Catalog Description

BE 450 Sustainable Engineering (3). Overview of sustainability concept; indicators of sustainability; applications of sustainability concepts to various engineering disciplines; green engineering; life cycle analysis; use of mass and energy balances in the design of sustainable systems; selected case studies. Pre: consent.

Course Justification

The proposed course: Sustainable Engineering is intended as an elective course for upper level undergraduate students of all engineering disciplines. This 3-credit course aims at introducing broad topics on sustainability as applied to various engineering disciplines. The course delivers a message that we live in world where the supply and availability of natural resources are finite and the life support capacity of earth is also limited. Many products, processes, and designs still in vogue, are environmentally unsustainable. The roles of engineers to develop environmentally sustainable systems are discussed with several examples and case studies. The course presents an overview of concepts of sustainability, and outlines the commonly acceptable definition, principles and indicators of sustainability. The course discusses some of the damages of conventional engineering designs/products/processes on environment with specific example and case studies. The course further introduces the green engineering concepts where the principles and tools of sustainable engineering are applied to various engineering disciplines. The course introduces the concept of life cycle assessment. The course also covers natural resources- global food production, global water resources, global energy resources and global material resources. The course also involves a semester-long project on a given topic where students will have an opportunity to analyze, interpret and discuss sustainability concept on their selected topics. All assignments will be an open-ended question involving engineering designs/processes/products, where students’ ability to critically synthesize the sustainability concepts will be tested.

This new course builds-up a strong connection with the current BE core courses, e.g. BE 260: Mass and Energy Balances; BE 405: Engineering Economics; and BE 410: Biomass Conversion to Biofuels/Bioenergy. Sustainability is a new concept that just started to emerge in engineering discipline, and Accreditation Board for Engineering and Technology (ABET) puts forward strong emphasis on sustainability concept in engineering education. Criterion 4 of ABET, which addresses the Professional Component of engineering education, includes the following statement:

“Students must be prepared for engineering practice through the curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating engineering standards and realistic constraints that include most of the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political.”

This is even so important for geographically isolated and import-depended state like Hawaii where our engineering students should be made aware of sustainability concepts. Currently there is no such course available at University of Hawai‘i at Manoa. The proposed course will provide an excellent opportunity for BE and College of Engineering (COE) students to understand the concept of sustainability as applied to various disciplines of engineering. Dr. Khanal is currently
in touch with Dept. Chairs of all four engineering programs (Civil and Environmental Engineering, Mechanical Engineering, Electrical Engineering, and Ocean and Resources Engineering) at UH Manoa with regards to adaption of the proposed course as a technical elective in their respective departments.

1. What is the course modification?
BE 450 is a new course.

2. Why is the course being requested?
The BE program and COE currently do not have any undergraduate level course that covers the broad topics of sustainability from engineering perspectives. The course aims to provide strong foundation of sustainability in engineering design, products and processes to BE/COE students, and better prepared them for professional career, where they can apply the sustainability concepts.

3. How will the content be organized?
This is a 3-credit course and will meet for 75 minute lecture, two times per week. In addition, the students will be divided into a group and each group will prepare a semester-long project on a given topic of sustainability. The students will prepare a group project and will deliver oral presentation at the end of semester.

BE 450: Sustainable Engineering
Department of Molecular Biosciences and Bioengineering
University of Hawai‘i at Mānoa

Instructors:
Samir K. Khanal, Ph.D., P.E.
Office: Agricultural Science 415K
Telephone: 956-3812

Office Hours: TBA
Email: khanal@hawaii.edu

Teaching Assistant: There will be a teaching assistant assigned for this class. If you have questions related to the material, you may request a meeting with the TA (TBA).

Meeting times and locations: The classes will be held in TBA. The venue and time will be TBA. The exam and field trip dates will be announced in the first class. Any change in class schedule will be announced a week in advance except for unforeseen circumstances.

Objectives of the course: The students completing this course will learn about the principles, indicators and general concept of sustainability. Student shall be able to apprehend the local, regional and global impacts of unsustainable designs, products and processes. Student shall be able to apply the sustainability concepts in engineering.
practice to mitigate the human impact on global systems.

