

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 search 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: 36-217 Min. grade C or 36-219 Min. grade C or 19-250 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.

19-402 Telecommunications Technology and Policy for the Internet Age

Intermittent: 12 units

Modern telecommunications is the nervous system of society. The Internet and wireless communications have transformed every aspect of our modern life. This course provides a comprehensive introduction to basic principles of telecommunications technology and the legal, economic, and regulatory environment of today's networks. Topics covered include the fundamentals of communication network technologies, including video, voice, and data networks; the rising dominance of wireless networks; principles behind telecommunications regulation from common carrier law and natural monopoly to information diversity, privacy and national security; traffic differentiation on the Internet and the debate over network neutrality; universal service and the digital divide; mergers, antitrust, and the changing industrial structure of the communications sector. We will explore current topical questions such as the future of competition; the shift of entertainment video from cable and satellite to Internet delivery; how cloud computing concepts are transforming networks; and communications support for the Internet of Things. Comparison with European approaches to telecommunications regulation. Special emphasis on how new technologies have altered, and are altered by, regulation. Junior, Senior or graduate standing required.

Prerequisites: 73-100 and 73-102

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 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 graduate students.

19-421 Emerging Energy Policies

Intermittent: 9 units

Interested in what's happening in energy policy and how to analyze potential policy options in response? Focusing on current hot topics in energy policy, students will learn the basic principles of public policy analysis and underlying techniques such as program evaluation, cost benefit analysis, life cycle analysis, price analysis, and risk analysis as well as the variety of policy mechanisms available. Class time will include a combination of faculty and guest speaker lectures, discussion of issues, videos, and problem solving. Students will review and edit Wikipedia entries on an energy policy topic of their choice, and then analyze policy options resulting in an executive summary or paper on that topic. While the course has no prerequisites, students should feel comfortable with scientific and technical topics. Upon completion of this course, students should have a deeper and more strategic understanding of the opportunities and challenges associated with emerging energy policies. Open to seniors. Open to juniors with permission only.

19-425 Sustainable Energy for the Developing World

Fall and Spring: 9 units

This course examines the current state of the energy system in developing countries and the challenges these countries will face in sustainably meeting their energy needs in the 21st century. The following are examples of questions and issues we will cover throughout the semester. What is the current status of the energy system in the developing world? What is the role of energy in supporting economic growth and alleviating poverty? What are the future energy needs of developing countries? What are the challenges developing countries will face as they build/improve their energy systems? What technologies are available to meet the energy challenges in the developing world?

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

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/>)

19-429 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.

19-500 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.

19-605 Engineering Privacy in Software

Spring: 12 units

Privacy harms that involve personal data can often be traced back to software design failures, which can be prevented through sound engineering practices. In this course, students will learn how to identify privacy threats due to surveillance activities that enhance modern information systems, including location tracking, behavioral profiling, recommender systems, and social networking. Students will learn to analyze systems to identify the core operating principles and technical means that introduce privacy threats, and they will learn to evaluate and mitigate privacy risks to individuals by investigating system design alternatives. Strategies to mitigating privacy risk will be based on emerging standards and reliable privacy preference data. Students will have the opportunity to study web-, mobile- and cyber-physical systems across a range of domains, including advertising, healthcare, law enforcement and social networking. In addition, students will know how, and when, to interface with relevant stakeholders, including legal, marketing and other developers in order to align software design with privacy policy and law.

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

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

This course takes a broad view of infrastructure systems to include physical infrastructure and information networks. The course will consider the need to protect these critical infrastructures from both degradation as well as malicious attacks. Infrastructure management generally depends on public-private partnerships to ensure long-term viability. We will look at relevant academic literature on the topics of infrastructure needs and requirements. We will explore the use of automated sensing and computer network systems to facilitate management.

19-624 Emerging Energy Policies

Intermittent: 12 units

Interested in what's happening in energy policy and how to analyze potential policy options in response? Focusing on current hot topics in energy policy, students will learn the basic principles of public policy analysis and underlying techniques such as program evaluation, cost benefit analysis, life cycle analysis, price analysis, and risk analysis as well as the variety of policy mechanisms available. Class time will include a combination of faculty and guest speaker lectures, discussion of issues, videos, and problem solving. Students will review and edit Wikipedia entries on an energy policy topic of their choice, and then analyze policy options resulting in an executive summary or paper on that topic. While the course has no prerequisites, students should feel comfortable with scientific and technical topics. Upon completion of this course, students should have a deeper and more strategic understanding of the opportunities and challenges associated with emerging energy policies. Open to seniors. Open to juniors with permission only.

