Department of Engineering and Public Policy Courses

About Course Numbers:

Each Carnegie Mellon course number begins with a two-digit prefix that designates the department offering the course (i.e., 76-xxx courses are offered by the Department of English). Although each department maintains its own course numbering practices, typically, the first digit after the prefix indicates the class level: xx-1xx courses are freshmen-level, xx-2xx courses are sophomore level, etc. Depending on the department, xx-6xx courses may be either undergraduate senior-level or graduate-level, and xx-7xx courses and higher are graduate-level. Consult the Schedule of Classes *(https://enr-apps.as.cmu.edu/open/SOC/SOCServlet/) each semester for course offerings and for any necessary pre-requisites or co-requisites.*

19-101 Introduction to Engineering and Public Policy

Fall and Spring: 12 units
This course examines interactions between technology and society, and the related processes of public and private decision-making. Classes involve a mix of lecture, discussion, and hands-on activities where students tackle interdisciplinary issues with both quantitative and qualitative methods. Students complete individual and group assignments that build skills in analysis and communication relevant for future careers. Past project topics include: using drone imaging to assess algal blooms in Lake Erie, incorporating renewable electricity generation on campus, reducing credit card fraud through data analytics, and creating standards for additive manufacturing of critical airplane parts.

19-201 Professional Issues in Engineering, Science, Technology and Public Policy

Fall: 1 unit
The course provides an overview of the academic and professional domain of technology-centered policy. Content includes career exploration, networking practice, ethics and professional responsibilities, academic advising, alumni speakers, and other topics as relevant. Intended for sophomores enrolling in the Engineering and Public Policy (EPP) Additional Major and the Science, Technology and Public Policy (STPP) Additional Major.

19-211 Ethics and Policy Issues in Computing

Spring: 9 units
Should autonomous robots make life and death decisions on their own? Should we allow them to select a target and launch weapons? To diagnose injuries and perform surgery when human doctors are not around? Who should be permitted to observe you, find out who your friends are, what you do and say with them, what you buy, and where you go? Do social media and personalized searches restrict our intellectual horizons? Do we live in polarizing information bubbles, just hearing echoes of what we already know and believe? As computing technology becomes ever more pervasive and sophisticated, we are presented with an escalating barrage of decisions about who, how, when, and for what purposes technology should be used. This course will provide an intellectual framework for discussing these pressing issues of our time, as we shape the technologies that in turn shape us. We will seek insight through reading, discussion, guest lectures, and debates. Students will also undertake an analysis of a relevant issue of their choice, developing their own position, and acquiring the research skills needed to lend depth to their thinking. The course will enhance students' ability to think clearly about contentious technology choices, formulate smart positions, and support their views with winning arguments.

19-213 The American Railroad: Decline and Renaissance in the Age of Deregulation

Intermittent: 6 units
Railroads in the USA are often considered as a subject for nostalgia or public sector failure, an image largely based on passenger service. However, the USA's private sector freight rail industry is considered a model for the world as the result of its renaissance following deregulation in 1980. This is a "stealth" industry whose history and economics are both intertwined and complex. Students will gain a basic understanding of the industry's history and economics and its role in the national transportation network, with special attention to the past half-century. In addition, students will participate in small group research projects in particular areas of special interest - for example, economic history, industry and safety culture, network economics, utility regulation or transportation policy.

19-301 Decision Making Methods for Engineers and Scientists

Fall: 9 units
This course covers various economic, statistical, and decision analysis techniques used for examining complex decisions where technology, society, and policy interconnect. Topics covered include: estimation techniques, benefit-cost analysis, decision trees, dealing with uncertainty, risk perception and analysis, survey design and implementation, utility theory, heuristics and biases in inference and prediction, methods for combining information from different sources and dealing with conflicting objectives.
Prerequisites: 36-219 Min. grade C or 19-250 Min. grade C or 36-217 Min. grade C or 36-220 Min. grade C

19-303 Cryptocurrencies, Blockchains and Applications

Spring: 9 units
Note: Previously offered as 19-355. Cryptocurrencies such as Bitcoin have gained large popularity in recent years, in no small part due to the fantastic potential applications they could facilitate. This course will first provide an overview of the technological mechanisms behind cryptocurrencies and distributed consensus and distributed ledgers ("blockchains"), introducing along the way the necessary cryptographic tools. It will then focus on more advanced blockchain applications, such as "smart contracts," that is, contracts written as code. Finally, the course will also introduce some of the legal and policy questions surrounding cryptocurrencies. Prerequisites: Introduction to Computer Systems or equivalent strongly recommended

19-351 Applied Methods for Technology-Policy Analysis

Spring: 9 units
This course synthesizes concepts from economics, statistics, decision analysis, and other humanities and social science areas as they relate to analysis of technology and public policy issues. Students will focus on applying skills, tools, and techniques of social science to critically examine issues of current importance to society that have engineering systems at the core, and how public policy can be informed by the results of these analyses. Students will discover the relationship between formulating research questions considering a wide range of perspectives (e.g., political, ethical, social, economic, and legal aspects) and implementing the appropriate research methods for answering them. The course will emphasize interpretation and communication of analysis results in written and oral presentation, especially to non-technical audiences. As a precursor to the EPP Project courses, the course also prepares EPP juniors for structuring real-world problems into a feasible work plan, and to deal with revising work plans as work proceeds.
Prerequisite: 36-220

19-403 Policies of Wireless Systems

Intermittent: 12 units
This course will address public policy issues related to wireless systems. It investigates policies related to a wide variety of emerging wireless systems and technologies, including current and next-generation cellular systems, wifi and white space devices, emerging methods of accessing spectrum, communications systems for emergency responders (firefighters, police, emergency medical services), current and next-generation television, and satellite communications. This can include the government role in facilitating the creation of infrastructure, in advancing competition among broadcasters and communications service providers, in using scarce spectrum efficiently, in promoting public safety and homeland security, and in protecting privacy and security. Because these are inherently interdisciplinary issues, the course will include detailed discussions of technology, economics, and law, with no prerequisites in any of these areas. Senior or graduate standing required.

