

Department of Engineering and Public Policy Courses

Note on Course Numbers

Each Carnegie Mellon course number begins with a two-digit prefix which designates the department offering the course (76-xxx courses are offered by the Department of English, etc.). 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. xx-6xx courses may be either undergraduate senior-level or graduate-level, depending on the department. xx-7xx courses and higher are graduate-level. Please 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 the processes of public and private decision making and of policy formation, which shape the evolution of a technology and its impact on our society. Technology plays an important role in shaping our worlds. At the same time, social forces often play a central role in the evolution of a technology. A particular technology such as an automobile or computer is chosen to study technology and policy in context. Specific topics covered in the case of the automobile includes automotive design and manufacture, safety, pollution, fuel economy and their interactions. In each area, we discuss the technological and institutional issues, their interaction, the possible need for public policy and the factors that govern the policy. The course will involve several group problem-solving sessions.

19-201 EPP Sophomore Seminar

Fall: 1 unit

The Sophomore Seminar has the objective of introducing the student to the interdisciplinary nature of Engineering and Public Policy problems. This is achieved through the use of case studies dealing with aspects of decision-making and ethics in policy issues which have a technological basis. Students are introduced to the technical and policy dimensions of these problems as well as to skills such as data collection and analysis, group work, and oral and written presentations. A few seminars by EPP graduates and faculty are occasionally included to give the student an idea of careers and EPP problems.

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.

19-301 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: 36-220 Min. grade C or 36-217 Min. grade C

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

19-325 Technology and Policy Writing for Lay Audiences

Fall and Spring: 9 units

This course is designed to teach the fundamentals of persuasive, accurate writing about technical, highly specialized information for a general audience, based on an axiom attributed to Albert Einstein: If you can't explain it simply, you don't understand it well enough. Readings will be selected from writing style guides, and from nonfiction and science fiction literature. Course work will include the translation of data and journal articles into prose for a sophisticated general audience, as well as original writing.

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.

19-355 Special Topic: Cryptocurrencies, Blockchains, and Applications

Spring

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. Units: 9 (without semester-long project) or 12 (with semester-long project) Prerequisites: 15-213 or equivalent strongly recommended

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

19-365 Water Technology Innovation and Policy

Spring: 9 units

Innovation in water technologies is necessary to confront profound water resource challenges facing countries around the world. Students successfully completing this course will be able to discuss the factors and conditions that drive innovation in the water sector. Students will begin by describing and classifying the historical drivers for innovation in water treatment, including technical, economic, and regulatory drivers. After an introduction to the fundamental principles of water treatment technologies, students will identify present day technology shortcomings and distill these into discrete design objectives. Students will then formulate and answer quantitative and qualitative questions that respond to these design objectives by leveraging their knowledge of engineering fundamentals, regulatory tools, and pricing policies. Comparing their own solutions with those proposed in the peer-reviewed academic literature in engineering and the social sciences, students will evaluate the technical feasibility, usability, and social desirability of proposed water innovations in developed and developing countries and summarize their findings in policy briefs. Prerequisites: 19-101 or 19-201 or 12-100 or 06-100

19-402 Telecommunications Technology, Policy & Management

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 computer 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 in broadband access; 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 communications regulation. Special emphasis on how new technologies have altered, and are altered by, regulation. Junior or Senior standing required.

Prerequisite: 73-100

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. This course is cross-listed as 18-650, 19-403, 19-713, and 95-824. Senior or graduate standing required.

19-411 Global Competitiveness: Firms, Nations and Technological Change

Fall: 9 units

Global Competitiveness 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 & graduate students.

19-421 Emerging Energy Policies

Intermittent: 9 units

As the world moves toward shale gas, renewable energy, and alternative vehicle technologies, many interesting policy issues arise. These issues are the subject of discussion among engineers, scientists, policymakers, nongovernmental organizations such as environmental groups and the public. All influence public policy decision making. 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. 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.

