

## EES 4860/6860 – Environmental Sustainability

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**Time:** T/Th 2:00-3:15pm  
**Location:** WFIC 310  
**Instructors:** Michael Carbajales-Dale;  
email: [madale@clemsn.edu](mailto:madale@clemsn.edu)  
**Office hours:** By appointment  
**TA:** Jacob Arnold  
email: [jarnol4@clemsn.edu](mailto:jarnol4@clemsn.edu)  
**Office hours:** By appointment



### PREREQUISITES:

Junior standing in College of Engineering and Science.

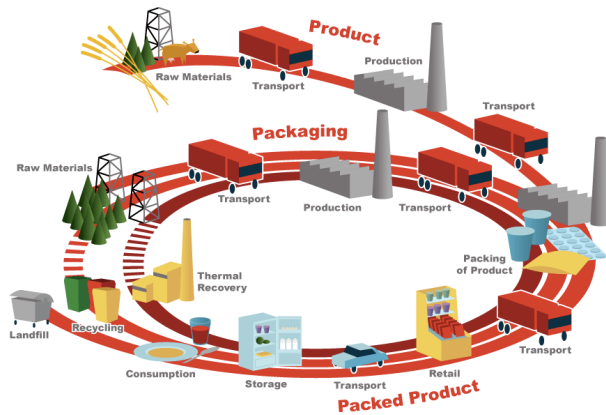
### COURSE DESCRIPTION:

The late 20th century marked a paradigm shift in environmental practices. Instead of treating environmental considerations as unavoidable costs occurring at the end of a process, companies began to strategically rethink environmental initiatives. Proactive environmental management opportunities include the practice of pollution prevention, industrial ecology, and design for the environment – concepts which dismiss end-of-pipe treatment as the primary option for industrial wastes. Instead, recent legislation and reconceived environmental strategies attempt to integrate environmental considerations in industrial systems by using a systems approach to manufacturing and examining the life cycles of products, incorporating total cost accounting, extended producer responsibility and design-for-end-of-life into decision making processes.

### COURSE OBJECTIVES:

Over the course students will:

1. Learn about the economic, social, and environmental aspects of sustainability and some frameworks for defining and measuring progress toward a sustainable society.
2. Explore the major impacts that humans have on the environment.
3. Be introduced to:
  - a. life cycle assessment (LCA); a framework for evaluating the environmental impacts of products and services over their full life cycle, from raw materials extraction (cradle) to end-of-life disposal or re-use (grave); and
4. Engage in experiential learning activities:
  - a. conduct a research project to quantify the environmental impacts associate with a product using LCA.



## GLOBAL CHALLENGES

This course is a Global Challenges course. Throughout the course, we will be asking questions such as:

- How is the global environmental sustainability challenge shared, for example among nations, communities of interest, or industries?
- What is the scope of the global environmental sustainability challenge, for example temporal, geographical, or those impacted?
- What is its impact for us and our world?

The semester group project will be a global challenges signature assignment. Please see the rubric below for global challenges.

## CRITICAL THINKING:

This course is a Clemson Thinks<sup>2</sup> (CT<sup>2</sup>) critical thinking seminar. CT<sup>2</sup> is a campus-wide initiative developed to increase and enhance students' critical thinking skills. What is critical thinking? For the purposes of this course, we understand critical thinking to be, "a habit of mind characterized by the comprehensive exploration of issues, ideas, artifacts, and events before accepting or formulating an opinion or conclusion." (AAC&U 2009). Critical thinking is a self-aware process of thinking in a clear and

systematic way in order to gain a deeper understanding. To do so requires engaging in meta-cognition, which means reflecting on our own thinking by recognizing our biases, assumptions, and considering how we create knowledge. Critical thinking does not come naturally; therefore, we must practice critical thinking – which is one of the goals of this course.

