# The University Of Toledo

## NEW COURSE PROPOSAL

* denotes required fields

Level (check one)*
- ○ Undergraduate
- ◉ Graduate

**Will this course impact program requirements?** ○ **Yes** ◉ **No** **If yes, a Program Modification must be completed.**

Type of course (check all that apply):

☐ Academic Skills Enhancement ☐ Writing Intensive (WAC) ☐ Honors

☐ Univ. Core: ○ *English* ○ *Hum* ○ *Math* ○ *Nat. Sciences* ○ *Social Sciences*

*Multicultural:* ○ *Diversity of US Culture* ○ *Non-US Culture*

☐ Transfer module: ○ *Arts&Hum* ○ *Engl* ○ *Math* ○ *Nat Sci & Phys* ○ *Soc Sci*

*(to be considered as core curriculum, question 18 must be completed)*

1. College*: Engineering
   Department*: ~~Biology~~ Civil Engineering
2. Contact Person*: Defne Apul Phone: 530-8132 (XXX - XXXX) Email: defne.apul@utoledo.edu
3. Alpha/Numeric Code (Subject area - number)*: CIVE - 8670

   If this is a renumbering, please request an electronic copy of the old course approval through the Register's Office at x4865, and attach it to #15 in this form. Remember to delete the old course ID in #13.

**Administrative Use Only**

**Code:**

**Approved** (senate or Grad Council)

**Effective Date:** / / **(mm/dd/yyyy)**

**CIP Code:**

**Sub:** **Prog:** **Level:**

4. Proposed title*: Life Cycle Engineering

   Proposed effective term: Fall 2012 OSA
5. Planned enrollment per section: 10 per term: 10
6. Is the course cross-listed with another academic unit? ○ Yes ◉ No

   Is the course offered at more than one level? ◉ Yes ○ No

   If yes to either question, please list additional Alpha/Numeric codes, and submit a separate New Course form or Course Modification form for the course(s) referenced below.

   a. CIVE - 6670 b. - c. -

   Approval of other academic unit (signature)

   Name and title

   If course is to be offered at more than one level, attach an explanation of the different requirements that students must meet for each level. If the requirements are the same for each level, justification must be provided.
7. Credit hours*: Fixed: 3 or Variable: to
8. Delivery Mode:

| | Primary* | Secondary | Tertiary |
|---|---|---|---|
| a. Activity Type† | * Lecture | | |
| b. Minimum Credit Hours | * 3 | | |
| Maximum Credit Hours | * 3 | | |
| c. Weekly Contact Hours | * 3 | | |

†Choices are: Lecture, Recitation, Seminar, Regular Lab, Open Lab, Studio, Clinic, Field, Independent Study, Workshop, Computer Assisted Instruction, Other

9. Terms offered: ☑ **Fall** ☐ **Spring** ☐ **Summer**

   Years offered: ◉ **Every Year** ○ **Alternate Years**
10. Are students permitted to register for more than one section during a term? ◉ No ○ Yes

    May the courses be repeated for credit? ◉ No ○ Yes Maximum Hours
11. Grading System*:

| Undergraduate | Graduate |
|---|---|
| ○ Normal Grading (A-F,PS/NC.PR, I) | ◉ Normal Grading (A-F,PS/NC.PR, I) |
| ○ Passing Grade/No Credit (A-C, NC) | ○ Grade Only (A-F) |
| ○ Credit/No Credit | ○ Satisfactory/Unsatisfactory (G only) |
| ○ Grade Only (A-F, PR, I) | ○ Audit only |

○ Audit only ○ No Grade

○ No Grade

12. Prerequisites (must be taken **before**): a. - b. - c. -

◉ PIN (Permisson From Instructor) ○ PDP (Permission From Department) Reset

Co-requisites (must be taken **together**): a. - b. - c. -

13. If course is to replace an existing, course(s) will be deleted, and when should that deletion occur?

| | Course to be removed from inventory | Final Term to be offered ( YYYYT. i.e. use 20064 for Fall'06 ) |
|---|---|---|
| a. | - | |
| b. | - | |
| c. | - | |
| d. | - | |

14. Catalog description* (**30 words Maximum**)

This course discusses the life cycle concept for engineered systems. Course content includes the greenhouse gas protocol, life cycle assessment methodology, life cycle impact assessment, and matrix calculations for life cycle analysis.

15. Attach an electronic copy of a complete outline of the major topics covered.

Syllabus: * Browse...

Additional Attachment 1: Browse...

Additional Attachment 2: Browse...

16. Where does this course fit in the University/College/Department curriculum? (Be specific by course level, if applicable). Indicate prospective demand.

This course will be offered for any PhD student.

17. If the proposed course is similar to another course in the College or University, please describe the difference and provide a rationale for the duplication. (If this course duplicates material covered in another course within your department or college or in another college, attach a letter of endorsement from that area's dean and department chairperson indicating their support. Clarify the manner in which this course will differ).

