

GREEN ENGINEERING AND SUSTAINABLE DESIGN

SPRING 2016

ENAS 360 / ENVE 360 / ENVE 660 / FES 96108

MONDAYS / WEDNESDAYS 1 – 2:30 PM

CENTER FOR ENGINEERING INNOVATION AND DESIGN (CEID)

COURSE DESCRIPTION

This course will provide a hands-on foundation to green engineering and the design and assessment of green products. Approaching sustainability from a design perspective requires the need for a fundamental conceptual shift from the current paradigms of product toward a more sustainable system, based on efficient and effective use of benign materials and energy. Through the course assignments, class exercises, and a semester-long team project, students will be challenged with the same issues facing our production and consumption systems today.

The course will be organized around the “engineering design process” from 1) opportunity definition, 2) criteria definition, 3) ideation, 4) alternatives assessment, and 5) solution selection, implementation, and monitoring. To begin, the mega-trends driving sustainability discussions will be presented and the case for the need to innovate new greener product systems will be made. The course will emphasize quantitative and rigorous analysis of green design in addition to the tools needed to develop these designs.

The foundational principles of the course can be summarized in the five *I*'s: (1) *Innovation* – we can't solve problems at the same level of thinking used to create them, (2) *Inherency* – we can't solve problems without looking at the nature of system that created them, (3) *Interdisciplinary* – we can't solve problems without looking at other aspects of the problem, (4) *Integration* – we can't solve problems without connecting segments at a system level, and (5) *International* – we can't solve problems without considering the context of the problems.

The current approach to design, manufacturing, and end of life will be discussed in the context of examples and case studies from various sectors. This will provide a basis for what and how to consider designing green products, processes, and systems. Fundamental engineering design topics include pollution prevention and source reduction, separations and disassembly, virtual and rapid prototyping, life cycle design, management, and assessment

COURSE OBJECTIVES

This course is designed to provide students with the following capabilities:

1. To collaborate effectively with people from varying backgrounds to perform structured sustainable design innovation exercises, from concept to prototype, using a defined process
2. To practice ideation techniques and demonstrate them in conjunction with sustainability criteria in designing solutions to presented opportunities

3. To rigorously and quantitatively assess green attributes of product and processes using among other criteria water, material and energy efficiencies and flows, and end of life options
4. To perform basic and streamlined life cycle design, management, and assessment as well as multi-criteria decision analysis
5. To practice and demonstrate proficiency in utilizing the resources (both human and capital) of the CEID in the design and development of a product or service that meets performance, cost, and “green” criteria
6. To become familiar with the current frameworks for green design and articulate the pros and cons of these strategies

TEAM DESIGN CHALLENGES

There will be two team-based comprehensive design challenges during this course. For each challenge, teams will be tasked to design an innovative solution to a real-world sustainability challenge. The various challenges and guidelines will be introduced with sufficient time for you and your team to succeed. The projects will require following the design process introduced in the course and will include **defining an appropriate design statement, conducting an alternatives assessment, and developing sophisticated concept designs and/or prototypes culminating in a final presentation.** Periodic updates and milestones will be required throughout the semester to ensure that adequate progress is being made and that the team is working in an appropriate direction. More details about the project scope, structure, and deliverables will be available in late February for the midterm challenge and in in early March for the final challenge.

As for with any long-term and team-based assignment, it is imperative that you work with your team to develop a set of norms and expectations for your group. It is also critical that you do not wait until the proverbial last minute to embark on these design journeys. *You and your team are expected to dedicate and manage enough time to test, fail, debate, iterate, test and fail, experiment, brainstorm, create, dream, sketch, and test and fail again.*

REQUIRED FOR THIS COURSE

This class is fundamentally about innovation and design in a sustainability context. Given the emphasis on innovation and design, it is necessary to try and fail, it is critical to tolerate others trying and failing, and it is imperative that effectiveness of the team design process is as important as success of the solution.

It is our sincere hope that as a graduate of this course you will be a thoughtful stakeholder as well as a fundamental and systems thinker, a designer, an innovator, and practitioner of sustainability. Your questions, thoughts, and comments are valuable and encouraged throughout this class. Remember, “Some look at things that are, and ask why. Others dream of things that never were and ask why not?” You should ask “why not?” a lot.

PREREQUISITES

You **MUST** be a member of CEID prior to the end of shopping period. Details on becoming a member can be found at: <http://ceid.yale.edu/member/#membership>.

A clear and concise expression of your interest in embarking on this journey via an email to Prof. Anastas, Prof. Zimmerman, and Mr. Kwan with the subject line – “GESD Wannabe” by 5 PM on Jan 22.

This expression must include that you are a member of CEID, that you have completed the necessary training, and explain why you want to take this class and how your experience will contribute OR how the experience of this class is vital to your training

COURSE MATERIALS

The course syllabus, schedule, readings, necessary software links, supplementary material, homework assignments, and other relevant information will be posted on the web page at <https://classesv2.yale.edu>. You are responsible for the material posted here and presented in lectures. Assigned readings/videos are expected to be reviewed prior to coming class and you be prepared to discuss the materials.