19-625 Sustainable Energy for the Developing World

Fall and Summer: 12 units

This course examines the current state of the energy system in developing countries and the challenges these countries will face in sustainably meeting their energy needs in the 21st century. The following are examples of questions and issues we will cover throughout the semester. What is the current status of the energy system in the developing world? What is the role of energy in supporting economic growth and alleviating poverty? What are the future energy needs of developing countries? What are the challenges developing countries will face as they build/improve their energy systems? What technologies are available to meet the energy challenges in the developing world?

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

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.

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

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 complex, high dimensional networks, from both a static and a dynamic perspective. Across an unlimited application space, graph theoretic, statistical, and 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 confidence estimation, constraints on data collection and bias, and key research findings and challenges are examined. Illustrative networks discussed include social media based (e.g., twitter), disaster response, organizational, semantic, political elite, crises, terror, and 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 numerous other areas are explored. Key issues addressed: Conceptualization, measurement, comparison and evaluation of networks. Identification of influential nodes and hidden groups. Network emergence, evolution, change and 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 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 Special Topics: 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.

19-666 Energy Policy and Economics

Intermittent: 6 units

This course will begin with a review of microeconomic concepts and tools necessary for analysis of the topics covered in the class. The course will explore how past energy technology policies and choices are intertwined with pathways of economic development, social impacts, macroeconomic measurement and performance. This course will explore how a wide variety of policy mechanisms- technology policy, utility regulation and restructuring, emissions policies, multilateral interventions and agreements, and corporate strategies-can shape energy use and the environmental impacts of energy systems. Study examples will draw from both developed and developing countries.

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

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.

19-670 Quantitative Entrepreneurship: Analysis for New Technology Commercialization

Spring: 12 units

This course provides engineers with a multidisciplinary mathematical foundation for integrated modeling of engineering design, manufacturing, and enterprise planning decisions for commercializing new technologies and products. Topics include economics in product design, manufacturing and operations modeling and accounting, consumer choice modeling, survey design, conjoint analysis, optimization, model integration and interpretation, and professional communication skills. Students will apply theory and methods to a team project for a new product or emerging technology, developing a business plan to defend technical and economic competitiveness. This course assumes fluency with multivariable calculus, linear algebra, and probability theory.

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

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 E&TIM Seminar on Innovation Management in Practice

Intermittent: 6 units

Innovation has been described as "the intersection of invention and insight, leading to the creation of social and economic value." Companies increasingly rely on innovation to establish and drive their success. Public policy makers see innovation as a critical driver for economic development. This course is an opportunity to learn about innovation management from those in the front lines. How are innovation opportunities identified? What are the challenges to realizing these opportunities, and how can the challenges be addressed? What roles are played by processes, technologies and the business environment, as well as by individuals in organizations? This course will feature speakers who drive innovation in a variety of settings, paired with readings from the innovation literature that will help frame the presentations and discussion.

19-682 The Strategy and Management of Technological Innovation

Intermittent: 12 units

Strategy is distinctive approaches executives use to realize firm performance goals. In this course, we will prepare you for analyzing how technology and innovation affects how executives formulate and execute strategies. This course teaches how incorporating technology and innovation into the corporate strategy of the firm can achieve profitable and sustainable competitive advantage. It addresses the role of technology management in both emerging and established firms, and examines how all of the firm's activities, assets, and relationships must complement one another in order to capture value from innovation. The course will progress in two parts. We will first cover how strategy is formulated through frameworks, models, and tools essential for those actively engaged in the innovation process within a firm and apply these to case studies illustrating their importance in technology industries. We will then cover the obstacles that prevent firms from executing the ideal strategy. In each framework we analyze during the class, we will have the following objectives: 1) Recognizing the performance metric targeted by each framework 2) Identifying the assumptions each framework makes about firm structure, the speed of market and technological change 3) Analyze the strengths and weakness of each framework 4) Apply tools suited for each framework to determine the appropriate strategy that the firm should undertake 5) Using organizational theory to recognize obstacles that prevent the firm from implementing the desired strategies and how to overcome such barriers to implementation

Course Website: <https://cmu.box.com/s/zjvqn8ne12sjwqmtvev2w49s78ij5m5> (<https://cmu.box.com/s/zjvqn8ne12sjwqmtvev2w49s78ij5m5/>)

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 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 D and operating businesses where R and D is the source of competitive advantages. Although we will heavily focus on R and D, emphasis is placed on viewing R and 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.