Memorizing facts and being able to regurgitate definitions or procedures is not a sufficient skill set to understand and address the complex problems facing our world today. We need to develop the ability to *reason*, *evaluate*, and *decide* if we are to become successful in future careers and effective stewards of our future. **We will apply this strategy to environmental claims made in research, popular culture, and news.**

## STUDENT LEARNING OUTCOMES:

Student learning outcomes (SLOs) will adhere to the SMART framework; specific, measurable, attainable, relevant, and timely. Additionally, SLOs from this course will align with the universal CT2 SLOs wherein students should (1) explore complex challenges; (2) analyze multi-dimensional problems; (3) extrapolate from one conceptual context to others; (4) synthesize alternative solutions to multi-dimensional challenges; and (5) effectively communicate complex ideas.

After taking the course, students should be able to:

1. Demonstrate critical thinking through analysis of complex global challenges
  - a. Explain, with examples, the dependence of society on natural systems
  - b. Recognize and explain the interconnection among human infrastructure and natural systems, as

- exemplified by the food-energy-water-climate nexus
2. Evaluate how varying perspectives influence global challenges
    - a. Assess environmental topics from different viewpoints, e.g. anthropocentrism vs. biocentrism
  3. Analyze multi-dimensional problems
    - a. Identify and evaluate environmental impacts and implications
    - b. Describe impacts that humans have on the environment and the most important activities associated with these impacts, e.g. burning of fossil fuels emits greenhouse gases, run-off from fertilizers causes eutrophication
    - c. Construct a logical argument regarding a topic in environmental sustainability, e.g. the future of bioethanol
    - d. Assess both positive and negative aspects of a proposed solution to an environmental, social, or economic problem
    - e. Evaluate data for consistency with established facts, hypotheses, or methods
    - f. Interpret quantitative relationships in graphs, tables, charts, etc
    - g. List and interpret definitions of sustainability, e.g. the Strong Model of Sustainability or the Daly rules
    - h. Analyze, summarize, and critique different opinions regarding the meaning of environmental sustainability
  4. Extrapolate from one conceptual context to others
    - a. Develop and justify one's own hypotheses, interpretations, or positions.
    - b. Locate and use primary and secondary sources to conduct research
  5. Synthesize alternative solutions to multi-dimensional challenges
    - a. Assess problem definitions and conclusions in terms of
    - b. Quantitatively evaluate 'green' or 'eco' claims made about products or policies;

- c. Generate alternative designs for existing products or systems
  - d. Compare the relative merits or deficiencies of product/system (re)designs
  - e. Identify the limitations of one's own hypotheses, interpretations, or positions.
6. Effectively communicate complex ideas
  - a. Prepare and deliver an oral presentation, or produce an audio-visual piece to communicate their research project;
  - b. Compose an 'op-ed' piece presenting an argument.

## CLASSROOM STRATEGIES

Since critical thinking does not come naturally, during the course we will undertake a variety of learning activities to practice and hone our skills:

**Lectures:** Lecture content is being offered asynchronously this semester. As such, there will be no 'lectures'. Scheduled class times will be open as drop-in office hours for students. Participation will be assessed in a variety of ways including informal discussions (e.g. of readings), web-based polls, and quizzes. Online lectures will be provided through Canvas and will have associated *online assessments* (e.g., self-graded questions) that must be completed in order to gain credit. You should build on concepts presented in the course in your assignments and position statements throughout the course.

**Readings and videos:** Throughout the course you will complete a variety of readings and videos expanding on or providing examples of topics discussed in the classroom. For each of these readings or videos, you will be required to complete an associated *online assessment* in Canvas. You should use examples from these materials to help support the arguments you

make in your assignments and position statements throughout the course.

**Case Studies:** Focused in-class exploration of issues in a specific place/context. Students should prepare outside of class by completing readings and performing web searches to provide general environmental, social, and economic context and issues for the case being studied that can be shared with the class. Extra material brought to the class (and posted in Canvas) to enrich case study discussions will contribute to your *participation* grade. Note that most case studies will also have an assessment or position statement associated with it.