NA

18. If the course is intended to meet a University Undergraduate **Core** requirement, complete the following and submit a course syllabus using the *template*:

Please explain how this course fulfills the general education guidelines. (*Guidelines* are available in *Faculty Senate Website*)

NA

**Course Approval:**

Department Curriculum Authority: Ashok Kumar Date Month / Day / Year Oct 25/2011

Department Chairperson: Ashok Kumar Date Month / Day / Year Oct 25/2011

| | | |
|---|---|---|
| College Curriculum Authority: | Patricia A. Pelue | Date Month 10 / Day 31 / Year 2011 |
| College Dean: | Roland Sawyer | Date Month 10 / Day 31 / Year 2011 |

*After college approval, submit the original signed form to the Faculty Senate (UH 3320) for undergraduate-level courses; for graduate-level courses submit the original signed form to the Graduate School (UH3240). For undergraduate/graduate dual-level courses, submit the proposals to each office.*

| | | |
|---|---|---|
| Faculty Senate Undergrad. Curriculum Comm.: | | Date Month / Day / Year |
| Faculty Senate Core Curriculum Comm.: | | Date Month 10 / Day 13 / Year 2011 |
| Graduate Council: | | Date Month / Day / Year |
| Office of the Provost: | | Date Month / Day / Year |
| Registrar's Office: | | Date Month / Day / Year |

Submit New Course Proposal

**You will see a confirmation page after you press the "Submit" button. If you do not see the confirmation page, please call x 4320 or send an email to ProvostWebMaster.utoledo.edu. Thanks.**

before Cgpol Oct 24 2011

**Explanation of Extra Work that Students Taking CIVE 8670 will do compared to students signed up for CIVE 6670**

PhD students taking the CIVE 8670 level course will be required to complete all work that MS students would be doing in the CIVE 6670 course. In addition, PhD students will be asked to complete an additional assignment that they would then present to class in a half hour lecture or activity. The nature and details of the assignment will be mutually agreed upon between the instructor and the student.

**Detailed Syllabus for CIVE 6670/8670 Life Cycle Engineering**

**Facilitator, Dr. Defne Apul, The University of Toledo, Department of Civil Engineering**

**Table of Contents of This Syllabus**



This course has no exam. Grading scheme is based on assessments summarized on page 4. While this course has no exam, it will require much time and you will need to submit many assessments and do many preps to be able to succeed in class. Plan accordingly. About 9 hrs per week commitment is required to be successful in this class. Note that this course involves a real-life semester long project (page 9).



**The University of Toledo**
**Department of Civil Engineering**
**CIVE 6670/8670 Life Cycle Engineering**
**3 Credits, Offered in Fall Semesters**

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

**Meeting times:** First meeting will be on August 22, 2011, M, 5:30-8:00pm, Palmer Hall 3050. After this first meeting, the regular class meeting time will be changed to another time based on availability of students.

**Textbook:** There is no single textbook for this course. I will share handouts and resources with you for each topic we discuss.

**Course format:** This course is developed based on Fink's taxonomy of significant learning (Fink, 2003). As discussed in Fink's book I believe that good courses are courses that...

- challenge students to significant kinds of learning
- use active forms of learning
- have teachers who care – about the subject, their students, and about teaching and learning
- have teachers who interact well with students
- have a good system of feedback ,assessment, and grading.

Fink's ideas on six critical aspects of learning are summarized in the table below. To achieve these learning aspects, students in the class will be reading and discussing literature, working on some quantitative assignments, and a semester long project. The project for this semester is the development of life cycle based design guidelines for rainwater harvesting systems.

**A Taxonomy of Higher Level Learning**

| *Type of Significance* | *Key Component of Learning Involved* | *Special Value* |
|---|---|---|
| Learning how to learn | Learning | Provides capability for long-term continuation of learning. |
| Motivation | Caring | Provides the energy (short term or long term) for learning; without this, nothing is significant |
| Human Dimension | Self, Others | Connects one's self to oneself and to others; gives human significance to the learning. |
| Integration | Connecting | Adds power by connecting different ideas, disciplinary perspectives, and/or realms of life. |
| Application | Thinking, Acting | Allows other learning to become useful. |
| Foundation | Knowing | Provides necessary information for other kinds of learning. |

Fink, L. D. (2003). Creating significant learning experiences: An integrated approach to designing college courses. San Francisco:Jossey-Bass.

**Late assignments:** 10 % will be deducted for every day the assignment is late. Assignments should be submitted before class starts.