**Textbook:** *Industrial Ecology and Sustainable Engineering*

**Reference books:**
*Handbook of Sustainable Engineering*

*Sustainable Design: The Science of Sustainability and Green Engineering*

*Sustainable Engineering Practice: An Introduction*
Committee on Sustainability, American Society of Civil Engineers (2004).

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Committee on Sustainability, American Society of Civil Engineers (2004).

**Other reference materials:** Relevant reports, journal papers, case studies, and other supplementary reading materials will be posted on Laulima: [https://laulima.hawaii.edu/portal](https://laulima.hawaii.edu/portal)

(Log on with your UH username and password)

**Prerequisites:** Consent

**Catalog Description:** 3 credits. Overview of sustainability concept; indicators of sustainability; applications of sustainability concepts to various engineering disciplines; green engineering; life cycle analysis; use of mass and energy balances in the design of sustainable systems; selected case studies.

**Grading:**
- Class participation: 10%
- Mid-term: 20%
- Final exam: 25%
- Homework: 25%
- Term project: 20%

**Learning outcomes:** After completion of this course, student would:

- learn the sustainability concepts;
- be able to quantify sustainability, and resource availability;
- to able to rationalize the sustainability based on scientific merits;
- understand and apply sustainability concepts in designs, product developments and processes across various engineering disciplines;
- be able to make a decision in applying green engineering concepts;
- understand the role and responsibility of engineers in sustainable development;
- become a lifelong advocate of sustainability in society.

Tentative Syllable

<table>
<thead>
<tr>
<th>Week</th>
<th>Topics</th>
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<tbody>
<tr>
<td>1</td>
<td>Course outline; Introduction of sustainability concepts; Roles of engineers in developing sustainable society; Video shows.</td>
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<tr>
<td>2</td>
<td>Humanity and Technology; Master equation of sustainability; Models for population growth; Natural resources availability.</td>
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<tr>
<td>3</td>
<td>Definitions, principles and indicators of sustainability; Quantification of sustainability.</td>
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<tr>
<td>4</td>
<td>Definitions, principles and indicators of sustainability; Quantification of sustainability (cont.).</td>
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<tr>
<td>5</td>
<td>Some examples with calculations on sustainability quantification; Links between industrial activities and sustainability issues; Evaluation of important criteria for sustainable development.</td>
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<tr>
<td>6</td>
<td>Natural resources- Global food production; Global water resources; Global energy resources; Global material resources.</td>
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<tr>
<td>7</td>
<td>Natural resources- Global food production; Global water resources; Global energy resources; Global material resources (cont.).</td>
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<tr>
<td>8</td>
<td>Natural resources- Global food production; Global water resources; Global energy resources; Global material resources (cont.).</td>
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<tr>
<td>9</td>
<td>The concept of green engineering; Process/product design; Pollution prevention; Process life cycle; and Green technology and sustainability.</td>
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<tr>
<td>10</td>
<td>The concept of green engineering; Process/product design; Pollution prevention; Process life cycle; and Green technology and sustainability (cont.).</td>
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<tr>
<td>11</td>
<td>Design for environment and sustainability: Customer product.</td>
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<tr>
<td>12</td>
<td>Design for environment and sustainability: Building and infrastructure.</td>
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<tr>
<td>13</td>
<td>Life cycle assessment; Examples and case studies.</td>
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<tr>
<td>14</td>
<td>Life cycle assessment; Examples and case studies (cont.).</td>
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<tr>
<td>15</td>
<td>Sustainable engineering in Government and Society.</td>
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</table>

**Group project presentation**

**Contribution to Meeting Professional Component:**

**Mathematics and Basic Sciences:** Apply the knowledge of math and basic sciences in the design of sustainable systems. Physical, chemical, and biological sciences are used to understand the underlying principles exploited in sustainable development.
Engineering Topics: The course draws the concepts from agriculture, economics, chemistry, biochemistry, microbiology; thermodynamics, energy and mass balances in sustainable design, and in product and process developments.

General Education: Students are expected to understand the impact of conventional engineering practice/designs on the greater contexts that lead to unsustainability, demonstrate an ability to communicate ideas during classroom discussion, and intelligently and critically discuss contemporary issues/challenges our society is facing.

