EK 210: Introduction to Engineering Design
Spring 2021
Syllabus

Course Description:

A two-credit introductory course to the principles of engineering design, intended to give second- year undergraduates a basic understanding of the process of converting a product from concept through design and prototyping.

Format:

In order to accommodate the LfA environment and to maintain university social-distancing requirements, required hours of class time will be structured as follows:

- Every student will be required to watch one hour of asynchronous lectures and complete on-line quizzes demonstrating mastery of material before attending class.

- There will be two sections (A1 and A2) that are "remote-only" and intended primarily for international students unable to attend classes on campus. Each section will meet for 105 minutes.

- The remaining sections are LfA. Ordinarily, an LfA section will also meet for 105 minutes. However, depending upon the number of on-campus students, each section may be divided into two "platoons". If your instructor determines that platooning is necessary, each platoon will meet for 80 minutes. Your instructor will communicate directly with your section if this is necessary.

- All LfA sections will also be live streamed via Zoom to accommodate students who choose not to return to campus.

- Students will be evaluated on the basis of assignments linked to the in-class labs or demos and on a team design project. All assignments will either be "paper designs" (e.g., circuit diagrams, sketches, functional decompositions) or will utilize a combination of pre-made kits, standard parts found in any hardware store, and materials available from EPIC.

Philosophy:

Engineering Design is “a systematic, intelligent process in which designers generate, evaluate and specify designs for devices, systems or processes whose form and function achieve clients’ objectives and users’ needs while satisfying a specific set of constraints.”

Engineering Design is:

a) Ubiquitous: This definition applies equally to the design of mechanical devices, electronic circuitry, software or large infrastructure projects.
b) Multi-disciplinary: Multiple different skill sets are required to achieve a design goal. Engineers must also work with manufacturing and marketing professionals and must have some basic understanding of these disciplines.
c) Open-ended: There is not a unique answer to most design problems.
d) Requirements-driven: Engineering designs must qualitatively and quantitatively address both stated and unstated customer needs.
e) Constrained: Engineering designs are constrained by time and financial resources.
f) Dependent upon communications skills: Even the best designs will not be generally adopted if engineers fail to adequately convey their ideas to key stakeholders.
g) Relevant: Engineers engaged in both scientific research and commercial engineering routinely encounter design problems.

The fundamental assumption underlying this course is that the best way to learn these concepts in a **socially distanced hybrid classroom format** is a project-based course in which students conduct **both individual and team-based projects**, following a rigorous design process to create a prototype.

The course proceeds linearly through the design process steps, including problem definition, conceptual design, preliminary design, final design, and communication/presentation.

All teams will complete the same project: design of a real-world needed product. Through the semester, the instructors will walk through the design process for a product of similar scale and scope. This in-class design will serve as a model for student-led designs, which take place entirely outside of the classroom. To ensure that students have the tools to completer their designs successfully, several in-class lectures will be dedicated to skills development in technical subjects generally related to the design projects chosen for the semester.

All products used for in-class and student projects will involve:

a) Reasonably complex mechanical problems requiring materials selection and structural analysis
b) Sensing of the external environment
c) Internal processing of information
d) Communications interfaces with the external environment

Schedule:

Over the course of the semester, students will complete assignments related to their design project, culminating in a presentation of their prototype design and its performance.

	Topic	On-Line Learning Content	In-Class Activity	Assignments
1	Overview of the Course	Basic principles and steps in the design process Safety Sketching and drawing	Class organization and requirements Review of kit contents Basic principles and steps in the design process Discussion of engineering drawing and measurement	
2	Reverse Engineering and Product Teardown Oral and Written Communication for Engineers	Reverse engineering Oral communication Written communication	Reverse engineering Bill of Materials Functional Analysis / Decomposition Design Evaluation, including Human Interface	Individual Assignment 1: Reverse engineer something simple and available in home or dorm (e.g., mechanical pencil, stapler, iron.) Create a 5 slide Power Point with BOM, functional decomposition, sketches and a design evaluation.
3	Skills Development I: Basic Electronics, Sensors and Actuators	Basic electronics	Soldering Demonstration Sensors	

