics determined by research of participants and by research areas of interest and matching these interests with faculty and organization research projects. At the end of the seminar, the student has faculty advisor, research project, thesis proposal and plan. Restricted to SDM students.
P. Hole

EDS.811 Technology Policy Internship Seminar
Prereq: None
G (Fall; partial term)
2-0-1 [P/D/F] H-LEVEL Grad Credit
Designed to enhance your ability to manage and lead in challenging times through a series of self assessment instruments, case studies, and workshops. The objectives are to increase awareness of your strengths and weaknesses as a leader, provide a battery of instruments and surveys to help one understand the way one operates in an organizational setting, and offer strategies and tips on how to leverage one’s strengths and weaknesses and develop a leadership plan. Restricted to entering students in the Technology and Policy program. Information: B. Arntzen

EDS.812 Technology Policy Internship Seminar
Prereq: ESD.10
G (Fall)
1-1-1 [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit
Seminar examines what technology policy is in practice. Considers the question of “Who achieves what, when, how, and why?” regarding technology policy. Students who completed summer internships present and dissect their experiences with special reference to specific cases in which they participated.
F. Field
ESD.83 Doctoral Seminar in Engineering Systems
Prereq: Permission of instructor
G (Fall)
4-0-8 H-LEVEL Grad Credit
Examines core theory and contextual applications of the emerging field of Engineering Systems. Focuses on analysis of scholarship on key concepts such as complexity, uncertainty, fragility, and robustness, as well as a critical look at the historical roots of the field and related areas such as systems engineering, systems dynamics, agent modeling, and systems simulations. Contextual applications range from aerospace to technology implementation to regulatory systems to large-scale systems change. Special attention to the interdependence of social and technical dimensions of engineering systems. Restricted to students enrolled in ESD doctoral program.
C. Magee, J. Sussman

ESD.86j Models, Data and Inference for Socio-Technical Systems
(Same subject as 15.078j)
Prereq: ESD.83, 6.041, or permission of instructor
G (Spring)
3-0-9
Use data and systems knowledge to build models of complex socio-technical systems for improved system design and decision-making. Enhance model-building skills, including: review and extension of functions of random variables, Poisson processes, and Markov processes. Move from applied probability to statistics via Chi-squared t and f tests, derived as functions of random variables. Review classical statistics, hypothesis tests, regression, correlation and causation, simple data mining techniques, and Bayesian vs. classical statistics. Class project.
R. Larson, R. Welsch

ESD.863j System Safety Concepts
(Same subject as 16.863j)
Prereq: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit
Use data and systems knowledge to build models of complex socio-technical systems for improved system design and decision-making. Enhance model-building skills, including: review and extension of functions of random variables, Poisson processes, and Markov processes. Move from applied probability to statistics via Chi-squared t and f tests, derived as functions of random variables. Review classical statistics, hypothesis tests, regression, correlation and causation, simple data mining techniques, and Bayesian vs. classical statistics. Class project.
N. G. Leveson

ESD.864j Modeling and Assessment for Policy
(Same subject as 12.844j)
Prereq: ESD.10 or permission of instructor
G (Spring)
3-0-6 H-LEVEL Grad Credit
Explores how scientific information and quantitative models can be used to inform policy decision-making. Develops an understanding of quantitative modeling techniques and their role in the policy process through case studies and interactive activities. Addresses issues such as analysis of scientific assessment processes, uses of integrated assessment models, public perception of quantitative information, methods for dealing with uncertainties, and design choices in building policy-relevant models. Examples focus on models and information used in Earth system governance.
Staff

ESD.87 Social Science Concepts and Methods
Prereq: ESD.83, ESD.86; or permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit
Introduction to social science approaches to developing questions, designing research, and collecting data about complex systems. Overview of the different social science paradigms for developing research questions, as well as issues of measurement and research design. Covers various modes of data collection with emphasis on how the different elements of research design contribute to more powerful and persuasive results. Students develop skills in designing and completing social science-based research, as well as in critically assessing related work.
Limited to 15.
L. D’Ambrosio

SPECIAL SUBJECTS AND RESEARCH

ESD.910, ESD.915 Research in Engineering Systems Division
Prereq: Permission of instructor
G (Fall, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit
For research assistants in the Engineering Systems Division when assigned research is not used for thesis, but is approved for academic credit. Credit for this subject may not be used for any degree granted by ESD.
Information: R. Larson

ESD.911–ESD.913 Independent Study in Engineering Systems
Prereq: Permission of instructor
G (Fall, IAP, Spring)
Units arranged [P/D/F]
Can be repeated for credit
Opportunity for study of advanced topics in Engineering Systems Division not otherwise included in the curriculum at MIT. Offerings are initiated by faculty on an ad-hoc basis subject to ESD approval.
Information: R. Larson

ESD.921 Teaching in Engineering Systems Division
Prereq: Permission of instructor
G (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit
For teaching assistants in Engineering Systems Division in recognition of educational value derived from satisfactory performance of assigned duties, and for other qualified students interested in teaching as a career. Laboratory, tutorial, or classroom teaching under supervision of a faculty member. Credit for this subject may not be used for any degree granted by ESD.
Information: R. Larson

ESD.501 Special Undergraduate Subject in Engineering Systems Division
Prereq: Permission of instructor
U (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit
Opportunity for study of topics in Engineering Systems Division not otherwise included in the curriculum at MIT. Offerings are initiated by faculty on an ad-hoc basis subject to ESD approval.
Information: R. Larson

ESD.520–ESD.522 Special Graduate Subject in Engineering Systems Division
Prereq: Permission of instructor
G (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit
Opportunity for study of advanced topics in Engineering Systems Division not otherwise included in the curriculum at MIT. Offerings are initiated by faculty on an ad-hoc basis subject to ESD approval.
Information: R. Larson
ESD.S30–ESD.S31 Special Graduate Studies in Engineering Systems Division
Prereq: None
G (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit

Opportunity for individual or group study of advanced topics in Engineering Systems Division not otherwise included in the curriculum at MIT. Offerings are initiated by faculty on an ad-hoc basis subject to ESD approval.
Information: R. Larson

ESD.S40–ESD.S43 Special Graduate Studies in Engineering Systems Division
Prereq: Permission of instructor
G (Fall, IAP, Spring, Summer)
Units arranged H-LEVEL Grad Credit
Can be repeated for credit

Opportunity for individual or group study of advanced topics in Engineering Systems Division not otherwise included in the curriculum at MIT. Offerings are initiated by faculty on an ad hoc basis subject to ESD approval.
Information: R. Larson

ESD.S50, ESD.S51 Special Graduate Studies in Engineering Systems Division
Prereq: Permission of instructor
G (Fall, IAP, Spring, Summer)
Units arranged [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

Opportunity for individual or group study of advanced topics in ESD not otherwise included in the curriculum. Offerings are initiated by faculty on an ad hoc basis subject to ESD approval.
Information: R. Larson

ESD.THG ESD Graduate Thesis
Prereq: Permission of instructor
G (Fall, Spring, Summer)
Units arranged H-LEVEL Grad Credit
Can be repeated for credit

Program of research, leading to the writing of an SM or PhD thesis to be arranged by the student with a member of the ESD faculty. A minimum of 24 thesis units are required for the SM degree.
Information: R. Larson

ESD.URG Undergraduate Research
Prereq: None
U (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit

Undergraduate research opportunities in Engineering Systems.
Information: R. Larson