EVEN 3550: Sustainability Principles for Engineers
Spring 2017, Monday-Wednesday-Friday, 11:00-11:50am, 150 ECCR

Course Description

This is a fundamental sustainability course for EVEN students. This course introduces students to sustainability principles in the field of environmental engineering. During this class, students will apply these principles to engineering problems in order to evaluate the environmental, economic, and social implications of engineering and design decisions. Topics include definition(s) of sustainability, main engineering sustainability challenges (e.g., water, energy, climate, and materials), pollution generation and prevention, and sustainability assessment tools (e.g., life cycle assessment).

Course Objectives

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

1. Define sustainability, in particular, as it applies to engineering problems.
2. Describe the main sustainability challenges in engineering (e.g., water, energy, climate, materials, etc.).
3. Calculate and balance the material and energy flows over multiple life cycle stages of engineered systems.
4. Describe the mechanisms of environmental impacts due to pollution (e.g., for smog, ozone depletion, eutrophication, etc.).
5. Interpret life cycle assessment results to recommend potential solutions engineering problems.
6. Compare engineering systems and justify engineering design decisions based on the results of sustainability assessments by identifying and describing the relevant environmental, economic, and/or social impacts.

Instructor

Sherri M. Cook, Ph.D. ("Professor Cook")
Assistant Professor, CEAE Department
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*Office Hours (ECES 103D):
Mondays: 1:00-2:00pm
Fridays: 9am-10am

Teaching Assistant

Christopher Jones ("Topher")
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*Office Hours (ECES 103D):
Thursdays: 4:30-5:30pm
Wednesdays: 12:00-1:00pm

*Attending office hours is the most effective way to get your questions answered and get additional help.

Pre-/Co-Requisite

CVEN 3414: Fundamentals of Environmental Engineering

Textbook and Notes

Sustainability: A Comprehensive Foundation, by Tom Theis & Jonathan Tomkin
(Available as a free pdf or e-book at: http://cnx.org/content/col11325/latest/)
Other texts as provided (announced on D2L)

Student Work and Grading

Exams (2)	30%
Final Exam	20%
Assignments**	40%
Participation & Professional Conduct	10%

**Assignments include homework, quizzes, current event presentations, and any additional assignments as announced in class; the 40% of the final grade be distributed approximately: 25% homework, 13% quizzes, and 2% current event presentations.

Exams. All exams will be closed note/closed book. Exams will be a mixture of problems to be solved (modeled after in-class examples and homework assignments) and conceptual questions (from the reading, lecture materials, and discussions). Equally (if not more) important is one's understanding of fundamental concepts. Exam concepts will be cumulative, so the second exam will build upon the first exam and all class material will be covered by Final Exam.

Homework: Homework assignments will be due at the start of the class period. Late homeworks will be accepted, with a 50% penalty, until the solution is posted; after that time, no late homeworks will be accepted. Homework is used primarily as a learning tool in this class (vs. an assessment tool), and it is designed to be an extension of the lecture. So it is essential that each student complete homework assignments in order to fully grasp concepts that will be tested on exams. Students are allowed (and encouraged) to discuss problem solving strategies with their classmates; however, each student must hand in solutions that have been generated individually. Violations of the honor code will be strictly enforced.

Use the following homework format requirements to be evaluated for full credit:

- Use only one side of engineering paper or unlined white paper.
- Complete the assignment using pencil or black ink.
- Include your name and page number on each page of your homework.
- Staple all pages together.
- Write legibly.
- Clearly explain all steps and assumptions.
- Show all work and include units on all values.
- Box the final answer with the proper units and significant figures.

Quizzes. To emphasize important concepts from the reading material and to help prepare students for lectures and class discussions, quizzes will be given regularly. The quizzes will be open book and must be completed independently. Quizzes are to be completed on the D2L website by the specified deadline. Quiz questions will be formulated from the assigned reading. In addition, unannounced quizzes may be given in class.

Current Event Presentations. To increase the number and diversity of the topics covered in class and to help students keep up with current research and news, each student will present on a current affair with a short presentation (about 2 minutes). The presentation will need to give an overview of a relevant sustainability challenge or topic and provide a brief description of how to apply sustainability principles to help solve the problem. An example presentation will be given during class and a PowerPoint slide template will be provided. All presentations must be uploaded by 9am the day of the presentation.

