Appendix D. Course Syllabi

1. Alternate Energy Systems

University of Kentucky

SUMMARY:

Offered by: Electrical and Computer Engineering
Instructor(s): Paul Dolloff

Number of times taught: Twice
Class size: 30 to 100
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: >50%

Student Level: Upper division and graduate (2:1)
Students' Major: ≥90% Electrical and Computer Engineering

Course Syllabus
EE 599 – Alternate Energy Systems
SPRING 2008
Tue & Thur 5:00 - 6:15
207 RGAN: R. G. Anderson (Mechanical Engineering) Building

Instructor: Paul A. Dolloff, Ph.D.
Email: Paul.Dolloff@ekpc.coop
Phone 859/745-9389 work (direct)
859/744-4812 work (operator)
859/749-2524 cellular
859/527-3501 home

Textbook: There is no official textbook for this course. Relevant reading material will be on file in the Engineering Library – third floor, Anderson Tower.

Outcomes: Basic understanding of alternative electric generating systems including:
1). Generating Technologies
2). Renewable Energy Sources
3). Interconnection Issues

Lecture Topics

1). Generating Technologies / Renewable Energy Sources
   - a). Solar
   - b). Wind
   - c). Waste Gas
   - d). Fuel Cells
   - e). Microturbines
   - f). Energy Storage

2). Interconnection Issues
   - a). Customer Load Characteristics
   - b). IEEE Standard
   - c). On grid and off grid considerations

3). Costs/Revenue

Field Trips
There will be a field trip to the 24-hour dispatch center at East Kentucky Power . Scheduled during a class period, the tour will include a lecture on economic dispatch.

Rates Lecture
This course may include a guest lecture program discussing the process by which an electric utility requests a rate increase – a request to charge the customer more for electricity. This class period will include a mock hearing.

Examinations
There will be two exams and a final exam; there is no mid-term exam. The first two exams will be scheduled during the course of the class and may be in take-home form. The final exam will be given during the University's scheduled time and will be course comprehensive.

Makeup exams will be allowed only after receiving permission from the instructor prior to the exam's scheduled time.

Project
There will be one project that will design a photovoltaic (PV) system for a residential customer. Project details to be given during the course. The student is responsible for performing research, specifying equipment, defining costs, determining the pay back period, and writing a final report.

Homework
Periodically, homework assignments will be made and collected for grade.

Attendance
Attendance shall not be taken; however, attendance is strongly encouraged as much of the course material will be taken from the instructor's notes and experiences.

Grade Weightings
Each assignment carries the following overall course percentage:

Exam 1	20%
Exam 2	20%
Final Exam	20%
Project	30%
Homework	10%

Grading System
Unless the performance or circumstances associated with a particular student indicate otherwise, the final grade in the course will be based on the following scale:

90 –100	A
80 – 89	B
70 – 79	C
60 – 69	D
below 60	E

2. Alternative Energy Systems

California State University, Sacramento

SUMMARY

Offered by: Mechanical Engineering
Instructor(s): Tim Marbach

Number of times taught: Three or more
Class size: 10 to 30
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: 10 to 25%

Student Level: 95% Upper division
Students' Major: ≥90% Mechanical Engineering

ME196R: Alternative Energy Systems

Spring 2007

Instructor: Tim Marbach, Ph.D.
E-Mail: TMarbach@csus.edu
Phone: (916) 278-6089
Office: Riverside Hall 4038
Office Hours: Tuesday and Thursday 2:00-3:30 p.m.

Course Goals

By the end of this course, everyone will be able to:

1. Explain important ideas and concepts of alternative energy systems, including but not limited to the topics listed on page 3 of this syllabus.
2. Formulate, solve, and analyze real-world alternative energy system problems with a methodological, systematic approach based on the thermodynamic principles at the heart of each technology. This includes analyzing the performance, efficiency, economics and risks of each technology.
3. Connect the principles and techniques learned in this course with other subjects and utilize these principles and techniques to solve multi-disciplinary engineering problems.
4. Contribute to the success of a diverse engineering team. Build self-confidence by solving complicated problems and addressing difficult issues.
5. Value sustainability and recognize the importance and necessity of clean and sustainable energy.
6. Identify and locate sources of information related to alternative energy systems and apply the information to complete an authentic project.

Course Materials:

Text: Boyle, G., Renewable Energy: Power for a Sustainable Future, 2nd Edition, Oxford University Press, 2004.

Communication:

E-mail: Administrative and content related information will be distributed through e-mail regularly. I will also respond to any of your questions by e-mail.

Office Hours: For more technical/conceptual questions requiring thorough explanation and interaction, please visit me during my office hours or catch me anytime that I am in the office. E-mail me to schedule an appointment.

Website: Assignment descriptions, homework and test solutions and additional resources will be placed on WebCT. Check it often for important and helpful documents.

http://gaia.ecs.csus.edu/~marbacht/

Learning Activities:

Tests: Two tests and one comprehensive final.

Individual Homework: Four (± 2) individual problem-solving homework sets.

Individual RATs: Readiness Assessment Tests (RATs) will be given after important reading assignments. These will be brief multiple choice quizzes to assess your understanding of the reading.

Learning Portfolio: A brief 2-4 page self-reflection of **what** and **how** you learned in this course.

Team RATs: After you take a RAT individually, you will then take it as a team.

Team Mini-Projects: Five small design projects completed in your teams.

Team Project: A team-based, authentic research project (includes a professional memo-style report and an oral presentation).

Team Assessment: You will assess the contributions of each of your teammates and yourself on the team activities.

Policies

Class Attendance: I expect everyone to attend and participate in class. A significant fraction of your grade is composed of in-class activities. Thus, you will not succeed in the course if you do not come to class.

Make-up Tests: If you miss a test for a legitimate reason (illness requiring medical attention), you must contact me before the test. You must bring documentation of your doctor/hospital visit and take a makeup test.

Homework and Assignments: Assignments are due at the BEGINNING of class. I will accept one late assignment (up to 24 hours late) with no questions asked. Additional late homework is subject to the following:

0 to 24 hours late: 66 % credit
24 to 48 hours late: 33 % credit
More than 48 hours late: 0 % credit

Disabilities: If you have a disability and require accommodations, you need to provide disability documentation to SSWD, Lassen Hall 1008, 916-278-6955. Please discuss your accommodation needs with me after class or during my office hours early in the semester.

Plagiarism: I expect everyone to acknowledge all sources of information when writing. Plagiarism will not be tolerated and will be reported to the University.

Topics to be Covered:

Topic	**Week**
Introduction and Technology Assessment Tools	1
Energy Systems of Today	2
Renewable Fuels	3-4
Fuel Cells	5-6
Test 1	**7**
Wind Power	7-8
Solar Power/Solar Heating	9-10
Oceanic Power	11
Geothermal Power	12
Test 2	**13**
Advanced Topics, Discussion, Project	13-14
Student Presentations	**15**
Final Exam	**Finals Week**

A detailed calendar with due dates for assignments and readings is available on WebCT.

Grading Policy

Individual Activities

Test 1	10 %
Test 2	10 %
Final Exam	15 %
Homework	10 %
Individual RATs	7.5 %
Learning Portfolio	7.5 %

Team Activities

Team RATs and In-Class Activities	10 %
Team Mini-Projects	15 %
Team Project and Assessment	15 %

3. Alternative Energy Systems

University of Detroit Mercy

SUMMARY

Offered by: Mechanical Engineering
Instructor(s): Mark Schumack

Number of times taught: Once
Class size: 10 to 30
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Upper division and graduate (3:1)
Students' Major: ≥90% Mechanical Engineering

Alternative Energy Systems
ME481
Term III, 2006-07

COURSE DESCRIPTION: A course focusing on alternatives to conventional energy systems for power generation, refrigeration, and transportation. Students will apply principles of thermodynamics, fluid mechanics, and other engineering disciplines to the analysis of solar, wind, nuclear, geothermal, tidal, and fuel cell power systems. An overview of global energy use and modeling will be presented. Other course topics include alternative fuels for transportation, new developments in energy storage, and the role of energy efficiency improvements in the achievement of a more equitable and sustainable global energy distribution. Environmental and economic issues surrounding the various alternatives will be addressed.

PREREQUISITES: E314 (Fluid Mechanics), E315 (Thermodynamics I)

PREREQUISITES BY TOPIC: Conservation of mass and energy for pumps, turbines, heat exchangers, and compressors; energy equation for pipe pressure drop calculations; entropy; thermodynamic property tables; solution of first order ordinary differential equations.

REFERENCE TEXTS (NOT REQUIRED):

The following books are basic texts on thermodynamics, fluid mechanics, and heat transfer:

1. Moran and Shapiro, *Fundamentals of Engineering Thermodynamics*, any edition, Wiley.
2. Cengel and Boles, *Thermodynamics, An Engineering Approach,* any edition, McGraw-Hill.
3. Wood, *Applications of Thermodynamics*, 2nd Edition, Waveland Press, Inc.
4. Young, Munson, and Okiishi, *Fundamentals of Fluid Mechanics*, any edition, Wiley.
5. Incropera and DeWitt, *Introduction to Heat Transfer*, any edition, Wiley.
6. Cengel, *Heat Transfer: A Practical Approach,* any edition, McGraw Hill.

The following books cover some of the topics discussed in this course to various extents:

7. Larminie and Dicks, *Fuel Cell Systems Explained*, 2000, Wiley.
8. Ristinen and Kraushaar, *Energy and the Environment*, 1999, Wiley.
9. Hinrichs and Kleinbach, *Energy: Its Use and the Environment*, 3rd Edition, Brooks/Cole
10. Rubin, *Introduction to Engineering & the Environment*, 2001, McGraw-Hill.

11. Decher, *Energy Conversion: Systems, Flow Physics and Engineering*, 1994, Oxford University Press.
12. Kruger, *Alternative Energy Resources*, 2006, Wiley.
13. Sorensen, *Energy Conversion Systems*, 1983, Wiley.
14. Logan, *Turbomachinery*, 2nd Edition, Marcel Dekker, Inc.
15. Angrist, *Direct Energy Conversion*, latest edition, Allyn and Bacon, Inc.
16. Weston, *Energy Conversion*, 1992, West Publishing Co.
17. Tester et al., *Sustainable Energy: Choosing Among Options,* 2005, MIT Press.

MISCELLANEOUS: You should check the course website at *http://knowledge.udmercy.edu/* regularly for homework solutions, old exams, and important announcements.

INSTRUCTOR: Mark Schumack, Room E273, Telephone: 993-3370, e-mail: schumamr@udmercy.edu, fax: 993-1187.

OFFICE HOURS: Monday, Wednesday 9 – 11 AM; Wednesday 2 – 4 PM; Thursday 12 – 3 PM; anytime my office door is open; or by appointment.

LECTURE: TR 3:45 - 5 PM, room E210

COURSE OBJECTIVES: To apply thermal science principles learned in earlier courses to a variety of alternative energy conversion processes, and to develop in the student an appreciation for global energy limitations and the importance of energy conservation.

COURSE OUTCOMES: After taking this course, students will be able to:

1. Understand global energy use and nonrenewable energy source depletion rate models (program outcomes h, j)
2. Analyze combined-cycle power plants (program outcomes a, k)
3. Analyze Stirling cycle power and refrigeration systems (program outcome a, e)
4. Analyze absorption refrigeration cycles (program outcome a, e)
5. Apply engineering relationships to the design of solar energy systems (program outcomes a, j)
6. Apply engineering relationships to the design of wind energy systems (program outcomes a, j)
7. Apply engineering relationships to the design of geothermal energy systems (program outcomes a, j)
8. Apply engineering relationships to the design of tidal and other energy systems (program outcomes a, j)
9. Apply engineering relationships to the design of nuclear energy systems (program outcomes a, j)
10. Apply fundamental fuel cell relationships (program outcome a)
11. Understand the issues surrounding alternative fuels for transportation (program outcomes a, j)

12. Design energy storage systems (program outcome c)

COMPUTER USAGE: Students should be familiar with spreadsheet packages, particularly with entering cell formulas, graphing and mathematical functions.

TOPICS:

- Review of thermodynamics
- Energy use and resource depletion models
- Combined gas and vapor power cycles
- Stirling cycles
- Absorption refrigeration cycles
- Solar energy fundamentals
- Wind energy fundamentals
- Geothermal energy fundamentals
- Tidal and other energy fundamentals (as time permits)
- Nuclear power
- Fuel cells
- Alternative transportation fuels and systems
- Energy storage: flywheels, compressed gas, thermal energy

GRADING:	Homework and inclass projects	30%
	Term Project	15%
	3 75-minute exams	55%

GRADING SCALE: A 95-100, A- 90-94, B+ 85-89, B 80-84, B- 75-79, C+ 70-74, C 65-69, C- 60-64, D+ 55-59, D 50-54

EXAM SCHEDULE (TENTATIVE):

Exam I	Thursday, June 14
Exam II	Thursday, July 19
Exam III	Final exam week (week of August 13)

HOMEWORK POLICIES: Homework will be assigned every week and will be due typically the following week. You may do your homework with others if you like, but your motivation must be to understand the material and not simply to copy what someone else has struggled with (exam grades are a strong reflection of how well you understood homework problems). Although it is an ugly situation and occurs infrequently, if you copy another's work you will receive (as a minimum) a zero on the assignment.

IMPORTANT DATES:

May 28	Memorial Day (UNIVERSITY CLOSED)
June 1	Last Day to Drop a Course without a "W"

July 4	Independence Day(UNIVERSITY CLOSED)
July 23	Last Day to Withdraw
August 13-18	Final Exam Week

ACADEMIC INTEGRITY: Everything submitted for grading is expected to be a student's own work. Anything suspected otherwise will be dealt with according to the College policy - see the Engineering Science Student Handbook.

Mechanical Engineering Program Objectives

1) To produce engineers who understand the performance of engineered products and systems in terms of the relevant fundamental principles of math, science and the humanities, whether they are practicing engineers or students in graduate engineering programs.

2) To produce engineers who excel in the professional practice of mechanical engineering. Professional practice includes the ability to identify, design, and implement solutions to technical problems through a multiplicity of laboratory, analytical and communication methods within a business climate.

3) To produce engineers who are aware of how their roles as technical professionals and leaders affect the wider human community, who serve not only as employees or employers but as socially-conscious citizens, and who are motivated by moral principles in their professional and personal lives.

Mechanical Engineering Program Outcomes

Graduates from the Bachelor of Mechanical Engineering program at the University of Detroit Mercy will have:

a) an ability to apply knowledge of math, science and engineering principles to manufacturing, thermal systems, and mechanical engineering.
b) an ability to design and conduct experiments, as well as to analyze and interpret data relating to thermal and mechanical systems.
c) an ability to design thermal and mechanical systems, components or processes to meet desired needs.
d) an ability to function effectively on multi-disciplinary teams.
e) an ability to identify, formulate, and solve mechanical engineering problems.
f) an understanding of professional and ethical responsibility.
g) an ability to communicate effectively.
h) the broad education necessary to understand the impact of engineering decisions in a global and societal context.
i) a recognition of need for, and an ability to engage in life-long learning.
j) an awareness of current trends and global issues related to the mechanical engineering profession.
k) an ability to use techniques, skills, and modern engineering tools necessary for mechanical engineering practice.
l) a full year of industrial experience.
m) a general knowledge of chemistry and an in-depth knowledge of calculus based physics.
n) the ability to apply advanced mathematics through multivariate calculus and differential equations.
o) a familiarity with statistics and linear algebra.

4. Chemical Engineering Plant Design

University of North Dakota

SUMMARY

Offered by: Chemical Engineering
Instructor(s): Wayne Seames

Number of times taught: Three or more
Class size: 30 to 100
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: 10 to 25%

Student Level: Upper division and graduate (9:1)
Students' Major: ≥90% Chemical Engineering

CHEMICAL ENGINEERING 411
Chem Eng Plant Design I

INSTRUCTOR: Dr. Wayne Seames, HH308; email: wayne_seames@mail.und.nodak.edu

REQUIRED TEXT:
Ulrich, G.D. and P. T. Palligarnai, Chemical Engineering Process Design and Economics: A Practical Guide, 2nd Ed., 2004, Process Publishing.

OPTIONAL TEXTS:
1. Basel, W.D., Preliminary Chemical Engineering Plant Design, 2nd Edition, 1990, Van Noostrand.
2. Turton, Richard, et. al., Analysis, Synthesis, and Design of Chemical Processes, 2nd Edition, 2003, Prentice Hall.

COURSE OBJECTIVES
1. Provide an introduction to how projects are executed
2. Provide an introduction to the design process
3. Allow participants to become familiar with process simulators
4. Allow participants to apply engineering economics and cost estimation to prototype design problems
5. Provide useful techniques to improve engineering job performance in critical areas such as writing and verbal communication. Advanced communications skills will be practiced during this course – both oral and written.
6. Synthesize knowledge learned throughout the Chemical Engineering curriculum and apply in innovative and informed ways.

COURSE CONTENTS:
1. The Project Life Cycle
   - Basic Concepts
   - Scoping Studies
2. The Design Process
   - Overview
   - Preliminary Designs
   - Safety Considerations
   - Environmental Considerations
   - Energy Considerations
3. Economics and Cost Estimation
   - Basic Concepts
   - Economic Measures
   - Preliminary Cost Estimates
   - Preliminary Revenue Estimates
   - Preliminary Balance Sheets
   - Sensitivity Analyses/Fuzzy Benefits
4. The Process Engineering Profession
   - Effective Business Writing
   - Effective Meetings
   - Formal & Informal Presentations

Grades will be determined based on student's performance in four areas. The weighting for each area is as follows:

Individual Homework Assignments = 10%	Design Project 1 = 15%
Design Project 1 Review Meeting = 5%	Design Project 2 = 20%
Design Project 2 Review Meeting = 5%	Mid-term Exam = 20%
Final Exam = 25%	

There will be two design projects during the semester. Design projects will be presented orally at a design review meeting. Written design material must be turned in to the Instructor by 4:00 p.m. on the due date prior to the design review meeting. **No late written design project material will be accepted**. It is the student's responsibility to obtain a meeting time mutually acceptable to the Instructor and the students. All students in the work team must be present and substantially contribute to the oral presentations. Written communications assignments will be included with each individual homework set.

5. Civil Engineering Systems

Georgia Institute of Technology

SUMMARY:

Offered by: Civil and Environmental Engineering
Instructor(s): Adjo Amekudzi and Michael Meyer

Number of times taught: Three or more
Class size: 30 to 100
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: 25 to 50%

Student Level: Undergraduate, upper and lower division (7:3)
Students' Major: ≥90% Civil and Environmental Engineering

CEE 3000: CIVIL ENGINEERING SYSTEMS

Fall 2007
Location: Mason 142
Time: T/TH: 1:35 – 2:55P
Credits: 3 hours

Instructor	
Dr. Adjo Amekudzi Office: SEB 229 Phone: 404-894-0404 Email: adjo.amekudzi@ce.gatech.edu Office Hours: MW 1:30 – 3:00P and by appointment URL: www.ce.gatech.edu/~aa103/	
Co-Instructors	
Dr. Michael Meyer Office: SEB 330 Phone: 404-385-2246 Email: mike.meyer@ce.gatech.edu Office Hours: By appointment URL: www.ce.gatech.edu/~mm39/	**Dr. Lisa Rosenstein** Office: SEB 325 Phone: 404-385-0347 Email: lisa.rosenstein@ce.gatech.edu Office Hours: By appointment URL:www.ce.gatech.edu/fac_staff/research_bio.php?active_id=lr3

Course Description

This course introduces students to a Sustainable Engineering (SE) approach for planning, design, implementation, operation and renewal of civil engineering systems. The concept of sustainability is introduced as the operating paradigm for making decisions over the lifecycle of civil engineered facilities. Sustainability is concerned with continued progress and development of human communities while ensuring preservation of the natural and human environment to enable such development to continue. The *systems approach* is introduced as essential for SE, in how problems are defined, how analysis tools are used to evaluate the performance of facilities and services, how benefits, costs and risks are incorporated into decision-making, how the natural environment and social equity are considered; how facilities are operated and maintained after implementation, and renewed at the end of their useful lives.

Course Evaluation

The course grade is based on performance in four (possibly five) areas. With a 90% average or higher at the end of the semester, you will be exempt from taking the final exam (with sufficient evidence from work on the project that an "A" is deserved in the course).

3 Quizzes	30%
5 Homework Assignments	25%
1 Project Report/Team Presentation	25%
2 Communications Assignments	10%
1 Final Exam	10%

Course Conduct

This Georgia Tech Honor Code is the standard of conduct for this course. The Honor Code is available at http://www.honor.gatech.edu/.

Course Organization
The course is organized into four modules as follows:

Module 1: Sustainable Engineering and the Systems Approach

What is sustainability? How is it defined for civil engineered systems? What issues today make such a paradigm necessary for civil and environmental engineers? What are the present limitations with sustainability as an operational framework? What is a system? What is the systems approach? How does it relate to Sustainable Engineering in planning, design, project implementation, operations and renewal of civil engineered systems? How do engineers plan for systems? How do they represent systems for performance analysis purposes? How can we mathematically evaluate system performance? How do we address the social and environmental impacts of systems? How do we systematically approach infrastructure renewal?