**Group discussions:** Student led exploration of content through focused discussion of material. Students must prepare *outside of class* by completing readings, performing supporting independent research, and preparing a *Position Statement* (must be posted *before class* on the appropriate Canvas discussion board). In class, students will discuss positions statements within small groups to develop a single, coherent statement for the group that is clearly thought out, supported by data, and takes in multiple points of view to present possible options or resolutions to the question posed. Each group will subsequently present their results to the class to identify commonalities and differences among the groups.

**Active learning:** There will be a number of activities throughout the course, including role-playing scenarios and serious games. These are mainly to stir thoughtful discussion around a topic, but may be asked about for homeworks and exams.

**Signature assignment:** students will work in groups to evaluate the environmental impacts of a product/activity throughout the whole of its life cycle from material extraction, through

processing, fabrication operation and final disposal. Groups will perform the major steps of an LCA for the product/activity and design strategies to improve its environmental performance. The final deliverables will be communicating the project through a project website and 10-15 min presentation/video to the class.

#### **PRE- AND POST-COURSE ASSESSMENT OF CRITICAL THINKING:**

The CT<sup>2</sup> program is being implemented as a campus-wide research effort to improve the University's ability to teach students critical thinking skills. As a result, *students may be required to complete two general critical thinking exams* (one at the beginning of the term and one at the end) that will be used to study the effectiveness of different teaching methods. *The results of these exams do not count toward your grade or degree progress at Clemson and only aggregate results will be used to evaluate the teaching strategies of this course versus other CT2 courses.*

**California Critical Thinking Skills Test:** In this course, we will use the California Critical Thinking Skills Test to evaluate and monitor your growth in critical thinking. The test will be administered as part of homework. Please ensure that you are in a low distraction environment and have sufficient time to finish the test to achieve a score that accurately reflects your abilities.

#### **CRITICAL THINKING ARTIFACTS:**

Most of the reading assignments in this course serve as artifacts to demonstrate your refinement of critical thinking skills over the term. These will be evaluated using the AAC&U Critical thinking VALUES rubric (AAC&U 2009) which has been posted to Canvas.

## RESOURCES:

**Required:** Readings are taken from [\*Taking Sides: Clashing Views in Sustainability\*](#) (CVS) by Robert Taylor, which students are **required to purchase**. Lecture notes will be posted to Canvas (clemson.instructure.com). It is recommended that you bring these materials to class in either electronic or paper format.

**Useful, but not required:** The content for this course is largely based upon [\*Industrial Ecology and Sustainable Engineering\*](#) by TE Graedel and BR Allenby (G&A, 2nd edition 2009). Students are not required to purchase this book, but it will be a useful supplement to the class material. Additional content is taken from [\*Environmental Issues: An Introduction to Sustainability\*](#) by McConnell and Abel. Again, students are not required to purchase, but it is a useful supplement. A guide to writing for environmental engineers has been written by Tchobanoglous & Leverenz (2013) [\*A Guidance Manual on the Preparation of Technical Reports, Papers, and Presentations\*](#).

**TENTATIVE SCHEDULE (SUBJECT TO CHANGE)**

Week	Topic	Reading		HW posted	Project deliverables
		G & A Ch.	CV		
1	Introduction	1	1	1	
2	Models and Frameworks for Sustainability	2 & 7	13	2	
3	Intro to Lifecycle Assessment (LCA), OpenLCA Tutorial, project planning	11-13		3	
4				4	<b>Proposal</b>
5					<b>Open LCA tutorial</b>
6	<b>Revision (Tues) and Midterm 1 (Thurs)</b>			-	
7	Human activities and environmental impacts		3 11(E&S)	5	<b>Literature review</b>
8				6	
9				-	<b>Data</b>
10				-	
11	<b>Spring break</b>				
12	Industrial Ecology and Design for X	3-5, 16	10	7	<b>LCA model</b>
13					
14	Pollution prevention, green chemistry & engineering	8	8	8	<b>Results</b>
15	Group project work session				
16	<b>Final presentations</b>			<b>Final presentation + project website</b>	

## GRADING

### Breakdown of grade assignment:

	EES 4860	EES 6860
Participation	20%	10%
Proposal	-	10%
Projects	50%	50%
Exam	30%	30%

### Participation:

Participation is made up of class attendance, engaging in class activities, online discussions and handing in homework.