19-411 Science and Innovation Leadership for the 21st Century: Firms, Nations, and Tech

Fall: 9 units
Science and Innovation Leadership for the 21st Century introduces students to the fundamental principles surrounding global competitiveness and technological change in the 21st century. The course is broken into three sections. The first section introduces students to competing economic, sociological, and political science theories on the structures supporting technological change. The second section presents contemporary literature on technological change. The concluding section leverages lessons from the preceding two sections to evaluate national innovation systems, and the factors that lead to national comparative advantage. Students should leave the class able to reflect competently on what the existing literature tells us about the factors influencing global technology competitiveness, and on how modern changes in the structures supporting innovation as well as technology itself may be changing the rules of the game for firms and for nations. The course is open to undergraduate juniors, seniors and amp; graduate students.

19-416 AI Governance: Identifying & Mitigating Risks in Design & Dev of AI Solutions

Fall and Spring
With AI and ML finding their way into an increasingly broad range of products and services, it is important to identify and mitigate the risks associated with the adoption of these technologies. This course reviews the different types of risks associated with AI and discusses methodologies and techniques available to identify and mitigate these risks. The course introduces students to ethical frameworks available to identify and analyze risks. It also examines best practices emerging from both government and industry efforts in this area. This includes looking at new regulations such as the EU AI Act as well as emerging frameworks such as the one developed by NIST. The course also examines frameworks developed by leading companies and how these frameworks combine both technical and non-technical approaches. It further discusses changes that need to be enacted by organizations to adopt more systematic approaches to AI governance. This course combines a mix of technical, policy, and management discussions.

19-427 Special Topics: Energy Innovation and Entrepreneurship

Fall: 9 units
Want to be an energy innovator, business entrepreneur, social entrepreneur, or intrapreneur? Students in this class will learn the fundamentals of energy innovation and entrepreneurship, and how innovation and entrepreneurship in energy differs from that in other fields. Students will then develop a business and non-market strategy for an idea of their own, or in response to a real-world challenge proposed by a business, industry, or a non-governmental organization. The resulting strategy can, if students wish, be submitted for student competitions that typically take place each spring throughout the United States.

Course Website: https://cmu.box.com/s/zjvqn8ne12sjwqmtvev2w49s78ij5sm5 (https://cmu.box.com/s/zjvqn8ne12sjwqmtvev2w49s78ij5sm5/)

19-428 Special Topics: Market Engineering and Applications

Intermittent: 9 units
An introduction to market-engineering concepts and applications to contemporary market-design problems such as resource allocation, information aggregation, and decentralized control. Concepts apply the theory of linear algebra, optimization and statistics. Course reservations for Seniors and Juniors with permission. Application areas include: - energy systems, - environmental management (e.g., cap-and-trade systems), - wildlife management (e.g., fishing licenses), - oil-development leases, - exchanges for organ transplants, - information markets, and - matching systems for medical-residency programs.

19-429 Climate Change Science and Solutions

Fall and Spring: 9 units
This course consists of four parts. The first part will provide a primer for those who are curious about the physical mechanisms by which climate is determined, and by which climate change occurs. The treatment of these mechanisms will not be overly quantitative, and no knowledge of meteorology or atmospheric science is needed. College-level physics, as well as basic calculus and basic chemistry, is, however, needed. The second part will describe the projected consequences of climate change, as well as those that are already occurring. This part will also familiarize students with how societies might adapt to these changes. The third part will explore (and critique) some of the tools that decision-makers use to quantify and compare the damages caused by these consequences. The final part of the course will discuss some of the technologies that could be used to prevent dangerous climate change.

19-433 Data Science for Technology, Innovation and Policy

Intermittent: 9 units
Students will learn how to use R to collect, organize, and analyze data in technology, innovation, and policy-related domains. The focus will be on the practical issues faced when conducting data analyses, correctly implementing and interpreting statistical models, and summarizing results for clients and research purposes.

19-440 Combustion and Air Pollution Control

Intermittent: 9 units
Formation and control of gaseous and particulate air pollutants in combustion systems. Basic principles of combustion, including thermochemical equilibrium, flame temperature, chemical kinetics, hydrocarbon chemistry, and flame structure. Formation of gaseous and particulate pollutants in combustion systems. Combustion modifications and postcombustion technologies for pollutant control. Relationship between technology and regional, national, and global air pollution control strategies. The internal combustion engine and coal-fired utility boiler are used as examples.

19-451 EPP Projects I

Fall and Spring: 12 units
Students work in multidisciplinary teams (engineers and scientists, humanities and social scientists, public policy and management graduates) on a cutting edge project topic with very little in the way of pre-digested analysis or solutions. Topics include both technical and social dimensions, multiple constraints on the solutions, and require multi-dimensional analyses. Students are given a general goal, and are expected to discover existing knowledge on the topic, and to research existing technologies and relevant policies. Using this background and their technical and social analysis education as appropriate, students then create new knowledge on the subject and analyzing technology impacts, policy alternatives, or other relevant options as topics necessitate. This knowledge is communicated to an external advisory panel, selected from experts and constituencies of importance to the issue through formal presentations and a written report. #19451 is the first of two EPP Projects course experiences for EPP additional majors, students taking EPP Projects I are learning how to use their skills from prior EPP courses in solving complex, unstructured problems and developing skills for effective project completion.