Module 2: Mathematical Tools and Systems Performance Analysis

What techniques can be used to analyze the technical performance of systems? Methods presented include optimization by calculus, linear programming, queuing theory, computer simulation, probability and statistics for addressing uncertainty. What are the strengths and limitations of these techniques in the sustainability paradigm?

Module 3: Economic Decision-Making Tools and Project Evaluation

How do engineers identify the "best" among competing alternatives? What techniques can be used for such comparisons, e.g., net present worth, benefit-cost ratios, internal rates of return? How do we consider non-monetary benefits and costs in our assessment? What types of assessments are conducted to capture environmental and social impacts? What types of mitigation strategies are used to manage environmental and social impacts? How do engineers make decisions on systems operations, maintenance and renewal once a facility has been constructed and service begins?

Module 4: Project Presentations

The final lecture periods will be used for project presentations. Project presentations are a critical component of your engineering communications education. Your attendance will contribute to your grade for the oral communications component of this course. You are expected to attend and participate in **all** presentations in order to obtain full credit for this module of the course. During the oral presentations, you can earn bonus points for thoughtful questions that demonstrate a thorough understanding of the course material.

Engineering Communication
An important objective of this course is to develop basic skills in Engineering Communication. Homework and project presentations are designed to provide opportunities for this development, and will be partially graded on the student's ability to communicate effectively. Dr. Lisa Rosenstein, the School of Civil and Environmental Engineering's expert in Engineering Communication, will participate in this course and should be viewed as an important resource in developing written, oral and visual presentations.

Library Information Skills
Another important objective of this course is to develop basic library information and research skills (manual and electronic). Again, the project is designed to develop and assess these skills. In particular, the quality, range and balance of information sources used in the project will be evaluated. Ms. Lisha Li, the Civil Engineering Librarian for the Institute, will participate in the course by presenting a workshop on the basics of Library Information and Research Skills and should be considered an important resource as you develop your written reports. She can be reached at lisha.li@library.gatech.edu or 404-385-7185.

Course Web
The course web pages are located at https://t-square.gatech.edu/portal. Course handouts, lecture notes, homework assignments, exam solutions and other resources will be posted on the web.

Course Outcomes
The School of Civil and Environmental Engineering has adopted a set of desired outcomes for the undergraduate education program. This course is designed to meet the following outcomes:

1) Understanding civil engineering solutions in a global, societal and environmental context, consistent with the principles of sustainable development

2) Solving engineering problems by applying fundamental knowledge of math, science and engineering

3) Identifying, formulating and solving civil engineering problems that meet specified performance, cost, time, safety and other quality needs and objectives

4) Working and communicating effectively both individually and within multidisciplinary teams

5) Obtaining a solid understanding of professional and ethical responsibility, and a recognition of the need for and ability to engage in life-long learning

6) Experiencing an academic environment that facilitates and encourages learning and retention

Course Objectives
Upon completion of this course, the student should be able to:
1) Explain how the concept of sustainability is fundamental in the planning, design, project implementation, operation and renewal of civil engineered facilities
2) Evaluate quantitatively the performance of civil engineering systems and discuss the strengths and limitations of such evaluations
3) Use engineering/economic decision making tools to identify the best economic project alternative and discuss the limitations of such tools for incorporating environmental and social impacts in lifecycle decision making for facilities
4) Discuss approaches for incorporating environmental and social equity considerations in the planning, design and operation of engineering projects
5) Apply performance analysis, economic decision making, environmental and social impact analysis tools in an integrated manner to comparatively assess the quality of different civil engineered facilities or competing alternatives
6) Discuss and apply various approaches to address risk in systems analysis, and
7) Demonstrate the basics of professional technical communications: written, oral and visual.

Policies on Homework and Exams
Please note that all assignments **must** be handed in on the due date. Only medical reasons will be considered for late assignments. Only in extreme cases will late homework will be accepted with a penalty. In addition, personal trips must be scheduled around exams as exams **will not** be rescheduled to accommodate early trips home or any other trips of a personal nature.

Course Reader
The course reader is a compilation of articles and book chapters on civil engineering systems and sustainability. The reader is required for the course and is available at the *Engineer's Bookstore* (748 Marietta Street). Additional material will be given out to supplement the reader.

Course Outline

Week	Class	Date	Topics	Assignments
1	1	Aug 21	Course overview; Introduction to sustainability: trends, definitions, measurement; Systems representation and analysis; Planning from a systems perspective; Performance-based planning; Context sensitive solutions, Asset Management; Environmental and Social Impact Assessment	Project description out
	2	Aug 23		
2	3	Aug 28		HW1 out
	4	Aug 30		
3	5	Sept 4	Mathematical models, Optimization by Calculus	HW1 due
	6	Sept 6		Library Workshop*
4	7	Sept 11	Engineering Communication I: Written	COM1 out
	8	**Sept 13**	**QUIZ #1**	HW2 out
5	9	Sept 18	Engineering Communication II: Visual	COM1 due/COM2 out
	10	Sept 20	Optimization by Linear and Integer programming; Queuing Analysis; Incorporating uncertainty in systems analysis; Intro to Engineering Economy: Time Value of Money, Present worth, Factor Tables, Inflation	Project Bibliography due
6	11	Sept 25		COM2 due
	12	Sept 27		HW2 due
7	13	Oct 2		
	14	Oct 4		HW3 out
8	15	Oct 9	**FALL BREAK**	
	16	Oct 11	Equivalent uniform annual worth, Effective Rates, Arithmetic Gradient	
9	17	Oct 16		HW3 due
		Oct 18		
10	18	Oct 23	**QUIZ #2**	
	19	Oct 25	Geometric Gradient, Project Evaluation: Net Present Worth, IRR, Benefit/Cost Analysis, IRR	HW4 out
11	20	Oct 30		HW4 due
	21	Nov 1		HW 5 out
12	22	Nov 6	Engineering Communication III: Oral	HW5 due
	23	Nov 8	Depreciation, Spreadsheet Financial Tools, MCDM Methods, Ethics	Draft Report due
13	24	Nov 13		
	25	**Nov 15**	**QUIZ #3**	
14	26	Nov 20	**TBA**	
		Nov 22	**SCHOOL HOLIDAY**	
15	27	Nov 27	**PROJECT PRESENTATIONS**	
	28	Nov 29		
16	29	Dec 4		
	30	Dec 6		Final Report due
17		**Dec 12**	**FINAL EXAM [11:30A -2:20P]**	

*Homer Rice Center, GT Library 1 West

DISCLAIMER:

The instructor reserves the right to amend this syllabus as necessary. Any changes will be announced in class.

CEE 3000: CIVIL ENGINEERING SYSTEMS
School of Civil & Environmental Engineering
Georgia Institute of Technology
Fall 2007

READING LIST

Module 1: A Sustainability Perspective

Introduction to Sustainability

1) George Musser. **The Climax of Humanity**, Scientific American Special Issue: Crossroads for Planet Earth, September 2005.
2) Joel E. Cohen. **Human Population Grows Up**, Scientific American Special Issue: Crossroads for Planet Earth, September 2005.
3) Jeffrey D. Sachs. **Can Extreme Poverty be Eliminated?** Scientific American Special Issue: Crossroads for Planet Earth, September 2005.
4) Stuart L. Pimm and Clinton Jenkins. **Sustaining the Variety of Life**, Scientific American Special Issue: Crossroads for Planet Earth, September 2005.
5) Amory Lovins. **More Profit with Less Carbon**, Scientific American Special Issue: Crossroads for Planet Earth, September 2005.
6) Barry R. Bloom. **Public Health in Transition**, Scientific American Special Issue: Crossroads for Planet Earth, September 2005.
7) Herman E. Daly. **Economics in a Full World**, Scientific American Special Issue: Crossroads for Planet Earth, September 2005.
8) W. Wayt Gibbs. **How Should We Set Priorities**? Scientific American Special Issue: Crossroads for Planet Earth, September 2005.
9) Erla Zwingle. **Cities -- Challenges for Humanity**, National Geographic Magazine, November 2002.
10) Richard J. Kapka. **Megaprojects -- They are a Different Breed**, Public Roads, July/August 2004.
11) B. Blanchard and W. Fabrycky, **Introduction to Systems**, Chapter 1, Systems Analysis and Engineering," Prentice-Hall, 1998.
12) A. R. Pearce and J. A. Vanegas. **Defining Sustainability for Built Environment Systems: an Operational Framework**, International Journal of Environmental Technology and Management, Vol. 2, Nos. 1/2/3, 2002.

Systems Perspectives of Planning and Design/Systems Analysis

13) T, Jewell. **The Planning/Design Process**, Chapter 1, A Systems Approach to Civil Engineering Planning and Design, Harper and Row, 1986.
14) C. S. Revelle, E. E. Whitlatch, and J. R. Wright, **Explaining Systems Analysis**, Chapter 1, Civil and Environmental Systems Engineering, Prentice-Hall, 2004.
15) Gwendolyn Hallsmith, **Systems Thinking for Communities**, Chapter 4, The Key to Sustainable Cities, Meeting Human Needs, Transforming Community Systems, New Society Publishers, 2003.

Module 2: Mathematical model representation of Civil Engineering Systems, System Analysis Methods

16) J. Liebman. **Introduction to Optimization**, in Planning and Design of Civil Engineering Systems, University of Illinois, 1997.
17) C. S. Revelle, E. E. Whitlatch, and J. R. Wright, **Models in Civil and Environmental Engineering**, Chapter 1, Civil and Environmental Systems Engineering, Prentice-Hall, 2004.
18) C. S. Papacostas and P. D. Prevedouros, **Queuing and Simulation,** Chapter 14, Transportation Engineering and Planning, Prentice-Hall, 2001.
19) P. Ossenbruggen. **Decision Analysis**, Chapter 4, Systems Analysis for Civil Engineers, John Wiley and Sons, 1984.

Module 3: Decision-Making Tools, Engineering-Economic Analysis, Project Evaluation, Incorporating Environmental Criteria, Incorporating Sustainability Criteria

20) P. Erickson. **Overview of Environmental Impact Assessment**, Chapter 1, A Practical Guide to Environmental Impact Assessment, Academic Press, New York, 1994.
21) W. R. Hudson, R. Haas, and W. Uddin. **Framework for Infrastructure Management**, Chapter 2, Infrastructure Management, McGraw-Hill, 1997.

6. Civil Systems and the Environment

University of California, Berkeley

SUMMARY

Offered by: Civil and Environmental Engineering
Instructor(s): Arpad Horvath, William Nazaroff, David Dornfeld, Alex Ferrell

Number of times taught: Three or more
Class size: 30 to 100
Class format: 4 hours of lecture per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Graduate and upper division (9:1)
Students' Major: 67% Civil and Environmental Engineering
23% Other engineering
10% Non engineering

CE268E
Civil Systems and the Environment

Catalog Description: Methods and tools for economic and environmental analysis of civil systems. Life-cycle planning, design, costing, financing, and environmental assessment. Industrial ecology, design for environment, pollution prevention, external costs. Models and software tools for life-cycle economic and environmental inventory, impact, and improvement analysis of engineered systems. Focus on manufacturing, construction, transportation, operation and maintenance, and end-of-life.

Objectives:

- To develop an understanding of the economic and environmental implications of engineered systems. Examples focus on products, processes and services, with particular emphasis on infrastructure, transportation, manufacturing, and the service industries.
- To teach practical methods and tools needed to reduce the environmental footprint of engineered systems, thus contributing to sustainable development.
- To encourage research on the interactions of engineered systems and the environment.
- To educate "tomorrow's civil systems engineers and master integrators" about the concepts, methods, and tools of environmentally-conscious construction, transportation, and infrastructure.
- To gain hands-on experience with the latest environmental analysis software from around the world.

After taking this course, students should be able to analyze the environmental impacts of engineered systems.

Text and Readings: The class Reader is available from Copy Central (on Hearst at Euclid).

You are responsible for the reading assignments for each class, in addition to the homework assignments. If you do not understand something in the text, please come and ask questions. Course lectures will not cover all the material for which you are responsible.

In addition to the Reader, the following references may prove to be useful (books marked with an * are on reserve in the Engineering Library):

- Graedel, T. E. and Allenby, B. R. (2003), "Industrial Ecology." 2nd ed., Prentice Hall, Upper Saddle River, NJ, ISBN 0-13-046713-8.
- Curran, M. (1996), "Environmental Life-Cycle Assessment." McGraw-Hill, ISBN 0-07-015063-X.
- Carpenter, T. G., Ed. (2001), "Environment, Construction and Sustainable Development - Volume 2 Sustainable Civil Engineering." John Wiley & Sons, Ltd., ISBN 0-471-81311-7.
- Haimes, Y. Y. (1998), "Risk Modeling, Assessment, and Management." John Wiley & Sons, Inc., ISBN 0-471-24005-2.
- Moavenzadeh, F (1994), "Global Construction and the Environment." John Wiley & Sons, Inc., ISBN 0-471-01289-0.
- Ossenbruggen, P. J. (1994), "Fundamental Principles of Systems Analysis and Decision-Making." John Wiley & Sons, Inc., ISBN 0-471-52156-6.
- ReVelle, C. and McGarity, A. E. (1997), "Design and Operation of Civil and Environmental Engineering Systems." John Wiley & Sons, Inc., ISBN 0-471-12816-3.

Assignments, Examinations and Grading:

Contributions to the course grade are:

- 4 homeworks @ 7% (28%)
- 1 field trip (5%)
- Midterm project report (12%)
- Final project presentation (5%) and final project report (35%)
- Final exam (15%)

Assignments are due at the beginning of the class period, as per the course schedule below. Late submissions will be penalized at a rate of 10% per working day.

Field Trips: Three field trips will be organized outside of class hours (on Fridays). Participation in one of these is mandatory. Naturally, space permitting, you are welcome on all field trips!

Course Project: The course will provide an opportunity and forum for the development of an original paper that analyzes current issues, and presents alternative solutions. The goal is to make an original contribution to the environmental systems analysis or policy literature and discussions.

A course project should be completed on a topic of your choosing, mutually agreed upon with the instructor. The instructor will review the abstract of the project, and approve it or suggest changes if appropriate. The project should be written up in a midterm and a final report of professional quality, addressing the relevant issues and actual or possible solutions, with references to the literature. A final presentation of the course project will be scheduled in the last two weeks of the semester.

Accommodation of Special Circumstances: Please see the instructor for accommodation of religious beliefs, disabilities, and other special circumstances.

7. Computational Aspects of Solar Energy

University of Nevada-Las Vegas

SUMMARY

Offered by: Mechanical Engineering
Instructor(s): Robert Boehm

Number of times taught: Three or more
Class size: Less than 10
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Graduate
Students' Major: ≥90% Mechanical Engineering

Mechanical Engineering Department
University of Nevada, Las Vegas

ME 714 Computational Aspects of Solar Energy Spring 2008

Course Objectives: To provide a practical basis for the simulation and design of solar energy systems. Emphasized are the transient nature of these types of systems and the special requirements this makes for their analysis. Items covered through computer code development are fundamentals of solar radiation, collectors (both thermal and photovoltaic), concentrators, receivers, storage elements, building energy performance, and systems. Analysis will be performed by computer codes of the students' own composition. Some commercial code applications will also be used.

Conduct of the Course: In addition to limited lectures, the key course element will involve the assignment of major analysis problems. On the day the assignment is due, students will be chosen in advance in a rotating sequence to present formally in PowerPoint the overall solution. In all students' cases, the results of work on a particular project should be described in a written form that outlines the procedure applied (including any equations used) and a corresponding generalized flow diagram of the program, and output for some typical case(s). While students are encouraged to consult with one another in the development of the codes, each student should do her/his own work. Most assignments will take place over 4 class periods. Class will not meet on pre-announced days.

Text: Duffie and Beckman, SOLAR ENGINEERING OF THERMAL PROCESSES (3rd Ed), John Wiley and Sons. This text is suggested but not required. You will need to refer to some texts throughout the course.

Other Reference Materials: Goswami, Kreith and Kreider, PRINCIPLES OF SOLAR ENGINEERING (2nd Ed); Stine and Harrigan, SOLAR ENERGY FUNDAMENTALS AND DESIGN; SOLAR ENERGY JOURNAL; JOURNAL OF SOLAR ENERGY ENGINEERING (ASME); American Solar Energy Society Meeting Proceedings; International Solar Energy Society Proceedings; and Proceedings of the Intersociety Energy Conversion Engineering Conference (IECEC). Web sites that may yield information are those of NREL (www.nrel.gov), Sandia (www.sandia.gov), NOAA and its derivatives (www.noaa.gov). Helpful in checking calculations may be the NREL publication: "Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors," http://rredc.nrel.gov/solar/pubs/redbook/.

Grading: This will be assigned in proportion to the amount of time given to each project. It will be divided between the oral presentation and the written work submitted. There will be no exam.

Tentative Schedule:

Class Days	Item
1-4	Fundamentals of the solar resource. Predictive weather models, sources of weather data, typical weather tabulations (Rick Hurt), sun angles, radiation on inclined surfaces. Project 1, Weather Data Archiving and Manipulation.
5-8	Thermal radiation interaction with surfaces, pertinent heat transfer phenomena, selective surfaces, glazing and mirror performance. Project 2, Flat Plate Collector Performance. *Monday February 18 is a school holiday*.
9-12	Building energy simulation. (Li Zhu) Approaches to simulating the energy performance of buildings. Summary of available software. In addition, she will give two presentations on research work at her lab in China. Project 3, Building Simulation
13-16	Fundamentals of thermal energy storage, phase-change compared to sensible storage, modeling approaches (mixed, stratified, phase change). Project 4, Simulation of Thermal Storage Element. *Spring Break is March 17-21.*
17-20	Solar water heating approaches, system simulation. Project 5, Domestic Water Heating Design.
21-24	Power system descriptions (trough and dish), incorporation of storage, system analysis. Project 6, Simulation of a Trough-type Solar Power System.
25-28	Fundamentals of photovoltaics (PV), cell models, battery forms, battery models. (Sachin Deshmukh) Project 7. Simulation of a Grid-Connected PV System.

8. Design of Thermal Systems

University of Dayton

SUMMARY

Offered by: Mechanical Engineering
Instructor(s): Kelly Kissock

Number of times taught: Three or More
Class size: 10 to 30
Class format: 3 hours of lecture plus 3 hours of "other" contact per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Upper division and graduate (6:4)
Students' Major: ≥90% Mechanical Engineering

Design of Thermal Systems MEE 471 / 571

University of Dayton, Winter 2006

Instructor:	Dr. Kelly Kissock; KL 363F; 229-2852; kkissock@udayton.edu
Class web site:	www.engr.udayton.edu/faculty/jkissock
Meeting time and place:	M,W 4:30-5:45 in KL 403
Office hours:	Drop-ins and appointments welcome
Refernce Texts:	Introductory thermodynamics and heat transfer texts Availability Analysis: A Guide to Efficient Energy Use, M.J. Moran Thermal Design and Optimization: A. Bejan, G. Tsatsaronis, M. Moran Design of Thermal Systems: W.F. Stoecker
Final Exam:	Mon, May 1, 2006, 4:30-6:20 pm

Overview

The course is intended to be a capstone experience, integrating thermodynamics, heat transfer, engineering economics, optimization techniques, and computer programming in a design framework.

Outline

System design methodology

Thermodynamic modeling:

- Steady-state conduction, convection and radiation heat transfer
- First law analysis
- Transient heat transfer
- Fluid flow
- Combustion
- Heat exchangers
- Second law and exergy analysis

System simulation (one or more of the following):

- Sequential substitution
- Newton/Raphson method
- Numerical methods

System optimization (one or more of the following):

- Economic anaysis
- Heat exchanger networks
- Calculus methods: LaGrange Multipliers
- Search methods
- Geometric programming
- Linear programming

Goals

1) To acquire the knowledge and skills necessary to design and analyze thermal systems through methods of system simulation and optimization.
2) To improve our ability to communicate technical information.

Grading

Assignments	40 %	(No late homework accepted)
Three design projects or in-class exams or	60 %	
Total	100%	

Graduate students will have extra homework problems and be graded seperately.
* Please identify yourself if you require special accommodations to facilitate learning.