Participation. Tackling engineering sustainability challenges requires the collection and analysis of quantitative and qualitative data as well as the use of critical thinking while considering multiple perspectives, therefore lectures will be supplemented with in-class discussions, exercises, and group work. Active participation in classroom discussions is encouraged. In-class exercises will be collected at random for grading. Also, the instructor may call on individuals randomly to discuss what they know about concepts that were in the reading assignments but that may not have been presented in class yet. Therefore, it is imperative for learning that students keep up with assigned readings and actively participate during class. Class attendance will be recorded on random days. Excused absences will not count against your participation grade (documentation will be required to confirm).

Professional Conduct: This is a fundamental course that you are taking to prepare yourself as a professional in the engineering field. You are expected to act professional and respectful during classroom activities. For written communications, your presentation must be professional (e.g., clean and organized papers and writing). For email communications, include "CVEN 4834" in the subject line and write well thought out and professional emails (e.g., correct grammar, clear writing, etc.). Students are responsible for regularly checking their e-mails from me and for the announcements and materials posted on the Desire2Learn website.

Grading Policy: Graded material will be returned as soon as possible and solutions will be available on D2L. Questions about the assessed material is strongly encouraged throughout the semester. Questions about grading will only be considered (1) within one week of the assignment or exam being returned and (2) with a professional, brief, and written explanation of requested grading changes based on the student's review of the posted solution. If a re-grade is conducted, then the entire assignment or exam may be re-evaluated and re-graded.

Distribution of final grades will take into consideration an individual's absolute performance and performance relative to others in this class. Grade distributions are expected to fall along a traditional scale of: 90 – 100 = A+/A/A-; 80 – 89 = B+/B/B-, etc. The grade distribution will not be stricter than this, but may be easier. A scaling factor ("curve") may be added to a particular exam or assignment if I judge it to be necessary. Any scaling factors used will be announced as needed.

Approximate Course Schedule:

The approximate schedule will be updated throughout the semester. There will be **two in-class exams during the semester and a final exam at the end of semester. In-class exam dates will be announced and finalized two weeks before each exam.** The final exam will be scheduled by the university (in May). In general, homework assignments and reading quizzes will be assigned on a weekly basis. Assignments have been designed to help students take advantage of out-of-lecture time and will be an extension of the lectures. Students should expect to spend about 9 hours each week working on course material outside of class, as indicated by the course credit hours. Assignment deadlines will be stated on each assignment; any changes to these deadlines will be announced in class, on the D2L site, and/or emailed to the class.

Approximate Course Schedule[1]:

DATE	TOPIC	READINGS (to be completed before class)	ASSIGNMENTS (due before the start of class)	HANDOUTS
Jan 18	Course Introduction & Sustainability Definitions ***[Topic 1]***	Reading #1 – EPA Primer		
Jan 20	Environmental Concepts ***[Topic 1]***	Reading #2 – Text Ch. 1 (Intro to Sustainability)		H1
Jan 23	Life Cycle Assessment (environmental, social) ***[Topic 1]***			H2
Jan 25*	Guest Lecture: Prof. Tad Pfeffer – Climate Change			
Jan 27	Social Concepts: Stakeholder Engagement ***[Topic 1]***	Reading #3 – Social Example	**Homework#1** **Quiz#0**	
Jan 30	Economic Concepts: Environmental and Resource Economics ***[Topic 1]***	Reading #4 – Text 6.2 (Tragedy of the Commons)		H3
Feb 1	Economic Concepts: Present Worth Analysis ***[Topic 1]***	Reading #5 – Economic Examples	**Quiz#1**	H4
Feb 3*	Water Footprint Water Use & Perceptions ***[Topic 2]***	Reading#6 – Freshwater Crisis Reading#7 – Water Short List		H5
Feb 6	Pollution Overview & Conservative Pollutant Mass Balance ***[Topic 2]***	Reading#8 – Mass Balances Reading#9 – Text 5.4 (Water Pollution)		H6-MB1
Feb 8	Non-conservative Pollutant Mass Balance ***[Topic 2]***		**Quiz#2**	H6-MB2
Feb 10	Non-conservative Pollutant Mass Balance ***[Topic 2]***		**Homework#2**	H6-MB3 H7
Feb 13	Energy Terms and Sources ***[Topic 3]***	Reading#10 – NAP Report Reading#11 – Kilowatt-hour Reading#12 – IEA Energy Outlook Summary		H8
Feb 15	Energy Analysis: Efficiency ***[Topic 3]***	Reading#13 – Energy Analysis	**Quiz#3**	H9-EA1
Feb 17	Energy Analysis: Efficiency Cont'd ***[Topic 3]***		**Homework#3**	H9-EA2
Feb 20	Life Cycle Energy Energy Use & Perceptions ***[Topic 3]***	Reading#14 – Solar PV Life Cycle Energy Reading#15 – Energy Short List Reading#16 – Climate Change Behavior Change		H9-EA3 H10
Feb 22	Water – Energy Nexus ***[Topic 3]***	Reading#17 – IEA Water-Energy Nexus		H11
Feb 24	Water – Energy Nexus ***[Topic 3]***		**Homework#4**	H11-Ex1
Feb 27	Recent Water Crises: Case Study ***[Topic 2]***	Reading#18 – Flint Case Study (NYTimes) Reading#19 – Olson Science Report		H7
Mar 1	Recent Water Crises: Case Study ***[Topic 2]*** Review (if time)			H7
Mar 3	**Exam 1**		**Exam 1**	

DATE	TOPIC	READINGS (to be completed before class)	ASSIGNMENTS (due before the start of class)	HANDOUTS
Mar 6	Climate and Greenhouse Gas Definitions ***[Topic 4]***	Reading#20 – Text Ch. 3 sections Reading#21– Black-body Radiation		H12
Mar 8	Energy CO2 Emissions ***[Topic 4]***	Reading#22– IEA Redrawing the Energy-Climate Map		H13-Ex1
Mar 10	Energy CO2 Emissions Continued ***[Topic 4]***	Reading#23—– Good News	**Quiz#4**	H13-Ex2
Mar 13	Global Warming Potential ***[Topic 4]***		**Homework#5**	H14
Mar 15	Mitigation: Stabilization Wedges ***[Topic 4]***	Reading#24– Wedges Reading#25– Economic Cost of Climate Change		
Mar 17	Mitigation: Carbon Footprint and Perceptions ***[Topic 4]***			
Mar 20	Pollutant Sources and Impacts ***[Topic 5]***	Reading#26–Air Pollutants Reading#27– EPA Smog Reading#28– EPA Ozone	**Homework#6**	H16
Mar 22	Pollutant Sources and Impacts Cont'd ***[Topic 5]***			
Mar 24	Stationary Sources ***[Topic 5]***	Reading#29– EPA Emissions Control Measures	**Quiz#5**	H17
Mar 27	**No Lecture** – Spring Break			
Mar 29	**No Lecture** – Spring Break			
Mar 31	**No Lecture** – Spring Break			
Apr 3	Mobile Sources ***[Topic 5]***	Reading#30– Master's & Ela Air Pollution Section	**Homework#7**	H18
Apr 5	Guest Lecture: Prof. Readey –CAP Case Study ***[Topic 5]***			
Apr 7	Exam Review			
Apr 10	**Exam 2**		**Exam 2**	
Apr 12	Material Resources: Use and Exhaustion ***[Topic 6]***	Reading#31– Ashby Ch. 1 Reading#32– Ashby Ch. 2		H19-Use
Apr 14	Material Resources: Criticality and Life Cycle ***[Topic 6]***			H20-LC
Apr 17	Material Resources: Material Flow Analysis ***[Topic 6]***	Reading#33– Ashby Ch. 3	**Quiz#6**	H21-MFA
Apr 19	LCA: Methods ***[Topic 7]***	Reading#34– ISO 14040 Reading#35– EPA LCA		H22
Apr 21	LCA: Methods (LCIA, software) Paper vs. Plastic (if time) ***[Topic 7]***	Reading#36– LCIA Reading#37– Paper vs. Plastic	**Homework#8**	
Apr 24	LCA: Unused Medication ***[Topic 7]***	Reading#38– Unused Medication Disposal		H23
Apr 26	LCA: Unused Medication ***[Topic 7]***			
Apr 28	LCA: Paper vs. Plastic ***[Topic 7]*** Class Evaluation		**Homework#9**	
May 1	LCA: Drinking Water Disinfection ***[Topic 7]***			
May 3	LCA: Case Study TBD ***[Topic 7]***		**Quiz#7**	
May 5	Review		~~**Homework#10**~~	
May 7	Final Exam (7:30-10pm)		**Final Exam**	