Course Website: <https://cmu.box.com/s/zjvqn8ne12sjwqmtvev2w49s78ij5sm5>**19-424 Energy and the Environment**

Intermittent: 9 units

This course will explore the relationships between environmental impacts and the utilization of energy through a series of case studies on topics of current interest. Such topics might include the use of renewable and non-renewable fuels for electric power generation; energy use for automobiles and other transportation systems; energy use for buildings and industrial processes; and environmental issues such as urban air pollution, ozone formation, acid rain, and global warming. The emphasis will be on analysis of energy-environmental interactions and tradeoffs, and their dependency upon engineering design choices, economic variables, and public policy parameters. Junior or Senior standing in CIT or permission of instructor.

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>**19-427 Special Topics: Energy Innovation and Entrepreneurship**

Fall: 9 units

In this class, students will learn the fundamentals of energy innovation and entrepreneurship, how innovation and entrepreneurship in energy differs from that in other fields, and practice these skills by either developing a business and non-market strategy for an idea of their own, or build upon energy technological innovations developed by CMU faculty or scientists and engineers in federal laboratories. The resulting strategy can, if students wish, be submitted for competitions that typically take place each spring at CMU, Pittsburgh, and throughout the United States.

Course Website: <https://cmu.box.com/s/zjvqn8ne12sjwqmtvev2w49s78ij5sm5>**19-432 Special Topics: Bitcoin and Cryptocurrencies**

Spring: 6 units

Provides an understanding of the technology, usability, business, and regulatory issues of digital currencies in the context of the cryptocurrency, Bitcoin. How does it work? How do people use it? Can I make money with it? Is it safe? Is it legal? To address these questions, we investigate Bitcoin's underlying technology; digital wallets; Bitcoin mining; cybersecurity; and regulatory issues.

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.

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

19-443 Special Topics in EPP: Climate Change Science and Adaptation

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.

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

19-451 EPP Projects

Spring: 12 units

Interdisciplinary problem-solving projects in which students work as leaders or members of project teams. Problem areas are abstracted from local, state and national situations and involve the interaction of technology and public policy, with different projects being chosen each semester. Oral and written presentations concerning the results of project studies are required. NOTE: All students will enroll in section A at first. During the 1st class, students will choose either project A or B. Those choosing B, will be moved into that section.

19-452 EPP Projects

Fall: 12 units

Interdisciplinary problem-solving projects in which students work as leaders or members of project teams. Problem areas are abstracted from local, state and national situations and involve the interaction of technology and public policy, with different projects being chosen each semester. Oral and written presentations concerning the results of project studies are required.

19-458 Special Topics: Organizational Theory for Engineers

Spring: 9 units

Why do so many technical problems of global importance persist even when there exists engineering solutions? This course will explore the organizational challenges that can hinder the deployment of engineering solutions towards solving some of our most critical global technical challenges. We will explore a variety of organizational theories such as institutional theory, network theory, social movement theory, and actor-network theory and then see how they are applied to a variety of engineering systems such as those around energy, mechanical design, water, information and communication technology, and other such civil infrastructure. By the end of the course, students will be able to a) learn how to read and synthesize organizational research from a variety of theoretical lenses, b) understand how such research can apply to a variety of engineering systems, and c) learn how to advance and conduct engineering research that incorporates an organizational perspective. Intended for graduate students; seniors and juniors with permission.

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

19-461 Invention & Innovation for Materials Intensive Technologies Part 1

Fall: 4.5 units

Two 4.5 unit classes that can be taken in sequence or as stand-alone mini's. Courses will be cross-listed between EPP and MSE. This course is intended to instill a sense of how technologies are conceived and brought to market. The students will be exposed to a variety of formalized invention and innovation processes/concepts and will be asked to complete projects that will pull from the full range of their engineering training. It is intended for seniors who are eager to creatively apply their learned knowledge skills, and who are interested in invention, innovation, and entrepreneurship. The first half (part 1 (19461), mini 1) will focus on the process of invention for devices and technologies that are enabled by materials functionality. This will start by providing historical context and addressing the questions "What is invention?" This will be followed by an assessment of various systematic methods by which the process of invention is practiced, with a specific focus on materials intensive devices and products. The second half of the course (part 2 (19462), mini 2) will examine innovation theory in the context of materials intensive technologies. Specifically, the concepts of incumbency, disruption, value chain, supply chain, funding models and paths to market will be addressed. In this class, significant time will be dedicated to covering the impact of international market and technology development.