Design of Thermal Systems, MEE 471 / 571
University of Dayton, Winter 2006

Num	Date	Topic	Reading	HW
1		Course mechanics and introduction		
2		Principles of design		1
3		Conduction, convection, radiation	Heat transfer text:	2
4		First law with multi-mode heat transfer	Heat transfer text:	3
5		Energy storage and finite difference	Heat transfer text:	4
6		Entropy & second law	Class notes	
7		Entropy & second law	Class notes	
8		Entropy of ideal gasses and liquids	Class notes	
9		Availability analysis	Class notes	
10		Availability analysis	Class notes	
11		Second law efficiency	Class notes	
12		Second law efficiency	Class notes	
13		Choosing temp of heat / boundary interp	Class notes	
14		Entropy generation minimization	Class notes	
15		Test 1: Thermodynamic analysis		
16		Heat exchanger modeling	Stoecker: 80-93	
17		Heat exchanger modeling	Stoecker: 80-93	
18		Heat exchanger networks: pinch method	Class notes	
19		Heat exchanger networks: pinch method	Class notes	
20		Optimization	Stoecker: 143-152	
21		LaGrange multipliers	Stoecker: 161-176	
22		LaGrange multipliers	Stoecker: 161-176	
23		Search methods	Stoecker: 186-209	
24		Test 2: HXs and Lagrange optimization		
25		Search methods	Stoecker: 186-209	
26		Search methods	Stoecker: 186-209	
27		Linear programming	Stoecker: 260-291	
28		Linear programming	Stoecker: 260-291	
Fin Ex		Linear programming	Stoecker: 260-291	
		Summary		
		Final Exam: Optimization		

9. Design for Environment

University of Texas at Austin

SUMMARY

Offered by: Chemical Engineering
Instructor(s): Dave Allen

Number of times taught: Three or More
Class size: 30 to 100
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Upper division
Students' Major: ≥90% Chemical Engineering

Design for Environment
Course Description
Spring 2008
Chemical Engineering 341
(Unique #s 14290)

Professor David Allen (475-7842)
CPE 3.462
allen@che.utexas.edu

Class Hours: MWF 11-12 CPE 2.220

Office hours: Immediately before class, immediately after class, and by appointment.

2000-2002 Catalog Data: Overview of environmental assessment tools for chemical processes and products, including life cycle and risk assessments. Overview of design tools for improving environmental performance of chemical processes, including unit operations and flowsheet analysis methods.

Textbook:
D.T. Allen and D. Shonnard, *Green Engineering: Environmentally Conscious Design of Chemical Processes*, Prentice Hall, 2001.

Additional References (online at www.utexas.edu/research/ceer/che341):
Course notes and supplemental reading materials

Knowledge, Abilities, and Skills Students Should Have Entering This Course:
1. Set-up and solve steady-state macroscopic mass and energy balances. (ChE 317)
2. Basic concepts in general chemistry, chemical reaction rate equations (Ch 301)

Course Objectives
The goal of this course is to present the engineering tools that are used to improve the environmental performance of chemical products and processes. This includes assessment tools, such as life cycle assessment and risk assessment, as well as design tools such as heat and mass exchange network synthesis.

Knowledge, Abilities, and Skills Students Should Gain From This Course:
1. An understanding of important environmental issues, and how chemical processes and products impact the environment
2. A conceptual understanding of risk assessment
3. A familiarity with major pieces of environmental legislation
4. An appreciation of the ethical duties and responsibilities of engineers in environmental problem solving
5. Ability to assess the environmental fate of chemicals
6. An ability to estimate exposures to chemicals
7. Ability to identify and evaluate the environmental impacts of materials and reaction pathways

8. Ability to assess the environmental performance of process flow sheets
9. Ability to improve the environmental performance of unit operations
10. Ability to improve the environmental performance of process flowsheets
11. Ability to evaluate potential economic benefits of superior environmental performance
12. Quantitative and qualitative understanding of product life cycles
13. Quantitative and qualitative understanding of the role of chemical processes in industrial material and energy flows

Impact on Subsequent Courses in Curriculum:
This course is a senior/graduate elective and therefore does not impact additional courses in the curriculum.

Topics:

I. Introduction to environmental issues, regulations and risk assessment (Defining the problem, an overview of environmental issues, waste generation and management, exposures and risk assessment, environmental legislation, the roles and responsibilities of chemical engineers)
II. Assessing and improving the environmental performance of chemical processes (Assessing environmental fate and impacts of chemicals, green chemistry, assessing the environmental performance of flowsheets, pollution prevention for unit operations, flowsheet analysis for pollution prevention (HAZOP and Pinch technology), total cost accounting
III. Life Cycle Assessment and Industrial Ecology
IV. Case Studies

Grading
15% Homework (Most homeworks will not be graded, but short in class quizzes will be given, based on homework problems; lowest quiz grade can be dropped)

25% One in-class exam (no make-up exams will be given)

35% Final exam is Thursday, May 8, 2008, 2-5.

25% One individual project and an individual presentation.

The University of Texas at Austin provides upon request appropriate academic adjustments for qualified students with disabilities. For more information contact the Office of the Dean of Students at 471-6259, 471-4241 TDD or the College of Engineering Director of Students with Disabilities at 471-4382.

Policy on Scholastic Dishonesty: Students who violate University rules on scholastic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and/or dismissal from the University. Since such dishonesty harms the individual, all students, and the integrity of the University, policies on scholastic dishonesty will be strictly enforced. For further information, please visit the Student Judicial Services web site at www.utexas.edu/depts/dos/sjs/.

10. Earth Systems Engineering and Management

Arizona State University

SUMMARY

Offered by: Civil and Environmental Engineering, School of Sustainability; Consortium on Science and Policy Outcomes
Instructor(s): Brad Allenby

Number of times taught: Three or More
Class size: 30 to 100
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Upper division
Students' Major: ≥90% Civil and Environmental Engineering

CEE 400: Earth Systems Engineering and Management
Course Overview and Syllabus
Spring 2008

Thursday 4:40-7:30
BYAC 270

Course Objectives: To introduce students to the conceptual and practical challenges arising from the design, operation and management of earth systems in the context of the anthropogenic earth, characterized by integrated human/natural/built complex adaptive systems at local, regional and global scales. Emphasis will be on characteristics and fundamentals of technology systems; complex adaptive systems behavior and evolution; and associated cultural, ethical, and managerial behaviors, with a focus on the need for multidisciplinary approaches; and current patterns in technological evolution.

At the end of the course, students should be able to:

1. Define earth systems engineering and management;
2. Identify and explain critical principles of ESEM; and
3. Be able to use ESEM concepts and principles to explore a topic of their choice in a systemic and integrated way in their term paper.

In addition to domain-specific goals, this course is also intended to help students:

1. Understand professional and ethical issues in the context of engineered and earth systems;
2. Learn to communicate in short essay form;
3. Understand issues and impacts of engineering solutions at a broad cultural and geographic scale extending across urban, regional, national and global scales;
4. Understand the need and develop the capability to participate in lifelong learning; and,
5. Take into consideration contemporary issues and environmental impacts in civil and environmental engineering practices.

Introduction: A principal result of the Industrial Revolution and associated changes in human demographics, technology systems, cultures, and economic systems has been the evolution of an Earth in which the dynamics of most major systems, whether human or natural, are increasingly impacted by human activity. For this reason, scientists are increasingly calling the current era the "Anthropocene," which can be roughly translated as the Age of Humans. Moreover, the accelerating pace of technological evolution – particularly the coming convergence of nanotechnology, biotechnology, information and communication technology (ICT), robotics, and cognitive sciences – will both reinforce the human domination of the dynamics of earth systems, and pose significant challenges to existing cultural and ethical norms and patterns. The evolution of these technology systems, and the critical role that will be played by engineers and technologists in their design, implementation and management, require not just traditional professional expertise, but a broader and more sophisticated understanding of what engineering as a profession will require in the coming decades.

This course will introduce the concept of earth systems engineering and management (ESEM) based on the perspective of the Earth as a terraformed planet, and the technological, economic and cultural patterns that have contributed to its evolution. The potential operational, cultural and ethical implications of future evolutionary pathways will be explored, with emphasis on the challenges they pose for engineers and technologists.

The course grade will consist of three components: class participation; a homework component which will primarily reflect short essays on class topics; and a term paper. Homework is due at the beginning of class on the day it is assigned.

Grading:

- Class participation: 20%
- Homework: 40%
  - Each missing or late paper is minus 5%
  - Failure to meet minimum quality standards is minus 3%
- Term paper: 40%
  - Term paper grade breakdown:
    - Grasp and use of ESEM principles: 30%
    - Organization, structure, and persuasiveness 30%
    - Proper format 20%
    - Presentation (e.g., no typos, complete sentences) 20%

Primary Texts: *Reconstructing Earth* (Allenby)
Radical Evolution (Garreau)
Readings handed out in class
Neuromancer (Gibson) **or** *The Diamond Age* (Stephenson)
(an alternative science fiction novel may be substituted by agreement with the instructor)
Films: *The Matrix* (part 1 only); *Ghost in the Shell*

Term Paper: research paper, not more than 10 pages of text, bibliography should include at least two non-Internet journal or book sources. Topic to be approved by instructor. Relevant dates:

By February 21: submit proposed topic to instructor (email acceptable)

By March 6: submit one page outline of term paper to instructor

By April 24: submit final paper

Tentative Schedule Overview (subject to change)

January 17: Welcome to the Anthropocene. Overview of critical themes. Introduction to important dimensions of the anthropogenic earth, including demographics (population growth, urbanization), technology (agriculture, hydrologic engineering), resource consumption (water, energy, materials consumption), natural cycles and human impacts on them (carbon, nitrogen) and economic patterns (growth in global GDP, distributive patterns in GDP) that characterize the Anthropocene.

Reading: Smil article.

January 24: Welcome to the Anthropocene, continued.

Reading: Smil article

Homework: one page essay based on Smil article predicting which culture – US, EU, Russia, China, India, or other of your choice - will be ascendant 100 years from now. Support your prediction with data from the Smil article.

January 31: Earth Systems Engineering and Management. Introduction to the concept and principles of ESEM, with references to systems engineering, adaptive management, and industrial ecology. Several examples of ESEM systems, including the climate change negotiation process as nascent ESEM, the Everglades, urban systems, and genetically modified organisms (GMOs) will be presented, and a set of operational principles derived from them.

Reading: *Reconstructing Earth,* chapter 9; ESEM reading, governance principles reading.

Homework: one page essay on how climate change can be reframed as a carbon cycle management challenge.

February 7: Why does the world look the way it does? An overview of critical elements of global culture and their sources. Where mental models come from, and why they are important, using "sustainable development" as an example. Different ways to conceptualize environmentalism, and the implications of different views. The postmodern critique of science and technology, and the undermining of the authority of the S&T discourse.

Reading: *Reconstructing Earth,* chapters 1-6, 8.

February 14: Complex Adaptive Systems. Introduction to differences between complex and simple systems (predictability, non-linearity, threshold effects, etc.). Overview of common models for complexity, including landscapes, cellular automata, and the like. Implications of complexity for understanding, designing, dialoging with, and attempting to guide integrated human/natural/built systems. Attempts by management disciplines (Senge's "learning organizations" and theories of the network centric firm) and resource governance regimes (adaptive management) to adapt to complexity.

Reading: *Reconstructing Earth,* chapter 7; Chapters 7 and 9 on complexity and principles of earth systems engineering and management, on blackboard.

Homework: one page essay answering the question: what is the difference between science and faith, using environmental science as the example. The last paragraph should explain why understanding this difference is important to ESEM.

February 21: Technology and technical evolution. Introduction to technological change, including the concepts of technology clusters, core and peripheral cultures, and the auto-catalyzing nature of technologies. Overview of design, including sample methodologies. Differing perspectives on the risks posed by technological systems, and who should be responsible for such risks. Discussion of historical experience with foundational technological change, including the Industrial Revolution, and the cultural and economic implications of the evolution of railroads in the United States.

Reading: Technology handout (next three classes). Begin reading *Radical Evolution.*

Homework: one page essay on the definition of technology, and the relation of technology to culture and human interaction with the physical environment.

February 28: Technology and technical evolution continued. Discussion of three critical technologies – automotive, information and communication technology, and chemistry – taken as cultural, economic, and artifactual systems.

Reading: continuation of previous week. Watch *The Matrix* (1^{st} in series only).

March 6: Technology as Cultural Phenomenon. Technology as aligned with religion in European tradition (and not in others); social and constructive nature of technology. Historical efforts to halt technology: 11-12 century Islam; 15^{th} century China; opposition to Industrial Revolution in UK. American technological optimism as compared to European responses (Precautionary Principle, etc.). Tendency to see new technologies as transformative, and how some of them were (railroads in American economic history and American folklore).

Reading: Finish technology readings.

Homework: one page essay on film as method for presenting integrated vision of future technologies in a social, cultural and economic context, using *The Matrix* as an example.

March 20: Technology systems: automotive, green chemistry, and electronics industries as examples of complex earth systems.

Reading: Urban systems handout, resiliency handout.

March 27: Urban systems and corporations as examples of complex adaptive systems, and case studies in earth systems engineering and management. Growing importance of network centric management structures. Resilience as a management objective.

Reading: material on Freeport Mine and sustainability

Homework: one page essay on intersection of ICT and urban systems evolution: what effects may be anticipated as enhanced ICT capabilities, including autonomic computing, are introduced into urban systems at all scales?

April 3: Guest lecture on Freeport Mine project

Reading: begin reading *Neuromancer* by William Gibson, or *The Diamond Age* by Stephenson (choose one).

April 10: Technology, culture, and ethics. Why has the West, and more recently the United States, been the major locus of technological evolution? A review of the major ethical structures as they provide potential guidelines for evaluating technological choices and their impacts: Kantianism (Categorical Imperative), utilitarianism, Christianity (chain of being), etc. Postmodernism, Deconstruction, and Contingency. Social complexity and relativism; deconstructionism; cultural constructs and postmodernism. Creating an ethics appropriate to evolving complex adaptive systems: microethics, social ethics, and macroethics.

Reading: Planetary ethic handout; AAAS article on macroethics; finish reading science fiction novel.

Homework: one page essay discussing relationship among theology, technology, and cultural ascendancy. Refer back to your first essay based on the Smil article, and ask how theology, technology and culture contribute to your prediction of what culture will become globally dominant in the future.

April 17: Introduction to NBRIC: nanotechnology, biotechnology, robotics, information and communication technology (ICT), and cognitive science. Where the fields are now, and scenarios that have been introduced regarding possible evolution of the technologies, including near term, fairly possible scenarios (e.g., extension of human life in developed countries to well over 100, the DARPA "advanced soldier") to much more speculative scenarios ("species tourism," functional immortality). Learning to perceive and critique fundamental changes that technological evolution may create, such as whether biodiversity is shifting from an "evolved" to a "designed" phenomenon, and whether "species" is an obsolete measure of biodiversity. Homework will include watching the Japanese anime film *The Ghost in the Shell,* which deals (in a typical anime way) with issues of intelligence extended through the Net (e.g., once your intelligence is wired to the Net, do you become susceptible to software viruses? How do we bound what we intuit ourselves to be physically once cognitive functionality is located not in space and time, but in cyberspace?).

Homework: Watch *The Ghost in the Shell*. Write one page essay on the implications of human intelligence becoming integrated with software systems, and thus subject to viral attack, using *The Ghost in the Shell* as the example, and using either the Gibson or the Stephenson book to back up your main points.

April 24: What is Human? As technological evolution, particularly NBRIC, accelerates, changes that are already occurring in human cognitive and biological systems can be anticipated to accelerate as well. Technological and cultural evolution are rapidly approaching a critical point in the evolution of the human species, and the anthropogenic planet on which it now resides. Among the potential implications are the integration of technology and the human, resulting in a profusion of different "models of the human," and a cultural and ethical structure which is highly contingent.

Paper due on April 24 by beginning of class. May be submitted by email, on blackboard, or in class. Remember to check that your format and citations are ASCE standard.

11. Energy and the Environment

Kettering University

SUMMARY

Offered by: Mechanical Engineering
Instructor(s): Ahmad Pourmovahed

Number of times taught: information not provided
Class size: information not provided
Class format: 4 hours of lecture per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Upper division
Students' Major: information not provided

MECH-527 Energy and the Environment

Prerequisites: None (Senior Standing)
Co-requisites: None

Description: This course covers energy conversion and conservation, fossil fuels, renewable and bio-fuels, solar, geothermal and nuclear energy, alternative energy (wind, water, biomass), hydrogen as an energy carrier, historical context of the technology, the role of energy in society (economic, ethical, and environmental considerations), energy forecasts and the trend toward a hydrogen economy. Public policy, global warming and CO2 footprints and offsetting are also discussed. Several laboratory experiments including windmills and solar heating and power generation systems will be included in this course.

Textbook: Nersesian, R.L., *Energy for the 21st Century: A Comprehensive Guide to Conventional and Alternative Sources*, M.E. Sharpe, 2006

Reference: Fanchi, J.R., "Energy Technology and Directions for the Future", 2004

Grading:				
	Mid-term exam	25%	Final Exam	30%
	Project	20%	Laboratory Experiments	25%

Week	Topic
1	A Brief History of Energy Consumption
2	Energy Conversion and Conservation
3	Fossil Energy, Nuclear Energy
4	Solar Energy, Geothermal ,Wind and Water, **Laboratory Experiment 1**
5	Biomass and Synfuels, **Midterm Exam**
6	Hydrogen – An Energy Carrier, **Laboratory Experiment 2**
7	Electricity Generation and Distribution
8	Energy and the Environment
9	**Laboratory Experiment 3**
10	Energy Forecasts, Public Policy and Global Warming
11	**Final Exam**

Laboratory Experiment	*Topic*	*Equipment*
1	**Solar Water Heating**	**Hampden H-SST-1-CDL**
2	**Ethanol Production**	**Hampden H-ETS-1-CDL**
3	**Wind Mill**	**TBD**

Prepared by: Ahmad Pourmovahed, Professor of Mechanical Engineering

12. Energy and the Environment

Rice University

SUMMARY:

Offered by: Civil and Environmental Engineering, Earth Sciences, and Environmental Studies
Instructor(s): Daniel Cohan

Number of times taught: Twice
Class size: 30 to 100
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: 25 to 50%

Student Level: Lower division, upper division, and graduate (5:12:3)
Students' Major: 55% Civil and Environmental Engineering
25% Other engineering
20% Non-engineering

CEVE / ESCI / ENST 307
ENERGY AND THE ENVIRONMENT
SPRING 2008

Meeting Times and Location:
T/Th 9:25 – 10:40 a.m., Mech Lab 251

Instructor:
Daniel Cohan, Ph.D.
Assistant Professor of Environmental Engineering
Office: Mech Lab 104
Phone: 713-348-5129
Email: cohan@rice.edu

Office Hours:
Office visits are encouraged and are available by appointment.

Course Description:
Securing sufficient, reliable, and affordable supplies of energy in an environmentally sustainable manner is among the greatest challenges facing society in the 21st century. Appreciating and addressing this complex challenge requires consideration of the various physical, technological, and societal forces that shape energy use and its impact on the environment.

This course will explore the physical principles of energy and how various sectors and fuels impact Earth's environment and climate. We will also examine policies and technologies that could foster more sustainable use of energy resources. The course will include a group project in which students will consider the environmental and other implications of a particular energy source from a variety of perspectives.

Course Objectives:
This course aims not only to impart a heightened understanding of energy and the environment, but also to build skills in research, analysis, and critical thinking that will catalyze a lifetime of engagement with this complex topic. Among the learning objectives for this course, students completing this course will be able to:

1) Identify key environmental impacts of various energy sources
2) Compute the energy return on investment, efficiency, and resource intensity for an energy source
3) Obtain objective, credible data and projections for energy availability, consumption, and impacts, and critically evaluate conflicting estimates
4) Compare and contrast the challenges posed by regional air pollution and global climate change, and distinguish between control technologies that address one or both of these phenomena
5) Present a persuasive case for how an energy source should be used in an environmentally sustainable manner, considering the perspectives of multiple stakeholders

Prerequisites:
While there are no explicit prerequisites, this course will apply quantitative approaches and scientific principles to examine energy and the environment. Physics and calculus background at the level of PHYS 101 and MATH 101 (or AP equivalents) are strongly recommended. Please contact the instructor if you have questions regarding your preparation.

Textbook and Readings:
Gordon J. Albrecht, "Energy: Physical, Environmental, and Social Impact" (Third Edition), Pearson Prentice Hall, 2006.
The textbook has a companion website, http://physics.prenhall.com/aubrecht, which contains chapter extensions and other resources. Additional readings from outside sources will be assigned and made available on the OwlSpace website for the course.

Honor System Policy:
All students are expected to adhere to the Rice Honor Code. Exams will be given under the honor system and must be entirely a student's own work, using only resources that are explicitly authorized for that exam. Unless otherwise stated, written assignments may be discussed but must be written individually a student's own words, with proper citation of any references used.

Disability Statement:
If you have a documented disability that will impact your work in this class, please contact me to discuss your needs. Additionally, you will need to contact the Disability Support Services Office in the Ley Student Center.

Grading:
Students will be evaluated by their performance on the following:

Written assignments (Problem sets and/or short essays)	30%
Midterm Exam I	15%
Midterm Exam II	15%
Group project (Oral presentation and written report)	15%
Final Exam	25%

All assignments are expected to be completed on time by 4 p.m. of the due date and may be submitted in class or to Dr. Cohan's mailbox on the first floor of Mech Lab. Late assignments will incur a penalty of 25 points and will not be accepted after solutions are distributed.