**Academic Dishonesty:** 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. You should read UT's policy on academic dishonesty available at: http://www.utoledo.edu/dl/students/dishonesty.html

**Course Objectives:**

This course will improve your foundational knowledge on (understanding and remembering ideas, information):

- life cycle assessment method
- life cycle impact assessment
- matrix calculations for life cycle assessment problems
- global warming potential / characterization factors
- carbon footprint analysis
- climate action plan

Time permitting, we may work on improving your foundational knowledge on these topics as well:

- water footprint analysis
- sustainability reporting
- ecological design principles
- LEED, sustainable construction
- Biomimicry
- natural step, backcasting
- water infrastructure and building systems

This course will improve your application skills such as:

- Performing simple life cycle assessment studies for a given process using EIOLCA and GaBi software
- Evaluating 'greenness' of products
- Critically reviewing articles and websites related to life cycle engineering
- Communicating technical information (in writing and orally)
- Managing your time
- Managing projects
- Creative, critical, and practical thinking and solutions

This course will improve your ability to integrate and connect ideas, people, realms of life such as:

- Connecting the engineering, environmental, social, and economic factors that make engineering analysis, design or solutions sustainable or not
- Developing diverse interactions and partnerships towards managing a project

This course will teach you about yourself and others (human dimension of learning). You will:

- Learn how you can use life cycle assessment to make more informed personal decisions in your life
- Learn how to effectively contribute to project goals in a team effort
- Develop your own work ethic towards submitting deliverables on time
- Learn about how you communicate with others
- Learn about the stakeholders of your semester long project

This course will teach you new feelings, values, interests (caring dimension of learning). At the end of the class you might:

- Get more interested in various sustainability problems and the connections among them
- Be more interested in following up-to-date advances on sustainable solutions and assessment techniques
- Recognize the un-sustainable practices within and around your life and profession and try to develop and implement sustainable solutions to improve them
- Feel overwhelmed but satisfied to have completed a meaningful project

This course will give you opportunities to be a better student and a self-directed learner by:

- Asking you to identify the problem, determine what information is needed to solve it, and develop a strategy to address the problem



**Planned Schedule** (Tentative: might change depending on student interest and class progress)

| Date | Discussion topic | In Class Activity | Assessment and Prep Due That Day | Points |
|---|---|---|---|---|
| Week 1, August 22 | Intro to sustainability | Go over syllabi, student introductions, presentation by Dr. Apul, IPAT eqn | | |
| Week 2, August 29 | Intro to sustainability | Discussion of assessment 1, Dr. Apul presents on GHG accounting including methods and UT, Toledo, and Lucas County results | **Assessment 1:** Mihelcic, Brundtland, Bill Gates | 20 |
| Week 3, September 5 | Labor day - no class | - | | |
| Week 4, September 12 | Greenhouse gas inventory methods | Discussion of GHG reports of UT, City of Toledo and Lucas County, project time | **Assessment 2:** GHG questions | 20 |
| Week 5, September 19 | Introduction to LCA | Intro to LCA presentation by Dr. Apul, hands on EIOLCA exercise | **Assessment 3:** Carbon calculator<br>**Prep 1:** Browse through LCA links | 20 |
| Week 6, September 26 | Application of LCA to sanitation problems | Discussion of EEAST model, Anand and Apul papers | **Prep 2:** Browse through Anand and Apul papers and EEAST model | 0 |
| Week 7, October 3 | Emission calculations for environmental services | EEAST model, solid waste, wastewater, water treatment calculations for Toledo, Assessment 7 by student 1 | **Assessment 4:** Project first progress report (peer graded)<br>**Prep 3:** Read through solid waste, wastewater calculations | 20 |
| Week 8, October 10 | Computational structure of LCA | Refined inventory problem, Assessment 7 by student 2 | **Assessment 5:** EIOLCA HW<br>**Prep 4:** Read Chapter 2 of Computational Structure of LCA | 20 |
| Week 9, October 17 | Fall break – no class | | | |
| Week 10, October 24 | Computational structure of LCA | Inventory problem and its solution, Assessment 7 by students 3 and 4 | **Assessment 6:** EEAST assignment<br>**Prep 5:** Read Chapter 3 and 5 of Computational Structure of LCA | 20 |
| Week 11, October 31 | Process based LCA software | GABI in class exercise, Assessment 7 by students 5 and 6 | | |
| Week 12, November 7 | Green product or peer reviewed literature | Assessment 7 by students 7 and 8 | **Assessment 8:** Project second progress report (peer graded) | 10 |
| Week 13, November 14 | Urban sustainability, municipal codes | ???Visit UEI, Katie Rousseau's visit??? | **Prep 6:** Browse through urban sustainability and food LCA links | |
| Week 14, November 21 | Student selected topics | **Choose from:** water sustainability, WE LEED credits, GRI, sustainability reporting, ecological, water footprints, Biomimicry and ecological design principles, technical writing skills | **Prep 7:** To be determined based on topic | |
| Week 15, November 28 | Student selected topics | | | |
| Week 16, December 5 | Project presentation | Final presentation, | **Assessment 9:** Final presentation (peer graded) | 20 |
| Finals Week, December 14 | Project report submission | Email Dr. Apul your final report by 7:00pm on December 14 | **Assessment 10:** Final report (peer graded) | 30 |
| **Varying times** | Green products or peer reviewed literature | Students will present Assessment 7 in different times throughout the semester. | **Assessment 7:** Green product or peer reviewed paper | 20 |
| | | | **Total available pts** | **200** |