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

19-462 Invention Innovation for Materials Intensive Technologies Part 2

Fall: 4.5 units

Note: students must take and pass 27-501/19-461 to take 27-502/19-462. Two 4.5 unit classes that can be taken in sequence or as stand-alone mini's. Courses will be cross-listed between EPP and MSE. This course is intended to instill a sense of how technologies are conceived and brought to market. The students will be exposed to a variety of formalized invention and innovation processes/concepts and will be asked to complete projects that will pull from the full range of their engineering training. It is intended for seniors who are eager to creatively apply their learned knowledge skills, and who are interested in invention, innovation, and entrepreneurship. The first half (part 1 (19461), mini 1) will focus on the process of invention for devices and technologies that are enabled by materials functionality. This will start by providing historical context and addressing the questions "What is invention?" This will be followed by an assessment of various systematic methods by which the process of invention is practiced, with a specific focus on materials intensive devices and products. The second half of the course (part 2 (19462), mini 2) will examine innovation theory in the context of materials intensive technologies. Specifically, the concepts of incumbency, disruption, value chain, supply chain, funding models and paths to market will be addressed. In this class, significant time will be dedicated to covering the impact of international market and technology development.

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

19-466 Spec Topic: Stochastic Discrete Choice Models: Estimation and Behavioral Theory

Fall: 9 units

This course will cover the rational and behavioral foundations of discrete choice models, current behavioral theories, and estimation methods. Content will include an overview of the history of thinking about discrete choice models, rational foundations, behavioral theories, signal detection theory, multinomial logit, mixed logit using restricted MLE and monte-carlo simulation, and experimental design. If time permits we will cover item-response models and Bayesian methods.

19-486 Special Topics: New Technology Commercialization: Public Policy Strategies

Spring: 9 units

During this project-based class, students will develop non-market strategies for real-world clients. As defined, by David Baron, "The nonmarket environment consists of the social, political, and legal arrangements that structure interactions among companies and their public." This class will focus on non-market strategies at the intersection of new technologies, public policies, and business. Entrepreneurs and innovators interested in commercializing technology in the biomedical, energy, transportation, information technology, robotics, aerospace, food, healthcare, and other industries require more than knowing whether a technology works and the potential market. Non-market factors such as regulations, standards, and grants influence product, price, location, research, development, and testing, and other decisions. As a result, public policies provide both opportunities and challenges for the commercialization of an invention. Only by recognizing these opportunities or overcoming these challenges can an invention become a commercialized innovation.

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

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 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 important 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 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. Much of the course will be taught in a graduate seminar style in which all students will be expected to do a weekly reading assignment and each week different students will prepare a presentation for the class. Students will also work on a group project throughout the semester. The course is open to all graduate students who have technical backgrounds. The 12-unit course numbers (19734, 08-734 and 5-836) are for PhD students and masters students. Students enrolled in these course numbers will be expected to play a leadership role in a group project that produces a paper suitable for publication. The 9-unit 500-level course numbers (19534, 08-534 and 05-436) are for juniors, seniors, and masters students. Students enrolled in these course numbers will have less demanding project and presentation requirements.

19-624 Emerging Energy Policies

Intermittent: 12 units

As the world moves toward shale gas, renewable energy, and alternative vehicle technologies, many interesting policy issues arise. These issues are the subject of discussion among engineers, scientists, policymakers, nongovernmental organizations such as environmental groups and the public. All influence public policy decision making. 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. 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 graduate students and seniors. Open to juniors with permission only.

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

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>

19-626 Climate Science and Policy

Intermittent: 12 units

This course will survey both scientific and policy issues associated with climate change. We will begin by surveying important factors governing the Earth's climate including solar and terrestrial radiative equilibrium and ocean heat storage and transport. Next, we will discuss the several perturbations or "forcings" that industrial society has imposed on Earth's climate: changes in greenhouse gas concentrations, ozone, and aerosols. The course will examine how complex climate feedbacks lead to significant uncertainty regarding the response of the Earth to these forcings. Decision-making strategies that policy makers can use to deal with these uncertainties will be discussed. We will outline major impacts of climate change on society as well as natural systems and strategies for mitigating climate change.