TENTATIVE SCHEDULE (*subject to change*)

DATE	THEME	TOPIC	TEXTBOOK	OUTSIDE READING*
1/8	**Introduction**	The Energy Challenge	Chaps. 1 & 5; Ext. 5.1	Readings from US DOE
1/10	**Energy: Physical Principles**	Work, energy, and power	Chap. 3; Exts. 3.5, 3.6, 3.7	
1/15		Energy efficiency and thermodynamics	Chap. 7; Ext. 7.6	
1/17		Electricity	Chap. 4; Ext. 4.3	
1/22	**Energy: Sectors**	Electric Sector	Chap. 8, 13.1	Readings from NREL, CBO, and US DOE
1/24		Transportation Sector	Chap. 15	Readings from US DOE, Sci. American, MIT, and IEEE
1/29	**The Environment**	Water; Research librarian guest speaker	Chap. 13.2-13.7	Readings from Nature, US DOE
1/31		Climate	Chap. 16, 17; Ext. 21.1	Readings from IPCC
2/5		Air	Chap. 14; Ext. 14.5	Reading from US EPA
2/7		Emissions control; carbon capture & storage	Exts. 14.1, 17.6	Readings from Energy Policy and IPCC
2/12	**EXAM**	**EXAM 1**		
2/14	**Evaluation Metrics**	Metrics for evaluating energy options		Readings TBA
2/19		Evaluating metrics (cont.)		Readings TBA
2/21	**Policy Responses**	Policy responses: Types of approaches, historical examples		Readings TBA

2/26	**Fossil Fuels**	Oil	Chap. 12.1-12.3; Exts. 12.5, 12.6, 12.7	Readings from GAO (p. 1-39), US DOE, Ann. Rev. Environ. Resources, Energy Policy
2/28		Natural Gas	Chap. 12.4	Readings from US DOE, Am Chem Council, Energy Policy
3/3 – 3/7		SPRING BREAK		
3/11		Coal	Chap. 12.5, Ext. 12.9	Readings from US DOE, Sci. American, & opposing views
3/13	**Alternative Fuels**	Energy conservation & efficiency	Chaps. 9, 11	Readings from Scientific American, Energy Policy
3/18	**EXAM**	**EXAM 2**		
3/20		Facilities tour, energy conservation at Rice		
3/25		Nuclear	Chaps. 18, 19, 20; Exts. 19.3, 19.5, 20.12	Readings from MIT, Scientific American
3/27		Solar	Chap. 21; Ext. 21.4	Readings from Sci. American, NREL
4/1		Wind (Guest speakers)	Chap. 21.3; Exts. 21.2, 21.3	Reading from NRC
4/3		SPRING RECESS		
4/8		Biofuels (Guest speaker: Safe Renewables Corp.)	Chaps. 23, 24; Ext. 23.1	Readings TBA
4/10		Hydroelectricity, Oceans, & Geothermal	Chaps. 22, 25.3, Ext. 25.3	Readings TBA
4/15		Hydrogen as an energy carrier	Chap. 25.4; Ext. 25.5	Readings from Sci. American
4/17		Futuristic options	Chap. 25.2	Reading from Sci. American
4/22	**Summary**	Summing it up: Prospects for the future		
		FINAL EXAM		

*Outside reading assignments will be made available via the course OwlSpace website. Extensions are available at the textbook website: http://physics.prenhall.com/aubrecht

13. Energy Efficient Buildings

University of Dayton

SUMMARY:

Offered by: Mechanical Engineering
Instructor(s): Kelly Kissock

Number of times taught: Three or More
Class size: 10 to 30
Class format: 3 hours of lecture plus 3 hours of "other" contact per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Upper division and graduate (2:3)
Students' Major: ≥90% Mechanical Engineering

Energy Efficient Buildings, MEE 420/569

Instructor: Kelly Kissock
Office: KL 363F W: 229-2852 H: 294-6101
kkissock@udayton.edu: http://www.engr.udayton.edu/faculty/jkissock/http/EEB/420main.htm
University of Dayton, Winter, 2007

Logistics

Meeting time and place:	M, W, 3:00-4:15 KL-403
Final Exam:	Th, May 3, 10:10 am – 12:00 pm
Office hours:	Anytime, drop-ins and appointments welcome
Text:	None
Supplementary references:	Heat and Cooling of Buildings, Kreider & Rabl
	Heating Ventilating and Air Conditioning, McQuistion & Parker
	Refrigeration and Air Conditioning, Stoeker & Jones
	Thermal Environmental Engineering, Threlkeld
	ASHRAE Handbook: Fundamentals
	Simplified Energy Analysis Using the Modified Bin Method, Knebel
	Energy Engineering, Mitchell
	Solar Engineering of Thermal Processes, Duffie & Beckmen

Course Goals

- To appreciate why improved designs and operation of building systems are important to our society.
- To acquire an overview of the knowledge and skills necessary to design and operate healthier, more comfortable, more productive, and less environmentally destructive buildings.
- To improve our ability to solve engineering problems through the application of economic, heat transfer, fluid mechanic, and thermodynamic principles and the use of computers.
- To improve our ability to communicate technical information.

Grading

Homework (no late HW accepted; lowest score will be dropped)	
2 Projects (graded as double homeworks)	
Total (final grades curved)	100 %

Students enrolled in MEE 420 and MEE 569 will be graded separately.

Overview

Since prehistory human beings have sought to improve their immediate environment by building shelters. This course begins with a review of the variety and ingenuity of human shelters. The variety suggests that no single design or paradigm is optimal for all circumstances. If that is so, what are the forces shaping the designs of modern buildings? What are the social, economic and environmental impacts of buildings? In this course, we will seek to develop enlightened designs that are both responsive to the forces shaping buildings and that foster broad social, economic and environmental progress.

To do so, we will broadly define the building heating and cooling (HC) system to include all aspects of the building that influence its internal thermal environment. The building's walls, ceilings, floors, windows, orientation and internal equipment, as well as mechanical heating and cooling equipment, become design variables, which must be considered in concert with the building's intended use and climate. Thus, the course emphasizes an integrated, whole-building approach to designing heating and cooling systems.

To design such responsive and enlightened building systems, students are called upon to creatively integrate their understanding of heat transfer, thermodynamics, fluid mechanics, computer programming, and engineering economics in homework and projects. We will not cover "rules of thumb", "cookie cutter" techniques for reproducing current building systems. As such the course serves as an excellent capstone course for the mechanical engineering curriculum.

- Please identify yourself if you require special accommodations to facilitate learning.

Energy Efficienct Buildings Syllabus
For 27 1:15 minute meetings

Lecture	Area	Subject
1	Context	History of Heating and Cooling with Building Form
2		Why E/3?
3		Energy Economics
4	Loads	Sequence of Analysis, Energy Balance, Weather Data
5		Walls
6		Ceiling and Ground Losses
7		Infiltration
8		Windows and Solar Gain
9		Internal Heat Gains and Design Loads
10	Residential Equipment	Furnaces
11		Air Conditioners
12		Heat Pumps
13	Energy Analysis	Degree-Day Method
14		Inverse Modeling
15		Simulating Residential Building Energy Use: E/3 Houses
16	Commercial Buildings	Commercial HVAC Systems
17		Campus Buildings Tour
18		Lighting, Daylighting and Internal Loads
19	Air Distribution Systems	Psychrometrics
20		Sizing Air Handlers and Chillers
21		Duct System Design
22		Fan Systems (CAV/VAV)
23		Outdoor Air Control
24	Heating and Cooling Plant	Piping and Pump Systems
25		Chillers and Cooling Towers
26		Boilers and Steam Systems
27	Energy Analysis	Simulating Commercial Building Energy Use: E/3 Buildings
Fin Ex		

14. Energy Efficient Manufacturing

University of Dayton

SUMMARY:

Offered by: Mechanical Engineering
Instructor(s): Kelly Kissock

Number of times taught: Three or More
Class size: 10 to 30
Class format: 3 hours of lecture plus 3 hours of "other" contact per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Upper division and graduate (2:3)
Students' Major: ≥90% Mechanical Engineering

Energy Efficient Manufacturing
MEE 499-02/578-01

Instructor: Kelly Kissock
Office: KL 361 W: 229-2852 H: 294-6101
kkissock@udayton.edu: www.engr.udayton.edu/faculty/jkissock
University of Dayton, Winter 2008

Logistics

Meeting time and place:	M,W 4:30-5:45, KL 221 Final Exam: M, April 28, 4:30–6:20
Office hours:	Anytime, drop-ins and appointments welcome
Text:	Class handouts and homepage
Homepage:	http://www.engr.udayton.edu/faculty/jkissock/http/EEM/EEMmain.htm

Course Goals

- To appreciate the importance of industrial energy efficiency.
- To learn practical techniques for improving industrial energy efficiency.
- To improve your ability to solve engineering problems through the use of engineering and economic fundamentals.
- To improve your ability to communicate technical information.

Grading

Homework and Quizzes (no late HW; lowest score dropped)	40 %
Exams and Projects	60 %
Total (final grades curved)	100%

Students enrolled in MEE 590 will do additional readings and will be graded separately.
Please identify yourself if you require special accommodations to facilitate learning.

Overview

This course presents a systematic approach for improving manufacturing energy efficiency. The course begins with a review of industrial energy use and a survey of models of sustainable industrial production. The approach for improving industrial energy efficiency involves performing a boundary analysis of energy and material flows, developing calibrated models of plant energy use, applying the inside-out approach for identifying savings opportunities, applying engineering fundamentals to determine expected savings, and techniques for measuring energy savings. Specific energy systems covered include electrical systems, lighting, motor drive systems, compressed air systems, process heating, process cooling, industrial heating, ventilation and air conditioning, and combined heat and power.

Energy Efficient Manufacturing Syllabus
For 27 1:15 minute meetings

Lecture	Area	Subject
1	Introduction	Motivation for energy efficiency
2		Manufacturing energy use and approach
3	Baseline Analysis	Electricity billing analysis
4		Gas billing analysis / Calibrated energy use models
5		Statistical analysis
6	Electrical Systems	Electrical system savings opportunities
7	Lighting Systems	Electric lighting
8		Natural lighting
9	Motor Drive Systems	Motor drive systems
10	Exam #1	
11	Compressed Air Systems	Compressed air system overview
12		Compressed air savings opportunities
13		Compressed air savings opportunities
14	Fluid Flow Systems	Fluid flow fundamentals
15		Piping
16		Pumps
17		Ducts/Fans
18	Exam #2	
19	Process Heating Systems	Insulation / open tanks
20		Heat exchangers
21		Combustion
22		Boilers and steam systems
23	Process Cooling Systems	Cooling towers
24		Chillers and heat exchanger networks
25	Heat, Vent and Air Cond Sys	Manufacturing HVAC
26	Combined Heat and Power	CHP
27	Economic Decision Making	Economic Decision Making / Tracking Savings
Fin Ex	Final Exam	

15. Energy Engineering Design Workshop:

University of Massachusetts, Lowell

SUMMARY

Offered by: Energy Engineering and Mechanical Engineering
Instructor(s): John Duffy

Number of times taught: Three or More
Class size: Less than 10
Class format: 1 hour of discussion plus 2 hours of lab

Portion of course focused on sustainable engineering: information not provided

Student Level: information not provided
Students' Major: information not provided

Energy Engineering Design Workshop, 24.504 or 22.504

John Duffy, Instructor
Fall, 2007

GOALS:
Development of student creativity and engineering design skills in the process of meeting established design objectives with consideration of economic factors, safety, reliability, aesthetics, ethics, and social impact. Development and use of design methodology, synthesis, analysis, and ideally construction, testing, and evaluation. (Adapted from ABET guidelines)

COURSE OBJECTIVES:
The specific objectives of this course include selection of a topic and team, preparation of a proposal, design and analysis of a solar system, and preparation of a written and oral report.

The learning objectives include the following but will vary depending on the kind of project selected and will be developed by each group and the instructor and specified in the proposal. By the end of the course, the student will be able to:

- Apply the principles learned in other courses in the curriculum to the design of an energy system
- Develop and meet performance criteria through the design of a device or system
- If applicable, manufacture a prototype
- If applicable, test the prototype and evaluate the extent to which the device or system meets the performance criteria
- Evaluate the economic, safety, reliability, and social impact of the device or system design
- Write a logical and concise report on the design process and results
- Make a presentation to stakeholders about the design criteria, process, and results.

This course is highly individualized and also highly structured. Students divide into design groups of two or three.

Each design group will meet with the instructor for one weekly review meeting. No regularly scheduled lectures will be held.

COURSE SCHEDULE (tentative):

Draft proposal submitted	September 27
Mid-term Presentation	November 1
Draft Final Report Submitted	November 29
Final Presentation	December 6
Revised Final Report Submitted	December 14

GRADING WEIGHTS:

Design, Synthesis, Analysis	20%
Participation	15%
Project Notebook	10%
Formal Report	25%
Mid-term Presentation	15%
Formal Presentation	15%

GRADING CRITERIA:
The grading for the entire course will be based on: creativity; research; meeting of goals and constraints; technical sophistication; constructing and testing a prototype; practicality; completeness; detail; analysis of environmental, economic, legal, aesthetic, social, safety, reliability issues; writing clarity. Cooperation is encouraged; consequently, there is no curve for this section of the course, that is, no preset number of any grades. If all do well, all get a good grade.

PARTICIPATION:
The level of effort that individual design team members expend will be continually monitored. It is expected that for the three-credit graduate course each student will devote 12 hours per week. In order to encourage involvement, the following will be required:

Group leader: Each week a different member of the design team will be responsible for conducting the weekly design review meetings. The group leader will follow a typed agenda that he/she has prepared. The group leader will also collect the weekly time sheet from each member of the team. These time sheets are to be submitted at the beginning of the weekly meeting.

Weekly time sheet: Weekly time sheets should include a very brief summary of what was attempted and accomplished, the number of hours worked, and when they were worked.

Engineering notebooks: Each student is required to keep a record of the work that he/she has done on the project. A three-ring binder with subject dividers should be used. Records of all project-related activities should be organized in the notebook (i.e., calculations, sketches, notes, references, phone logs, printouts, etc.). Notebooks will be reviewed at each design review meeting.

PROJECT NOTEBOOK:
Each group will maintain a project notebook that provides a record of key engineering activities of the project. A three-ring binder with subject dividers should be used to organize material. PC files (on diskettes or via e-mail or on a web page) that can be deciphered with software available to the instructor are encouraged in lieu of, or as part of, notebooks. Project notebooks are normally kept by the instructor. Material will be added to the notebook as an aspect of the design is completed.

FORMAL REPORT:
Each group will submit a formal, typed report on all the work completed during the semester. The instructor(s) will review the reports. Design groups will revise and resubmit their reports. Each member of the team will write at least one chapter (with authorship noted in the report). Reports will not be accepted unless typed.

FORMAL PRESENTATION:
Each group will make a formal presentation of the design activities for the semester. The presentation will last ten minutes for each student, with a five minute question period by the review committee. Each member of the team will deliver a portion of the presentation. Each team will be required to attend the presentations of the other teams.

Proposal Guidelines for 22.504 Energy Design Workshop

The basic idea of a proposal is to convince the reader that your proposed work is important and needs to be done and that you have the resources (knowledge, information, materials, space, time) to complete the work by the time you say. It is important to break down the work into several distinct tasks and to specific deliverables and due dates.

Elements of the proposal:

Introduction: Give a brief background; indicate why the proposed work needs to be done.

Goals and objectives: Explain what you want to accomplish; objectives are measurable goals. [Be specific. For example: The goal is to design, build, and test a solar water pasteurizer for remote regions of the world. The objectives are to design a collector to deliver 20 gallons per typical day in Malvas, Ancash, Peru of pasteurized water for a target cost of $200; to build a prototype collector to deliver 2 gallons per day in Lowell; to measure water properties and solar irradiation and to estimate the collector efficiency during a typical day in Lowell and to extrapolate the results to performance in Peru.]

Approach: Give a brief outline of how you propose to achieve the objectives. What previous work and analytic tools will you use? What materials, tools, software, and test equipment will you need? Are these available?

Tasks: Very important; break down the proposed work into steps. [For example: Task 1: Search for available information, previous work, and components for purchase in the library, internet, etc. Task 2: Set performance goals; use methods from solar engineering courses and literature to size the collector, choose materials, predict performance. Task 3: Size parts and make a sketch of the complete system. Task 4: Construct prototype in the lab… Task 10: Write final report. Task 11: Prepare and give final presentation.]

Time estimates: Present a table with each task and estimated person-hours to be spent by each team member. The sum of all the hours for each team member should be equal to the typical number of hours spent on a three-credit hour graduate course: 12 hours per week for 14 weeks: 170 hours, including time to develop proposals. For an undergraduate 3-credit-hour course, 9 hours per week is expected. Then include a time line with planned start and completion dates for each task. Examples:

Task Time Requirement Estimates

Task	Person A	Person B
1. Lit. search	12	12
2. Design Parts A, B	20	15
3. System Design	12	18
….	…	…
Total person-hours:	170	170

Time Line [or Gantt Chart]

Task	Start	Complete
1	Week 3, or Sep 18	Week 5, or Sep 30
2	Week 3, or Sep 18	Week 6, Oct. 6
…	…	…
10	Week 13	Week 14, due date

Budget estimate:

Item	Availability	Cost estimate
Copper tubes and plate	Scrap in ME machine tool lab	none
Wood	Local lumber yard	$20
Test equipment	Solar lab, roof	none

Deliverables: Include reports, presentations, prototype…and estimates of delivery dates.

Conclusion: Very briefly summarize the proposal and make a final statement about why the work should be done and how you have the capability and resources to complete the tasks and meet the objectives on time.

16. Energy Technology and Policy

Georgia Institute of Technology

SUMMARY

Offered by: Industrial and Systems Engineering and Public Policy
Instructor(s): Valerie Thomas and Marilyn Brown

Number of times taught: Three or More
Class size: 10 to 30
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Graduate
Students' Major: 20% Industrial and Systems Engineering and Public Policy
50% Other engineering
30% Other non-engineering

School of Public Policy
School of Industrial and Systems Engineering

Energy Technology and Policy
PUBP 8803D
ISYE 8803
Wednesday 1:30-4:30 pm
Location: ESM 212

Instructors: Drs. Valerie Thomas and Marilyn Brown

Course Description
This course examines the policies and technologies affecting the production and use of energy, focusing in particular on innovative and sustainable energy options. The course provides a fundamental understanding of energy systems, including historical trends of supply and demand, resources and technologies, and related economic, global climate change, and security issues. Policies and technology associated with different energy systems will be examined including plug-in hybrid electric vehicles, ethanol, and other alternative transportation fuels; smart buildings and advanced lighting; industrial ecology approaches; solar and wind systems; and the next generation of nuclear energy. Policies will be examined at the national and international scale, and at the state and local level where novel approaches are often first introduced. Given the ubiquitous nature of energy in modern society, this course will offer insights for students pursuing a diversity of careers. The course has no formal prerequisites.

Texts:
- *Energy and American Society – Thirteen Myths.* B. K. Sovacool and M. A. Brown (eds.), 2007. ISBN-13; 978-1-4020-5563-8.
- *Physics of Societal Issues.* David Hafemeister. Spinger, 2007.

Grades and Examinations

Class Participation:	10%
Class project:	25%
Mid-term exam:	20%
Final exam:	25%
Homework, Quizzes:	20%

Because of the highly interactive nature of the course, *10 percent* of the student's grade depends on general class participation. Students are expected to come to the class having read the assigned readings and prepared to discuss the material. The instructors will encourage dialogue by helping the students lay out the facts, pose questions, and help the class discover and understand the underlying principles.

Students will work in teams to complete a class project dealing with some energy policy or energy technology issue. The results will be summarized in a presentation to the class near the end of the semester. The project is worth *25 percent* of each student's grade.

There will be two exams: *20 percent* of the grade is based on a mid-term exam and *25 percent* of the grade is based on the final exam.

The remaining *20 percent* of the grade is based on the completion of homework and quizzes.

Schedule and Reading Assignments

Week 1 (January 9). VT and MB
Energy Overview
Overview of energy issues: history of energy use; energy, climate and the economy.

- A Thousand Years of Energy Use in the United Kingdom. *The Energy Journal* **19**(4). Fouquet R and Pearson PJG, 1998.
- *Developing an "Energy Sustainability Index" to Evaluate U.S. Energy Policy,* Marilyn A. Brown and Benjamin K. Sovacool, Georgia Institute of Technology School of Public Policy Working Paper, December 2006 (http://www.spp.gatech.edu/faculty/workingpapers.php).
- *Hafemeister*. Chp. 10 (pp. 249-262) The Energy Situation

Week 2 (January 16). VT
Petroleum

Ending the Energy Stalemate. National Commission on Energy Policy. Chapter 1, pp. 1-18.
http://www.energycommission.org/files/contentFiles/report_noninteractive_44566feaabc5d.pdf

- *Hafemeister: Chp. 10 pp. 262-266*. 16.6 Petroleum Economy (pp. 417-421). Energy/Environment Chronology, pp. 446-453.
- The End of Cheap Oil, Colin J. Campbell and Jean H. Laherrere, *Scientific American* **278** (3) March 1998, pp. 78-83.