19-452 EPP Projects II

Fall: 12 units
Students work in multidisciplinary teams (engineers and scientists, humanities and social scientists, public policy and management graduates) on a cutting edge project topic with very little in the way of pre-digested analysis or solutions. Topics include both technical and social dimensions, multiple constraints on the solutions, and require multi-dimensional analyses. Students are given a general goal, and are expected to discover existing knowledge on the topic, and to research existing technologies and relevant policies. Using this background and their technical and social analysis education as appropriate, students then create new knowledge on the subject and analyzing technology impacts, policy alternatives, or other relevant options as topics necessitate. This knowledge is communicated to an external advisory panel, selected from experts and constituencies of importance to the issue through formal presentations and a written report. The second of two EPP Projects course experiences for EPP additional majors, EPP Projects II is the capstone course. Students apply their skills and knowledge from EPP Projects I, demonstrating project framing, decomposition, and developing analyses. Students in this second course are expected to be course leaders, assisting students taking the course for the first time in navigating project communications and tasks.

19-469 Behavior, Decision and Policy

Intermittent: 9 units
Behavioral science can inform policy making in three ways: (a) improving two-way communication between the public and policy makers; (b) creating policies that make realistic assumptions about human behavior; (c) disciplining the expert judgment needed to analyze risks. The course will introduce and discuss the technical and ethical foundations of behavioral research and risk analysis, setting them in their historical, social, and political context. It will apply them to a wide variety of technology-related policies, including energy (e.g., conservation, nuclear power), environment (e.g., climate, pollution), health (e.g., vaccines, COVID-19), national security (e.g., terrorism, intelligence analysis), and others, including ones proposed by students. Students will acquire a critical perspective on policies in their lives, society, and profession. The course is open to juniors, seniors, and graduate students, who have not taken 84369/84669.

19-488 Special Topics: Behavioral Mechanism and Design

Fall: 9 units
This course will focus on attempts to reduce behavioral and social problems using behavioral research. We will review and discuss behavioral phenomena from three distinct perspectives - economist, psychologist, and behaviorist - mapping out the basic constructs and fundamental assumptions each entail. A point of focus will be understanding basic models of learning and the challenges of predicting behavior. Throughout the semester we will see that in many cases, there is high sensitivity to economic incentives, but not always in the expected direction. Thus, an intelligent design of the reward system can allow for better coping with systematic social and organizational issues. Classes will blend lectures, active discussions, and group projects. Each project begins with a practical problem defined in class, and groups use the tools discussed to develop policy or intervention proposals and presentations. Students will learn to analyze empirical phenomena in decision science and behavioral economics, appreciate the importance of theory-driven predictions, and take first steps in designing environments aiming to minimize social conflicts.

19-500 Directed Study in EPP: Undergraduate

All Semesters
Students may do undergraduate research as one course for EPP technical elective credit, with an EPP faculty member, or on an approved project with a faculty member from another department. The research credits must be pre-approved by your advisor, and should result in a written product, one copy of which should be sent to EPP.

19-534 Usable Privacy and Security

Spring: 9 units
There is growing recognition that technology alone will not provide all of the solutions to security and privacy problems. Human factors play an essential role in these areas, and it is important for security and privacy experts to have an understanding of how people will interact with the systems they develop. This course is designed to introduce students to a variety of usability and user-interface problems related to privacy and security and to give them experience in understanding and designing studies aimed at helping to evaluate usability issues in security and privacy systems. The course is suitable both for students interested in privacy and security who would like to learn more about usability, as well as for students interested in usability who would like to learn more about security and privacy. Students will also work on a group project throughout the semester. The course is open to all students who have technical backgrounds. The 12-unit course numbers (17-734, 5-836, 19-734) are for PhD students and masters students. Students enrolled in these course numbers will have extended homework assignments and will be expected to play a leadership role in a group project that produces a paper suitable for publication. The 9-unit course numbers (17-334, 5-436, 19-534) are for undergraduates and masters students (if permitted by their program).

19-550 Undergraduate Research

Intermittent
Students may do undergraduate research as one course for EPP technical elective credit, with an EPP faculty member, or on an approved project with a faculty member from another department. The research credits must be pre-approved by your advisor, and should result in a written product, one copy of which should be sent to EPP.

19-602 Current Topics In Privacy Seminar

Fall and Spring: 3 units
In this seminar course students will discuss recent papers and current public policy issues related to privacy. Privacy professionals from industry, government, and non-profits will deliver several guest lectures each semester.

19-603 Data Science for Technology, Innovation and Policy

Intermittent: 12 units
Students will learn how to use R to collect, organize, and analyze data in technology, innovation, and policy-related domains. The focus will be on the practical issues faced when conducting data analyses, correctly implementing and interpreting statistical models, and summarizing results for clients and research purposes.