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

19-627 Special Topics: Energy Innovation and Entrepreneurship

Fall: 12 units

In this class, students will learn the fundamentals of energy innovation and entrepreneurship, how innovation and entrepreneurship in energy differs from that in other fields, and practice these skills by either developing a business and non-market strategy for an idea of their own, or build upon energy technological innovations developed by CMU faculty or scientists and engineers in federal laboratories. The resulting strategy can, if students wish, be submitted for competitions that typically take place each spring at CMU, Pittsburgh, and throughout the United States.

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

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.

19-648 Special Topics: International Climate Adaptation & Infrastructure Innovation

Spring: 6 units

Although an international problem, climate change will affect each country's critical infrastructure in diverse ways. This course will focus on understanding how international communities are adapting and innovating to reduce critical infrastructure risk. Students will be able to list and describe natural hazards affected by climate change, focusing on their impacts on natural and built critical infrastructure systems in physically, socially, and economically diverse countries. Students will then use cost-benefit analysis, the triple bottom line approach (physical, social, economic), and robust decision making to analyze, compare, and contrast different countries' responses. The class will culminate in a final paper and presentation on one country's approach to decision-making under uncertainty for adaptation. Learning Objectives: By the end of the semester, you should be able to:

- Understand risk.
- o Define risk, hazard, vulnerability, exposure, adaptation, hazard mitigation, greenhouse gas mitigation.
- o Explain the link between some natural hazards and climate change
- o List 10 natural hazards and their impacts on the international community.
- Analyze outcomes/impacts.
- o Predict how physically, socially, and economically detrimental a given natural hazard will actually be in different critical infrastructure systems.
- o Compare and contrast different adaptations to reduce risk.
- Create recommendations for improving adaptation in an international community

19-653 Climate Change Mitigation

Intermittent: 12 units

Assessment of technological and policy options for responding to the threat of climate change. Overview of climate-change science: sources, sinks and atmospheric dynamics of greenhouse gases. Current systems for energy supply and use. Technological options for low-carbon energy supplies: fossil fuels with sequestration and renewable sources. Technological options for improving end-use energy efficiency in buildings and in transportation. Geo-engineering the climate. Policy frameworks for implementing reductions of greenhouse gas emissions. 4 hours lecture

19-665 Environmental Politics and Policy

Fall: 6 units

Engineers, scientists, policymakers, industry, environmental groups, and the public all influence environmental policy making, and should have an understanding of past and current environmental issues, technologies, policies, programs, and politics. Using a case study approach, students will learn how to use program evaluation to analyze the effectiveness of past policies (e.g., CFCs, DDT) and apply the lessons learned to conduct policy analysis of current environmental challenges (e.g., nanotechnology, climate change). Students will gain an understanding of the variety of policy mechanisms available to attain environmental goals including the use of voluntary standards. Student interest will guide topic selection for both issues discussed in class and for project work. Class time will include a combination of faculty and guest speaker lectures, discussion of issues, videos, and problem solving time. While the course has no prerequisites, students should feel comfortable with scientific and technical topics.

19-666 Energy Policy and Economics

Intermittent: 6 units

This course will review how past and future energy technology trajectories are intertwined with pathways of economic development, business investment decisions, social needs, and political priorities. Emphasis will be placed on clean energy and promising technological trajectories for the future. 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>

19-670 Quantitative Entrepreneurship: Analysis for New Technology Commercialization

Intermittent: 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>

19-671 Tech Startup: Tools and Techniques

Spring: 6 units

19671 (Session 1) - The first year or two of a tech start-up sets 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 remedies that challenge by exposing the student the practical reality of creating and evaluating business concept. This class should help the student answer (or know how to find the answer) to the following questions: When thing of 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 with the big companies? 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.

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

19-672 Special Topics: Tech Entrepreneurship and Innovation

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.

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

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.