Week 3 (January 23). VT and MB
Nuclear Energy

- The Future of Nuclear Power (MIT). Executive Summary and Chapter 1. http://web.mit.edu/nuclearpower/
- *Hafemeister* Chapter 1, section 1.1: Nuclear Age, Nuclear Proliferation (pp. 3-5); Chapter 5 (pp. 105-128) Nuclear Proliferation; Chapter 7 Nuclear Pollution (pp. 163-170, 7.7 Geologic Repositories p. 185-190); Fusion Power (pp. 333-334); Plutonium Economy (pp. 422-425).

Week 4. (January 30). MB
Coal and Carbon Sequestration

- Rubin, *Introduction to Engineering and the Environment*, Chapter 5. Electric Power Plants and the Environment.

- Hawkins, D. G., D. A. Lashof, and R. H. Williams (2006) "What to Do about Coal," *Scientific American*, **195** (3), 68-75.
- Socolow, R. H. (2006) Can We Bury Global Warming, Scientific American, July 2005, pp. 49-56.
- Hafemeister: Air and Water Pollution 6.1, 6.2, 6.3, 6.4, pp. 137-144 (Acid Rain pH, Clean Air Act and Allowance Trading, Pollution Scaling).
- The Future of Coal (MIT)

Week 5. (February 6). VT & MB
Wind and Solar Energy, Biopower, Renewable Portfolio Standard

- Lovins, Amory (1976) "Energy Strategy: The Road Not Taken", *Foreign Affairs*, 65 – 96.
- Sovacool and Brown, *Energy and American Society*, "Energy Myth Seven – Renewable Energy Systems Could Never Meet Growing Electricity Demand in America" by Rodney Sobin
- *Hafemeister*: Renewable Energy Chapter 13. Solar Buildings Chapter 12.

Week 6. (February 13) MB
State Energy Policies.
Energy Policy Act of 2005 and the Georgia State Energy Plan (Exercise 3)

- *State Energy Strategy for Georgia,* Selected Readings, December 14, 2006 (http://www.georgiaenergyplan.org/).
- Brown, Marilyn A. and Sharon (Jess) Chandler, 2008. "Governing Confusion: How Statutes, Fiscal Policy, and Regulations Impede Clean Energy Technologies," *Stanford Law and Policy Review,* forthcoming.
- Sovacool and Brown, *Energy and American Society*, "Energy Myth Six – The Barriers to New and Innovative Energy Technologies are Primarily Technical: The Case of Distributed Generation (DG)" by Benjamin K. Sovacool and Richard F Hirsh

Week 7. (February 20) MB & VT
Review of Key Concepts for Midterm
Energy Efficiency: Buildings and "Smart Growth"

- Sovacool and Brown, *Energy and American Society*, "Energy Myth Nine – Energy Efficiency Improvements Have Already Maximized Their Potential" by Amory B. Lovins
- Sovacool and Brown, *Energy and American Society*, "Energy Myth Ten – Energy Efficiency Measures are Unreliable, Unpredictable, and Unenforceable" by Edward Vine, Marty Kushler, and Dan York
- IPCC (Intergovernmental Panel on Climate Change). 2007. *Mitigation Options for Residential and Commercial Buildings,* Chapter 6: *"Climate Change 2007: Mitigation of Climate Change.*

- *Hafemeister*: Chapter 11 Energy in Buildings; Chapter 14 Enhanced End-Use Efficiency (through 14.6 p. 364).

Week 8. (February 27) Midterm Exam
Continuation of Buildings and "Smart Growth"

Week 9. (March 5). MB & VT
The Electric Grid, Transportation Energy Policy, and Plug-in Hybrid Electric Vehicles. MB

- *Siting Critical Energy Infrastructure.* National Commission on Energy Policy, pp. 4-21. http://www.energycommission.org/ht/display/ContentDetails/i/1580/pid/493
- Sovacool and Brown, *Energy and American Society*, "Energy Myth Eight – Worldwide Power Systems are Economically and Environmentally Optimal" by Thomas R. Casten and Robert U. Ayres
- Sovacool and Brown, *Energy and American Society*, "Energy Myth Four – The Hydrogen Economy is a Panacea to the Nation's Energy Problems" by Joseph Romm
- Hafemeister: 14.8 Utility Load Management, pp. 365-371.

Industrial Ecology and Industrial Efficiency.
Natural Gas, Combined Heat and Power, Cogeneration.

- Sovacool and Brown, *Energy and American Society*, "Energy Myth Six – The Barriers to New and Innovative Energy Technologies are Primarily Technical: The Case of Distributed Generation (DG)" by Benjamin K. Sovacool and Richard F Hirsh
- Daniel Yergin and Michael Stoppard, "The Next Prize," *Foreign Affairs*, Vol. 82, No. 6, July/August 2003, pp. 103-114.
- *Hafemeister*. 14.7 Cogeneration, pp. 364-366.

Week 10 (March 12) VT
Transportation Efficiency. Biofuels and Hydrogen

- Keith, D. W. and Farrell, A. E. (2003) "Rethinking hydrogen cars," *Science*, **301**, 315 – 316.
- Sovacool and Brown, *Energy and American Society*, "Energy Myth Three – High Land Requirements and an Unfavorable Energy Balance Preclude Biomass Ethanol from Playing a Large Role in Providing Energy Services" by Lee R. Lynd, et al.
- *Ending the Energy Stalemate*. National Commission on Energy Policy. Chapter 4E (Non-Petroleum Transportation Fuels), pp. 70-78. *http://www.energycommission.org/files/contentFiles/report_noninteractive_44566feaabc5d.pdf*
- *Hafemeister*. Transportation Chapter 15 pp. 378-396.

Spring Break March 17-21

Week 11. (March 26). MB
Climate Change. Carbon Dioxide and Other Greenhouse Gases

- Sovacool and Brown, *Energy and American Society*, "Energy Myth Twelve – Climate Policy Will Bankrupt the U.S. Economy" by Eileen Claussen and Janet Peace
- "What Drives the Ice Age Cycle?" *Science* **313** 28 July 2006, p. 455.
- *4th Assessment Report. Summary for Policymakers* by Intergovernmental Panel on Climate Change, 2007.
- Collins, et al. 2007. "The Physical Science Behind Climate Change," *Scientific American, pp. 64-73, August.*
- *Hafemeister,* Chapter 8 Climate Change.

Week 12. (April 2). VT
Technologies to Address Climate Change

- Socolow, R. and S. W. Pacala (2006) "A Plan to keep Carbon in Check", *Scientific American*, **195** (3), 50-57.
- *Strategic Plan* (U.S. Department of Energy, Climate Change Technology Program, DOE/PI-0005) September, 2006, Chapters 1-3, pp. 1-56 (www.climatetechnology.gov).
- Cruzen, P. "Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?" *Climatic Change* **77**: 211-217, 2006.

Week 13. (April 9). MB
Climate Policy: UNFCCC, Kyoto Protocol and Carbon Trading
& Project Presentations

- *Ending the Energy Stalemate*. National Commission on Energy Policy. Chapter 2, pp. 19-29. http://www.energycommission.org/files/contentFiles/report_noninteractive_44566feaabc5d.pdf
- Sovacool and Brown, *Energy and American Society*, "Energy Myth Thirteen – Developing Countries Are Not Doing Their Part in Responding to Concerns about Climate Change" by Thomas J. Wilbanks

Week 14. (April 16). MB and VT
Project Presentations

Week 15 (April 23) MB & VT
Global Energy Policy
Review of Key Concepts for Final Exam

- Sovacool and Brown, *Energy and American Society*, "Conclusions – Replacing Myths with Maxims: Rethinking the Relationship Between Society, Energy, the Future, and Sustainability, by Benjamin K. Sovacool and Marilyn A. Brown
- Vaitheeswaran, Vijay V. (2003), *Power to the People – How the Coming Energy Revolution Will Transform Industry, Change Our Lives, and Maybe Even Save the Planet*, Farrar, Straus and Giroux, New York. Chapter 11: "Micropower Meets Village Power"

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Schedule for Class Projects and Final Exam

March 12: 250-word Summary of Topic for Class Project
March 26: Quality draft of Class Project Report
April 25 (Friday): Final Project Report Due
April 29 (Tuesday): Final Exam 11:30 am - 2:20 pm

17. Environmental Engineering

Oklahoma State University

SUMMARY

Offered by: Chemical Engineering
Instructor(s): Karen High and Jan Wagner

Number of times taught: Three or More
Class size: Less than 10
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: 10 to 25%

Student Level: Upper division
Students' Major: ≥90% Chemical Engineering

CHE 4343
ENVIRONMENTAL ENGINEERING
Spring 2002

Class: **TTh** **9:00 - 10:15 AM** **Engineering North 514**

Instructors:

Karen A. High
423 Engineering North

Voice: (405) 744-5280
FAX: (405) 744-6338
high@okstate.edu

Jan Wagner
423 Engineering North

Voice: (405) 744-5280
FAX: (405) 744-6338
jwagner@ceat.okstate.edu

Professor High and Wagner will try to maintain open office hours outside of regularly scheduled classes and other commitments. Students are encouraged to schedule appointments using email.

Objectives:

1. Understand the history and status of current National and state environmental regulations
2. Predict the movement and fate of chemicals in various media
3. Conduct multi-media pollution assessments
4. Apply science and engineering principles to pollution minimization and prevention
5. Understand and assess environmental risk
6. Appreciate green chemistry and green engineering concepts.
7. Understand the impact of waste treatment and pollution prevention on the economics and profitability of industry
8. Conduct life cycle analyses of chemicals

Textbook:

The required textbook for this course is:

Allen, D. T.; Shonnard, D. R. 2002, *Green Engineering: Environmentally Conscious Design of Chemical Processes*, Prentice Hall, Upper Saddle River, NJ.

Supplemental handouts will be provided on occasion.

Course Grade:

Your grade in the course will be based on your performance on the following items:

1.	Homework and quizzes	100
2.	Three (3) 1 hr. examinations	300
3.	Class participation and reports	100

Final semester averages will be based on these 500 points and computed according to the following equation:

$$Average = \frac{Total\_Pts.}{500}$$

Grades will be assigned by ranking the semester averages and assigning letter grades based on class performance and instructor experience and judgment (that is, the grades will be "curved").

Unless prior arrangements have been made with the instructors, homework must be turned in at the beginning of class in the classroom. **Late work receives no credit**; homework assignments and design projects that are turned in late will receive a grade of zero. Absence from an examination can be excused only under the following circumstances:

1. When arrangements are made with the instructors ***prior to the time of the exam***.
2. When a written doctor's certificate indicating that the student was physically unable to take the exam is presented.

Course Organization:

A brief course outline is attached. There are two general categories of course requirements: (1) individual homework, quizzes, and exams and (2) class participation and reports.

Class Attendance/Participation:

Class attendance is considered important, but it will not count directly toward your grade except for special events that will be announced ahead of time. However, you will not be permitted to turn in any work late unless you have prior permission from the instructors to miss class. Pop quizzes will not be made up under any circumstances.

Drop Policy:

The drop policy as described in Section 5.4, University Academic Regulations, in the OSU Catalog will be observed. See the Syllabus Attachment for important dates.

Academic Dishonesty:

Academic dishonesty is a particularly serious matter in one's professional studies and will be dealt with at the most severe level of punishment. If there is clear and convincing evidence of academic dishonesty (including plagiarism or unauthorized exchange of information on reports), all of those deemed guilty will be dropped from the course and receive an "F" as the final grade of record. Appeals of such action can be made to the Academic Appeals Board.

Activities such as copying another student's homework or cheating on examinations are clearly in the realm of dishonest acts. A subtler, but equally unacceptable activity, is plagiarism. Plagiarism is the representation of someone else's ideas as if they are your own. Where the arguments, data, designs, etc., of someone else are being used in a paper, report, oral presentation, or similar academic project, the fact must be made explicitly clear by citing appropriate references. The references must fully indicate the extent to which any parts of the project are not your own work. (For example, it would be plagiarism to credit someone else with the content of only one paragraph in a paper, if in fact you are borrowing two pages of the paper from this source.) You must not suppose that only verbatim copying requires crediting. Paraphrasing of someone else's ideas is still using someone else's ideas, and they must be acknowledged.

To avoid the appearance of plagiarism, you must not be sloppy in the way you cite references. If you take material word-for-word from a source, you must put that material within quotes or in indented paragraphs and provide proper references. If you have any questions concerning whether or not the way in which you are using materials could be construed as plagiarism, consult one of the faculty before you submit the work for credit.

Except when explicitly stated otherwise, we encourage students to study and work together on homework to accelerate the learning process. However, we also expect that all work that you submit is your individual effort. That is, it is inappropriate for groups of students to collectively solve a problem and submit duplicate solutions. This is considered a form of plagiarism. Instead, each student should generate their own solution, which at most incorporates the general concepts developed by the group study. Again, if you have any questions on this matter, check with one of the instructors. An obvious exception to the above is when the assignment requests a group report.

Special Accommodations for Students:

If you believe you have a disability and need special accommodations of any nature, the instructor will work with you and the Office of Disabled Student Services, 326 Student Union, to ensure that you have a fair opportunity to perform in this class. Please inform the instructor of such disability and the desired accommodations immediately after the first scheduled class period.

KH/JW 10/24/2008

18. Environmental Engineering

The University of Houston

SUMMARY

Offered by: Civil and Environmental Engineering
Instructor(s): Shankar Chellam

Number of times taught: Three or More
Class size: 10 to 30
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: Less than 10%

Student Level: Upper division
Students' Major: ≥90% Chemical Engineering

ENVIRONMENTAL ENGINEERING
CIVE 3331 (Section#01723)

1:00 p.m. – 2:30 p.m. on Mondays and Wednesdays in Room/Building E312–D3

Professor: Dr. Shankar Chellam – Room N-113 Building D.
Tel. 713-743-4265, Fax: 713-743-4260, E-mail: chellam@uh.edu

Textbook: "Introduction to Environmental Engineering and Science" 2nd Ed. by Gilbert M. Masters, Prentice Hall. *Please bring the textbook to every class.*

Course objectives:

1. Impart knowledge of the current issues in environmental science and engineering.
2. Teach fundamental concepts of environmental systems, especially related to pollutant treatment (purification) and migration.
3. Help students learn how to approach environmental engineering problems and design concepts in a systematic and organized fashion.

Performance criteria: By the end of the semester, the students are expected to:

1. Use the world-wide-web and libraries to find legislative and technical documents relevant to environmental engineering.
2. Be capable of writing critical essays on selected environmental issues.
3. Apply material balance equations in the analysis of environmental engineering problems.
4. Analyze data to support engineering decisions.
5. Conceptually design and select appropriate treatment processes for pollutant removal or purification.

Office hours: Tue. and Thu.: 1:00 – 4:00 p.m. and Fri. by appointment.
I will have an open-door policy. However, I prefer that you make appointments because I may not necessarily be in my office.

Topics:

Introduction to environmental engineering and science

Airborne and waterborne pollutants

Transformation processes; chemical reactions including stoichiometry, equilibrium, kinetics, and partitioning; Transport phenomena; general materials balances, and mass and particle transport

Water quality engineering; oxygen demand, pollution prevention and treatment

Air quality engineering; sources, pollution control and treatment, and models

Sustainability (your projects and technical reports/presentations) will focus on this topic.

Grading:

Best of 3 spot quizzes (in class)	15%
Exam 1 (in class)	15%
Exam 2 (in class)	15%
Project/Technical report	10%
Final Exam (in class)	30%
Homework assignments	10%

Five short (15 – 20 minutes duration) spot quizzes will be given but only three will be counted towards your final grade. Exams and quizzes cannot be made up implying that your attendance in class will assist you. Students with adequate documented reason(s) (e.g. a car accident) for missing the first exam may take the final exam at 55% weight. The final exam will be on Wednesday, Dec. 13th from 2 p.m. – 5 p.m.

Homework: I expect every student to turn in a clean, well-written copy of his or her homework assignment. You can (and should) work together, but please do not copy. Unless otherwise specified, you will have one week to complete each assignment. They will be due to me at the start of each class. Class participation is an integral component of undergraduate education and will be considered favorably for borderline grades.

Catalog Listing: **Prerequisites.** Chemistry including fundamental laws, atomic and molecular structure, states of matter, equilibrium, kinetics, and elementary inorganic and organic chemistry; CHEM 1112, 1332, and credit for or concurrent enrollment in ENGI 2334.

Description. Introduction to air, water, and environmental pollutants and design concepts for treatment.

Note: *It is not permitted to use a cell phone during my class unless you obtain my permission beforehand.*

Students with special needs should contact the Student Service Center, Room 307 (Tel. 713 743-5400).

19. Environmental Engineering Chemistry

The University of Toledo

SUMMARY

Offered by: Civil Engineering
Instructor(s): Defne Apul

Number of times taught: Once
Class size: Less than 10
Class format: 2.5 hours of lecture per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Graduate
Students' Major: ≥90% Civil Engineering

University of Toledo
Department of Civil Engineering
CIVE 6640/8640 Environmental Engineering Chemistry
3 Credits, Fall 2007

Professor: Dr. Defne Apul, NI3030, Defne.Apul@utoledo.edu, (419) 530 8132

Meetings: M 5:30pm-8:00pm, Palmer 3200

Office Hours: You can stop by any time my door is open or you can make an appointment.

Resources: Handouts from me, the internet, Google, Google-Scholar, libraries, Web of Science, online or paper copies of scientific articles, any textbook on water chemistry, contaminant fate and transport, and life cycle assessment.

If you are interested in purchasing a water chemistry book, I recommend the following:

Snoeyink & Jenkins, Water Chemistry, John Wiley & Sons, 1980
Comments: Basics, easy to follow

Benjamin, Water Chemistry. McGraw Hill, 2002.
Comments: Excellent resource but difficult for beginners

James N. Jensen, A problem solving approach to Aquatic Chemistry, Wiley, 2002.
Comments: More detailed than Snoeyink, also easy to follow

Reading assignments:
The bulk of this course will be reading assignments, projects, and in-class discussions. Please keep up with your reading assignments and participate in discussions.

Web address: Go to http://www.dl.utoledo.edu . Login using your UTAD account.

RESPONSIBILITIES

The word teacher in my opinion is an inaccurate description of the ideal classroom environment. I cannot teach you anything if you do not learn it. Learning happens with you, I can only facilitate it. Especially at the grad level, you are responsible and mature enough to learn on your own and use resources available to you to help with your learning. I see my role in this class as the 'facilitator'. It is your responsibility to make every attempt to stay engaged, participate, and contribute to your and others' learning.

I expect you to attend all classes and participate in discussions. Doing the homework, putting your best effort in the project, and participating in classroom discussion are all very important. I expect you to be inquisitive, not passive. I also expect you to work with your classmates and share what you know with them during and outside class meeting times.

You should remain academically honest on in-class work, exams, and assignments. Academic honesty and dishonesty is a broad topic, but we might summarize the rules here by saying "Don't take credit for any work that is not your own." Among other things, this refers to cheating on exams, copying (plagiarizing) material without stating where it came from, or not participating in group work (and yet taking credit for it). I take academic dishonesty seriously and will not tolerate any kind of plagiarism or cheating, so please consult me if you are in doubt or have questions.

If you have any concerns or issues about these expectations you have to come see me the first week of the class. Otherwise, I will assume that you accept this responsibility.

PURPOSEFUL LEARNING

In your progress through this course, there are certain things I will want you to "know" or "be able to do" by the end of the semester. I will post or hand out lists of these 'objectives" throughout the semester. Tests will cover **only** those objectives listed, and no problems or questions will be given on examinations which are not implied by one of those lists. The things that aren't on the objectives lists are not unimportant; they just aren't as important as the things that are listed, in my opinion. You'll learn some of the things that aren't listed anyhow, and that's a bonus. I want you to concentrate your study time on the listed objectives, however, so that you'll be learning **on purpose** those concepts and skills which I consider fundamental in the course. The lists of objectives for a particular portion of the course are not set in stone, and I will consider input from the class on modifications to the topical objectives. For example, if there is particular interest in a given topic, it may be possible to spend a greater effort in studying that area, with a concomitant revised set of objectives. I will accept written or oral suggestions for objectives from students at any time during the semester.

POLICIES AND PROCEDURES

- If you miss a test without either a certified medical excuse or prior instructor approval, you will get zero for that exam.
- Make up exams will not be assigned unless a request for one is approved prior to the exam or supported by a medical certificate.
- Reflections on reading assignments will be posted online by each student. You will get no credit for these assignments if you do not post them on time.
- Assignments that do not require online posting must be turned in by class time on the due date. Late assignments will be penalized 20 % per every week day (by 3:30 pm).
- You are encouraged to work together on homework so you can discuss the problems and learn more than you would if you worked on your own. While working with others, don't forget about academic dishonesty. The idea is to learn together not copy from someone or let someone else do the thinking for you.