19-608 Privacy Policy, Law, and Technology

Fall: 12 units
This course focuses on policy issues related to privacy from the perspectives of governments, organizations, and individuals. We will begin with a historical and philosophical study of privacy and then explore recent public policy issues. We will examine the privacy protections provided by laws and regulations, as well as the way technology can be used to protect privacy. We will emphasize technology-related privacy concerns and mitigation, for example: social networks, smartphones, behavioral advertising (and tools to prevent targeted advertising and tracking), anonymous communication systems, big data, and drones. This is part of a series of courses offered as part of the MSIT-Privacy Engineering masters program. These courses may be taken in any order or simultaneously. Foundations of Privacy (Fall semester) offers more in-depth coverage of technologies and algorithms used to reason about and protect privacy. Engineering Privacy in Software (Spring semester) focuses on the methods and tools needed to design systems for privacy. This course is intended primarily for graduate students and advanced undergraduate students with some technical background. Programming skills are not required. 8-733, 19-608, and 95-818 are 12-unit courses for PhD students. Students enrolled under these course numbers will have extra assignments and will be expected to do a project suitable for publication. 8-533 is a 9-unit course for undergraduate students. Masters students may register for any of the course numbers permitted by their program. This course will include a lot of reading, writing, and class discussion. Students will be able to tailor their assignments to their skills and interests. However, all students will be expected to do some writing and some technical work.

19-617 Infrastructure Management

Intermittent: 12 units
All civilizations depend on infrastructure - the underlying, often hidden foundation of a society's wealth and quality of life. This course provides an introduction and overview of global infrastructure issues as framed against the essential role of infrastructure in supporting sustainable and equitable development. The course offers a wide perspective on infrastructure and infrastructure systems including transportation, energy, water, and communications, and places a heavy focus on interdependence, resiliency, and supply/demand management. Covered topics range from condition, needs, and performance assessment methods to discussions of the infrastructure life cycle—planning, construction, and operations. An independently developed student project provides an opportunity for students to explore areas of infrastructure management of personal interest. Our overarching purpose is for students to develop an understanding of the essential role of infrastructure systems in enabling human communities to thrive.

19-627 Special Topics: Energy Innovation and Entrepreneurship

Fall: 12 units
Want to be an energy innovator, business entrepreneur, social entrepreneur, or intrapreneur? Students in this class will learn the fundamentals of energy innovation and entrepreneurship, and how innovation and entrepreneurship in energy differs from that in other fields. Students will then develop a business and non-market strategy for an idea of their own, or in response to a real-world challenge proposed by a business, industry, or a non-governmental organization. The resulting strategy can, if students wish, be submitted for student competitions that typically take place each spring throughout the United States.

19-629 Climate Change Science and Solutions

Fall and Spring: 12 units
This course consists of four parts. The first part will provide a primer for those who are curious about the physical mechanisms by which climate is determined, and by which climate change occurs. The treatment of these mechanisms will not be overly quantitative, and no knowledge of meteorology or atmospheric science is needed. College-level physics, as well as basic calculus and basic chemistry, is, however, needed. The second part will describe the projected consequences of climate change, as well as those that are already occurring. This part will also familiarize students with how societies might adapt to these changes. The third part will explore (and critique) some of the tools that decision-makers use to quantify and compare the damages caused by these consequences. The final part of the course will discuss some of the technologies that could be used to prevent dangerous climate change.

19-639 Policies of the Internet

Fall: 12 units
This course will address public policy issues related to the Internet. This may include policy issues such as network neutrality and the open Internet, Internet governance and the domain name system (and the role of the United Nations), copyright protection of online content, regulation of indecency and pornography, universal access to Internet and Internet as a "human right", government surveillance of the Internet, Internet privacy and security, and taxation of electronic commerce. It will also teach some fundamentals of Internet technology. Because these are inherently interdisciplinary issues, the course will include detailed discussions of technology, economics, and law, with no prerequisites in any of these areas. Senior or graduate standing required.

19-640 Dynamic Network Analysis

Spring: 12 units
Who knows who? Who knows what? Who communicates with whom? Who is influential? How do ideas, diseases, and technologies propagate through groups? How do social media, social, knowledge, and technology networks differ? How do these networks evolve? How do network constrain and enable behavior? How can a network be compromised or made resilient? Such questions can be addressed using Network Science. Network Science, a.k.a. social network analysis and link analysis, is a fast-growing interdisciplinary field aimed at understanding simple and amp; high dimensional networks, from both a static and a dynamic perspective. Across an unlimited application space, graph theoretic, statistical, and amp; simulation methodologies are used. An interdisciplinary perspective on network science is provided, with an emphasis on high-dimensional dynamic data. The fundamentals of network science, methods, theories, metrics and amp; confidence estimation, constraints on data collection and amp; bias, and key research findings and amp; challenges are examined. Illustrative networks discussed include social media based (e.g., twitter), disaster response, organizational, semantic, political elite, crises, terror, and amp; P2P networks. Critical procedures covered include: basic centralities and metrics, group and community detection, link inference, network change detection, comparative analytics, and big data techniques. Applications from business, science, art, medicine, forensics, social media and amp; numerous other areas are explored. Key issues addressed: Conceptualization, measurement, comparison and amp; evaluation of networks. Identification of influential nodes and hidden groups. Network emergence, evolution, change and amp; destabilization. Graduate course taught every other year. Prerequisite: Undergraduate-level statistics course or instructor permission. Linear algebra is recommended. Students are encouraged to bring and amp; use their own data, or to use provided data.