			Exercise: Demonstration of optical sensors, thermal sensors, operational amplifiers.	
4	Skills Development II: Arduino and Other microprocessors	Arduino Other Microprocessors	Hands-on Arduino training. Exercise: Use of Arduino: At what frequency can we no longer see a blinking light blink? Measure temperature. Control servo position. Use temperature to control servo position.	<u>Individual Assignment 1:</u> Due <u>Individual Assignment 2:</u> Make the Arduino display the temperature on an LCD. With hot water and cold water, measure and plot the time response of the temperature sensor. Show photo of working system with ID in picture.
5	Skills Development III: Machines and Materials Skills Development IV: Human Interfaces	Material selection Machine Tools	Machine tools. Exercise: Demonstration of performance differences between identical parts 3D printed and 5-axis machined. Demonstration of laser cutting. Demonstration and discussion regarding 3D printing. Discussion of human – machine interface.	
6	Problem Definition	Writing a problem statement Determining client objectives and constraints Doing market research Working in teams	Problem definition for an **infrared thermometer.** Exercise: The client is BU medical center, and client need is to temperature of everyone walking through the front door. Development of objectives, metrics, and constraints. Examination of interaction scenarios and market research steps. Team meetings.	<u>Assignment 2:</u> Due <u>Team Assignment 1</u>: Define the problem for **commercial pulse oximeter**, which will be the STUDENT project theme through the semester. Consider the problem statement, objectives, metrics, and constraints.
7	Conceptual Design	Exploring the design space Establishing functional requirements	Review of problem statements. Discussion of merits of individual solutions. Exercise: Development of glass box functional decomposition and functions	<u>Team Assignment 1:</u> Due <u>Team Assignment 2:</u> Create a glass box functional decomposition and function /

			for an **infrared thermometer**. Selection of means. Team meetings.	means chart for the **commercial pulse oximeter**
8	Preliminary Design I	Modeling Issues to consider before building physical models and prototypes Fundamental concepts for mathematical modeling Types of mathematical models and solutions Uses of mathematical models	Review of Team Assignment 2. Building models Exercise: Developing a math model for measuring temperature in an **infrared thermometer.** Team meetings.	Team Assignment 2: Due Team Assignment 3: Build two mathematical models for your **pulse oximeter** project. Team Assignment 4: Build a physical model of the packaging for your **pulse oximeter.**
9	Preliminary Design II	More modeling Background materials related to infrared thermometry and pulse oximetry.	Review of Team Assignment 3. Science and physics of pulse oximetry. Team meetings.	Team Assignment 3: Due
10	Preliminary Design III	Compact bibliography of available resources.	Review of Team Assignment 4. Overview and operation of specific components used in pulse oximetry. Team meetings.	Team Assignment 4: Due Team Assignment 5: Complete final design and manufacture of your **pulse oximeter** project prototype.
11	Detailed Design Design for Manufacturing and Design for Sustainability	Detailed design Design for Manufacturing and Design for Sustainability	Detailed design specifications Exercise: Review detailed design specifications for **an infrared thermometer**, including drawings, assembly, circuit schematics, software flow charts, housings, etc. Team meetings.	
12	Engineering economics and ethics	Ethics in design and the responsibility of the engineer Engineering Economics	Overview of engineering economics and ethics. Team meetings.	

13**	Project Presentations		Presentations by each team.	Team Assignment 5: Due

** Monday and Thursday sections meet 14 times and the 13th class will be used for team meetings and meetings with the instructor.

Courseware:

All on-line modules may be found on Blackboard Learn. If you are uncertain how to ask Blackboard Learn, please ask one of the instructors.

Assignments and Grading:

You will be graded on the following criteria:

- Individual Assignments 1-2 will each count for 10% of your overall grade.
- Team Assignments 1-4 will count for 10% of your overall grade.
- Team Assignment 5 will count for 30% of your overall grade.
- Your personal class attendance and contribution will count for 10% of your grade.

Also note that if you fail to complete the on-line modules, your grade may be dropped up to one letter grade.

Other Notes:

If you are a student with a disability or believe you might have a disability that requires accommodations, please contact the Office for Disability Services (ODS) at (617) 353-3658 to coordinate any reasonable accommodation requests. ODS is located at 19 Deerfield Street on the second floor.

Attendance in class or on-line is mandatory. **If, over the course of the semester, you decide to either move from on-campus learning to remote learning, or vice versa, you must notify your instructors immediately** In the event of illness or other family emergency, please notify both the instructors and your team. Failure to do so will be regarded as an unexcused absence and will be considered as we determine your "Participation and Attendance" grade. Note that religious events are not considered unexcused absences. See the Policy on Religious Observance for more details.

All homework and reports should be handed in via hard copy, unless otherwise specified by one of the instructors. Late work will be deducted one letter grade, unless previously approved by an instructor.

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