Relation to ABET Program Outcomes: BE 450 contributes to following outcomes:

(b) solve problems involving: physics; inorganic and organic chemistry; and/or general and microbiology;
(c) solve engineering problems involving statics, dynamics, fluid mechanics, and thermodynamics;
(d) design a system, component, or process in which biology plays a significant role;
(e) design and conduct experiments to gather information for engineering designs;
(f) use modern engineering techniques, skills, and tools to define, formulate, and solve engineering problems;
(g) function effectively in large and small groups;
(h) identify professional and ethical responsibilities;
(i) communicate effectively in large and small groups;
(j) understand the impact of engineering solutions on the surrounding context;
(k) recognize the need for life-long learning, and;
(l) intelligently discuss contemporary issues.

4. What other courses at UHM closely parallel the proposed course, and in what way will the latter make a distinct contribution?

No course currently exists at UH Mānoa that covers the broad topics of sustainable engineering. Therefore, the proposed course is extremely important to broaden-up the concepts of sustainability among BE and COE students.

5. Where or how does the proposed course fit into the current and future curriculum?

The course is intended to introduce the concept of sustainability as it applies to various engineering disciplines, which is currently lacking in the engineering curriculum. The proposed course provides a unique opportunity for BE and COE students to expose them to emerging field of sustainability. The course “Sustainable Engineering” is currently being offered in nearly all top-rated universities globally. ABET also emphasizes that sustainability concept be included in engineering education.

Given the broad coverage of sustainability concepts, it is envisioned that the proposed course could fulfill the significantly important component of engineering curriculum at the University of Hawai‘i at Mānoa.
6. Why is the number of credits and level justified? Explain the prerequisites and the absence thereof.

In order to cover the broad spectrum of concepts of sustainability and to fulfill the sustainability component of engineering education in undergraduate level, 3 credit hours are suggested. All senior engineering students with good standing can take this course. For other students, consent from the course instructor is needed.

7. How will the course assist students to achieve the critical skills and competencies expected of CTAHR graduates?

   i) **Written Communications.** Students will be asked to review journal papers and reports, and summarize the findings as part of a semester-long project on sustainability. Students will be guided as how to prepare a write-up and will be graded with comments. In addition, students will also be asked to read supplementary reading materials for assignments.

   ii) **Oral Communications.** Students will deliver oral presentation on chosen sustainability project at the end of semester. In addition, there will be numerous class discussions on various issues of sustainability. 10 points are allocated for classroom discussion.

   iii) **Analytical/problem solving skills.** An integral part of this course is to use basic scientific and engineering skills in the selected projects and assignments that require critical thinking skills and holistic approach.

   iv) **“Real world” experience.** Field visits and selected case studies will provide students with an opportunity to expose to ‘real world’ engineering systems and issues encountered in the fields. In addition, students will be exposed to several examples of sustainability concept in designs/processes/products as relates to the course.

   vi) **Computer skills.** Students will gain practice with standard computer software for drawing, data analysis, and engineering graphics.

   viii) **Global perspective.** Sustainable engineering encompasses various issues ranging from natural resources, human impact on environment to renewable energy issues, and these issues are of global importance. Thus, the course and classroom discussion will provide students with opportunity to comprehend the sustainability issues on a larger-scale.

8. How will students be evaluated?

There will be two exams. The exams will be closed book and the problems will be designed to check students’ critical and logical thinking skills. The students will be encouraged to take active participation in the classroom discussion. In addition, students will be given a semester-long sustainability project on a selected topic. The mark distributions are given below:

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UHM-1 Form for BE 450, 10/1/2010
9. What are the minimum qualifications for teaching this course? Is a qualified instructor now available?

A Ph.D. degree in engineering with relevant experience in civil engineering, environmental engineering and renewable energy with professional licensure is required. The course will be taught by Dr. Samir K. Khanal. Dr. Khanal is an Assistant Professor in the Department of Molecular Biosciences and Bioengineering and has nearly 10 yrs of professional and academic experience. Dr. Khanal has strong foundation in civil engineering, environmental engineering and renewable energy. These three fields are critically important components of sustainability. Therefore, Dr. Khanal is qualified to teach the course Sustainable Engineering.

10. How will the course be financed, assuming no further cutbacks?
In general, no special equipment or supplies will be required. The proposed course will be financed by department and college instructional funds if needed.

11. Has the course been offered before? Is there a demand for it?
This course has never been offered. With growing emphasis on sustainability in engineering education, there is a relatively large demand for the course in UHM.

12. Is the course cross-listed with another department?
No