19-654 Regulation of Internet Edge Platforms

Fall: 6 units
Social media, search and e-commerce platforms are under attack all over the world: antitrust lawsuits, complaints about "fake news," partisan bias, and disinformation on social media, calls to remove liability protections for platforms that post user-provided content, to regulate content and online marketplaces. In this course we will examine competing economic and policy approaches to the treatment of these platforms. We will examine where these companies fit in the Internet ecosystem; how these firms make money (e.g. targeted advertising); traditional principles of antitrust and their application to multi-sided platforms; issues of Free Speech versus Disinformation on social networks, and how these firms differ from traditional media; and a comparison of proposals for structural versus behavioral regulation. Readings will be drawn from technical, economic, legal and policy sources. Students will be encouraged to contrast competing approaches to these issues via in-class debates and written assignments.

19-658 Corporate Venturing & Innovation

Intermittent: 6 units
: Startups aren't the only career destination for aspiring and experienced entrepreneurs - large, established companies need entrepreneurs more than ever to help them avoid the risk of being disrupted. The future survival of many large companies is in the hands of entrepreneurs who understand both technology and business - learn the skills you will need to engage corporate executives on the topic of corporate venturing. This course is created to help entrepreneurs design corporate venturing programs for large companies who want to avoid being disrupted by innovative and more nimble startups *How can you convince corporate executives to invest in corporate venturing capabilities? *How can you be successful as an entrepreneur inside a large company that is set on its ways? *How can a large company compete with faster and more nimble startups by building their own?

19-659 Economic Regulation of Networked Industries

Fall: 6 units
Economic Regulation of Networked Industries; This course will examine principles of economic regulation of networked industries such as gas, electricity, water and telecommunications, including economic justifications for price regulation (e.g. natural monopoly); alternative approaches to price regulation (Rate of Return, Price Caps), cost allocation and pricing in multiproduct industries (e.g. Ramsey prices); tariff design (single and multipart tariffs, capacity charges, peak load pricing); regulation in the presence of competition (cross subsidy and predatory pricing; access pricing); and institutional issues in regulatory agencies (design of independent regulatory agencies, incorporation of public input, public choice theory, regulatory capture).
Prerequisite: 73-102

19-664 Special Topics: Advancing Low Carbon Transition in Industry

Intermittent: 12 units
As a widely used and globally traded product, steel is essential to modern life, but its production is highly energy intensive and accounts for roughly 8% of global greenhouse gas emissions. This project course will work with a major U.S. and Pittsburgh-based steel producer to assess technology pathways for the decarbonization of their organization. Students will learn and apply engineering economic approaches as well as perspectives from organizational processes and business strategy to analyze and compare decision alternatives. Skills to be acquired include deep understanding of industrial processes and decarbonization technologies, engineering cost and real options analysis, business strategy and organization, the role of public policy, and project workflow management and presentation skills. The course will involve regular interaction with the executive sponsor and technical lead, as well as experts on steelmaking technology and climate policy, with high potential for impact.

19-668 Electric Vehicles: Technology, Economics, Environment and Policy

Intermittent: 12 units
In this course, students will read academic literature, government documents, and popular press to develop a broad understanding of the technology, economic, environmental and policy dimensions of electric vehicles. Topics may include (1) TECHNOLOGY: Battery technology, design, application, degradation and innovation; electric vehicle technologies and designs; the electric power grid; (2) ECONOMICS: cost; consumer behavior; infrastructure; electricity dispatch; automotive externalities; the Gruenspecht effect; (3) ENVIRONMENT: life cycle assessment; air pollution; greenhouse gas emissions; marginal grid emission factors; renewables; vehicle to grid; hydrogen; (4) POLICY: effectiveness, efficiency, uncertainty and equity; short-run versus long-run effects; fleet standards; incentives; mandates; policy interactions; intellectual property; and policies in the US, China, EU, Japan, and local jurisdictions. Fundamentals covered at an introductory level to support readings may include time value of money, economies of scale, social welfare analysis, externalities, valuation of reduced mortality risk; choice modeling, regression, life cycle assessment, optimization, game theory, and other topics. Fluency with algebra and calculus is assumed.

19-669 Behavior, Decision and Policy

Intermittent: 12 units
Behavioral science can inform policy making in three ways: (a) improving two-way communication between the public and policy makers; (b) creating policies that make realistic assumptions about human behavior; (c) disciplining the expert judgment needed to analyze risks. The course will introduce and discuss the technical and ethical foundations of behavioral research and risk analysis, setting them in their historical, social, and political context. It will apply them to a wide variety of technology-related policies, including energy (e.g., conservation, nuclear power), environment (e.g., climate, pollution), health (e.g., vaccines, COVID-19), national security (e.g., terrorism, intelligence analysis), and others, including ones proposed by students. Students will acquire a critical perspective on policies in their lives, society, and profession. The course is open to juniors, seniors, and graduate students, who have not taken 84369/84669.

19-671 Tech Start-up: Market Discovery

Spring: 6 units
The first three years of a technology start-up are the most critical; when the company's DNA or trajectory is set. Too few entrepreneurs appreciate this fact and, as a result, many start without the essential skills talents and capabilities needed to set the company on a successful path. Some of these entrepreneurial skills can only be learned through starting and growing a business while others can be learned. This course attempts to bridge the challenging gap between learning and doing entrepreneurship. We introduce you to an essential skill of market discovery or learning to create, develop and evaluate your concept of your business. Is my idea a real innovation? Is it also a business or a product or neither? How do I know how big the market is for my product? What are the technology market and competitive risks in my idea and how do I assess them? Can I compete? Can I sell it? How? When? Where? Students will have the opportunity to apply their newfound practical skills gathered in part from lectures from experienced entrepreneurs and investors to case studies role-playing and solving actual problems of local tech businesses. The best way to learn entrepreneurship is by doing, which is why this course will use 'true-to-life' scenarios as the anchor for the course. The class will be divided into 4 teams will focus on a company that is either (1) a student idea for new start-up, (2) an existing start-up (ideally local) or (3) a hypothetical start-up proposed/conceived by the students, the professor or both