19-681 Managerial and Engineering Economics

Intermittent: 12 units

The course emphasizes the application of economic principles (e.g., marginal analysis, supply and demand, competitive equilibrium, imperfect competition and monopoly) and fundamentals of engineering economics (e.g., quantifying costs and benefits, net present value, decision making under uncertainty) to managerial decision making. Topics include production and costs, elements of decision analysis, market mechanisms, pricing decisions, and information economics. The coverage of these topics fosters an understanding of the organization of firms and markets and firm decision making in the context of exploring, evaluating, and managing opportunities for technological innovation and diffusion.

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>

19-684 Engineering and Technology Innovation Management in Practice

Intermittent: 6 units

Innovation takes place inside organizations, whether it's a small company, a large corporation, a university or a government laboratory or agency. In this course, we will focus on the people who lead innovative organizations, what they do to promote and sustain innovation, and the skills and attributes they need to be successful. The instructor's experience as President of Carnegie Mellon, guest lecturers from industry and the literature 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 innovative organizations, and the skills and attributes they will need for success. 19684 is part of the Engineering and Technology Innovation Management (E&TIM) Masters Program. E&TIM students should register for the 6 unit course, reflecting the supplemental course requirements for E&TIM. Other students are welcome to enroll for the 3 unit course.

19-687 Principles and Practices of R&D Management

Intermittent: 6 units

This course considers key issues and trade-off in R&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&D and operating businesses where R&D is the source of competitive advantages. Although we will heavily focus on R&D, emphasis is placed on viewing R&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.

19-691 Special Topics: Decision-Making Methods for Innovation Management

Fall: 6 units

In this course, there will be several main elements all focused around the decision-making process that corporations typically use in making decisions regarding innovation / R&D investments. This course will build upon the financial concepts that were initially discussed in Finance of Innovation Management (19-689). Specifically this course will build on the following: Basic concepts around an appropriate decision-making process that should be used for making investment decisions related to innovation management and other strategic decisions. Discussion around the framework of decision quality and how this framework is used to improve the decision-making process around innovation decisions and other strategic decisions. Discussion of decision-making under uncertainty and the use of decision analysis methods that are commonly used to make Innovation / R&D investment decisions to assess the value of potential innovation decisions. Introduction to real options theory to include discussion of various calculation methods including the Black Scholes model and the binomial model and to consider the practical issues of implementing such an evaluation methodology. Should have taken 19-689 or elementary accounting / financial management course or by permission of instructor. Prerequisite: 19-689 Min. grade C

19-692 Special Topics: Strategic Marketing and Product Management for Tech Innovations

Intermittent: 12 units

The purpose of this master's level course is to develop the knowledge and skills needed to formulate marketing and product strategies for new technological product/service innovations in their market introductory phase. The course introduces the principles, concepts, frameworks and proven practices for analysis and strategic decision-making in an uncertain and constrained environment (i.e. when ample historical data and large budgets don't exist.) The course uses lectures, readings, group exercises, and an individual project with instructor feedback to achieve the learning objectives. The primary work in this course is hands-on application of the material by the student to create a strategic marketing plan for their own, approved product innovation idea with evaluation and feedback from the instructor. A customer-centric orientation is emphasized throughout the course. The course addresses strategic marketing decisions and activities including identifying value creation opportunities; generating and selecting innovation ideas; understanding the market, competition, customer needs and customer experience; segmenting, targeting markets; developing a positioning strategy and compelling customer value proposition; making marketing-mix decisions for product, pricing, route-to-market/distribution, and customer base development. The perspective of this course will be from a role of a strategic marketer, which is typically held by an entrepreneur/CEO, product manager, strategic marketing manager, product planning manager, new business development manager, or innovation manager. A syllabus and project description are available from the instructor.

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

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&D personnel are likely to face.

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

19-694 Special Topics: 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, 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.

19-696 Sustainable Development and Innovation

Fall: 9 units

This course will explore how technology and business contribute to sustainable development. Course segments will include examining global megatrends in ten major sectors (e.g., food, water, energy, health, etc.), opportunities and risks in these key sectors, and developing key metrics for success in sustainable development. Solution pathways that use existing, transferable, and new models in both policy and innovation will be discussed and proposed by the class. Issues for both large multi-nationals and start-ups will be covered. Class time will include a combination of lectures, guest speakers from industry, and problem solving activities. Students will experience how to create a business in this climate of sustainable development. Instructor is former CTO of Alcoa, and Co-Chair of the Vision 2050 project of the World Business Council for Sustainable Development. He is also currently an Advisor & Board Member at a number of Venture Capital firms and a Adjunct Prof. at CMU. The course is intended for MS students. Upper-level undergraduates may enroll with permission.