OVERALL COURSE OBJECTIVES

At the end of this course, you should be able to:

1. Critically review research articles
2. Extend your knowledge and skill base on a given topic by finding more information on it. Communicate what you find with your peers.
3. Use Visual MINTEQ and possibly HYDRUS or any other additional software to calculate equilibrium speciation and to predict the fate and transport of contaminants.
4. Complete a research report of acceptable quality on a project related to environmental chemistry, transport of contaminants, or life cycle assessment.
5. Calculate the equilibrium concentrations of multiple aqueous species given a simple environmental system.

More Detailed Learning Objectives will be posted online and updated prior to the exam. Use the online posted learning objectives to study for the exam and to guide you on what I expect you to get out of this class.

GRADING

Quantitative HW	20 %
Reading based HW	25 %
Leading a discussion on paper	10 %
Project	45 %
Total	100 %

A weighted grade of 90 or above is guaranteed an A, 80 or above at least a B, 70 or above at least a C, and 60 or above at least a D.

Topics I intend to discuss with you in this class:
<u>Chemistry and Contaminant Transport</u>
Concentration units
Thermodynamic basis for equilibrium
Nonideal behavior of ions and molecules in solution
Acids and bases
Aqueous complexation
Precipitation and dissolution
Oxidation / reduction
Adsorption isotherms
Surface complexation model (Maria Diaz)
Advection, molecular diffusion, and dispersion
Humic substances (Raja Chowdhury)
Monte Carlo method for propagating uncertainty
<u>Sustainability</u>
Sustainable development
Life cycle assessment
Environmental decision making

Tools you may learn to use in this class:
Water chemistry modeling: Visual Minteq
Contaminant fate and transport: HYDRUS1D
Life cycle assessment: EIO-LCA, Simapro(?), GREETS(?), BEES(?), BenReMod, PALATE
Other sustainability tools: Ecological footprint, LEED

Projects
All students will work on a research project that will involve literature review and possibly computer modeling. Projects will be graded based on the quality of the written report and presentations.

Additional Requirements for Ph.D. Students
Ph.D. students will be responsible for teaching one topic assigned to them. Material covered by Ph.D. students will be included in the exams. Ph.D. student lectures can include theory, examples, in-class exercises, assessment, and/or homework.

Tentative project ideas and groups:

Related to sustainability:

- Pick a road project (e.g. Indian road, US475 or an on-campus road) and do a life cycle assessment of the road and compare with pavement rating system (http://pavementinteractive.org/index.php?title=UW:Green_Roads)
- Environmental impact/ecological footprint of a UT grad student's two year residence on campus
- Life cycle assessment of Nitchke Building

Related to fate and transport:

Effect of material and contaminant properties on contaminant leaching from road construction materials

Deliverables

Each project group will submit at least four deliverables. The 4th one will be final report. Each group will also present their work in class at the end of the semester.

Class Format

Lectures given by Dr. Apul, Maria Diaz, Raja Chowdhury, and Amr, and Kaushik
Wiki/Epsilen site for students to upload their answers to reading questions
Discussion of papers
Discussion of the issues and progress related to term projects

Homework Due August 22

We will use the Epsilen platform for communication. I first need you to register to Epsilen before you can start using it.

To register, please follow these steps:

1. Go to: http://epsilen.com/Epsilen/Public/WhatIsEpsilen.aspx
2. Click on "click here to sign in" on the top left side of page
3. When the next page comes up, click on "register for an account"
4. Use your .edu email address to register. It will not accept .com addresses.
5. After you register, send me an email so I can look you up on Epsilen database to add you to the group.

Homework Due August 27

Go to www.dl.utoledo.edu. Login using your utad username and password. Download and read the two articles posted in the Homework folder. Type your answers to questions that I will post on September 21. Email me your answers by September 26 (midnight) the latest. Bring your answers to class.

Go to http://www.redefiningprogress.org/. Take the "Ecological Footprint Quiz" and determine your footprint. Write some short notes for yourself on the "Ecological Footprint" concept and what actions you can take to reduce your own footprint. Bring your notes to class on September 27.

To do in class:

On a piece of paper, answer the following questions.

What is your name?

What is your current or intended research area?

Why did you pick environmental engineering?

Why did you pick UT?

What do you plan to do when you graduate?

What do you plan to do in the decades following your graduation?

What do environmental engineers do?

What kind of problems do we work on?

What kind of tools do we have for solving these problems?

Tentative Schedule (Will definitely change!)

Meeting	Date	Chemistry Topic	Discussion paper	Project Deliverables	Person leading the article discussion
1	August 20	Course overview, concentration units			
2	August 27	Thermodynamics	Mihelcic et al., Brundtland report		Defne Apul
3	Sept 3	**Labor day, no class**			
4	Sept 10	Nonideal behavior of ions and molecules in solution, Manipulating equilibrium rxns	Biobased products	Deliverable 1	Kaushik
5	Sept 17	Acids and bases, definitions, nature and strength Equilibrium expressions for acid/base chemistry			Naveen
6	Sept 24	Dissolution /precipitation			Vamsi
7	Oct 1	Adsorption isotherms		Deliverable 2	Chirjiv
8	Oct 8	SCM, Maria Diaz			Vinay
No class	Oct 15	**Fall break, no class**			
9	Oct 22	SCM, Maria Diaz			Srikar
10	Oct 29	Humic, Raja			Dilip
11	Nov 5	Humic, Raja			Srihari
12	Nov 12	**Holiday, no class**		Deliverable 3	
13	Nov 19	Diffusion, advection			Amr
14	Nov 26	Diffusion, advection, monte carlo?			Dinesh
15	Dec 3	Presentations		Final report	
16	Dec 10	All fall grades due			

Projects
Water use and efficiency
Life cycle assessment of nitchke including LEEDS assessment

Ecological footprint: http://www.rprogress.org/ecological_footprint/using_the_footprint.htm

20. Environmental Life Cycle Analysis

University of Minnesota

SUMMARY

Offered by: Environmental Sciences, Policy, and Management
Instructor(s): Sangwon Suh

Number of times taught: Twice
Class size: 30 to 100
Class format: 2.5 hours of lecture plus 1 hour of "other" contact per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: information not provided
Students' Major: information not provided

ESPM 3603 / 5603 Environmental Life Cycle Analysis
04:00 P.M. - 05:15 P.M. , Tu,Th (09/04/2006 - 12/13/2006), CarlSMgmt 1-127 (see http://onestop.umn.edu/Maps/CarlSMgmt/)

Instructor:
Prof. Sangwon Suh

Office and Office hours
Sangwon Suh (sangwon@umn.edu):
BAE 224, 1390 Eckles Ave, Saint Paul, MN 55108; Friday, 10-11 AM

Catalogue Description

The course is designed to introduce to the concepts and procedures of Life Cycle Assessment (LCA) as an essential analytical element to Environmental Management System. LCA is a tool to quantify and manage environmental impacts associated with products and services throughout their life cycles, including production, use and disposal/recycling. The first half of the course will be devoted to the methods and principles of LCA: Goal and Scope definition, Life Cycle Inventory (LCI) analysis, Life Cycle Impact Assessment (LCIA) and Interpretation, that are the main phases of LCA, will be covered. In the second half of the course, students will have an opportunity to form small groups and, per each, choose a particular product or a service to apply LCA. Students will be given an opportunity to present their works at the end of the course. Completing this class, the students are expected to acquire basic knowledge and skills to design and carry out an LCA study and to incorporate the results with a firm's environmental management strategy. ISO 14040 series on LCA, that is a part of the International Standards, will be extensively utilized. The class will combine lecture, discussion and group project. The course is comprised with (1) lecture, (2) in-class activities, (3) guest lectures from industries, and (4) a group project.

Course objective

The principal objective of this course is to develop basic knowledge and skills necessary to design and implement an LCA project. This includes developing life-cycle perspectives, understanding the basic concepts and principles of LCA, gaining insights on the ISO 14040 series, understanding the procedures for LCA, developing proper analytical skills, implementing a project, working as a team, communicating with others. This course will also help you think critically in environmental decision-making that concerns products and services.

Text

Relevant course materials will be distributed during the course or will be available through the WebCT. What follows is a list of supplementary texts.

Heijungs R., Suh, S. 2002: *The Computational Structure of Life Cycle Assessment*. Kluwer Academic Publisher, Dordrecht, The Netherlands.

Guinée, J.B., M. Gorrée, R. Heijungs , G. Huppes, R. Kleijn, A. de Koning, L. van Oers, A. Wegener Sleeswijk, S. Suh, H.A. Udo de Haes, H. de Bruijn, R. van Duin, M.A.J. Huijbregts, 2002: *Handbook on Life Cycle Assessment. Operational Guide to the ISO Standards*. Kluwer Academic Publisher, Dordrecht, The Netherlands.

Late Work
All assignments must be submitted to Sangwon Suh by 4 p.m. on the stated date. Late work will be penalized one grade notch (e.g., 1 grade point) for each day it is late. The weekend counts as one day.

Course plan

Week	Lecture	Date	Topic	Principal Instructor	Assignments (due next class unless otherwise stated)
1	1	9/4	Introduction / Organization of the class	S	Draft carbon footprint calculation
	2	9/6	Life Cycle Thinking	S	Comparative assertion
2	3	9/11	ISO 14040 series: terms and definitions	S	
	4	9/13	Goal and Scope definition (I)	S	G&S for your Carbon footprint (CF) study
3	5	9/18	Goal and Scope definition (II); Life Cycle Inventory Analysis (I)	S	
	6	9/20	Life Cycle Inventory Analysis (II)	S	
4		9/25	Quiz	TA	
	7	9/27	Group formation	TA	
5	8	10/2	Guest lecture: Georjean Adams	G.A.	
	9	10/4	Life Cycle Costing	Dr. Lim	
6	10	10/9	Life Cycle Inventory Analysis (III)	S	Complete LCI for your CF study
	11	10/11	Life Cycle Impact Assessment (I)	S	
7	12	10/16	Life Cycle Impact Assessment (II)	S	
		10/18	Midterm exam (open book, be at the classroom)	S	
8	13	10/23	Attend the Biofuel conference		
	14	10/25	Planning presentation for the group work	S	
9	15	10/30	Planning presentation for the group work (cont'd) / Life Cycle Interpretation	S	
	16	11/1	Life Cycle Interpretation continued	S	
10	17	11/6	Recent advances in LCA / Design and implementation of an LCA project	S	
	18	11/8	Review of LCA case studies (I)	S	
11	19	11/13	Review of LCA case studies (II)	S	
	20	11/15	Managing LCA projects	S	
12	21	11/20	Group discussion on the project	TA	
13	22	11/27	Group work progress report (1)	S	
	23	11/29	Group work progress report (2)	S	
14	24	12/4	Guest speaker	John Carmody/ S	
	25	12/6	Group discussion on the project	S	

15	26	12/11	Group work final presentation Group work final presentation	S	

Assessment
Participation and in-class activities: 10%
Homework: 30%
Quiz 5%
Mid term exam: 15%
Group work: 40% (plan @ 10; progress reports @ 10; final presentation @10; final report @10)
Total 100%

Grading Scale
A= 90 to 100 percent; B= 80-89; C= 70-79; D= 60-69; F= less than 60

All the member of a group will acquire the same grade for the "Group project and presentation" part, unless contributions by individual members are reported to be substantially different among the members.

Academic integrity
Academic integrity is essential to a positive teaching and learning environment. All students enrolled in University courses are expected to complete coursework responsibilities with fairness and honesty. Failure to do so by seeking unfair advantage over others or misrepresenting someone else's work as your own, can result in disciplinary action.

SCHOLASTIC DISHONESTY: submission of false records of academic achievement; cheating on assignments or examinations; plagiarizing; altering, forging, or misusing a University academic record; taking, acquiring, or using test materials without faculty permission; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards, or professional endorsement.

Within this course, a student responsible for scholastic dishonesty can be assigned a penalty up to an including an "F" or "N" for the course. If you have any questions regarding the expectations for a specific assignment or exam, ask.

Attendance Policy
You are required to attend every class session, field trips, guest lectures, exams and student presentations. Each unexcused absence is cause for one point grade reduction in the participation score. **More than three unexcused absences** is cause for a failing grade.

To secure an excused absence, you must:

- To the best of your ability, contact the instructors before class to explain why you will be absent and to request an excused absence; and have a legitimate reason for absence as defined by the University of Minnesota. You must provide written documentation as soon as is reasonably possible. According to UMN policy, legitimate absences are for:
    - verified illness (**not** routine checkups!)
    - participation in athletic events or other group activities sponsored by the University
    - serious family emergencies
    - subpoenas
    - jury duty
    - military service
    - religious observances

Arriving at the class later than 15 min after the start of the class is considered as an absence unless the aforementioned criteria for excused absence are met.

21. Environmental Life Cycle Assessment and Green Design

Carnegie Mellon University

SUMMARY

Offered by: Civil and Environmental Engineering
Instructor(s): Scott Matthews

Number of times taught: Three or More
Class size: information not provided
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Graduate
Students' Major: information not provided

12-714/19-614: Environmental Life Cycle Assessment and Green Design
Third Mini, Spring Semester, 6 units

Catalog Description

Cradle-to-grave analysis of new products, processes and policies is important to avoid undue environmental harm and achieve extended product responsibility. This mini-course provides an overview of approaches and methods for life cycle assessment and for green design of typical products and processes. Process-based analysis models, input-output and hybrid approaches are presented for life cycle assessment. Example software programs are used in assignments. A life cycle assessment project is required.

Course Objectives

- Develop an understanding of the concept and framework of Life Cycle Assessment (LCA)
- Develop an understanding of the methods and challenges involved in applying LCA to relevant industrial and social issues
- Gain experience in how and when to use process-based, input-output based, and hybrid LCA methods
- Understand the assumptions, strengths and weaknesses of these types of LCA models.
- Learn how to document and publish LCA studies

Meeting Time and Place
Monday and Wednesday, 3:00-4:30, PH 7F, Mini A3 schedule

Instructors
Prof. Scott Matthews, PH 118-L, 412-268-6218, hsm@cmu.edu
TA: Aurora Sharrard, PH A7A, 412-268-7567, aluscher@andrew.cmu.edu

Overview
This course is part of the 'sustainable engineering' sequence within the graduate program in Civil and Environmental Engineering. This is the first substantive environmental LCA course to be taught at CMU, now in its third offering. CMU has been a leader in both sustainable engineering education, specifically LCA. You are taking the course at the right place.

As a mini, this course will be fast-paced and taught as a seminar/tutorial, with significant time and effort required for readings and work outside of the class period. Note that LCA is a conceptually simple idea – we teach the general method to high school students and they create valid and interesting models. The college-level difficulty comes from learning many methods of implementation, creating quantitative models, interpreting model results qualitatively and quantitatively, etc. Of course you are also expected to think more creatively and critically.

Those of you who have taken a class with me know that I try to create an environment for open discussion of material. This is reflected in my grading expectations, shown below.

Course Grading Notes

- Class participation is not explicitly part of your grade, but will be used in cases of borderline results (e.g., from B+ to A-).
- Assignments are due in class on the designated date (or in my office for final projects). The deliverable is a paper copy of your work. E-mailing your solutions is not sufficient. Homeworks submitted late will incur a penalty of 10% of total points per day late.
- Collaboration is working together to come to frame a problem and work through a solution, discussing results, and analyzing the process. All members of the group contribute, understand the process (sometimes by being taught by other members of the group), and are prepared to complete a similar problem by themselves afterward. Collaboration is encouraged on homework assignments. However, for individual assignments, individual submissions are required. While you may have worked with another in solving the problem the work you hand in must be your own.
- Cheating is copying someone else's work and handing it in as your own work. This is unacceptable.
- Plagiarism is using someone else's published work and not giving them credit. Several web sources or the library have guidelines for referencing work from published journals, books, or newspapers, and from websites.
- Cheating and plagiarism will be handled according to university policies, which include the penalty for the assignment (usually a zero grade), and reporting the incident to Student Affairs.
- Regrades are possible within a one week timeframe after the assignments are returned in class. After that time, no regrades will be considered (except for simple addition errors). To submit a regrade, you should attach a sheet of paper detailing your concerns about the score given and argue your point. Regrade requests should be handed to me in class and not put in my mailbox or under my door.

Four Problem Sets = 75%
One Final Project with Presentation = 25%

Course Materials
Where possible, all material handed out in class will be posted to the web site (http://www.ce.cmu.edu/~hsm/lca2006/). Lecture notes for the entire semester will be available as downloadable PowerPoint presentations. Ideally, slides will be posted weekly for the upcoming 2 class sessions. Students should still come to lecture, since the slide files only show overviews of the material being presented and additional instruction will be done on the board. Feel free to download and bring copies of these presentations to class to follow along. If you elect to do this, please help conserve paper by printing in PowerPoint's 'Handouts' option (2, 3, or 6 slides per page) and with duplex (double-sided) printing.

Textbook / Readings
No text is required. I will hand out or post all readings during the semester, and also provide copies of a nearly-published book on LCA written by several faculty and students of the Green Design Institute. Please help us check for errors – it will be published soon!

LCA is a field growing rapidly in scale and scope. Applications and results are released almost daily. Thus there is a large number of information available on the Internet.

Student Roles and Responsibilities
This class will be taught as a graduate course. For those of you unfamiliar with what this means, here is a short summary of how class will operate:

- All students are expected to read chapters or other handouts before each lecture
- I will lecture on the topic you read, and will lead discussions on the topic
- In lecture I will not generally review the text or use the same examples as done in the book
- There may be material/readings assigned that will not be lectured at all.

In short, this means that while we will follow the readings, I will not be simply reviewing them. Coming to lecture will not be a substitute for the reading, and vice versa. I will make more detailed lecture notes/annotations available for certain key concepts to help you. If you are uncomfortable with this arrangement, you should quickly decide whether to remain registered in the course.

Class Schedule

This preliminary course schedule is provided to you in the hopes that it will help you prepare for the first few weeks of class. There will certainly be changes to this schedule as the semester goes on based on the pace of class. The web site home page will always have the most up-to-date version, and changes will be announced in class. The topics, assignments, and suggested readings are given below.

Lect. No.	Topics / Readings	Misc
1 (Jan 18)	Green Design / Links with Sustainability Sequence	**Project Assign. Out**

History of LCA: from Pepsi to Paper v. Plastic. Europe v. US v. Japan

Readings:

- US EPA Introduction to LCA

Discussion Topics:

- *Connections with embodied energy discussions from 12-712*

  How do we approach 'designing a better/ "green" computer', i.e. how do we translate this high-level goal into a plan of attack? How do we define better? What information do we need to know in advance to be able to know if we succeeded?

2 (Jan 23)	LCA: History and Framework (cont.)	**HW 1 Out**

	UNEP, Life Cycle Assessment: What It Is and How to Do It, UNEP 1996.	
	ISO Framework Documents	
3 (Jan 25)	Process LCA Theory	**Proj. Proposal Due**
4 (Jan 30)	Process LCA Software?	**HW 1 Due** **HW 2 Out**
5 (Feb. 1)	Process LCA Case Studies	
6 (Feb, 6)	Issues in Process LCA	
	connection with EIO – process flow diagram with dollars as units	
7 (Feb. 8)	Economic Input-Output (EIO) Based LCA Theory	
8 (Feb. 13)	EIO-LCA Software	**HW 2 Due** **HW 3 Out**
9 (Feb. 15)	EIO-LCA Case Studies	
	Ochoa et al JIS Residential Buildings LCA	
	"Environmental Implications of Service Industries" Rosenblum, Jeffrey, Arpad Horvath and Chris Hendrickson, Environmental Science & Technology; 34(22); 4669-4676, 2000	
	Joshi 2000 JIE Product-EIO Fuel Tanks	
10 (Feb. 20)	Issues in EIO-LCA	
11 (Feb. 22)	Process/EIO-LCA Comparisons Hybrid LCA Models	**HW 4 Out** **HW 3 Due**
12 (Feb 27)	Life Cycle Impact Assessment Closed-Loop Supply Chains/Full Cost Accounting	
13 (Mar. 1)	Project Presentations	**HW 4 Due**
14 (Mar 6)	Project Presentations (cont.)	**Project Due**

Life Cycle Assessment
Course Project Assignment Details

The course project is intended to provide a realistic opportunity to apply the tools and methods covered in the mini-course. Be sure to cover all aspects of the LCA process (i.e., including suggestion of improvements). For the project, your assignment is to:

- choose an existing or proposed product or process
- select a set of impacts of interest for evaluation
- define an appropriate analysis boundary
- conduct a hybrid life cycle cost and environmental impact inventory
- develop a hybrid life cycle cost and environmental impact assessment
- compare your results to any similar analyses appearing in the literature
- suggest improvements to the product or process
- prepare a 1-2 page summary (that can be posted on the eiolca.net website) of how you could replicate your results there
- report your results in a project report (of less than 20 pages plus data tables) and a presentation

You may choose any product or process you would like. Some suggestions include:

- Texas' plan to build truck-only toll highways
- Comparing granite to concrete
- Comparing hydrogen to existing power or transportation energy sources
- Electro/mechanical devices such as solar cells, wind power generators or Segway transporters.
- Networks such as highways, railways, trucking companies, or power systems.
- Processes/systems such as telework, pharmaceutical production or cleaning.