**First Meeting's Activities**

1. Change class time.
2. Go over syllabus and intro to life cycle engineering ppt by Dr. Apul.
3. Student introductions and expectations from this class. Write on a piece of paper:
   a. your name and something about yourself,
   b. why you are in this class,
   c. what do you expect to get out from this class
   d. where you want to be headed with your career,
   e. what methods work best for YOU when you are learning something (e.g. reading, listening, doing, projects, work by yourself, watching something, internet etc...)
   f. some productivity tip you practice
4. Dr. Apul hands out following documents:
   a. Mihelcic et al., 2003 Sustainability science and engineering: the emergence of a new metadiscipline, Environmental Science and Technology, 37(23), 5314-5324
   b. World Commission on Environment and Development, 1987 Our Common Future, Brundtland report

**Homework for next class**

For the following questions, read the relevant material, then type and bring your answers to class:

From Mihelcic et al. and the Brundtland report:

c. What is the most commonly cited definition of sustainability? Where in Brundtland report is this definition written?
d. How does Mihelcic et al 2003 define sustainable engineering?
e. What is a peer reviewed article and how is it different than a report or other articles?
f. What do you think might be the significance of Mihelcic et al., 2003?
g. What do you think might be the significance of the Brundtland report?
h. Mihelcic et al mentions a tool called EIOLCA. Browse through www.eiolca.net. Write two questions that come to your mind related to EIOLCA.

From news articles on Bill Gates and his goal of reinventing the toilet:

http://mashable.com/2011/07/19/bill-gates-reinvent-toilet/
http://www.time.com/time/world/article/0,8599,2082509,00.html
http://www.huffingtonpost.com/2011/07/13/gates-foundation-initiative-clean-drinking-water_n_897134.html?ref=email_share
http://www.cbc.ca/news/health/story/2011/07/20/technology-toilet-gates-cheng.html

i. Why does Bill Gates want to reinvent the toilet?
j. How, if at all, is rainwater harvesting related to the news articles you read?



**Assessments**

**Assessment 1 (Individual)**

Responses to questions related to Mihelcic et al, Brundtland Report, and Bill Gates articles (see page 4 for what you need to submit for Assessment 1).

**Assessment 2 (Individual)**

You will need 10 resources for this assignment:

Resource 1: CIVE 4900 Spring 2011 students' report on Climate Action Plan for UT
Resource 2: CIVE 4900 Spring 2011 students' presentation on Climate Action Plan for UT
Resource 3: CIVE 6900/8900 Fall 2011 students' report on GHG inventory of City of Toledo
Resource 4: CIVE 6900/8900 Fall 2011 students' report on GHG inventory of Lucas County
Resource 5:CIVE 6900/8900 Fall 2011 students' presentation on Toledo and Lucas County GHG emissions
You can access resources 1-5 by going to the following page:
http://www.eng.utoledo.edu/civil/newweb/sustainability/Sustainability_Curriculum.html

Resource 6: Local government operations protocol for greenhouse gas inventory. You can access resource 5 at: http://www.theclimateregistry.org/downloads/2010/05/2010-05-06-LGO-1.1.pdf

Resource 7: GHG Protocol website and its standards section
http://www.ghgprotocol.org
http://www.ghgprotocol.org/standards

Resource 8: Presidents Climate Commitment
http://www.presidentsclimatecommitment.org/

Resource 9: University GHG Reporting System
http://rs.acupcc.org/

Resource 10:
http://www.cleanair-coolplanet.org/toolkit/

Prepare a typed document that answers the following questions:

1. What are scope 1 emissions? (copy/paste is ok)
2. What are scope 2 emissions? (copy/paste is ok)
3. What are scope 3 emissions? (copy/paste is ok)
4. What is a carbon footprint? What does it involve?
5. Each report has slightly different headings. Make a preliminary outline for the report YOU will be submitting at the end of this semester and submit this outline.
6. Write two questions about YOUR project for this semester.
7. What are some strengths and weaknesses of the students' reports?
8. What are some strengths and weaknesses of the students' presentations?
9. Using resource 6, answer the following questions:
   a. Look at Table D1 on page 185 of Resource 5. What do you get out of this table? Spend a little more time on sections of the table on solid waste and wastewater calculations as we might use these later on in class.
   b. Look at Table E1 on page 198 of Resource 5. What do these numbers mean?
   c. Look at Table G8 on page 211 of Resource 5. What do these numbers mean? What number would you use for emission calculations for Toledo area?
10. Write down at least 2 questions that came to your mind as you browsed through all the resources. Write down what is unclear to you.
11. Our library is a member of the OhioLink system. OhioLink has subscription to several databases that track peer reviewed publications. The database that I like is ISI Web of Knowledge. You can access this database by going to: http://www.ohiolink.edu/resources.cgi?by=subject → Click on Engineering → When list of databases come up, click on ISI Web of Knowledge. Use this database to locate the Mihelcic et al (2003) article.