19-697 Modern Prototyping Techniques

Spring: 12 units

Students in Modern Prototyping Techniques will explore a wide variety of tools and techniques for evaluating the feasibility of proposed new products, services, and solutions to business problems. They will work with an iterative process of: proposing solutions structuring tests to evaluate those solutions with prototypes creating the prototype efficiently and cost-effectively evaluating the effectiveness of the prototype learning from the experiment and iterating until an acceptable solution is found. There will be a strong focus on soliciting customer feedback as a basis for improvement and validation throughout the process. Students will learn prototyping techniques for addressing design, business, and technical problems. This will be a very hands-on course. Students will learn to use, and practice using, a diverse set of prototyping tools to complete their projects including computational, physical, visual design, and ethnographic tools.

19-698 Special Topics: "Principles and Practices of Corporate Entrepreneurship"

Fall: 6 units

This course defines the key concepts of corporate entrepreneurship as part of the process for building new business within an established organization. Emphasis will be placed on viewing corporate entrepreneurship as a part of the overall growth strategy, paying specific attention to how to integrate corporate entrepreneurship key practices with other kinds of strategic growth initiatives. The topics will include corporate entrepreneurship strategies, structures and processes, and decision making (at both the team and organizational levels) to achieve commercial impact. Key challenges that companies face when pursuing corporate entrepreneurship will be addressed the lack of tools and systematic frameworks for designing new businesses, the fit of entrepreneurial efforts at the organizational level, and the transition of successfully validated new business concepts to business units in order to achieve meaningful growth. Specific attention will be given to the context of technology-driven enterprise and technological innovation, as well as to the role that Technology and R&D organizations should play in uncovering new substantial paths to growth.

19-699 Special Topics: Institutions Entrepreneurship and Innovation

Intermittent

Institutional environment and public policy greatly affect incentives determining the direction of entrepreneurial activity and innovation that are the engines of economic growth. In societies with poor institutions, entrepreneurial talent is mostly directed towards seeking rents rather than generating productive innovations. But even in modern capitalist economies entrepreneurial activity and innovation are strongly influenced by public policies, for example, those related to intellectual property rights. This course seeks to provide students with analytical frameworks that will enable them to understand how various formal and informal institutional arrangements and public policy decisions influence entrepreneurial activity and innovation and how this, in its turn, affects economic efficiency and growth potential of nations.

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 Special Topics: 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 unstructured 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.

19-707 Special Topics: Multiple Criteria Decision Making

Fall: 6 units

Problems with multiple, conflicting objectives are ubiquitous in the private and, especially, the public sector. 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 multiobjective programming, multiattribute 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.

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

Course Website: <https://cmu.box.com/s/zjvqn8ne12sjwqmtvev2w49s78ij5sm5>**19-716 Special Topics Science and Technology Policy, Analysis and Processes**

Spring: 6 units

Science and technology policy is concerned with the allocation of resources for and encouragement of scientific and engineering research and development, the use of scientific and technical knowledge to enhance the nation's response to societal challenges, and the education of Americans in science, technology, engineering, and mathematics. This course will provide students with a better understanding of each of these areas and how decisions are made regarding science and technology at the national level and who influences those decisions. Upon completion of this course, students should have a deeper and more strategic understanding of how Washington works, how to analyze and present the results of science and technology policy analysis, and of long-term and emerging science and technology policy issues. Although the focus will be on the United States, these issues are as global as science and technology itself.

19-717 Introduction to Sustainable Engineering

Fall: 12 units

This course begins with an overview of the concept of sustainability, including changing attitudes and values toward technology and the environment through the twentieth century. Models for population growth, global food production, and global water resources are then presented, and current problems such as land use, urbanization, and energy and material resources are discussed. Models of industry based on life sciences are then explored, and tools for sustainable engineering are presented. These tools include metrics of sustainability, principles of design for the environment, methods for pollution prevention, and use of mass and energy balances in the design of sustainable systems. Prerequisite: senior/graduate standing in engineering or permission of the instructor.