[1]Schedule is subject to change (announcements will be made in class)

Learning Objectives:
By the end of each topic and the course, students will be able to:

- **Overall Course**
  - Define sustainability, in particular, as it applies to engineering problems.
  - Describe the main sustainability challenges in engineering (e.g., water, energy, climate, materials, etc.).
  - Calculate and balance the material and energy flows over multiple life cycle stages of engineered systems.
  - Describe the mechanisms of environmental impacts due to pollution (e.g., for smog, ozone depletion, eutrophication, etc.).
  - Interpret life cycle assessment results to recommend potential solutions engineering problems.
  - Compare engineering systems and justify engineering design decisions based on the results of sustainability assessments by identifying and describing the relevant environmental, economic, and/or social impacts.
- **Topic 1: Sustainability's Three Pillars**
  - Define sustainable development in theoretical and practical terms
  - Describe the major challenges to sustainable development
  - Apply sustainability concepts by
    - Defining and describing how to use the IPAT equation
    - Describe the three types of "footprints" used to estimate environmental impact
    - Defining stakeholder and stakeholder engagement
    - Defining and describing fundamental economic terms and the short-term impact (i.e., market response) of changing consumer consumption and production costs
- **Topic 2: Water**
  - Calculate water quality and quantity impacts
    - Define and calculate a water footprint
    - Conduct a mass flow balance
    - Determine the impact of conservative and non-conservative pollutants on rivers and lakes
  - Describe water use on a personal, household, and global scale
  - Describe efficiency measures and challenges
  - Describe the interconnection of water and energy (water-energy nexus)
  - Identify main water pollutants and their impacts
- **Topic 3: Energy**
  - Conduct an energy balance
  - Describe major sources of energy and energy use on a residential, national, and global scale
  - Calculate and apply energy efficiency metrics
  - Apply life cycle thinking to evaluate and calculate life cycle energy and material requirements
  - Describe efficiency measures and challenges

- **Topic 4: Climate Change**
  - Define climate and differentiate from weather
  - Describe the greenhouse gas effect
  - Define radiative forcings and describe the relationship between forcings and temperature for different gases
  - Describe the impact of natural and anthropogenic activities on atmospheric carbon dioxide emissions
  - Calculate and apply global warming potentials
  - Calculate carbon dioxide emissions associated with various activities (e.g., fuel combustion)
  - Describe climate change mitigation strategies
- **Topic 5: Air Resources and Pollution**
  - Define the 6 criteria air pollutants (CAPs) and their main sources and impacts of the 6 CAPs
  - Calculate pollutant emissions and resource consumption rates (e.g., from power plants)
  - Understand the impact of atmospheric stability on pollutant dispersion
  - Describe the factors that affect atmospheric stability
- **Topic 6: Material Resources**
  - Define reserves and resource base; describe the difference between them; state factors that can affect the balance between the two
  - Describe the types and amounts of materials used by society and how they have changed over time
  - Estimate the production rate, growth rate, and the time it will take to produce or exhaust a given resource
  - Define and identify critical materials
  - Conduct a material (mass) balance with recycling
- **Topic 7: Life Cycle Assessment**
  - Define life cycle assessment (LCA) and the four main phases of LCA as defined by the ISO 14040
  - State some common applications of LCA
  - Describe each step of and how to conduct each phase of an LCA: defining the boundary; defining the scope; inventorying each life cycle emission; choosing and applying a life cycle impact assessment method; and interpreting the results.
  - State the typical units of mid-point and end-point impact assessments.