EK 210: Introduction to Engineering Design
Spring 2019

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Course Time and Location: Sections A2 – A7 meet once weekly in EPIC

Course Credits: 2

Office Hours: By arrangement with individual instructor

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 deployment. Students will work in multi-disciplinary teams with time and budget constraints on externally sponsored design projects. Web-based lectures will cover topics concurrent with specific phases of the projects. The course will culminate in a "Design Competition."

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 and team-driven: Engineers with multiple different skill sets are required to work together to achieve a common 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 is a project-based course in which students conduct *team-based design projects*, under strict time limits and are then required to *communicate* these designs to others in a systematic fashion.

This course also assumes that an alternative method for learning the same concepts is reverse engineering: the act of taking products apart to deduce how they operate and are constructed, much as the human body is dissected in medical school.

Hence, the class begins with a simple three-week project to dissect and reverse engineer some simple (and inexpensive) products, such as insulin syringe pumps, blood glucose meters, cameras, toasters, or digital bathroom scales. The class then moves to a large ten-week design project in which you will move, at a rapid pace, through the various stages of designing a real-world product.

Projects are solicited from both regional industry, local non-profits and COE faculty and will have real application. Furthermore, these projects are not simply mechanical engineering-based. 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

Over the course of the semester, teams will be required to make five oral presentations (three to the class and two to faculty) and prepare two detailed engineering reports.

BU Hub Learning Outcomes:
Teamwork and Collaboration: The BU Hub defines two learning outcomes for teamwork and collaboration:

1. As a result of explicit training in teamwork and sustained experiences of collaborating with others, students will be able to identify the characteristics of a well-functioning team.

The goal of this course is to prepare you for your future career in engineering and often, engineers do not get to pick whom they work with. Therefore, faculty instructors determine team composition; students do not self-select. Optimal team size is four; teams are chosen such that they are mixed by major and number of engineering courses already taken.

To prepare you for working in a team environment, you will be given both on-line modules and readings on important topics. These modules and readings include:

(a) A module on the basics of project management and the various tools available to project managers to plan and coordinate resources.
(b) A module on team development and dynamics, reviewing the general evolution of teams from formation to high-performance.

(c) Modules on both oral and written team communications.
(d) Modules on team brainstorming and the generation and selection of ideas.
(e) Readings on design team dynamics.
(e) Readings on managing design projects.

You will also be given a minimum of one in-class lecture on team formation and dynamics.

Collaboration tools that are specifically taught or covered during these various modules, readings and lectures include team charters / contracts, work breakdown structures, team calendars and Gannt and PERT charts.

Your team will interact with the instructors in a one-on-one fashion on a weekly basis. During these sessions, we will enquire about team performance and to lead the team in solving any issues that may have emerged.

2. Students will demonstrate an ability to use the tools and strategies of working successfully with a diverse group, ***such as*** *assigning roles and responsibilities, giving and receiving feedback, and engaging in meaningful group reflection that inspires collective ownership of results.*

Twice per semester, you will be expected to honestly evaluate the performance of each of your teammates utilizing a standardized assessment form adapted from Van Duzer and Martin and deployed in a variety of courses throughout the College of Engineering.

While each student will self-identify and identify their team members during the evaluation process, the collective feedback for each team will be consolidated by the instructor, enabling he /she to provide a summary of team performance while protecting the anonymity of individual team members. Our collective experience is that this methodology allows us to gather more accurate data. After receiving the data, we are able to interact directly with teams to help teams address and solve both typical (e.g. poor team meeting norms or unreliable members) and atypical (e.g. cultural barriers) team issues.

Further, at three points during the semester (after both the reverse engineering and prototyping assignments and mid-way through the prototyping assignment), you will be explicitly asked to cease project work and evaluate roles and responsibilities, scheduling and the overall quality of your team's output.

Other Outcomes:

The course has other goals in addition:

I. Understand both that design is an “open-ended and ill-structured process” with no unique solution and the range of design problems (e.g., Boeing 787, software)
II. Learn techniques for reverse engineering and have some understanding of the complexity of seemingly simple products, basic supply chain and product architecture concepts.