We will be using two software packages throughout this course in addition to spreadsheets.

Sustainable Minds: <http://www.sustainableminds.com/>

A subscription to the online, browser based Eco-Design and LCA software package will be made available to you during the course of the semester. This cloud-based service will enable the integration of life cycle thinking during the product development processes.

Onshape: <https://www.onshape.com/>

Onshape is a cloud-based, fully functional 3D CAD platform. Sign up for a free account using your Yale email. No installs or licenses are required and it will work with Chrome, Firefox, Safari; Windows, Mac, and Linux. Project files can be stored on the cloud or downloaded for local storage; additionally .stl files can be generated using Onshape which is necessary for 3D printing.

(In lieu of a textbook, assigned readings will be posted on Classes v2)

PERFORMANCE EVALUATION

Grades will be assigned based on individual assignments (including journal entries), design activities, team design challenges and presentations as well as ongoing class participation. Scores will be weighted to compute final grades as listed below:

Individual assignments	20%
In-class design exercises	15%
Team design challenge 1	20%
Team design challenge 2	35%
Participation	10%

You may question our grading at any time. We will re-grade your work and adjust the score up or down according to the reassessment.

Your individual grade for the team design challenge will reflect both your team's performance in meeting the objectives of the challenge as well as input from your team members about your individual performance and participation.

All assignments will be due according to the schedule posted on ClassesV2. Late assignments will be marked down 5% per day.

(There are NO formal written exams in this class.)

PARTICIPATION

Your participation in this class is necessary and will be reflected appropriately in your performance evaluation as described above. Expect to be called on in every class period. You will also be required to work in groups, actively engage in group/class discussions, and deliver presentations.

INCLUSION

Designers are expected to treat others fairly, with respect and courtesy, regardless of such factors as race, religion, sexual orientation, gender, disability, age or national origin. ***In this class, you are expected to contribute to the overall campus climate such that others feel welcome, are respected, and are able to develop to their full potential.*** This will allow each person to contribute to the success of the class as a whole. Yale, the Faculty of Engineering, and your course instructors are committed to maintaining a productive, enjoyable and diverse campus environment.

ACADEMIC INTEGRITY

You are welcome to work together on homework sets – and are encouraged to do so. You must, however, come up with your own solutions to the problems. Turning in an exact copy of your classmates' homework is not acceptable. Dishonesty will not be tolerated. If a student is caught cheating, the matter will be handled in full accordance with the university's academic policies.

COURSE INSTRUCTORS

Prof. Paul Anastas
office: 219 Kroon Hall
hours: TBD
email: paul.anastas@yale.edu
phone: 436-5127

Prof. Julie Zimmerman
office: 313B Mason Lab
hours: TBD
email: julie.zimmerman@yale.edu
phone: 432-9703

ASSISTANT INSTRUCTOR

Thomas Kwan
Office: CEID or Mason Lab 316
Hours: Mondays at noon.
Email: Thomas.Kwan@yale.edu

TEACHING FELLOWS

Mark Falinski
Office: CEID
Hours: TBD
Email: Mark.Falinski@yale.edu

David McCarthy
Office: CEID
Hours: TBD
Email: David.McCarthy@yale.edu

COURSE SCHEDULE

DATE	Topic	Due
JAN 20	Overview, Design and innovation	
JAN 22 (FRIDAY)	Sustainability frameworks, Transformative innovation	Watch IDEO video
JAN 25	Design opportunities ⊗ 1 st design challenge	
JAN 27	Defining the opportunity ⊗ 2 nd design challenge	Assignment 1
FEB 1	Computer-aided design OnShape software introduction and tutorial	
FEB 3	There is no "I" in team ⊗ 3 rd design challenge	Assignment 2
FEB 8	Function and service	
FEB 10	⊗ 4 th design challenge	Assignment 3
FEB 13 (NOTE)	FIELD TRIP!?!	
FEB 15	Life cycle thinking	
FEB 17	Life cycle assessment Sustainable Minds software introduction and tutorial	
FEB 22	Life cycle costing	Assignment 4
FEB 24	⊗ 1 st design challenge v2 ∴ Team presentations	
FEB 29	Multicriteria decision analysis	
MAR 2	♥ Team Meetings	Assignment 5
MAR 7	Green Criteria ⊗ 5 th design challenge	
MAR 9	Solutions to midterm team design challenge ∴ Team presentations	Mid-course evaluation Team member and challenge selection
MAR 28	Design for Disassembly	
MAR 30	Working session ♥ Team Meetings	
APR 4	Stakeholder / Client meeting	
APR 6	Working session + checking in with teams ♥ Team Meetings	Opportunity Statement
APR 11	Working session + minding the gaps ♥ Team Meetings	
APR 13	Working session + perfection is the enemy of the good ♥ Team Meetings	Alternatives Generation and LCA
APR 18	∴ Team presentations	
APR 20	Working session + sustainability matters ♥ Team Meetings	MCDA and final design selection

APR 25	Working session + systems thinking ♥ Team Meetings	
APR 27	Finding True North	Initial prototype
MAY #	The Shark Tank Solutions to final team design challenge ∴ Team presentations	