### Exam:

One midterm exam will be given. *Students enrolled in 6860 will have more advanced exams than those in 4860.*

### Final letter grade:

Final grades will generally be assigned according to the scale given below. However, the instructor reserves the right to curve grades and/or use t-scores. In no case will curving be done if it results in a lower letter grade.

	A	B	C	D	F
EES 4860	90%	80%	70%	60%	>60%
EES 6860	90%	80%	70%	-	>70%

### ASSIGNMENTS:

Homework will be assigned most weeks (on Thursdays) via Canvas and will be due electronically (upload to Canvas) the following week (on Thursday), before the beginning of class. Homework content will include problem solving, reading assignments, written critiques of readings, etc. In addition to formal assignments, students are asked to pay attention to current topics in sustainability issues. Late homework will receive an automatic 5% deduction for every day

overdue. *Students enrolled in 6860 will have additional questions to complete on assignments.*

### PROJECTS:

#### Life cycle assessment:

The course will include a (3-4 person) group project. Groups will choose a common product and investigate the environmental impact throughout the product's life cycle. More information on the project can be found [here: https://spark.adobe.com/video/qi1T9xMxUduWZ](https://spark.adobe.com/video/qi1T9xMxUduWZ). Each group will give a presentation (15-20 min) at the end of the semester. This could be in the form of a slideshow, or a video. Part of your project grade will also be based upon an evaluation by your group colleagues. *Students enrolled in 6860 will also have to turn in a project proposal, which will form part of your final grade (10%). Attendance at presentations is mandatory.*

### POLICY:

- In the event of an unplanned absence by the professor, class will be cancelled after 15 minutes
- Academic honesty is expected. Any violation of Clemson University policy as described in the Student Handbook will not be tolerated and may result in a failing grade.
- Use of electronic devices will not be permitted during class, except for the purposes of taking notes.
- Any exam that was scheduled at the time of a class cancellation due to inclement weather will be given at the next class meeting unless contacted by the instructor.
- Any extension or postponement of assignments or exams must be granted by the instructor via email or Canvas within 24 hours of the weather-related cancellation.

## RUBRIC FOR GLOBAL CHALLENGES ASSIGNMENTS

	4	3	2	1
<b>Analysis of global challenges</b>	Challenge to be considered critically is stated clearly and described comprehensively, delivering relevant information necessary for thorough understanding.	Challenge to be considered critically is stated, described, and clarified so that understanding is not seriously impeded by omissions.	Challenge to be considered critically is stated and described, with ambiguities.	Challenge to be considered critically is stated without clarification or description.
<b>Influence of varying perspectives</b>	Interprets experiences from the perspectives of one's own and more than one worldview while demonstrating respect for other cultural groups.	Recognizes and uses dimensions of more than one worldview.	Identifies components of the worldview of others.	Catalogs one's own cultural worldview only.
<b>Global challenges and opportunities</b>	Insightfully and explicitly analyzes significant and complex challenges and opportunities in the natural and human world, while recommending strategies for improvement.	Insightfully and explicitly analyzes significant challenges and opportunities in the natural and human world.	Identifies significant challenges and opportunities in the natural and human world.	Superficially or simplistically identifies challenges and opportunities in the natural and human world.