    a. How many times has this article been cited?
    b. Copy paste the list of references that cited this article. Browse through the references that cited Mihelcic et al (2003). In what kind of journals, reports etc. were these other references published?
    c. Use Google scholar to determine how many times Mihelcic et al has been cited and by whom. Do your results from ISI Web of Science and Google Scholar match?

12. Browse through resource 7. Describe in a few sentences what information is available from resource 7. For what purposes might this resources be useful to you in you career?
13. Browse through resource 8. What is this webpage about? (copy/paste is OK)
14. Browse through resource 9. What is this webpage about? (copy/paste is OK)
15. Browse through resource 10. What is this webpage about? (copy/paste is OK)



**Assessment 3 (Individual)**
**Personal Carbon Footprint Assignment**
Calculate your carbon footprint and provide the answers to following questions.

a. Provide the results to your carbon footprint that shows the breakdown of emissions from different activities.
b. Why did you pick this calculator? What are its benefits compared to other calculators?
c. What are some of the major limitations and uncertainties associated with the carbon footprint that you just calculated for yourself? Discuss limitations and uncertainties separately. Consider what should ideally be included in your emissions.
d. Calculate the yearly cost of purchasing carbon offsets from three services that are available on the internet.
e. Develop a plan to reduce your carbon footprint and show the plan including how much reductions it will help you achieve. Some calculators do this for you. You can present their results.
f. On average, what is the carbon footprint of a US resident?
g. On average, what is the carbon footprint of a world resident?

**Here are some resources for your use:**

1. Carbon Footprint Calculators on the Internet

American Forests: http://www.americanforests.org/learn-more/carbon-calculator/
Austin's calculator: http://www.ci.austin.tx.us/acpp/co2_footprint.htm
Chuck Wright http://www.chuck-wright.com/calculators/carbon.html
The Conservation Fund http://www.conservationfund.org/gozero
Greenmountain: http://www.greenmountain.com/green-mountain-energy-company-store/carbon-calculator
USEPA http://www.epa.gov/climatechange/emissions/ind_calculator.html
Nature Conservancy: http://www.nature.org/greenliving/carboncalculator/index.htm
SafeClimate http://www.safeclimate.net/calculator/
TerraPass http://www.terrapass.com

2.Peer Reviewed Paper on Comparison of Carbon Calculators

Padgett et al. (2007) A comparison of carbon calculators, Environmental Impact Assessment Reivew, 28, 106-115.
Available for download from:
http://www.elsevier.com/authored_subject_sections/P09/misc/EIAR_28.pdf

**Assessment 4 (Group)**
**First Progress Report for Your Project**
Project description:
This semester you will work on developing design guidelines for rainwater harvesting systems. Rainwater harvesting is not a new technology but it is not widely used. Depending on the building type, location, and other site specific parameters, it may or may not make sense to use rainwater harvesting. You will use life cycle cost, energy, GHG emissions, available natural resources (e.g. water) and ecological design principles as your criteria to develop design guidelines for rainwater harvesting. You will relate your findings to the LEED building rating system. You can develop the guidelines for the US or for Toledo. We'll discuss this decision in class.

Some local groups are interested in your work:

1. City of Toledo, City Council Member Steve Steel
http://www.ci.toledo.oh.us/ToledoCityCouncil/CityCouncilMembers/tabid/209/Default.aspx
We will meet with Steve Steel at UEI: http://www.ueitoledo.com/
Steve is especially interested in changing/improving the city municipal code

2. Toledo-Lucas Sustainability Commission Chair, Jeff Grabarkiewicz
http://www.lucascountygreen.com/

3. American Rivers Healthy Waters Campaign, Katie Rousseou (Swarts)
http://www.raingardeninitiative.org/contactus.html

Some national organizations are interested in your work:

1. ARCSA: American Rainwater Catchment Systems , Bob Boulware
http://www.arcsa.org/
You should read Mr. Boulware's rainwater design guidelines document. Email me for a copy if I forget to post it on BB.