You should choose your application domain carefully. An ideal topic would be one for which data are readily available, one for which you have familiarity or expert knowledge, one which is of a manageable size, and one which has not been already analyzed.

You will be expected to work in groups, typically of 3 to 5 students. Your reports and presentations should be professional in nature, with calculations and results explained. The body of your report should be no more than 20 pages, although you may have data and sample calculations in an appendix.

Critical dates for the project:

January 25: Project proposals due, including group members, topic, short description of data sources and review of literature for existing studies. One or two pages in length.

March 1: First presentation date. (Groups will be assigned presentation times randomly).

March 6: Project reports due and second presentation date.

12-714 Life Cycle Assessment
Impact Weights Exercise

One of the difficulties in life cycle assessment is making trade-offs between different categories or types of impacts. Various methods have been proposed. For example, the EPA Science Advisory Committee chose to make priorities on the basis of:

- The spatial scale of the impact (large scales being worse than small)
- The severity of the hazard (more toxic worse than less)
- The degree of potential exposure
- The penalty for being wrong.

Suppose you have a large budget to work on pollution prevention in a company. Based solely on your perception of the relative hazards (that is, ignoring relative amounts of plant emissions or the cost of pollution prevention for different categories), what fraction of your budget would you place on the following impact reductions? Total must equal 100%.

1. Toxic water emissions: __________
2. Toxic air emissions: __________
3. Electrical energy efficiency __________
4. Toxic materials in products __________
5. Greenhouse gas emissions __________
6. Petroleum use __________
7. Solid waste reduction __________
8. Product recycling __________
9. Renewable energy production __________
10. Other:__________________ __________
11. Other:__________________ __________

Please fill out these categories and make percentage allocations. We will compile and discuss the class responses. Note: This is not a graded assignment, so feel free to express your own beliefs.

Name: ______________________________

22. Environmental Science in Building Construction

Milwaukee School of Engineering

SUMMARY

Offered by: Architectural Engineering & Building Construction; Environmental Engineering Program
Instructor(s): Carol Diggelman and Deborah Jackman

Number of times taught: Three or More
Class size: 30 to 100
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Upper division
Students' Major: ≥90% Architectural Engineering & Building Construction; Environmental Engineering Program

Winter 2007/2008

Milwaukee School of Engineering
AE 4121 ENVIRONMENTAL SCIENCE IN BUILDING CONSTRUCTION

Carol Diggelman, Ph.D.
Office: CC- 60A Telephone: 277-7320 Email: diggelma@msoe.edu.

S001:	**M-10:00 am– 12:00 pm (CC 48); W-12:00 pm (S341)**
S002:	**Tu-12:00 pm- 2:00 pm (CC-49); W-12:00 pm (S341)**
S003:	**Th-12:00 pm- 2:00 pm (CC-49); W-12:00 pm (S341)**
Office Hours:	**Tu- 2:00 pm, W- 2:00 pm and Th-2:00 pm or by appointment.**

LECTURE HOURS/WEEK: 3
LAB HOURS/WEEK: 0
CREDIT IN QUARTER HOURS: 3
PREREQUISITES: Chemistry 200 and 201, AE 1231, At least junior standing; but preferably senior enrolled in senior design

TEXTBOOK AND OTHER REQUIRED MATERIALS:

- Kibert, C.J. 2007. *Sustainable Construction: Green Building Design and Delivery,* 2nd Edition. John Wiley & Sons, Inc. Hoboken, New Jersey
- Brown, L.R. 2006. *Plan B 2.0: Rescuing a Planet Under Stress and a Civilization in Trouble,* Earth Policy Institute, W.W. Norton & Co. New York, N.Y. Download chapters from http://www.earth-policy.org/Books/PB2/Contents.htm .
- WasteCap Wisconsin C & D Debris Recycling packet from MSOE Bookstore.

COURSE DESCRIPTION:
This course introduces students to environmental aspects and impacts of construction materials, fuels and activities; environmental laws and regulations and elements of sustainable construction. Sustainable construction includes strategies for managing and reducing environmental aspects and impacts to land, air, water and living systems.

COURSE OBJECTIVES:
Upon successful completion of this course, the student will:

- Be introduced to major drivers, including climate change, ozone depletion, degradation of soil, air, water and biological diversity, and resource depletion, of the sustainable construction movement.
- Be able to document environmental impacts of construction materials, activities and operations.
- Be introduced to scientific concepts of sustainable construction.
- Be introduced to the LEED™ suite of standards, including categories, credits and certification process and scientific evidence that LEED™ strategies reduce environmental aspects and impacts.
    - Sustainable sites category
    - Energy and atmosphere category
    - Building hydrologic system category
    - Green building materials category

    - Indoor environmental quality (IEQ)
    - Construction operations, including recycling of materials, erosion and sediment control measures, and protection of indoor air quality
    - Elements and benefits of building commissioning
- Be introduced to tools for quantifying economic benefits of high performance/green buildings
- Be able to complete an independent research project (a search of the engineering literature, a concise written report and a presentation on that report) on a technology with potential to reduce environmental impacts (and increase LEED™ points) on the student's capstone project.

COURSE TOPICS:

- green building definitions and foundations
- green building assessment
- green building process
- sustainable sites and landscaping
- energy and atmosphere
- water
- materials
- indoor environmental quality
- construction operations
- building commissioning
- economic analysis of green buildings

GRADING MATRIX

Assignments

Embodied pollution problem	(due 11.30.07)	25 pts
Waste/recycling assignment	(due 12.21.07)	25 pts
LEED checklist	(due 01.18.08)	25 pts

Quizzes (7 20 min. quizzes- 25 points each; drop lowest 2; final exam- 100 pts) 225 pts

Technical report

1.	Project proposal	(due 12.07.07)	0 pts
2.	Data and key word search strategy	(due 12.14.07)	0 pts
3.	Rough draft	(due 01.11.08)	50 pts
4.	Presentation		25 pts
5.	Final report- (due at time of presentation)		100 pts

Portfolio must include items below: (due at time of final exam) 25 pts

1. Syllabus, quizzes, notes, construction waste management checklist, assignments, rough draft with grading matrix, PowerPoint presentation on disk, lecture notes (disk or paper),
2. LEED™ checklist
3. USEPA Part II. Self-audit checklists (disk)

http://www.epa.gov/compliance/resources/publications/assistance/sectors/constructmyer.html

4. AGC checklist
5. Information requested from owners
6. Material use checklist
7. Material storage checklist
8. Spill reporting and management
9. Waste management summary
10. Storm water pollution prevention plans
11. Training summary

Total **500 pts**

Extra credit: 25 pts

COURSE POLICIES:

- Timeliness and attendance
  - You are expected to be on time for each class.
  - Notify me by email of any absence as much in advance as possible.
  - There may be a penalty of 5% if you miss more than three hours of class.
- Submitting work/late work
  - All work must by typed, with one inch margins, double-spaced for drafts, single-spaced for final copies and submitted in 12 point Times New Roman.
  - Proofread for grammar and spelling prior to submission. Obvious failure to do this will result in a "revise and resubmit" grade.
  - Staple all multi-page submissions.
  - Put your name and a page number on every page you submit.
  - Avoid excessive use of abbreviations and jargon. Check to make sure you have explained all terms and spelled out abbreviations.
  - All writing must be original to you and this course; ideas from others must be properly cited.
  - Late work will only be accepted for 48 hours after the due date and will earn a maximum of C.
- Plagiarism- any confirmed act of plagiarism can result in a failing grade.
- Revise & re-submit
  - If a paper is handed back with "revise and resubmit," revisions must be completed and the paper turned in within 3 days for a new grade.
  - If not turned in, you will receive a grade of D.
- Grading standards
  - A= Exceeded criteria, work thorough, on time, participation excellent.
  - B= Work above minimum criteria in quality and thoroughness, on time.
  - C= Minimum work, assignments on time, meet criteria, work careless.
  - D= Mostly complete work; quality and/or quantity significantly below expectations.
  - F= Incomplete work, didn't follow assignment directions, no improvement in skills.

AE 4121 Course Syllabus Winter 2007/2008

Week. S 1,2,3 Dates	Topic	Reading	AGC	Quizzes/Assignments
1. S1. 11.26.07 1. S2. 11.27.07 1. S3. 11.29.07	Introduction and drivers for sustainability Plan B Ch.1 http://www.earth-policy.org/Books/PB2/PB2ch1.pdf Ch. 2. http://www.earth-policy.org/Books/PB2/pb2ch2.pdf	Kibert 1. 1-16 Kibert 2. 43-55		
1. Combined 11.28.07	**Connie Lindholm, WGBA http://www.wgba.org/**			
11.30.07	**Assignment 1**			**Due**
2. S1.12.03.07 2. S2. 12.04.07 2. S3. 12.06.07	Green Building Assessment https://www.usgbc.org/ShowFile.aspx?DocumentID=1915 and USEPA http://www.epa.gov/compliance/resources/publications/assistance/sectors/constructmyer/myer1c_solidwaste.pdf	Kibert 3. 55-78 Kibert 4. 79-97		**Quiz 1. Notes from Plan B Ch. 1 &2 and Kibert Ch. 1 & 2**
Combined 12.05.07	**Donald P. Gallo, Reinhart Boerner van Deuren, SC, Attorneys at Law http://www.reinhartlaw.com/webpages/0/bio.aspx?id=428**			
12.07.07	**1 page project proposal**			**Due**
3. S1. 12.10.07 3. S2. 12.11.07 3. S3. 12.13.07	Economic analysis of green buildings http://www.buildinggreen.com/auth/article.cfm?fileName=140401a.xml http://www.buildinggreen.com/auth/article.cfm?fileName=161101a.xml	Kibert 13. 327-346		**Quiz 2. Notes from EPA link and Kibert Ch 3 & 4**
Combined 12.12.07	**Theresa Lehmann, The Boldt Company, http://www.theboldtcompany.com/home.html**			
12.14.07	**Data search**			**Due**
4. S1. 12.17.07 4. S2. 12.18.07 4. S3. 12.20.07	Sustainable sites Plan B Ch.5 http://www.earth-policy.org/Books/PB2/pb2ch5.pdf	Kibert 6. 133-159		**Quiz 3. Notes from Building green link and Kibert Ch. 13**
Combined 12.19.07	**Dan Kabara and Kevin Donohue, Engberg Anderson Design Partnership Inc. http://www.eadp.com/whats_new.html#cityhall**			
12.21.07	**Waste recycling Assignment**			**Due**
5. S1. 01.07.08 5. S2. 01.08.08 5. S3. 01.10.08	Energy and atmosphere Plan B Ch.4 http://www.earth-policy.org/Books/PB2/pb2ch4.pdf	Kibert 7. 161-216	10	**Quiz 4. Notes from Plan B Ch. 5 and Kibert Ch. 6**

Combined 01.09.08	**Jeremy Poling, Assistant Project Manager, Strategic Services Group A. Epstein and Sons, International, Inc., http://www.epstein-isi.com/**			
01.11.08				**Rough draft /due**
6. S1. 01.14.08 6. S2. 01.15.08 6. S3. 01.17.08	Water-quantity and quality parameters Plan B Ch. 3 http://www.earth-policy.org/Books/PB2/pb2ch3.pdf	Kibert 8. 217-237	9	**Quiz 5. Notes from Plan B Ch.4 and Kibert Ch. 7**
Combined 01.16.08	**Willie Gonwa, Symbiont, http://www.symbiontonline.com/**			
01.18.08				**LEED™ checklist due**
7. S1. 01.21.08 7. S2. 01.22.08 7. S3. 01.24.08	Materials and the environmental impact of materials' consumption Diggelman notes	Kibert 9. 239-275	5, 6, 7, 8	**Quiz 5. Notes from Plan B Ch.3 and Kibert Ch. 8**
Combined 01.23.08	**Jenna Kunde, WasteCap Wisconsin http://www.wastecapwi.org/**			
8. S1. 01.28.08 8. S2. 01.29.08 8. S3. 01.31.08	Indoor Environmental Quality (IEQ) http://www.buildinggreen.com/auth/article.cfm?fileName=131001a.xml	Kibert 10. 277-306	11	**Quiz 6. Diggelman notes and Kibert Ch. 9**
Combined 01.30.08	**Steven Botic, Environmental Engineer, Applied Materials, http://www.appliedmaterials.com/news/index.html**			
9. S1. 02.04.08 9. S2. 02.05.08 9. S3. 02.07.08	Construction operations Presentations	Kibert 11. 309-316		**Quiz 7. Notes on IEQ and Kibert Ch. 10**
Combined 02.06.08	**Bryce Unger, C.G. Schmidt, http://www.cgschmidt.com/home/home.cfm**			
10. S1. 02.11.08 10. S2. 02.12.08 10. S3. 02.14.08	Class presentations			
Combined 02.13.08	**Commissioning TBD, J.F. Ahern and Sons http://www.jfahern.com/index.html**			
02.15.08	**Reports due**			**All work due**
TBD	**Final Exam - LEED practice test**			**Portfolio due**

AE 4121 TECHNICAL REPORT **Winter 2007/2008**

The goal of this project is to identify one line item from your senior design (or other) project that you would like to evaluate and possibly upgrade for LEED™ points. There is a universe of potential topics, including engineered wood products, high performance steel, stainless steel, aluminum, insulation, concrete admixtures or replacements (flyash, blast-furnace slag), sealants and adhesives, painting systems, new applications for plastics, CFC replacements, fire retardant materials, lighting fixtures, roofing materials, toilets, etc.

In your report you must do a search of the **engineering** literature. You may also search the general literature and the Internet; however, some of the information you will need will probably not be available there. You may interview practitioners and vendors, but there may be biased information from these sources. By contacting several practitioners or vendors, sources can be better evaluated for bias. All sources of information must be referenced in the body of the paper using http://w3.msoe.edu/library/technical_style_guide.shtml .

What is the current state-of-the-art (baseline) construction material or application? What is the alternative? A comparison must include **performance, life-cycle costs and environmental impacts**. How does the design life of the alternative compare with the baseline? What are capital and operating/maintenance costs over the life cycle for each? What is the difference in life cycle energy impacts? What is the difference in life cycle hazardous and solid waste impacts? What are end-of-life impacts? How recyclable is the material/application/product? Does the alternative contribute to indoor air pollution? What are construction issues? How many LEED™ points is this worth?

The length of the report should be about five pages per person. The topic should be chosen so that there is adequate material to cover the topic and the topic is not too broad to cover in depth. Each student will do a research projects on different aspects of your group's senior project. Reports may be attached to the senior design project report given to the client.

Below is the matrix that will be used to grade your rough draft and final report.

Grading Matrix for Paper: (Maximum length = 5 double-spaced pages per person.)		
Report Section	**Points**	**Your Points**
Abstract- In one paragraph (200 words or less) give purpose, methods, and **most important findings**.	**10**	
Project definition- Define baseline material/product/application/technology and alternative.	**10**	
Evaluation of performance- Summarize current literature on performance of alternative from engineering, Internet, vendor sources; compare performance of alternative to baseline.	**15**	
Standards, including ASTM standards. If no standards, indicate where you have searched.	**10**	
Evaluation of life cycle costs (including capital and operating)- Compare life cycle costs of alternative to baseline material/product/application/technology.	**15**	
Evaluation of life-cycle environmental impacts- Compare baseline and alternative for most important environmental impacts, including emissions, water, materials, wastes.	**10**	
Conclusions and recommendations- Give conclusions. Make recommendations regarding selection of alternative for senior design project.	**10**	
LEED™ points and defense of points- How many LEED™ points is this worth? What documentation is required? How are you justifying these points?	**10**	
References- From referred engineering journal and within past 5 years. Use MSOE format http://w3.msoe.edu/library/technical_style_guide.shtml .	**10**	
Appendix- Calculations, vendor information, MSDS, specifications, supporting information.		
Total	**100**	

AE4121. PRESENTATION EVALUATION **Winter 2007/2008**

PEER EVALUATIONS: Each presentation will be peer evaluated.

The criteria and point allocation are given below:

1. (10 PTS) **Quality of information.** ___
- Evidence of research in current peer-reviewed engineering literature
- Evidence of practitioner/vendor contacts
- Evaluation of performance comparison
- Evaluation of life-cycle cost comparison
- Evaluation of environmental aspects and impacts comparison

2. (5 PTS) **Quality of organization.** ___
- Concise opening/overview
- Information follows logical sequence
- Concise summary and conclusions

3. (10 PTS) **Quality of presentation.** ___
- Visuals
  - Readable
  - Easily understood
- Good eye contact with each member of audience
- Good voice projection
- Interesting
- Stayed in time allotment

4. (25 PTS) **Total** ____

Constructive comments:

23. Environmental Sustainability: Life-Cycle Assessment Tools

Rutgers, The State University of New Jersey

SUMMARY

Offered by: Environmental Sciences
Instructor(s): Uta Krogmann

Number of times taught: Once
Class size: Less than 10
Class format: 2 hours of lecture plus 2 hours "other" contact per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Graduate
Students' Major: 50% Environmental Sciences
50% other non-engineering

Rutgers University
Department of Environmental Sciences

16:375:625 ENVIRONMENTAL SUSTAINABILITY: LIFE-CYCLE ASSESSMENT TOOLS

Description: Theory of analytical tools to assess environmental sustainability of goods and services including sustainability metrics; material flow analysis; SETAC-EPA life-cycle assessment (LCA), Economic Input-Output life-cycle assessment and cost-benefit analysis. Application of LCA to the new New Jersey Meadowlands Commission (NJMC) observatory and classroom building in Lyndhurst, NJ.

Instructor: Dr. Uta Krogmann
Department of Environmental Sciences
ENR Building, 14 College Farm Road, Room 246
Email: krogmann@aesop.rutgers.edu

Schedule: Wednesday/Friday 10:55 am -12:15 pm.
ENR 223 and ENR 323 (on Friday only, starting 9/21)

References:

A list will be available on the course website.

Preliminary Schedule:

1. Introduction (9/5)
2. Major environmental issues (9/7)
3. Life cycle assessment - overview (9/12)
4. Life cycle assessment - inventory (9/14)
5. Life cycle assessment - impact assessment (9/19)
6. SimaPro[1] Workshop (9/21)
7. Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ (9/26)
8. Visit of the new New Jersey Meadowlands Commission observatory and classroom building (9/28)
9. No classes to compensate for SimaPro Workshop (10/3)
10. Work on project (10/5)
11. Streamlined LCA and Economic Input-Output life-cycle assessment (10/10)
12. Work on project (10/12)
13. Data sources and data uncertainties (10/17)
14. Work on project (10/19)
15. Critical review of LCA articles (10/24)
16. Work on project (10/26)
17. Critical review of LCA articles (10/31)
18. Work on project (11/2)
19. Sustainability metrics (11/7)

[1] SimaPro is a LCA software (see also http://www.pre.nl/)

20. Work on project (11/9)
21. Work on project (11/14)
22. Work on project (11/16)
23. Material Flow Analysis (11/21)
24. Visit of Willow School(11/28)
25. Cost-benefit analysis (11/30)
26. Work on project (12/5)
27. Sustainability at Johnson & Johnson (12/7)
28. Final project presentation (12/12)

Notes:

1. The group project of this course is the development of an LCA of the new New Jersey Meadowlands Commission (NJMC) observatory and classroom building in Lyndhurst, NJ.
2. Part of this course is the participation in the SimaPro workshop, a site visit to the new NJMC building and a site visit to another green building.
3. Check your e-mail regularly for important notices about the course. Class notes will be posted on the Environmental Sciences website (http://envsci.rutgers.edu/~krogmann/625). You need to register for access to the website by sending an email to krogmann@aesop.rutgers.edu.
4. Final grade determination
   - Class participation – 30%
   - Project report (incl. LCA in SimaPro) – 30%
   - Project oral presentation – 20%
   - Project poster – 20%

24. Environmentally Benign Design and Manufacturing

Massachusetts Institute of Technology

SUMMARY

Offered by: Mechanical Engineering
Instructor(s): Tim Gutowski

Number of times taught: Three or More
Class size: 10 to 30
Class format: 3 hours of lecture per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Upper division and graduate (1:1)
Students' Major: 80% Mechanical Engineering
20% Other engineering

2.83 (Grad) & **2.813** (Undergrad)
Environmentally Benign Design and Manufacturing

T.G. Gutowski (gutowski@mit.edu)

New 2/26/08

Spring 2008 **Mon. & Wed. 2:30 – 4 p.m.** **Room 35-520**

February	**Monday**	**Wednesday**
		6. Introduction
	11. Eco-Footprint	13. Scale, Flow and Cycles
	(Tues) 19. Sustainability?*	20. Intro to LCA
	25. "ELSA"	27. Scale and Efficiency
March		
	3. Visitor	5. Energy/Exergy
	10. Materials Production	12. "Coal" discussion
	17. Discussion	19. Quiz 1
	24. (Spring Break)	26. (Spring Break)
	31. Manufacturing	
April		2. Manufacturing
	7. End-of –Life	9. Recycling
	14. Remanufacturing	16. Design for…
	21. Patriots Day	23. Visitor
	28. Visitor	30. Presentations
May	5. Presentations	7. Field Trip
	12. Review	14. Quiz 2

* Monday schedule on Tuesday; 2.83 website: http://web.mit.edu/2.813/www/

25. Environmentally Conscious Design and Manufacture

Georgia Institute of Technology

SUMMARY

Offered by: Mechanical Engineering
Instructor(s): Bert Bras

Number of times taught: Three or More
Class size: 10 to 30
Class format: 6 hours of lecture per week

Portion of course focused on sustainable engineering: More than 50%

Student Level: Upper division
Students' Major: 80% Mechanical Engineering
20% Other engineering

ME 4171 – Environmentally Conscious Design and Manufacture

Instructor Prof. Bert Bras. Telephone: (404) 894-9667

Catalog Listing Inclusion of environmental considerations in engineering design; reduction of environmental impact by design; recycling; material selection; demanufacturing and remanufacturing; life-cycle considerations and trade-offs.