III. Become familiar with basic project management tools pervasive in engineering for planning, organizing, leading and controlling projects: team roles, Gantt and Pert charts, etc.
IV. Learn techniques for determining both market and customer needs; write project statements.
V. Understand the process of converting customer need into engineering specifications.
VI. Become exposed to both quantitative and qualitative techniques for generating multiple designs and then choosing the "best".
VII. Have a clear understanding of the distinction between models and prototypes; learn various techniques for building prototypes.
VIII. Have a rudimentary knowledge of mathematical modeling in design.
IX. Begin to practice effective engineering communication, including CAD programs and their uses.
X. Be exposed to principles of industrial design, including ergonomic, aesthetic and user-interface issues. Distinguish between good and bad industrial design.
XI. Have awareness of the relationship between design and mass production and good vs. bad manufacturing design. Be exposed to some general manufacturing concepts and have some awareness of product lifecycle considerations.
XII. Learn to work in teams.

These outcomes match to the ABET outcomes a-k as follows:

Program:	a	b	c	d	e	f	g	h	i	j	k
Course:	i-xi	vi,viii	i- xi	ii, iii, ix, xii	i, iv, v, vi, viii	x, xi	ix	i, ii, x, xi	i	i, ii, x, xi	i - xi
Emphasis:	5	2	5	5	4	2	4	4	2	3	5

Instructional Format, Course Pedagogy and Approach to Learning

Our intention is to reserve most of the 1:45 class time each week for you to work in teams on hands-on design projects.

During the first three weeks of class, you will work on reverse engineering an existing product. The exercise will get you thinking about design and will teach you about subjects as diverse as functional analysis, creating a bill of materials and design for manufacturing.

From the fourth week of class onward, you will work on a "real-world" product design problem. There will be six teams of four to five students each working on one of six design problems; again, "Real-world" means that each team will have a real client with a real need that you must fulfill.

In order to make this format work and to maximize the time available in class to be "hands-on", we have prerecorded about one hour of lecture material each week. This material is available on the Blackboard Learn class site and all of you have access to it. Topics covered in the modules will be changed during the semester, depending upon the needs of your class, but will generally include the following:

Topics (time spent in weeks):
Introduction to Engineering Design (1)
Engineering Communications (1)
Leading and Working in Teams and Basic Project Management Tools (1)
Understanding Customer Needs and Defining the Design Problem (1)
Tools for Prototyping (1)
Conceptual Design (2)
Preliminary Design (1)
Modeling the Design (1)
Principles of Industrial Design (1)
Product Economics (1)
Design for Manufacturing/Sustainability (1)

To make this class work, **you should review the lecture materials for each week prior to class, including the first class.** To access this week's lectures, merely click on "Week 1" in the sidebar, listen to the introduction and then follow the instructions.

Each week's lectures (or sessions) includes some short lectures from the instructors and other faculty at BU, some videos from external sources and at least one or two "quizzes" to ensure that you have read and understood the material. The lectures will also direct you to reading in your text that you should complete prior to class.

You may also find other valuable information about the class on the Blackboard Learn site, including the syllabus.

Books and Other Course Materials

The required textbook for this class is:

Dym, C. L. and Little, P. Engineering Design: A Project-Based Introduction 4th Edition, John Wiley and Sons, 2015.

It is available at either the BU Bookstore or on-line. You will be required to complete readings each week. See the schedule of class assignments below.

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 six criteria:

Your team's oral and written reports on the reverse engineering project (15%)
Your team's problem identification review (10%)
Your team's conceptual design review (10%)
Your team's preliminary design review (10%)
Your team's design project, including: (35%)
–A prototype
–Your team's presentations
–Your team's engineering report
Your personal class attendance and contribution to your team, as assessed by the instructors and your other teammates (20%)

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 is mandatory. Since this is a team-based class, failure to attend is not only a disservice to yourself but to your teammates. 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 taken into account 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.