19-672 Special Topics: Tech Start-up: Building Your Own Company

Fall: 6 units
(Session 2) - The first year or two of a tech start-up set the trajectory and character of that company for years to come. Too few entrepreneurs appreciate this reality and, as a result, many carry forward misperceptions and misconceptions about creating and building a successful tech company that set it on the path for failure. This class attempts to remedy that challenge by exposing the student the practical reality of building a team and funding a start-up team. This class should help the student answer (or know how to find the answer) to the following questions: How do I find manage and evaluate a start-up team Do I have the skill motivation and ability to be a tech entrepreneur? Can I build a company from scratch (really?)? Should I be the CEO Sales Account Manager VP of Engineering or something else altogether? How much money do I raise and where and when do I raise it? Students will have the opportunity to apply their newfound practical skills gathered in part from lectures from experienced entrepreneurs and investors to case studies.

19-680 ETIM Seminar on Innovation Management in Practice

Intermittent: 6 units
A definition of innovation is the combination of technology and commercialization to deliver social and economic value. Corporations utilize innovation to establish a competitive advantage and to differentiate in the marketplace. Public policy makers view innovation as a critical driver for economic development. This course will cover the fundamentals of innovation, and the many challenges associated with it. How are opportunities identified? What are the strategies used, and how can they then be implemented? What roles are played by processes, technologies, and the business environment, as well as by individuals in organizations? This course will include active classroom discussions and readings from the innovation literature to reinforce concepts, develop critical thinking and hone analysis skills. This is a core ETIM course, and as such other students will need instructor permission to enroll.

19-684 Engineering and Technology Innovation Management in Practice

Intermittent: 6 units
In this course, we will apply the fundamentals of innovation principles and practices to sponsored projects from corporations. You will work in teams to address the sponsors' objectives, using concepts such as six levers of innovation, seven innovation rules, design roadmapping, etc. Working closely with the sponsor is required so engaging in an appropriate professional manner is expected. Moreover, understanding how to approach team projects, manage team dynamics, and developing presentation skills will also be a part of the curriculum. The course is a culmination of utilizing your learnings from the ETIM program to address customers' needs.

19-685 Engineering Optimization without Project

Intermittent: 9 units
This course introduces students to 1) the process of formally representing an engineering design or decision-making problem as a mathematical problem and 2) the theory and numerical methods needed to understand and solve the mathematical problem. Theoretical topics focus on constrained nonlinear programming, including necessary and sufficient conditions for local and global optimality and numerical methods for solving nonlinear optimization problems. Additional topics such as linear programming, mixed integer programming, global optimization, and stochastic methods are briefly introduced. Model construction and interpretation are explored with metamodeling and model reformulation techniques, study of model boundedness, constraint activity, and sensitivity analysis. Matlab is used in homework assignments for visualization and algorithm development, and students apply theory and methods to a topic of interest in a course project. Fluency with multivariable calculus, linear algebra, and computer programming is expected. Students who are unfamiliar with Matlab are expected to learn independently using available tutorials and examples provided. 4 hrs lecture Prerequisites: None 19785 and 24785: 12-units including the team-based engineering optimization project 19685 and 24685: 9-units excluding the project

19-687 Managing Research, Development and Innovation

Intermittent: 6 units
This course considers key issues and trade-off in R and amp;D strategy and organization, paying attention to dynamic competitive contexts where technology plays a key role. These topics are treated assuming the perspective of the decision maker. It addresses typical problems of large, medium and small firms having a structured R and amp;D and operating businesses where R and amp;D is the source of competitive advantages. Although we will heavily focus on R and amp;D, emphasis is placed on viewing R and amp;D as a part (although, a key part) of the process of technological innovation; therefore, as an activity to be strongly and appropriately integrated with other functions to make innovation successful.

19-688 Tech Start Up: Market Discovery & Building Your Own Company

Intermittent: 12 units
The first year or two of a tech start-up set the trajectory and character of that company for years to come. Too few entrepreneurs appreciate this reality and, as a result, many carry forward misperceptions and misconceptions about creating and building a successful tech company that set it on the path for failure. This class attempts to remedy that challenge by exposing the student the practical reality of building a team and funding a start-up team. This class should help the student answer (or know how to find the answer) to the following questions: How do I find, manage and evaluate a start-up team? Do I have the skill, motivation and ability to be a tech entrepreneur? Can I build a company from scratch (really?)? Should I be the CEO Sales Account Manager VP of Engineering or something else altogether? How much money do I raise and where and when do I raise it? Students will have the opportunity to apply their newfound practical skills gathered in part from lectures from experienced entrepreneurs and investors to case studies. Previously this course was offered as two mini's #19671 and #19672

19-690 M.S. Project

Fall and Spring
For E and amp;TIM and EPP MS students only, with faculty approval.

19-701 Introduction to the Theory and Practice of Policy Analysis

Intermittent: 12 units
This course reviews and critically examines a set of problems, assumptions and analytical techniques that are common to research and policy analysis in technology and public policy. Topics covered include the difference between science, trans-science and policy analysis, policy problems formulated in terms of utility maximization, issues in the valuation of intangibles, uncertainty in policy analysis, selected topics in risk analysis, limitations and alternatives to the paradigm of utility maximization, issues in behavioral decision theory, issues related to organizations and multiple agents, and selected topics in policy advice and policy analysis for the federal government. The objective is to look critically at the strengths, limitations and underlying assumptions of key policy research and analysis tools and problem framing and sensitize students to some of the critical issues of taste, professional responsibility, ethics, and values that are associated with policy analysis and research.