19-718 Public Policy and Regulations

Spring: 6 units

Will provide an economic framework for identifying and analyzing investment and operation options facing agencies and forms (both in theory and practice); economic efficiency, utilization, pricing, and investment; and multi-objective evaluation. Intended for PhD's

19-722 Telecommunications, Technology Policy & Management

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 computer 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 in broadband access; 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 communications regulation. Special emphasis on how new technologies have altered, and are altered by, regulation. Junior or Senior standing required.

19-724 Materials for Energy Storage

Intermittent: 6 units

This course will examine functional materials used to store and release electrical energy. An overview of the thermodynamics of power, energy and energy storage will be used to motivate subsequent investigations into the dominant methods in use today: electrochemical, electrical, and electromechanical (chemical/combustion and nuclear processes will not be covered). For each sub-topic, the physical and chemical mechanisms exploited will be discussed, followed by a detailed exposition of specific materials functionality and device applications. Particular focus will be given to several relevant emerging technologies: Li-ion batteries, hydrogen-based fuel cells (polymer proton exchange membrane and solid-oxide based systems), and large capacitors (both electrolytic and dielectric).

Course Website: <https://cmu.box.com/s/zjvqn8ne12sjwqmtvev2w49s78ij5sm5>**19-758 Special Topics: Organizational Theory for Engineers**

Spring: 12 units

Why do so many technical problems of global importance persist even when there exists engineering solutions? This course will explore the organizational challenges that can hinder the deployment of engineering solutions towards solving some of our most critical global technical challenges. We will explore a variety of organizational theories such as institutional theory, network theory, social movement theory, and actor-network theory and then see how they are applied to a variety of engineering systems such as those around energy, mechanical design, water, information and communication technology, and other such civil infrastructure. By the end of the course, students will be able to a) learn how to read and synthesize organizational research from a variety of theoretical lenses, b) understand how such research can apply to a variety of engineering systems, and c) learn how to advance and conduct engineering research that incorporates an organizational perspective. Intended for graduate students and seniors; juniors with permission.

Course Website: <https://cmu.box.com/s/zjvqn8ne12sjwqmtvev2w49s78ij5sm5>**19-786 Spec Topic: Stochastic Discrete Choice Models: Estimation and Behavioral Theory**

Fall: 12 units

This course will cover the rational and behavioral foundations of discrete choice models, current behavioral theories, and estimation methods. Content will include an overview of the history of thinking about discrete choice models, rational foundations, behavioral theories, signal detection theory, multinomial logit, mixed logit using restricted MLE and monte-carlo simulation, and experimental design. If time permits we will cover item-response models and Bayesian methods.

19-801 Special Topics in IT: IT Innovation and Business in Africa

Intermittent: 6 units

Africa is often called the global economy's last frontier. Although Africa remains by far the poorest continent, in recent years several African countries have enjoyed sustained political stability and economic growth. Information technology (IT) is playing a significant role in the development of these economies. This course will explore the underpinnings and prospects for the future of IT and its applications in sub-Saharan Africa. Focusing on the most recent literature and reports on economic and technology development in Africa, the aim will be to understand the critical factors that will determine how technology will develop in Africa and what business models are likely to succeed in creating economically viable IT enterprises in this rapidly changing part of the world. Student assignments will include readings, presentations, and projects on selected topics of relevance to the course goals and objectives. The course is intended for graduate students familiar with information technology and its current applications who are interested in Africa as a prospective place of employment and entrepreneurship in IT and its applications.

19-802 Special Topics: Bitcoin and Cryptocurrencies

Spring: 6 units

Provides an understanding of the technology, usability, business, and regulatory issues of digital currencies in the context of the cryptocurrency, Bitcoin. How does it work? How do people use it? Can I make money with it? Is it safe? Is it legal? To address these questions, we investigate Bitcoin's underlying technology; digital wallets; Bitcoin mining; cybersecurity; and regulatory issues.