EK 210: Introduction to Engineering Design
Fall 2021

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Course Time and Location: Sections meet once weekly in EPIC

Course Credits: 2

Office Hours: Tutoring center hours in EPIC TBD.

Books and Other Course Materials

The optional 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.

Courseware

Blackboard: All on-line modules may be found on BlackBoard Learn. If you are uncertain how to use Blackboard Learn, please ask one of the instructors.
Gradescope: Assignments are posted, turned in and graded on Gradescope.

Assignments and Grading

You will be graded as follows:

Weekly individual assignments (20%)
Team reverse engineering assignment (10%)
Team problem definition assignment/design review (10%)
Team conceptual design assignment (10%)
Pair modeling assignment (10%)
Team final project including: (30%)
–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 (10%)

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 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.

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 oral presentations (to the class and to faculty) and prepare engineering reports.

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 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.

After that, you will work on a "real-world" product design problem. There will be 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 real needs 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 lecture material. This material is available on the Blackboard Learn class site.

To make this class work, **you must review the lecture materials for each week prior to class, including the first class.** To access a week's lectures, merely click on "Week #" in the sidebar. The weekly individual assignment will be related to these lectures. The relevant sections in your text for each week are shown in the class meeting table below.

Outline of Class Meetings and Assignments:

The overall schedule of events and assignments is shown below. Please note that multiple sections of this course will be taught this semester. Different sections may be aligned with different weeks even though they are meeting in the same week.

Week	**Topic**	**On-Line Learning Content**	**In-Class Activity**	**Optional Reading**	**Assignments**
1	Overview of the Course Reverse Engineering and Product Teardown	a) Class organization and requirements b) Basic principles of reverse engineering c) How to write a design problem statement d) Safety	a) Review of the course and first assignment (30 min) b) Discussion of Reverse Engineering (20 min) c) Team reverse engineering project (55 min)	Chapters 1, 2 & 3.	**Before class**: Indiv. Gradescope assignment. (Fan problem statement, glass box for screwdriver) **In class:** 1st teams formed. Team Reverse Engineering Product assignment discussed

Week	Topic	On-Line Learning Content	In-Class Activity	Optional Reading	Assignments
2	Sketching/CAD Problem statement, Functional analysis, BOM	a) Sketching and drawing b) CAD intro	a) Example FA & problem statement. Other review (20 min) b) Team reverse engineering project (80 min)	Chapter 9 Appendix II	**Before class**: Indiv Gradescope assignment (Sketch and OnShape) **In class**: Complete product teardown. Work on Team Reverse Engineering assignment
3	Means (Discuss various means from the reverse engineered products) Comments on sketches/CAD	a) Working with numbers b) Materials c) EPIC information	a) Student Presentations of Reverse Engineering aspects: BOM, FA (15 min) b) Discuss means c) Initiate Design Project d) Team assignments		**Before class**: Indiv. Gracescope assignment (EPIC safety quiz) Team reverse engineering assignment due. Team assessment due. **In class**: Project team formed, discuss project choice
4	Arduino	a) Arduino getting started b) More Arduino c) LED basics d) Resistors e) Potentiometer	a) Arduino challenge b) Assign projects at end of class c) Announce client meeting times		**Before class**: Indiv. Gradescope assignment (2 Arduino projects), State top 3 projects **In class**: Complete Arduino design challenge
5	Problem Definition, Client needs, Objectives/ metrics/ constraints	a) Problem identification and determining client objectives b) Customer needs c) Market research d) Team dynamics	a) Review of online material (15 min) b) Kick off Team Conceptual Design assignment (includes prob. Def) (90min): merge problem statements, merge and complete objectives/ metrics/constraints, start FA	Chapters 3, 4, and 5	**Before class**: Indiv Gradescope assignment (Client meeting, Prob. Statement, Objectives & metrics) **In class**: Team problem identification assignment Turned in at end of class
6	Conceptual Design	a) Establishing functional requirements b) Determining specifications c) Determining the design space d) Design alternatives e) Evaluating alternatives f) Effective presentations	a) Review of on-line material (15 min) b) Design review : Problem Definition. 1-on-1 with instructor c) Team Conceptual Design assignment (90 min) (merge FAs, create design space visual, select concept using quantitative method)	Chapters 6, 7, 8, 11	**Before class**: Indiv. Gradescope Assignment (FA,Morph chart) **In class**: Prob definition: design review. Work on Team conceptual design assignment

Week	Topic	On-Line Learning Content	In-Class Activity	Optional Reading	Assignments
7	Conceptual Design presentations Preliminary Design/modeling	a) Modeling:basic concepts b) Models vs Prototypes c) Types of models d) Examples of models Extra means videos	a) Team presentations (70 min) b) Modeling : power budget example (15 min) c) Assign Pair modeling assignment d) Compare product sketches	Chapter 12	**Before class**: Indiv Gradescope Assignment (Sketch of product, one function/mean model ideas) Team Conceptual Design assignment due Team assessment due **In class**: modeling discussion
8	Preliminary Design, Project management	a) Project management b) Effective writing	a) Review of online material (25 min) b) Team projects (80 min) merge GANTT charts work on Pair modeling assignment	Chapter 12, 11	**Before class**: Indiv Gradescope Assignment (GANTT chart, work on model) **In class**: Pair modeling assignment
9	Detailed design	a) Use of reverse engineering Means video	a) Discussion of different modeling efforts (30 min) b) Team projects (75 min) Finalize designs		**Before class:** Indiv Gradescope Assignment (working on model) Pair modeling assignment due **In class**: Finalize design, order parts
10	Design build, Design for Manufacturing and Design for Sustainability	a) Design for MN b) Design for sustainability	a) Review of assignment (15 min) b) Team projects (90 min) Design reviews 1-on-1 with instructors.) c)Final report/presentation info handed out	Chapter 14	**Before class**: Indiv Gradescope Assignment Produce parts for product Prepare design review info **In class**: 1-on-1 design review Work on project
11	Design build, Economics of design	a) Project cost b) Profitability c) Time Value	a) Review of on-line material (15 min) b) Team projects (90 min)	Chapter 13	**Before class:** Indiv Gradescope Assignment Work on project, start report **In class**: Show evidence of final report work
12/13	Design build		a) Review of effective written communication (15 min) b) Team projects (90 min)		

Week	Topic	On-Line Learning Content	In-Class Activity	Optional Reading	Assignments
13/14	Project Presentations		a) Team presentations (90 min) b) Course Evaluation (15 min)		**Before class**: Turn in team report and presentation. Team assessment due **In class**: Present design

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 on Gradescope, 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.

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 discuss team formation and dynamics in class.

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, the faculty will enquire about team performance and mentor 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, during the semester, you will be explicitly asked to 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:

Student:	1	2	3	4	5	6	7
Course:	i-xi	i-xi	ix	i, ii, x, xi	ii, iii, ix, xii	vi, viii	i
Emphasis:	5	5	4	4	5	2	2