19-702 Quantitative Methods for Policy Analysis

Intermittent: 12 units
Economic framework for identifying and analyzing investment and operation options facing agencies and firms, (both in theory and in practice); economic efficiency, utilization, pricing, and investment; and multi-objective evaluation.

19-703 Applied Data Analysis 1

Intermittent: 6 units
Students will gain a basic understanding of the estimation, interpretation, and diagnostic assessment of the most widely used statistical models in the social sciences. This includes: graphical and inferential statistics, multiple regression with interactions, logistic regression, multi-level models, and panel data. Assignments include six data analysis projects in R. 19703 is part 1, 19704 is part 2.

19-704 Applied Data Analysis 2

Intermittent: 6 units
Students will gain a basic understanding of the estimation, interpretation, and diagnostic assessment of the most widely used statistical models in the social sciences. This includes: graphical and inferential statistics, multiple regression with interactions, logistic regression, multi-level models, and panel data. Assignments include six data analysis projects in R. 19703 is part 1, 19704 is part 2.
Prerequisite: 19-703

19-705 Workshop Applied Policy Analysis

Intermittent: 6 units
This workshop course is about learning how to structure messy un-structured policy problems. It is designed to provide experience in setting up, analyzing, and writing about policy problems of the type that are used in the EPP Part B qualifying exam. Over the course of the semester, the class works through six or seven policy case problems. Much of the work is done in small groups. The principal focus is on integrating the qualitative and quantitative aspects of the problems and on identifying and practicing general problem-solving strategies. Remote option is only with permission of instructor. Students are expected to attend in person.

19-711 Science and Innovation Leadership for the 21st Century: Firms, Nations, and Tech

Fall: 12 units
Science and Innovation Leadership for the 21st Century introduces students to the fundamental principles surrounding global competitiveness and technological change in the 21st century. The course is broken into three sections. The first section introduces students to competing economic, sociological, and political science theories on the structures supporting technological change. The second section presents the contemporary literature on technological change. The concluding section leverages lessons from the preceding two sections to evaluate national innovation systems, and the factors that lead to national comparative advantage. Students should leave the class able to reflect competently on what the existing literature tells us about the factors influencing global technology competitiveness, and on how modern changes in the structures supporting innovation as well as technology itself may be changing the rules of the game for firms and for nations. The course is open to undergraduate juniors, seniors and amp; graduate students.

19-713 Policies of Wireless Systems

Intermittent: 12 units
This course will address public policy issues related to wireless systems, and to the Internet. It begins by investigating policies related to a wide variety of emerging wireless systems and technologies, including wifi computer networks, broadband to the home, broadcast radio and television, and satellite communications. This can include the government role in facilitating the creation of infrastructure, in advancing competition among broadcasters and communications service providers, in managing spectrum, and in protecting privacy and security. The course will then address Internet policy issues, which can include Internet governance and the domain name system, taxation, privacy and security, and intellectual property. Because these are inherently interdisciplinary issues, the course will include detailed discussions of technology, economics, and law, with no prerequisites in any of these areas. Note: ECE students must take this course under #18-650 only

19-716 AI Governance: Identifying & Mitigating Risks in Design & Dev of AI Solutions

Fall and Spring
With AI and ML finding their way into an increasingly broad range of products and services, it is important to identify and mitigate the risks associated with the adoption of these technologies. This course reviews the different types of risks associated with AI and discusses methodologies and techniques available to identify and mitigate these risks. The course introduces students to ethical frameworks available to identify and analyze risks. It also examines best practices emerging from both government and industry efforts in this area. This includes looking at new regulations such as the EU AI Act as well as emerging frameworks such as the one developed by NIST. The course also examines frameworks developed by leading companies and how these frameworks combine both technical and non-technical approaches. It further discusses changes that need to be enacted by organizations to adopt more systematic approaches to AI governance. This course combines a mix of technical, policy, and management discussions.

19-717 Sustainable Engineering Principles

Fall: 12 units
This course presents an overview of the concept of sustainability, including changing attitudes and values toward technology and the environment through the late twentieth and early twenty-first centuries. Relevant issues in sustainable engineering, including population growth, urbanization, energy, water, food and material resources are discussed. Tools for sustainable engineering are presented, including metrics of sustainability, principles of design for the environment, and use of material and energy balances in sustainable systems. Publicly available data sets and computational models will be explored to assess sustainability. A team-based project is required.

19-726 Mathematical Modeling of Environmental Systems

Spring: 12 units
Development and application of mathematical models for environmental systems. Material balance formulations and their solutions, computer implementation, model validation, uncertainty analysis, and use for projection and policy analysis. Applications to surface water, groundwater, atmospheric transport, indoor air pollution, and human exposure and risk.

19-728 Special Topics: Market Engineering and Applications

Intermittent: 12 units
An introduction to market-engineering concepts and applications to contemporary market-design problems such as resource allocation, information aggregation, and decentralized control. Concepts apply theory of linear algebra, optimization and statistics. Application areas include: - energy systems, - environmental management (e.g., cap-and-trade systems), - wildlife management (e.g., fishing licenses), - oil-development leases, - exchanges for organ transplants, - information markets, and - matching systems for medical-residency programs. All students are automatically placed on the wait list, EPP and ESTP students will be given first priority to enroll in the course. You will be notified once you are enrolled.

