EAEE E1100.001 A BETTER PLANET BY DESIGN

Lectures	MW	04:10P-05:25P	HAMILTON HAL 516
Recitation	F	11:00A-01:00P	825 Mudd

Instructor Information

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Course Description

Development of the infrastructure for providing safe and reliable resources (e.g., energy, water and other materials, transportation & health services) to support human societies while attaining environmental objectives. Introduction of problems by context, and common frameworks for addressing them through the application of appropriate technology and policy. An inter-disciplinary perspective that focuses on the interaction between human and natural systems. Alternatives for resource provision and forecasts of their potential environmental impacts through a context provided by real world applications and problems.

Innovations in technology and its utilization in infrastructure have radically changed life on earth over human history. Resource constraints that limit the local or regional carrying capacity have been overcome. As human populations have grown and migrated, local and global environmental impacts have. Higher intensity of resource use accompanies development and exacerbates problems caused by byproducts and wastes generated. A challenge to humanity in the 21st century is to manage resource use locally and globally to sustain improvements in quality of life. A retrospective look at key technologies that led to major changes in the production and distribution of food, water, energy, minerals, health, transportation and communication services and their ensuing environmental impacts provides the context for the analysis of the problems we face today, and their potential solutions. This course develops this context and explores some of the technologies that are being proposed to address emerging problems. A systems context is developed to understand the problems at the global, regional and local scales, with a discussion of the "components" to the solution, whether they are technology or policy elements. Students will work in groups on term projects that explore specific topics of interest that will vary from term to term. A typical term project may entail the development or use of a simulation model, or the design and testing of a prototype component.

Text: Readings and instructor notes. Book used in past years: Introduction to Engineering and the Environment by E. S. Rubin. Not required, but helpful

Format: 2 Sessions per week. Lectures and Group Working Sessions. Case Study/Term Project Emphasis.

Grading: Homeworks (6) = 30%. Term Project = 30%. Exam I = 20%. Exam II = 20%.

Prior Skills Expected: Freshman Physics, Chemistry and Mathematics. Use of Computers.
Skills Provided: Mathematical Problem Formulation, Systems Thinking and its Application, Application of principles of Physics, Chemistry and Mathematics to engineering and environmental problems, Computer based Simulation, Statistical Analysis and Optimization.

Topics Covered:

1. General Introduction/Overview
    a. Definition of Resources and Infrastructure elements (Water, Energy, Air, Materials, Ecology, Food), Environment, Society and Institutions
    b. The "Systems", their interaction and their physical and social scales
    c. Major Issues in providing resources and resulting environmental and socio-economic impacts.
    d. Role of technology in developing solutions - historical evolution
    e. Ethics, Culture and a historical/philosophical perspective on planetary and local resource use, environmental management. Major problems and catastrophes and adaptation.
    f. Design Principles
2. Population Dynamics and Resource Constraints
    a. Factors, History, links to resource availability and use, and environmental impacts
    b. Modeling population growth, including treatment of uncertainty and of resource and environmental capacity constraints
    c. Spatial factors constraining population growth and development dynamics and their prediction
    d. Environmental and Industrial Regulation - motivation, mechanisms and examples
3. A Global Environmental Problem - "Atmosphere and Climate Change":
    a. Definitions, Scenarios and Paleoclimate
    b. Concepts of Planetary Energy Balance and Role of trace gases
        i. Sources of Trace gases, anthropogenic factors, and links to resource use and population dynamics
        ii. Radiative effects of gases, their residence times and movement
        iii. Beyond radiation - dynamics of and projected changes in ocean-atmosphere circulation that in turn impact resources (water, energy, biota) available to us - the local dimension of the problem.
    c. Models - Simple and Complex. Quantifying and Assessing Uncertainty
        i. Concepts of Modeling Scale, System Representation and Uncertainty
        ii. Simulation/Scenario Generation and Data Analysis (introduced in context)
    d. The socio-political framework underlying climate change, including notions of environmental sustainability and equity
    e. Identify links to major resource uses and engineering options for source control and remediation at the planetary and local scales.
    f. Case studies of potential engineering responses
        i. Transportation systems

- Computing Fuel and Energy requirements, and atmospheric emissions for automobiles/mass transit
- Factors in improving fuel efficiency, and emission reduction of individual vehicles
- Alternate fuels/automobile design
- Mass transit vs automobile/modes of transportation
- Cost-benefit analysis of improvements - roles of individual, community and society
- Potential Innovations

ii. Electric Power Generation and Consumption
- Methods of generation (typical and renewable)
- Principles of energy conversion and byproduct generation
- Fossil Fuel system fundamentals and computation of generation and use efficiency
- "New" technologies, e.g., fuel cells, co-generation and low grade recovery
- Factors in site selection and environmental impact analysis, including use of land, water and other raw materials
- Benefit-cost analysis of alternate generating methods, conservation and efficiency improvement
- Potential Innovations

iii. Exotic compounds and their atmospheric effects
- Sources of CFCs and the ozone problem.
- Refrigeration and thermodynamics
- Ambient air quality monitoring and use restrictions
- Life Cycles of materials, phase transitions, impacts, and engineering solutions

iv. Large scale technological and policy solutions and their feasibility
- Carbon sequestration in the ocean/underground
- Changing planetary albedo
- Accord on emissions