**Definitions:**

Complex, multi-layered context: The sub-parts or situational conditions of a scenario that bring two or more ethical dilemmas (issues) into the mix/problem/context for students' identification

Context: The historical, ethical, political, cultural, environmental, or circumstantial settings or conditions that influence and complicate the consideration of any issues, ideas, artifacts, and events. Cross-relationships among the issues: Obvious or subtle connections between/among the sub-parts or situational conditions of the issues present in a scenario.

Perspective-taking: The ability to engage and learn from perspectives and experiences different from one's own and to understand how one's place in the world both informs and limits one's knowledge.



## **ACADEMIC INTEGRITY:**

*As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a "high seminary of learning." Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form.*

*Use of work turned in for credit on previous course must be discussed with the instructor. Acts of academic dishonesty will result in a formal written charge of academic dishonesty, including a description of the misconduct to Dr. Jeff Appling, Associate Dean of Undergraduate Studies.*

## **ACCESSIBILITY:**

*Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, course design, technology used for curricular purposes, or other campus resources. Students who experience a barrier to full access to this class should let the professor know, and make an appointment to meet with a staff member in Student Accessibility Services as soon as possible. You can make an appointment by calling 864.656.6848, by emailing [studentaccess@lists.clemson.edu](mailto:studentaccess@lists.clemson.edu), or by visiting Suite 239 in the Academic Success Center building. Appointments are strongly encouraged – drop-ins will be seen if at all possible, but there could be a significant wait due to scheduled appointments. Students who receive Academic Access Letters are strongly encouraged to request, obtain and present these to their professors as early in the semester as possible so that accommodations can be made in a timely manner. It is the student's responsibility to*

*follow this process each semester. You can access further information here: <http://www.clemson.edu/campus-life/campus-services/sds/>.*

## **TITLE IX STATEMENT:**

*Our school is committed to fostering a safe, productive learning environment. Title IX and our school policy prohibits discrimination on the basis of sex. Sexual misconduct – including harassment, domestic and dating violence, sexual assault, and stalking – is also prohibited at our school.*

*Our school encourages anyone experiencing sexual misconduct to talk to someone about what happened, so they can get the support they need and our school can respond appropriately.*

*If you wish to speak confidentially about an incident of sexual misconduct, want more information about filing a report, or have questions about school policies and procedures, please contact our Title IX Coordinator, which can be found on our school's website.*

*Our school is legally obligated to investigate reports of sexual misconduct after a formal complaint is filed or signed by the Title IX Coordinator, but a request for confidentiality will be respected to the extent possible.*

*Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. This policy is located at <http://www.clemson.edu/campus-life/campus-services/access/title-ix>. Ms. Alesia Smith is the Clemson University Title IX Coordinator, and the*

*Executive Director of Equity Compliance. Her office is located at 110 Holtzendorff Hall, 864.656.3181 (voice) or 864.656.0899 (TDD).*

#### **INFORMATION RELATED TO COVID-19 :**

*While on campus, face coverings are **strongly encouraged** in all buildings and classrooms. Face coverings are also encouraged in outdoor spaces where physical distance cannot be guaranteed. Please be familiar with the additional information on the Healthy Clemson website, such as the use of wipes for in-person classes.*

*Before coming to campus, all instructors and students should complete the [COVID-19 Self-Assessment Tool](#).*

*Instructors and students who are informed that they have a presumptive positive diagnosis or have tested positive for COVID-19 should immediately self-isolate and submit the COVID-19 Positive Test Reporting Form.*

*For a student who reports testing positive or is being asked to quarantine/isolate because of exposure to the virus, it will be up to the student to inform the instructor that they will be moving to online only instruction for at least the next two weeks. Students are directed to use the Notification of Absence module in Canvas to initiate this notification. Additional communication via email is encouraged; students should follow up with their instructor to develop a continued plan of study for each course. Students cannot be penalized in their grade for needing to move to online instruction.*

#### **REFERENCES:**

Association of American Colleges and Universities. (2009). *Critical thinking VALUE rubric*. Retrieved from <https://www.aacu.org/value/rubrics/critical-thinking>