19-751 Air Quality Engineering

Intermittent: 12 units
The course provides a quantitative introduction to the processes that control atmospheric pollutants and the use of mass balance models to predict pollutant concentrations. We survey major processes including emission rates, atmospheric dispersion, chemistry, and deposition. The course includes discussion of basic atmospheric science and meteorology to support understanding air pollution behavior. Concepts in this area include vertical structure of the atmosphere, atmospheric general circulation, atmospheric stability, and boundary layer turbulence. The course also discusses briefly the negative impacts of air pollution on society and the regulatory framework for controlling pollution in the United States. The principles taught are applicable to a wide variety of air pollutants but special focus is given to tropospheric ozone and particulate matter. The course is intended for graduate students as well as advanced undergraduates. It assumes a knowledge of mass balances, fluid mechanics, chemistry, and statistics typical of an undergraduate engineer but is open to students from other scientific disciplines.

19-785 Engineering Optimization

Fall: 12 units
This course introduces students to 1) the process of formally representing an engineering design or decision-making problem as a mathematical problem and 2) the theory and numerical methods needed to understand and solve the mathematical problem. Theoretical topics focus on constrained nonlinear programming, including necessary and sufficient conditions for local and global optimality and numerical methods for solving nonlinear optimization problems. Additional topics such as linear programming, mixed integer programming, global optimization, and stochastic methods are briefly introduced. Model construction and interpretation are explored with metamodeling and model reformulation techniques, study of model boundedness, constraint activity, and sensitivity analysis. Matlab is used in homework assignments for visualization and algorithm development, and students apply theory and methods to a topic of interest in a course project. Fluency with multivariable calculus, linear algebra, and computer programming is expected. Students who are unfamiliar with Matlab are expected to learn independently using available tutorials and examples provided. 4 hrs lecture Prerequisites: None 19785 and 24785: 12-units including the team-based engineering optimization project 19685 and 24685: 9-units excluding the project

19-788 Special Topics: Behavioral Mechanism and Design

Fall: 12 units
This course will focus on attempts to reduce behavioral and social problems using behavioral research. We will review and discuss behavioral phenomena from three distinct perspectives - economist, psychologist, and behaviorist - mapping out the basic constructs and fundamental assumptions each entail. A point of focus will be understanding basic models of learning and the challenges of predicting behavior. Throughout the semester we will see that in many cases, there is high sensitivity to economic incentives, but not always in the expected direction. Thus, an intelligent design of the reward system can allow for better coping with systematic social and organizational issues. Classes will blend lectures, active discussions, and group projects. Each project begins with a practical problem defined in class, and groups use the tools discussed to develop policy or intervention proposals and presentations. Students will learn to analyze empirical phenomena in decision science and behavioral economics, appreciate the importance of theory-driven predictions, and take first steps in designing environments aiming to minimize social conflicts.

19-819 A/B Testing, Design, and Analysis

Spring: 6 units
This course looks at how to use A/B testing to measure causal effects in online platforms in the era of big data analytics. We aim at answering questions such as how does the demand for a product change when the price does or the ratings do? How can we anticipate how sales and profits change if the firm changes its business strategy? Facebook, Google, Amazon and similar firms ask and answer questions of this kind everyday using their large online platforms. This course introduces fundamental concepts to correctly ask this type of question. We study frameworks to measure causal effects and we discuss their pros and cons. Every tool is discussed in the context of a specific example that students work on using real world datasets. Significant effort is placed on understanding how to design randomized experiments (aka A/B tests) to measure causal effects. We also discuss the most common challenges that arise when trying to design such experiments in the wild and in network settings. The concepts and tools discussed in this course are general in nature and can be applied in settings other than online platforms such as energy, transportation and education. The examples in class will be mostly drawn from our own work at the Heinz College on the media industry. Lectures are 3 hours long. In the first half of each lecture we go over concepts behind A/B tests and what to do when A/B tests are unavailable. The discussion is based on the ideas and intuition behind these concepts. In the second half of each lecture we go over specific examples and #8212; we study the associated datasets and the code used to analyze them properly. Student evaluation is based on five weekly homeworks and a brief term project to be developed in teams. Instructor: Pedro Ferreira, www.andrew.cmu.edu/user/pedrof Pre-requisites: Knowledge of R or STATA. A class in statistics and regression analysis or permission of the instructor.

19-867 From Data to Action

Intermittent: 6 units
This course introduces modeling frameworks and computational tools to address complex, ill-defined, large-scale decision-making problems that arise in policy and business. Through lectures and case studies, it covers advanced methods of decision-making under uncertainty in these major areas: (large-scale) deterministic optimization, stochastic/robust optimization, and sequential decision making. It will focus on modeling (how to formulate models to address policy or business problems), computation (how to solve large-scale problems), and applications in policy and business (how to integrate viewpoints of different stakeholders, how to select the scope of the model, etc.). Applications are drawn from a variety of real-world settings in transportation, energy, health, supply chain management, etc. Participants are expected to take "active learning" roles in the computational application of the materials presented in class using the python programming language and the Gurobi optimization solver. A term project simulates realistic and challenging issues where new solutions need to be developed, implemented and communicated. The prerequisites are an introductory course in Operations Research, such as Management Science I and II or Decision-Making under Uncertainty, and an intermediate Python course.
Prerequisites: 90-819 and 90-760 and 90-722