2. USGBC LEED rating system
Research to Practice Program: http://www.centerforgreenschools.org/r2p2.aspx and
http://www.centerforgreenschools.org/Libraries/Documents/Research_to_Practice_Call_for_Interest.sflb.ashx

Analysis tool for your project:
EEAST model: http://defneapul.wikispaces.com/Water+sustainability
Other life cycle costing and analysis methods/tools.

What to submit for the first deliverable:

1. Cover page
2. Tentative table of contents (i.e. your outline) for your anticipated final report
3. The introduction/problem statement section of your report. One to three paragraphs.
4. The objectives section of your proposal. This section should start with: "the goal of this study was to ..."
5. Your outline should include a section on Toledo municipal code. Write a preliminary version of this section on whether the code regarding rainwater harvesting should change and if yes in what way. You can access the Toledo municipal code by going here:
http://www.ci.toledo.oh.us/ToledoCityCouncil/tabid/206/Default.aspx
6. In addition, lay out team member roles and deadlines. Include this as an attachment.
7. Send a confidential email to Dr. Apul on your peer grades using the peer grading excel spreadsheet. This email is sent to Dr. Apul only, not to your team members.



**Assessment 5 (Individual)**
**EIOLCA assignment**

A household is considering purchasing a washing machine and has narrowed their choice to two alternatives. In addition tocst and other functional items, they wish to assess the energy consumption and greenhouse gas emissions over the lifetimes of the two alternatives:

- Machine 1 is a standard top-loading unit with a purchase cost of $500. This machine uses 40 gallons of water and 2 kilowatt-hours of electricity per load (assuming an electric water heater). The household would to roughly 8 loads of laundry per week with this machine.

- Machine 2 is a front-loading unit: it costs $1,000, but it can wash double the amount of clothes per load, and each load uses half the water and electricity.

-Which machine should this household buy?

a) Estimate the total annual costs of water and electricity for each of the two machines. Use these values along with the manufacturing costs to develop a purely cost-based comparison of the two machines over a 10-year period. Assume that electricity costs 8 cents/kWh and water is $2 per 1,000 gallons.
b) Use the same cost values as inputs into EIO-LCA to estimate the relative energy consumption and greenhouse gas emission over their life cycles. Ignore the disposal phase. Be sure to express the comparisons of the two machines in terms of use versus manufacturing effects.
c) Briefly discuss your results.

**Student solution worksheet:**
a. Calculate the total annual costs of water and electricity

| | Machine 1 | Machine 2 |
|---|---|---|
| Cost ($) | | |
| Water consumption per load (gal) | | |
| Electricity consumption per load (kWh) | | |
| Loads per week | | |
| Electricity cost ($/kWh) | | |
| Water cost ($/gal) | | |

Total annual cost of water:
Machine 1:
Machine 2:

Total annual cost of electricity:
Machine 1:
Machine 2:

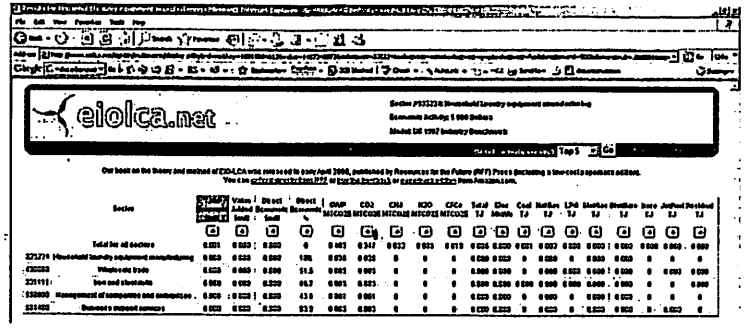
Total cost in a 10-year period:
Machine 1:
Machine 2:

b. Assume lifetime of washing machines is 10 years and ignore the disposal phase.

Manufacturing:
Goto EIO-LCA.net. Choose "lighting, electronic components, batteries and other industry". Select "household laundry equipment manufacturing" sector. Put in $500 and $1,000 as producer prices.

Water use:
Industry: mining and utilities
Sector: water, sewage and other systems
Dollar amount:

Electricity use:
Industry: mining and utilities
Sector: Power generation and supply
Dollar amount:




| Energy (Tj) consumption from | Manufacturing | Water use | Electricity Use | Total |
|---|---|---|---|---|
| Machine 1 | | | | |
| Machine 2 | | | | |

| GWP (mt CO2 equiv.) from | Manufacturing | Water use | Electricity Use | Total |
|---|---|---|---|---|
| Machine 1 | | | | |
| Machine 2 | | | | |



**Assessment 6 (Individual)**

**EEAST assignment (More details might or might not follow)**

**Use EEAST to analyze the economic and environmental implications of using alternative sanitation technologies in different types of buildings. Vary building type (home, dormitory, educational building and office).**

**Home (6 flushes /person /day)**
**Dormitory (5 flushes /person /day)**
**Educational building (3 flushes /person /day)**
**Office (4 flushes /person /day)**

