

2009 Global Seminar, Ghana

Sustainable Design: Creating New Solutions for Global Development

Objectives: The primary objective of the course is to introduce students to holistic concepts in sustainable design. The course will integrate on culture, development and design into a practical framework for the development of new products that can add value to natural resources.

Course Description: The course on sustainable design will introduce students to the integrated concepts that are needed for sustainable design in developed and developing countries. The course will be team taught in Africa to reinforce the concepts and provide the opportunity for experiential learning. No prior courses in science or engineering will be assumed. As such, the course will be open to students from all majors. It will introduce the fundamentals of science and engineering before presenting the concepts that can be used to guide sustainable design efforts. The course will be divided into 3 sections. In the first section, the fundamentals of design will be presented. This will include design approaches, graphics and computer aided design. This will be followed by a second section on mechanical properties and materials design. Subsequently, in the third section, practical design problems in transportation (bamboo bicycles and aerospace vehicles), affordable housing (earth-based construction and natural fiber-reinforcement), alternative energy (passive and active solar), health (nano-medicine and BioMEMS) will be used to introduce key concepts in sustainable design. The cultural and human aspects of design will be explored along with the implications for sustainable economic development. The course will be open to AB students, as well as students in the natural sciences and engineering from Princeton University. It will also be taken for credit by students at The Kwame Nkrumah University of Science and Technology (KNUST) and the Art Center College for Design.

Relation to Other Courses at Princeton University

The course will be complementary to following existing courses in the School of Engineering and Applied Sciences (SEAS) and the School of Architecture at Princeton:

- (i) Engineering design (MAE 321);
- (ii) Engineering design (MAE 322);
- (iii) Entrepreneurial engineering (MAE 435);
- (iv) Design of reinforced concrete structures (CEE 366);
- (v) Design of large scale structures: buildings (CEE 461);
- (vi) Design of large scale structures: bridges (CEE 462);
- (vii) Introduction to water pollution technologies (CEE 471);
- (viii) Environmental and civil engineering systems planning and design (CEE 477);
- (ix) Introduction to architectural thinking (ARC 203);
- (x) Introduction to architectural design (ARC 204);
- (xi) Energy and form (ARC 406);
- (xii) Solar energy conversion (EGR 431/MAE 431/ENV 431/ELE 431)

(xiii) Special topics in entrepreneurship: ventures to address global challenges (EGR 495);

However, unlike the existing courses, it will have no science or engineering pre-requisites. It will also be open to all AB students, as well as students in natural sciences and engineering. Furthermore, the course will present a holistic perspective of sustainability issues related to housing, transportation, energy, water and human health. It will, therefore, be complementary to existing design and sustainability-related courses at Princeton University.

Approach: The course will be team taught by a group of faculty and practitioners that can provide students with conceptual details and hands-on experiences that will show them how to go from ideas to markets. The 6 week long program will include lectures by Professors from Princeton University (Prof. Wole Soboyejo and Glenn Northey), Art College of Design (Patrick Kiruki), Kokrobrittey Institute (Renee Neblett), Southern University (Prof. Patrick Mensah), and The Kwame Nkrumah University of Science and Technology (Prof. Francis Momade, Prof. Samuel Kwofie, Prof. David Ampa, Prof. Emmanuel Sackey, Prof. David Ampa, Prof. Emmanuel Afari, Prof. Fred Akufo). The lectures will be combined with hands on lab sessions that will introduce the students to computer aided design, craft design and fabrication, and the design and construction of bamboo bicycles. Each student will be required to participate in group design projects.

The first 4 weeks will be spent at the Kokrobrittey Institute on the outskirts of Accra in Ghana. This will include a combination of lectures, hands on labs and tours of local historical and cultural sites. The fundamentals of design will be presented before exploring issues related to the design of affordable housing and bamboo bicycles. The group will then move on to the Kwame Nkrumah University of Science and Technology (KNUST), where the final two weeks will be spent exploring the sustainable design of alternative energy, health care solutions and aerospace vehicles.

Proposed Schedule:

Week/ Day	Lecture	Lab	Topic	Professor
1/1	1		Design and Development	Soboyejo
	2		Introduction to Design	Soboyejo
		1	Tour of Kokrobrittey	Neblett
			Discussion Session	Soboyejo
1/2	3		Design For Developing Countries	Soboyejo
	4		Introduction to Graphics	Soboyejo
		2	Graphic Design Session	Northey
			Discussion Session	Soboyejo
1/3	5		Introduction to ProEngineer	Northey
	6		The Design Process	Soboyejo