4. A Regional Problem - "The River Basin Environment"

a. Definitions, Concepts, Resource Use and Management Issues
   i. Human evolution and ties to water
   ii. Natural and environmental hazards, land use and the modification of hydrologic and ecologic function
      - Landforms, geologic materials and their mobilization due to natural and human causes
      - Ecological factors, habitats and environmental resources
   iii. Water, Energy, Environment and Hazard Mitigation: Traditional problems and solutions. Current Challenges and Objectives
   iv. Institutional Framework for Resource Management, Development and Environmental Regulation

b. Concepts of Supply and Demand and the Hydrologic Cycle
   i. Sources of Water and their variability
      - Surface, Groundwater, Reclaimed water
   ii. Linkage of Supply to Global Climate Variations and Prediction
   iii. Linkage of Demand to Population, Industry and Food Production
   iv. Ecological Needs and their characterization
   v. Interaction between water quantity and quality
   vi. Human and ecological health as a function of water

c. Multi-source and Multi-purpose water systems design
   i. The Everglades case study

ii. The Colorado River Case Study
iii. Arsenic in Bangladesh
iv. Simulation and scenario Analysis

5. An Urban Problem - "Sustaining a City - Urban Design"
   a. Functions of a Metropolitan Region, Evolution, and Patterns
   b. Humans as an ecological species
   c. Urban Infrastructure Systems - interactions and key design questions
   d. A New York City Case Study
   e. Alternate Case Studies - Planned Cities vs Organic Cities, Cultural Factors
   f. Simulation and Scenario Analysis
   g. Design of Policy and Infrastructure with regional and local demands.

Required Background

Since students will work in teams, we expect to be able to accommodate students with a wide variety of backgrounds in this class. However, please be aware that this is a class with significant technical content - concepts from physics, chemistry, mathematics, economics, statistics and earth and environmental sciences will be integrated and you will be expected to present well thought out summaries. Homeworks will entail synthesis of material from readings, as well as numerical and computer work. The work load will be commensurate with the level of the class and the credits assigned.

Homework Policy

Late homework will be marked down by 10%. Homework submitted after the solutions are posted will not receive credit.

Class Schedule for Spring 2012

Date	Topic	Materials	Lecture by	Due
1/18/2012	Introduction to the Class	Rubin Ch. 1 & 2	Lall & Park	
1/23/2012	Population Growth Models and Resource Use	Rubin Ch. 15.1, 2, 4	Lall	
1/25/2012	Global Environmental Problem - Climate Change	Rubin Ch. 12	Lall	
1/30/2012	Urban Air Pollution & Modeling Air Pollution	Rubin Ch. 8, 11	Lall	
2/1/2012	Electric Power Generation - Fossil Energy	Rubin Ch. 5	Park	**HW1**
2/6/2012	Emission Control during Energy Production CO2 and S	Rubin Ch. 5	Park	
2/8/2012	Carbon Cycle and Carbon Sequestration	Slides	Park	
2/13/2012	Solar, Wind and Hydro Energy	Rubin Ch. 5	Park	
2/15/2012	Hydrogen and Bio-Energy	Rubin Ch. 5	Park	**HW2**
2/20/2012	Fuel Cells and Catalysis	Posted materials	**Farrauto**	
2/22/2012	Nuclear Energy	Rubin Ch. 5	**Lackner**	
2/27/2012	Green Engineering and Life Cycle Analysis	Rubin Ch. 7	Park	
2/29/2012	Sustainable Development and Global Waste Management	Posted materials	**Themelis**	**HW3**
3/5/2012	Economic Analysis		Lall	
3/7/2012	**Exam I**			
3/12/2012	Spring Break			
3/14/2012	Spring Break			
3/19/2012	Water Main Issues: Quantity		Lall	
3/21/2012	Water Quality and Watertreatment		**Chandran**	**HW4**
3/26/2012	Agriculture: modeling plants and water		Lall	
3/28/2012	Nitrogen Cycle		Chandran/ Sanchez	
4/2/2012	Groundwater		Lall	
4/4/2012	Groundwater		Lall	**HW5**
4/9/2012	Arsenic in the water in Bangladesh/Microbes		Lex VG	
4/11/2012	Innovative water treatment methods		Somasundran	
4/16/2012	Water desalination		Park/Lall	
4/18/2012	Managing Climate Risk -- Floods, Dams		Lall	**HW6**
4/23/2012	Water in Ecosystems: Pollution, Degradation		Uriarte/Shahid	
4/25/2012	Final session for Term Project Q & A		Park & TAs	
4/30/2012	Project Presentation & Written report due		Park & TAs	
Exam Wk	**Exam II**			