**Turn in a mini report that includes a cover page, objectives, methods, results and discussion, and conclusions sections.**
**For purposes of this mini-study, we will skip the introduction, and abstract sections.**
**In methods section describe the parameters you changed and their values.**
**In results present graphs of cost, energy, and $CO_2$ payback periods. Discuss all figures/tables presented. Think through which figures to present don't copy paste all EEAST output to the report.**
**This is a mini report, so keep it to the point but include all necessary information.**

**Input Parameters:**

- **Precipitation Data – Toledo Ohio**
- **Building Length – 200 ft**
- **Building Width – 150 ft**
- **Building Height – 24 ft**
- **# of Stories - 2**
- **# of toilets per floor - 10**
- **Irrigation area – 2000 sf**
- **Building Type – Office (4 flushes/person/day)**
- **Occupancy – 150 ppl/day**
- **Toilet type – Standard (1.6 gpf)**
- **Pressure Provided by City – 30 psi**
- **Discount Rate – 3%**
- **Loan required – Yes to all (use assumed loan data)**

**Assessment 7 (Individual)**
**Green product or peer reviewed paper presentation**
You have two options for this assignment. You will either analyze a green product or you will review a journal article. Both are described below. You need to pick only one of the two. For either one of the assignments, you should share relevant materials with the class at least a day ahead of time to give class sometime to think and learn about your topic before coming into class.

**Option 1: Green product assignment (out of 50 points)**
Assignment grading is based on your in class performance. You should share materials (e.g. links, ppt, etc.) with the class ahead of time to give students some headsup

1. Select a 'green' product or technology and present it in class in 20 minutes. In analyzing whether the product is 'green' or not, it usually makes sense to compare the product to its alternative. If someone has already analyzed the product/technology you have in mind using LCA, you are welcome to present their findings.
2. Things you should discuss:
   a. (10 points)
      Introduce the product/technology and the functions/services it provides
      Explain why you picked this product
      Provide literature on the product (e.g. show its website, handout its specs, show articles related to it)
   b. (20 points)
      Discuss what is green and what is not green about it
   c. (10 points)
      Make a preliminary conclusion on whether you think the product is really green or not.
   d. (10 points)
      Answer questions from the audience

For part a, do your homework and know your product well. Use google, google scholar, google news and other information finding techniques to fill in your knowledge gaps.

For part b, present multiple perspectives:
- do a preliminary life cycle assessment to estimate energy use and emissions from throughout product lifecycle
- compare 'sustainable product' to 'conventional alternative'
- consider economic, environmental, and social implications of the product
- consider waste associated with different life cycle phases
- consider whether it promotes sustainable lifestyles
- consider if it requires too much expertise or high tech materials
- consider if it requires a lot of water, land, materials, energy, and other resources throughout its lifecycle
- consider other points...

**Option 2: Peer reviewed paper presentation**
Choose from the following list or choose an article of your interest that Dr. Apul has approved for you to present:

1. Hanandeh and Zein (2011) Are the aims of increasing the share of green electricity generation and reducing GHG emissions always compatible? Renewable Energy, 3031-3036.
2. Kim, M.H. and Kim, J.W. (2010) Comparison through a LCA evaluation analysis of food waste disposal options from the perspective of global warming and resource recovery, Science of the Total Environment, 408(19), 3998-4006
3. Colon et al. (2010) Environmental assessment of food composting, Resources Conservation and Recycling, 54(11), 893-904.
4. Any of the good papers on rainwater or wastewater LCA

**Suggestions for how to critically review the paper:**
1. Read the title and the abstract
2. Look at the figures and tables
3. Look to see who the authors are, where was the research done? In which journal was it published?
4. Read the conclusions



5. Go back and read the entire paper or certain sections of the paper. Repeat this step a few times until you feel comfortable with the article.
6. For your own work (not for this assignment), if you are looking for any specific information for your literature review (e.g. a method or a particular measurement) you probably don't need to read the entire paper, just read the relevant parts. For this assignment, you do need to read the entire paper and come to class well prepared to present it.

**Grading Scheme:**
Paper background (title, authors, info on journal, etc.) (5 points)
Introduction and objectives (5 points)
Methods (5 points)
Results and Discussion (10 points)
Summary and Conclusions (5 points)
Ability to understand and present the value of the paper as well as its strengths and weaknesses (10)
Ability to answer questions from the audience (10 points)

Here are some examples of questions you might want to discuss. Pick a few or generate your own.