Week/ Lecture Day	Lab	Topic	Professor
	3	CAD Lab Discussion Session	Northey Soboyejo
1/4	7	Mechanical Properties	Soboyejo
	8	Materials Selection Without Shape	Soboyejo
	4	CAD Lab Discussion Session	Northey Soboyejo
1/5	9	Mechanical Properties	Kwofie
	10	Material Selection and Design	Soboyejo
	5	Graphic Design Session Discussion Session	Northey Soboyejo
1/6	Weekend	Tour of local historic sites and cultural lectures	Neblett
2/1	11	Bending and Torsion	Mensah
	12	Shape Selection and Design	Soboyejo
	6	Shape Design Lab Discussion Session	Northey Soboyejo
2/2	13	Efficiency of Standard Sections	Soboyejo
	14	Process Selection and Design	Soboyejo
	7	Process Design Lab Discussion Session	TA Soboyejo
2/3	15	Forward and Reverse Engineering	Soboyejo
	16	Introduction to Machining	Northey
	8	Reverse Engineering Session Discussion Session	Northey Soboyejo
2/4	17	Fracture Mechanics and Design	Soboyejo
	18	Toughening Mechanisms	Soboyejo

Week/ Lecture Day	Lab	Topic	Professor
	9	Fracture Testing Lab	TA
2/5	19	Discussion Session Intro to Fatigue	Soboyejo Soboyejo
	20	Fatigue Design	Soboyejo
	10	Fatigue Design Lab Discussion Session	TA Soboyejo
2/6		Tour of Local Historic Sites and Cultural Lectures	Neblett
3/1	21	Local African Materials	Momade
	22	Bamboo Bicycle Design	Soboyejo
	11	Bamboo Bicycle Design Lab Discussion Session	TA Soboyejo
3/2	23	Introduction to Composites	Soboyejo
	12	Bamboo Bicycle Fabrication Discussion Session	TA TA
3/3	24	Introduction to Ply Theory	Soboyejo
	13	Fabrication of Bamboo Bicycles Discussion Session	Momade Neblett
3/4	25	Composite Design	Soboyejo
	14	Fabrication of Bamboo Bicycles	TA
3/5	26	Prepare Presentation Group Presentations	Students Students
3/6	Weekend	Travel to Local Historic Sites And Cultural Lectures	Neblett
4/1	27	Affordable Housing Concepts Earth Brick Fabrication Discussion Session	Soboyejo Neblett Soboyejo
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Week/ Lecture Day	Lab	Topic	Professor
4/2 28		Composite Design For Thermal Comfort	Soboyejo
	16	Straw Brick Fabrication And Rural Construction Discussion Session	Neblett Soboyejo
4/3 29		Clays For Water Purification	Soboyejo
	17	Water Purification Lab	Neblett
4/4 30		Holistic Design	Soboyejo
	18	Tour of Water Filter Factory In Accra	Soboyejo
4/5 31		Prepare Presentations Group Presentations Discussion Session	All Professors All Professors
4/6 Weekend		Travel to KNUST In Kumasi	
5/1 32		Alternative Energy Concepts	Soboyejo
		Ohm's Law and Charge Transport	Afari
	19	Ohm's Law Experiment Discussion on Electricity	TAs Afari
5/2 34		Introduction to Semi-Conduction	Ampa
		Introduction to Solar Cells	Akuffo
	20	Solar Cell Lighting Lab Discussion on Solar Lighting	TAs Ampa/Akuffo
5/3 35		Introduction to Light Emitting Devices (LEDs)	Sackey

Week/ Day	Lecture	Lab	Topic	Professor
	36		Design of Solar/LED Lanterns	Kiruki
		21	Solar/LED Lab Discussion on Solar Lanterns	TA Sackey/Kiruki
5/4	36		Solar Powered Refrigeration	Soboyejo
	37		Design of Solar Powered Refrigerator	Kiruki
		22	Testing of Solar Powered Vaccine Refrigerator Discussion on Solar Refrigerator	TAs Soboyejo/Kiruki
5/5	38		Sustainable Solar Enterprises: The Selco Model	Soboyejo
	39		New Frontiers in Alternative Energy	Soboyejo
			Preparation of Solar Group Presentations	All
5/6	Weekend		Tour of Ashaniti King's Palace and Local Sites Near Kumasi	All
6/1	40		New Frontiers in BioMEMS	Soboyejo
	41		Introduction to Polymers	Soboyejo
		23	Molding of PDMS BioMEMS Discussion on BioMEMS	TA
6/2	42		Introduction to Drug Delivery And Hyperthermia	Soboyejo
		24	Hyperthermia/Drug Delivery Labs	Soboyejo
			Discussion on BioMEMS	Soboyejo
6/3	43		Nanoparticles for Disease Detection And Treatment	Soboyejo

Week/ Lecture Day	Lab	Topic	Professor
	25	Tour of Immunology KNUST Lab Discussion on Nanomedicine	All Soboyejo
6/4 44		Bio-Inspired Design	Soboyejo
	45	New Fontiers in Aerospace Design	Soboyejo
		Tour of Boeing Company in Kumasi Discussion on Aerospace Design	All Soboyejo
6/5 46		Prepare Group Presentations Group Presentations Overview of Course	All All Soboyejo
6/6		Final Exams	All
6/7		Return to the United States	---

Class Enrollment:

An enrollment of 25 students is for the class. This will include a maximum of 15 students from Princeton, 5 students from KNUST and 5 students from Art Center College of Design. The 15 Princeton students will be paid for by Princeton University, along with the 5 KNUST students. The 5 Art Center Students will be paid for by Art Center College of Design.