Credits 3 credits. Lecture/discussion 3 hours per week.

Prerequisites Senior standing.

Textbook Selected chapters from:
- "Green Products by Design: Choices for a Cleaner Environment", US Congress, Office of Technology Assessment, OTA-E-541, US Government Printing Office, Washington, D.C., October 1992.
- "Environmentally Benign Manufacturing", International Technology Research Institute, World Technology (WTEC) Division, Panel Report, April 2001.

Both can be downloaded from the course website.

Suppl. notes Course notes and selected papers for reading are to be found on the Systems Realization Laboratory Web server under education and ME4171 (http://www.srl.gatech.edu/education/ME4171/).

Objective To provide Mechanical Engineering students and others interested in engineering design a view of how the environmental impact of engineering systems can be reduced by design.

Outcome
- The course is designed to give the students an opportunity to learn about environmentally conscious design and manufacture, the growing national and international efforts in reducing the environmental impact of products, and how the environmental considerations affect the design's technical, economical and quality requirements.
- The understanding of the students is fostered by means of various hands-on assignments.
- The students should be able to use the knowledge gained in this course in practical design situations.

Assessment

A grade is determined using the following means:
- Homework (40%)
- Final exam regarding the material covered (30%), and
- Major (group) project (30%). The students have to demonstrate the ability to apply the course material by designing an environmentally benign product and/or process.

Assessment of the project assignments is based on the originality/difficulty of the problem undertaken, technical content, and quality of report and results. Weightings may be subject to minor changes.

Dr. Bert Bras Telephone: 404-894-9667 Fax: 404-894-9342 E-mail: bert.bras@me.gatech.edu

Topics (subject to change and not necessarily in this order):

Introduction

Motivation and examples of environmental impact

Product life cycles

Business drivers
- Regulations;
- Triple Bottom Line;
- ISO 14000 Environmental Management Standards

Environmental impact reduction approaches
- Environmentally conscious design and manufacturing approaches;
- Sustainable development and industrial ecology;
- Biomimicry and biologically inspired design

Measuring environmental loads and impacts
- Mass & energy balances;
- Material toxicity & MSDS;
- Indicators and metrics;
- Spatial & temporal boundaries

Manufacturing & Pollution Prevention
- EPA guidelines, regulations, and procedures;
- Toxic Release Inventory;
- Pollution prevention practices;
- Nano-manufacturing

Recycling and Demanufacture
- Motivation (take-back legislation), concerns, definitions, examples;
- Recycling and demanufacture processes;
- Recyclability assessments;
- Design for Recycling practices, guidelines, methods, and tools;
- Trade-offs.

Life-Cycle Assessment (LCA)
- Motivation, definitions, approaches, examples;
- LCA methodology, steps, tools, problems;
- Life-Cycle Costing

Design for Environment
- Practices, guidelines, methods, and tools;
- Trade-offs.

Service, Reuse and Remanufacturing
- Motivation, issues, concerns, definitions, examples;
- Remanufacture processes (disassembly, inspection, cleaning, testing, and re-assembly);
- Remanufacturability assessments;
- Design for Remanufacture/Reuse practices, guidelines, methods, and tools;
- Lean remanufacture;
- Trade-offs.

Dr. Bert Bras Telephone: 404-894-9667 Fax: 404-894-9342 E-mail: bert.bras@me.gatech.edu

26. Fuel Cell Science and Technology

Colorado School of Mines

SUMMARY

Offered by: Ryan O'Hayre and Neal Sullivan
Instructor(s): Metallurgical and Materials Engineering

Number of times taught: Three or More
Class size: 30 to 100
Class format: 3 hours of lecture plus 1 hour of "other" contact per week

Portion of course focused on sustainable engineering: 10 to 25%

Student Level: Upper division and graduate (2:1)
Students' Major: 40% Metallurgical and Materials Engineering
60% Other engineering

Fuel Cell Science and Technology

Spring 2008; MWF 3:00-3:50PM; Hill Hall 204

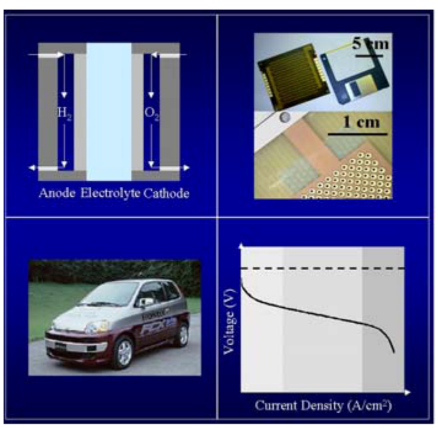
Instructor:	Ryan O'Hayre	**Instructor:**	Neal Sullivan
Office:	Hill Hall 354	**Office:**	Brown 309
Phone:	x3952	**Phone:**	x3656
E-mail:	rohayre@mines.edu	**E-mail:**	nsulliva@mines.edu
Office Hours:	MWF 11-11:50AM	**Office Hours:**	MWF 4:00-6:00PM
Teaching Asst.:	Michael Sanders	**Teaching Asst.:**	Tim Jochum
Office:	Hill Hall 384	**Office:**	Hill Hall 384
Phone:	x3176	**Phone:**	x3176
E-mail:	misander@mines.edu	**E-mail:**	tjochum@mines.edu
Office Hours:	MW 2-3:00PM	**Office Hours:**	T/R 2-3:00PM

Text: R. O'Hayre, S.W. Cha, F.B. Prinz *Fuel Cell Fundamentals* John Wiley and Sons, Inc., New York, New York, 2005

J.H. Hirschenhofer, D.B. Stauffer, R.R. Engleman, M.K. Klett, *DOE Fuel Cell Handbook*, 7^{th} Ed. (2002) *(Available for free on class website.)*

Prerequisites: Differential Equations (MACS 315) Physics I/II (PHGN100/PHGN200), Thermodynamics (MTGN351 or EGGN371 or CHEN357), equivalent, or instructor consent.

Audience: Targeted at advanced undergraduate or beginning level graduate students in the engineering or physical sciences. We anticipate diverse student backgrounds and furthermore recognize that the electrochemical concepts will be new to most students. Therefore, the material will be presented assuming no prior background in electrochemistry. Much of the material covered will be theoretical and fundamental in nature.



Description: Fuel cells provide one of the most efficient means for converting the chemical energy stored in a fuel to electrical energy. Fuel cells offer improved energy efficiency and reduced pollution compared to heat engines. While composed of no (or very few) moving parts, a complete fuel cell system amounts to a small chemical plant for the production of power. This course introduces students to the fundamental aspects of fuel cell systems, with emphasis placed on proton exchange membrane (PEM) and solid oxide fuel cells (SOFC). Students will learn the basic principles of electrochemical energy conversion while being exposed to relevant topics in materials science, thermodynamics, and fluid mechanics.

Outline:

- Fuel Cell Principles
  - What is a Fuel Cell?
  - Fuel Cell Thermodynamics
  - Fuel Cell Kinetics
  - Fuel Cell Charge Transport
  - Diffusion and Mass Transport
  - Fuel cell Modeling
  - Fuel cell Characterization

Fuel Cell Technology
- Fuel cell Types
- Fuel cell Stacking
- Fuel cell Systems
- Fuel cell Applications

Objectives: By the end of the course, students will have gained the skills and knowledge to demonstrate the following objectives:

- **Fuel Cell Characteristics.** Contrast the advantages and disadvantages of fuel cells to other energy conversion technologies (e.g. heat engines). Discuss the advantages and disadvantages between the various fuel cell types (SOFC, MCFC, PAFC, AFC, PEMFC).
- **Fuel Cell Thermodynamics.** Perform thermodynamic calculations to quantitatively predict ideal fuel cell voltages as a function of gas concentrations, pressure, and temperature. Calculate thermodynamic efficiencies. Perform heat and mass balances on fuel cell systems. Describe the basic mechanisms of fuel cell reactions, electron transfer, and ionic transport at the molecular scale.
- **Fuel Cell Kinetics.** Derive equations for activation, IR, and concentration losses in fuel cell systems. Assemble a complete (simple) analytical model for a fuel cell system and use it to predict fuel cell performance over a range of operating conditions (e.g. at various temperature, pressures, feed rates, etc.) Identify the most significant kinetic constraints that limit current fuel cell performance and suggest research directions to improve performance.
- **Fuel Cell Research.** Identify the major materials issues remaining in fuel cell design. Describe the most important characterization techniques used to test fuel cell performance and identify bottlenecks.
- **Fuel Cell Systems.** Describe the major strategies for fuel cell stacking. Compare planar vs. vertical fuel cell interconnection. Discuss the major fuel cell system applications (portable, transportation, stationary power) and be able to argue which fuel cell types are most suited for each application. Discuss and describe the ancillary equipment necessary for a complete fuel cell system (Compressors, humidification, reformers, heat management, power conditioning). Perform a basic economic analysis to predict the cost reductions necessary such that fuel cell systems can be economically competitive with current energy conversion technologies.

Grading: Fuel cell concepts will be illustrated with homework sets, a midterm, and a comprehensive final:

Homework (Undergraduates: 30%, Graduates: 25%) Homework is due at the beginning of class on the due date. Collaboration on homework is encouraged, although each person must turn in his or her own set of homework solutions. Complete work must be provided; answers without detailed supporting work will receive **ZERO** partial credit. Please box your final answers. **LATE HOMEWORK WILL NOT BE ACCEPTED.**

Midterm (Undergraduates: 30%, Graduates: 25%) An in-class midterm exam will be given, just before spring break, covering the material presented to that point in the lectures, homework, and readings. One page of hand-written notes (back and front) is permitted.

Final Exam (Undergraduates: 35%, Graduates: 35%) A comprehensive in class final exam (standard 2 hour exam) will be given at the end of the semester. Two pages of hand-written notes (back and front) are permitted.

Graduate Presentations (Undergraduates MUST attend: 5%, Graduates MUST present: 15%.) Graduate students will analyze a highly cited (> 25 citations) paper from the fuel cell literature. At semester end they will each give a ~5-10 minute presentation on the research addressed in the paper. Undergraduates should attend these presentations and will be graded on attendance/participation.

27. Fundamentals of Sustainability Science

Rochester Institute of Technology

SUMMARY

Offered by: Golisano Institute for Sustainability
Instructor(s): Tom Seager

Number of times taught: Once
Class size: Less than 10
Class format: 4 hours of lecture per week (quarter system)

Portion of course focused on sustainable engineering: More than 50%

Student Level: Graduate
Students' Major: 75% Other engineering
25% Non engineering

Rochester Institute of Technology
Rochester, New York

GOLISANO INSTITUTE FOR SUSTAINABILITY

NEW COURSE PROPOSAL
Fundamentals of Sustainability Science (5001-XXX)

1.0 **Title**: Fundamentals of Sustainability Science **Date**: Oct. 3, 2007
Credit Hours: 4
Prerequisite(s): A minimum of four credits in calculus (or higher), economics, and any one of the following: physics, chemistry or biology. Research experience and graduate standing recommended. Exceptions are by permission of Instructor.
Corequisite(s): none
Course proposed by: Dr. Thomas P. Seager

2.0 **Course information:**

	Contact hours	Maximum students/section
Classroom	4	30
Lab	0	NA
Studio	0	NA
Other (specify ________)	0	NA

Quarter(s) offered (check)
__X__ **Fall** _____ **Winter** ______ **Spring** ______ **Summer**

Students required to take this course: (by program and year, as appropriate)
None

Students who might elect to take the course:
Students who are interested in sustainability and the environmental aspects of manufacturing, production and other industrial activities will take this course. Several different types of students are expected to enroll, including:

- Graduate students and exceptional undergraduate students throughout RIT seeking electives in sustainability or preparing to participate in research related to sustainability; and
- Qualified employees of area manufacturing, engineering, or environmental services firms, as well as government employees, seeking additional education related to sustainability and environmental management, engineering and/or design.

For Curriculum Committee Review Only

3.0 Goals of the course (including rationale for the course, when appropriate):
This course will enhance students' understanding of the interaction between industrial, environmental/ecological and social systems by training them in the scientific method as it applies in a team-based transdisciplinary approach to sustainability, introducing them to systems thinking and the multiple scientific disciplines of sustainability and preparing them to conduct research in sustainable production and consumption systems. Students who successfully complete this course will be able to:

- Understand multiple perspectives on sustainability such as strong and weak formulations, different scientific approaches to sustainability and the importance of sustainability in relation to related research efforts such as green chemistry, eco-efficiency, or design for environment.
- Write research proposals and form hypotheses related to sustainable production and consumption and identify research needs at the linkages between different product life-cycle stages.

4.0 Course description (as it will appear in the RIT Catalog, including pre- and co-requisites, quarters offered)

5001-XXX Fundamentals of Sustainability Science
This course prepares students to conduct original research related to sustainable production and consumption systems and apply the scientific method in an integrative, team-based approach to graduate research. This course introduces the fundamental concepts of industrial ecology, ecological economics, ecosystem health and social ecology that are essential to understanding the interaction of industrial and ecological systems. Successful students will understand multiple perspectives on sustainability such as strong and weak formulations, the importance of sustainability as an ethical concept and a life-cycle approach to organizing research related to sustainability. It is a core course within the Sustainability M.S. and Ph.D. programs. (Enrollment in the Sustainable Production Systems program or permission of instructor) Class 4, Credit 4 (F)

5.0 Possible resources (texts, references, computer packages, etc.)
Please see end notes for a bibliographic listing of reading assignments.

6.0 Topics (outline):

6.1 Understanding Sustainability
- 6.1.4 Contrasting definitions on sustainability and sustainable development
- 6.1.5 Strong v. Weak formulations[1 2]
- 6.1.6 Resilience and Holling's panarchy[3]
- 6.1.7 Seager's sustainability spectrum[4]
- 6.1.8 Sustainability as an ethical concept[5 6]

6.2 The Sustainability Sciences

- 6.2.4 The evolution of environmental thinking and regulations
- 6.2.5 Systems thinking
  - 6.2.5.1 Industrial Ecology[7]
  - 6.2.5.2 Ecological Economics[8]
  - 6.2.5.3 Ecosystem Health[9]
  - 6.2.5.4 Human, Social and Political Ecology[10]
- 6.2.6 Eco-efficiency, green chemistry & design for environment

6.3 Assessing Sustainability
- 6.3.4 Understanding metrics and indicators[11]
- 6.3.5 A taxonomy for sustainability metrics[12]

6.4 A Scientific Method for Sustainability
- 6.4.4 Problem statement
- 6.4.5 Hypothesis & supporting evidence
- 6.4.6 Investigative method
- 6.4.7 Expected Results

6.5 Research in Sustainable Systems (student presentations)
- 6.5.4 Products and Production
- 6.5.5 Energy
- 6.5.6 Sustainable Consumption
- 6.5.7 Policy for Sustainability

7.0 Intended learning outcomes and associated assessment methods of those outcomes

7.1 Understand multiple perspectives on sustainability.
- 7.1.1 Learning Activities: Reading assignments and class discussion will introduce students to basic concepts regarding sustainability. Students will complete critical literature review papers that elucidate key concepts of their choosing in further detail. Results will be shared in individual presentations summarizing the findings of the review.
- 7.1.2 Students must earn a satisfactory grade on their paper and presentations. Grading criteria will include accuracy, originality, clarity and quality of presentation. Also, students will undergo a written examination regarding the concepts presented in class, including descriptions of terms and essay questions requiring synthesis of multiple concepts. Grading criteria will include consistency of argument, completeness and incorporation of examples drawn from literature.

7.2 Write research proposals
- 7.2.1 Learning activity. Lecture and discussion will introduce a viable research proposal outline. Example research proposals will be

circulated. Students will complete peer reviews of sample research proposals and participate in Instructor-guided mock panel discussions to generate a panel summary. Finally, students will develop individual essays stating a problem, research hypothesis and investigative approach that relates to their graduate or undergraduate research topics -- or some other area of their professional interest. Students will include the basis of the hypothesis and description of the salient independent and dependent variables, as well as descriptions of the intellectual merit and broader impacts of their work. At the conclusion of the class, students will defend a research proposal describing an investigative approach that informs their hypothesis. Students will submit original research proposals related to their individual topics of interest for review by the class.

7.2.2 Assessment: During the first month of class, students must submit an original hypothesis essay that is accepted by the Instructor. At the conclusion, the quality of the student proposal presentations will be judged in peer review. Students must earn satisfactory grades *on their review of their peers* as well as their presentations. Grading criteria for the presentations will include originality, clarity of thought, completeness and quality of written presentation as well as intellectual merit. Grading criteria on the reviews will include the quality and originality of questions asked during the proposal defense and written feedback delivered to the student presenters.

8.0 Program or general education goals supported by this course

This course will support graduate and undergraduate education objectives in programs that relate to the environment, business, production and policy throughout RIT. Furthermore, this course directly supports several program objectives in the proposed Sustainability Institute Ph.D. program, such as:

8.1 Specify quantifiable sustainability objectives and strategies for achieving them.
8.2 Model and improve complex industrial-environmental-social systems with respect to sustainability objectives.
8.3 Define and conduct forward-looking sustainability research.
8.4 Lead multidisciplinary teams working on sustainability issues.
8.5 Create new sustainable production/remanufacturing/recycling methods and to improve existing ones.

9.0 Other relevant information (such as special classroom, studio, or lab needs, special scheduling, media requirements, etc.)

A room suitable for group presentations and discussion must be secured.

For Curriculum Committee Review Only

10.0 Supplemental information
None.

11.0 Endnotes.

[1] Neumayer E. 2003. *Weak Versus Strong Sustainability: Exploring the Limits of Two Opposing Paradigms.* Edward Elgar: Northampton MA.

[2] Ayres RU, van den Berrgh, J. Gowdy, J. 2001. Strong versus weak sustainability: Economics, natural sciences, and consilience. *Environmental Ethics.* 23(2):155-168.

[3] Holling CS. 2001. Understanding the complexity of economic, ecological, and social systems. *Ecosystems*. 4:390–405.

[4] Seager TP. 2007. The science of sustainability. *Business Strategy and the Environment*. Accepted for publication.

[5] Cairns JJ. 2003. A preliminary declaration of sustainability ethics: Making peace with the executioner. *Ethics in Science and Environmental Politics*. 26:43-48.

[6] Shearman R. 1990. The meaning and ethics of sustainability. *Environmental Management*. 14(1):1-8.

[7] Seager TP, Theis TL. 2002. A uniform definition and quantitative basis for industrial ecology. *J. Cleaner Production*. 10(3):225-235

[8] Costanza R. 2001. Visions, values, valuation and the need for an ecological economics. *Bioscience*. 51(6):459-468.

[9] Rapport DJ. 2002. The health of ecology and the ecology of health. *Human and Ecological Risk Assessment*. 8(10:204-215.

[10] Keil R, Bell DVJ, Penz P, Fawcett L. 1998. *Political Ecology: Global and Local.* Routledge: New York NY

[11] Seager TP, Satterstrom FK, Tuler SP, Kay R, Linkov I. 2007. Typological review of environmental performance metrics (with illustrative examples for oil spill response). *Integrated Environmental Assessment & Management.* 3(3):310-321.

[12] Seager TP. 2004. Understanding industrial ecology and the multiple dimensions of sustainability. In *Strategic Environmental Management* by O'Brien and Gere Engineers. John Wiley & Sons: New York NY. ISBN: 0-471-09221-5.

See 3 companion Word documents for remainder of this Appendix.