Examples of General Questions

i. What is the scientific value of the paper?
ii. What is the overall message of the paper?
iii. What are the specific questions asked in this paper? Did the paper answer the questions thoroughly? What parts of the questions remain unanswered?
iv. Do you think the work was well done? Do you think the work was worth publishing?
v. What is new about this work? Do you think the work is important? If yes, why?
vi. Who would care about this info? What are the implications of this work?
vii. What is the most important idea/finding of the paper? (Ideally, every paper should have one clear idea, instead of several diffuse messages with no clear outcome.)
viii. Is the work original and valid?
    Originality means new experimental data, new interpretations of existing data, or new theoretical analysis of environmental data.
ix. Did the authors discuss their data and support the evidence based on prior publications?
x. How would you rate the originality, technical quality, clarity of presentation, and importance to field? (excellent, good, fair, poor)
xi. What other info would you have liked the authors to present in this paper?
xii. Is there sufficient information to possibly reproduce the results presented in the paper?
xiii. What are the strengths and weaknesses of the paper?

Technical Writing

xiv. Is the writing clear, concise, and relevant? Is the message clear?
xv. Are various sections of the paper well written?
    1. Abstract? Intro? Methods? Results? Discussion?
xvi. Do you think the figures and tables were worth including?

Methods

xvii. If it is a modeling paper, what are the input parameters, relevant equations, what do they mean?
xviii. What analytical instruments did they use to measure environmental data?
xix. Is there sufficient QA/QC?
xx. What materials did they work with?
xxi. What exactly did they measure?

Results and Discussion

xxii. Do you believe in their data?
xxiii. Did the authors present raw data or processed data with meaningful interpretation?
xxiv. Did the authors appropriately cite prior work?
xxv. What does figure/table xxx mean?
xxvi. Any other questions specific to the paper you picked

Here are some items you should pay attention to when reading a paper:
What are the components of the paper? Intro, experimental etc...
What type of information is given in the introduction, methods, results/discussion sections?
What kind of sentence structures were used? What tense, passive or active voice?
How did the authors cite other published papers?
Do you think the paper flows well?
Are the paragraphs well structured?

Examples of Paper Specific Questions
What computer model did they use?
Are data sources well documented and appropriate?



**Assessment 8 (Group)**
**Second Progress Report for Your Project**

1. Submit an improved report that is close to the final version. We'll discuss in calss details on what to include.
2. Submit the peer grading excel spreadsheet with your peer grades filled out. This should be a confidential email attachment sent to Dr. Apul only, not to your team members.

**Assessment 9 (Group)**
**Final presentation**
Final presentation to stakeholders.

**Assessment 10 (Group)**
**Final report**
Submit final report and copy of Dr. Apul's comments from mock grading. Dr. Apul will be MORE THAN HAPPY to mock grade your final report before you submit it for final grading.

**Preps**

**Prep 1:**
Browse through these resources:

1. http://www.epa.gov/nrmrl/lcaccess/lca101.html
2. www.eiolca.net
3. http://www.earthshift.com/
4. http://www.pre.nl/content/lca-methodology
5. http://www.life-cycle.org/
6. http://www.lcacenter.org/
7. http://www.springer.com/environment/journal/11367
8. http://resilience.eng.ohio-state.edu/eco-lca/
9. Do a search on web of knowledge using the keywords "life cycle assessment". What do you see?

**Prep 2:**

1. Read this article:
   Anand, C. and Apul, D.S. (2010) Cost, Energy, and CO2 Emissions Analysis of Standard, High Efficiency, Rainwater Flushed, and Composting Toilets, Journal of Environmental Management, 92, 419-4282.
2. Broswe through the EEAST model web page including the EEAST model and its description:
   http://defneapul.wikispaces.com/Water+sustainability

**Prep 3:**

1. Browse through pages 90-113 of the Local Government Operations protocol available from: http://www.theclimateregistry.org/downloads/2010/05/2010-05-06-LGO-1.1.pdf
2. Browse through this website: http://www.theclimateregistry.org/

**Prep 4:**

1. Read chapter 2 of Computational Structure of LCA. Email Dr. Apul if you don't have access to this chapter.
2. Browse through this website: http://www.leidenuniv.nl/cml/ssp/staff/heijungs/computationalstructure.html

**Prep 5:**

1. Read chapters 3 and 5 of Computational Structure of LCA. Email Dr. Apul if you don't have access to theses chapters.

**Prep 6:**
Browse through the following websites:

1. Urban Environmental Institute of Toledo: http://www.ueitoledo.com/
2. City of Toledo Council: http://www.ci.toledo.oh.us/ToledoCityCouncil/tabid/206/Default.aspx
3. Nitrogen footprint. Think about why this is relevant: http://n-print.org/sites/n-print.org/files/footprint_sal/index.html#/home
4. CHEFS model: http://www.cleanair-coolplanet.org/chefs.php
5. Browse through the following article:
   Munoz et al. (2010) Life cycle assessment of the average Spanish diet including human excretion, Int. J. of LCA, 15:794–805

**Prep 7: To be determined based on topic**