Boston University's academic conduct code may be found at *https://www.bu.edu/academics/policies/academic-conduct-code/.* A particular concern is plagiarism while writing engineering reports. Any copying of articles, websites, or other material from the web without citation will be considered plagiarism and will be referred to the judicial system at Boston University.

Outline of Class Meetings: Date, Topic, Readings Due, Assignments Due

The overall schedule of events and assignments is shown below. Please note that since ten different sections of this course will be taught this semester, you are responsible for determining the particular week's assignment for your section.

Week	Topic	On-Line Learning Content	In-Class Activity	Reading	Assignments
1	Overview of the Course Reverse Engineering and Product Teardown	a) Class organization and requirements b) Basic principles of reverse engineering c) Safety	a) Review of the course and first assignment (30 min) b) Discussion of Reverse Engineering and Engineering Drawing (30 min) c) Team projects (45 min)	Chapters 1 and 2	Teams formed. Reverse Engineering Product assignment handed out (Assignment #1.)
2	Oral and Written Communication for Engineers	a) Sketching and drawing b) Oral communication c) Written communication	a) Review of on-line materials (15 min) b) Team projects (90 min)	Chapter 9 and 11; Appendix B	
3	Basic Project Management and Working in Teams	a) Project management b) Working in teams	a) Student Presentations of Reverse Engineering Team Projects (90 min) b) Initiate Design Project (15 min)	Chapters 15 and 16	Assignment #1 due. Problem Definition assignment handed out. (Assignment #2.)
4	EPIC Boot Camp	a) Tools for prototyping	EPIC Boot Camp (105 minutes)	Appendix A	
5	Problem Definition	a) Overview of the engineering design process b) Determining client objectives c) Doing market research	a) Review of online material (25 min) b) Team projects (80 min)	Chapters 3, 4, and 5	Assignment #2 due Design Review requirements handed out (Assignment #3.)
6	Conceptual Design	a) Establishing functional requirements b) Determining the design space	a) Review of on-line material (15 min) b) Team projects (90 min)	Chapters 6 and 7	
7	Conceptual Design II	a) Creating design alternatives (revisited) b) Evaluating design alternatives	a) Team reports (90 min) b) Review of on-line material, next assignment (15 min)	Chapter 8	Assignment #3 due. (Design Reviews) Preliminary design assignments are handed out. (Assignment #4)

Week	Topic	On-Line Learning Content	In-Class Activity	Reading	Assignments
8	Preliminary Design	a) Issues to consider before building physical models and prototypes	a) Review of online material (15 min) b) Team projects (80 min)	Chapter 10	
9	Modeling	a) Fundamental concepts for mathematical modeling b) Types of mathematical models and solutions c) Uses of mathematical models	a) Review of on-line material (15 min) b) Team projects (90 min)	Chapter 12	
10	Principles of Industrial Design and Ethics in Design	a) An overview of industrial design b) Ethics in design and the responsibility of the engineer	a) Review of assignment (15 min) b) Team projects (90 min) **Note:** Preliminary design reviews are one-on-one with instructors.)	Chapter 17	Assignment #4 due. Final Detailed Design assignments are handed out. (Assignment #5)
11	Design for Manufacturing and Design for Sustainability	a) DfX b) Principles of design for assembly and manufacturing	a) Review of on-line material (15 min) b) Team projects (90 min)	Chapter 13	
12	Engineering Economics	a) Estimating product cost b) Profit and loss	Mon / Wed / Thurs / Fri a) Review of on-line material (15 min) b) Team projects (90 min) Tues a) Team presentations (90 min) b) Evaluation (15 min)	Chapter 14	Assignment #5 due for Tuesday section.
13	Project Presentations	None	Mon / Fri a) Team presentations (90 min) b) Evaluation (15 min) Wed / Thurs b) Team projects (105 min)		Assignment #5 due for Monday and Friday sections.
14	Project Presentations		Wed / Thurs a) Team presentations (90 min) b) Evaluation (15 min)		Assignment #5 due for Wednesday and Thursday sections.