19-689 Finance for Innovation Management

Intermittent: 6 units

In this course, there will be three main elements all focused around the innovation decision-making process: Basic financial concepts Business case development by innovation project managers. Tools and processes used in innovation decision-making With respect to financial concepts, the course will provide an introduction of the basic financial concepts that corporations use to capture their financial performance including the following: Basic financial statement information income statement / balance sheet / meanings / interpretations / analysis of financial statements/determination of cash flow / annual reports, etc. Performance metrics, ROI, Debt to Equity ratio, EPS, NOPAT, EBITDA, Liquidity, Days outstanding, other appropriate measures The intention of this introduction is to provide future project managers with a sufficient understanding of the financial information that is typically used in building a business case to make innovation decisions both in a corporate setting and in a more entrepreneurial setting. With respect to actual innovation decision-making, the course will examine the various tools and techniques that are used by (1) corporations to make investment decisions in specific R and D projects and (2) entrepreneurial organizations to make investments and decisions in new technical projects. This course will address a number of commonly used decision tools such as: (1) Discounting / Net Present Value calculations (NPV), IRR / Payback Period / ROIC / etc.; (2) Decision and Risk Analysis methodologies; and (3) Portfolio management Finally, the course will develop an understanding of the differences between how corporations and how entrepreneurial firms use these tools, examine the implications of financial analysis techniques on R and D decision-making, and will examine some of the suggested fallacies and the limitations of financial analysis of innovation management.

19-690 M.S. Project

Fall and Spring

For E and M.S. TIM and EPP MS students only, with faculty approval.

19-693 Managing and Leading Research and Development

Intermittent: 12 units

This course will provide an insider's look at issues in industrial research and development laboratories that future industrial R and D personnel are likely to face.

Course Website: <http://www.ece.cmu.edu/courses/items/18703.html>

19-694 Leadership and Innovation Management

Fall: 6 units

The attributes and skills of the contributors to innovation are important elements in the effectiveness of the innovation process and the success of the outcome. In this course, we will focus on these skills and attributes, including diversity and inclusion, with an emphasis on the leaders of innovation and innovative organizations. Selected literature, case studies, and guest lectures by leaders, as well as the instructor's own experience as Carnegie Mellon's eighth president, will be the sources from which the course will draw. Students will gain insight into the roles they may play in contributing to and leading innovation and organizations and the skills and attributes they will need for success.

19-695 Internship Practicum

Summer

Experiential learning opportunities are important educational options for undergraduate and graduate students. One such option is an internship, or practicum. If an internship is an explicit part of an academic program or is supervised by a faculty member, this course number may be used. Please consult the supervising faculty member concerning grading options and the appropriate number of units. NOTE: Special Permission required to register for this course

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.

19-707 Multiple Criteria Decision Making

Fall: 6 units

Problems with multiple, conflicting objectives are ubiquitous in the private and, especially, the public sector where tradeoffs among economic efficiency, equity and environmental quality are common. The objective of this course is to provide an overview of the techniques for the analysis and resolution of multiple criteria decision making (MCDM) problems. Topics will include multi-objective programming, multi-attribute utility theory and several MCDM methods such as the Analytical Hierarchy Process. The emphasis will be on theory and technique, but there will be several applications to demonstrate the methods. Undergraduate students require permission of the instructor to enroll.

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 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

19-714 Environmental Life Cycle Assessment

Spring: 12 units

Cradle-to-grave analysis of new products, processes and policies is important to avoid undue environmental harm and achieve extended product responsibility. This course provides an overview of approaches and methods for life cycle assessment and for green design of typical products and processes using the ISO 14040 family of standards. This includes goal and scoping definition, inventory analysis, life cycle impact assessment (LCIA), interpretation, and guidance for decision support. Process-based analysis models, input-output and hybrid approaches are presented for life cycle assessment. Example software such as MATLAB, Excel, and Simapro are introduced and used in assignments. A group life cycle assessment project consistent with the principles and tools of sustainability to solve real-world engineering problems is required.

Prerequisites: (12-421 or 12-706) and 12-712

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

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 Quality 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.

Prerequisite: 12-704

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

19-819 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 Decision Analytics for Business and Policy

Intermittent: 12 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. Using a combination of lecturing, case studies and class discussions, it covers advanced methods of decision-making under uncertainty in four major areas: large-scale optimization, discrete event simulation, stochastic optimization and queuing theory. The application of such methods are drawn from a variety of real-world settings in a variety of domains such as transportation, energy, information systems, health care, supply chain management, etc. Participants are expected to take active learning roles in the computational application of the materials presented in class using the R programming language and the CPLEX optimization solver. A term project simulates realistic and challenging professional situations where new solutions need to be developed, implemented and communicated. The prerequisite is an introductory course in Operations Research, such as Management Science I and II or Decision-Making under Uncertainty. The learning objectives of this course fall into the following categories learning advanced quantitative modeling and solution algorithms from the fields of Operations Research and Management Science (OR/MS) applying OR/MS methods systematically to model complex decision-making problems faced in practice implementing simulation and optimization methods with large-scale datasets using state-of-the-art software evaluating the challenges and trade-offs in quantitative modeling and computation communicating technical models and results effectively based on the context and the audience

Prerequisites: 90-760 and 90-722 and 90-819