Introduction to Product Development

Syllabus

GENERAL INFORMATION

Faculty:

- *Alice M. Agogino*, Department of Mechanical Engineering, 415 Sutardja Dai Hall (CITRIS Building), (510) 642-6450, agogino@berkeley.edu

- *Michael Borrus,* Haas School of Business and XSeed Capital, mborrus@berkeley.edu

Graduate Student Instructors:

- Laura Burkhauser, Haas School of Business, burkhauser@berkeley.edu

- Mallory Daly, Mechanical Engineering, mallorycdaly@gmail.com

- Edward Zhu, Mechanical Engineering, edward.zhu@berkeley.edu

Reader: TBA

Designer-in-Residence: Daniel "Dahyun" Lim, limdan7@berkeley.edu

Class Meetings:

11:00 am – 12:30 pm T Th (310 Jacobs Hall). Optional workshops noon-1:00 pm F (210 Jacobs Hall)

Office Hours and Optional Discussion/Workshops:

Agogino: Th 2:00-4:00 pm, 415 Sutardja Dai Hall (CITRIS Building) or after class
Borrus: T, 1-2:30 pm, Haas School of Business,F502 Haas or after class

GSI Hours: TBA

DESCRIPTION

This course provides an introduction to the design process and conceptual design of products. It provides an experience in preliminary project planning of complex and realistic mechanical engineering systems. Design concepts and techniques are introduced; the student's design ability is developed in a design project or feasibility study chosen to emphasize innovation and ingenuity, and provide wide coverage of engineering and business topics, with an emphasis, this semester, on entrepreneurship opportunities. Design optimization and social, environmental, economic, and political implications are included. There is an emphasis on hands-on creative components, teamwork, and effective communication. There is a special emphasis on the management of innovation processes for the development of sustainable products, from product definition to sustainable manufacturing and financial models. Both individual and group oral presentations will be required. This semester two sections of the class (UGBA290T-2 business and ME110 mechanical engineering and other disciplines) will join forces to enable a multidisciplinary team learning experience.

TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

Reading Materials: The primary reading material for the class is the textbook *Product Design and Development* (Fifth or sixth Edition) written by Karl Ulrich and Steve Eppinger (available in hard copy, rental and digital form).   This book is a very basic text that provides a step by step view of how new product development processes are to be conducted. There should be used,

rental, ebook version of the textbook available at reduced cost. See:
https://bcourses.berkeley.edu/courses/1298185/pages/cheaper-versions-of-textbook.
Supplemental required course reading materials will also be available on bCoures.

bCourses Use: We will make extensive use of the course bCourses web site to both communicate information to you and to converse with you about your homework and your projects.   You will find the course listed on http://bCourses.berkeley.edu/.   Once you have formed your project groups, we will set up group pages on which we expect you to store your working documents for your project.   The faculty will review the group pages regularly to provide feedback on your work.   Our experience is that the teams that heavily use their bCourses pages and email connections do better in the class, and we strongly encourage you to use them.

COURSE OBJECTIVES

This course provides hands-on and real world experience in the development of innovative and realistic customer-driven engineered products. Design concepts and techniques are introduced, and the student's design ability is developed in a design project or feasibility study chosen to emphasize ingenuity and provide wide coverage of engineering and business topics. Innovative thinking is nurtured. Students will be expected to use tools and methods of professional practice (e.g., optimal design, solid modeling, life cycle assesment, market analysis) and use these tools to consider the social, economic, environmental and political implications of their products. Both individual and group oral presentations will be required.

DESIRED COURSE OUTCOMES

Students can expect to depart the semester understanding new product development processes as well as useful tools, techniques and organizational structures that support new product development practice in the context of the "triple bottom line" – economy, environment and society.

TOPICS COVERED

Product development processes and organization, product planning, triple bottom line, high performing teamwork, CAD/ solid modeling, customer/user needs assessment, personas and empathic design, translating the "voice of the customer", concept generation, concept selection, concept development, decision analysis, concept testing, taguchi method and experimental design, product architectures, design for variety, design for environment, life cycle assessment, design for assembly/ manufacture, prototyping, design costing, information technologies, design optimization, engineering ethics, universal design and entrepreneurship, innovation and intellectual property.

GRADING

Your course grade will be determined as follows:

> 10% on the quality of your preparation for and participation in class discussions
> 30% on the quality of your individual assignment solutions
> 10% for your final design journal
> 30% on the quality of your team's work on project-related assignments and final report
> 20% on the quality of your team's final project presentation and prototype

Team Peer Assessments: At midsemester, we will ask for individual peer assessments of the contributions made by your team mates.   This midsemester assessment will *not* be considered in preparing your final team grade; they are considered an "early warning" for struggling teams.

There will also be an end-of-semester peer assessment, which could have an influence on your final participation score and individual grade.

CLASS PREPARATION AND PARTICIPATION

Readings are meant to guide your thinking about the class assignments. Readings are given in the class schedule; we expect you to come to class prepared to discuss the readings and the suggested questions.   In any given class session, a handful of students may be called upon specifically to speak about the readings and answer questions about them.   If you have prepared in advance according to the syllabus, you will have no problem responding when called upon.   Your individual class participation grade will be based upon your in-class remarks during discussions and will be judged by the teaching staff.

INDIVIDUAL ASSIGNMENTS

We have periodically assigned individual exercises to have you experiment with some of the concepts we are teaching. These are due at the start of each class, unless otherwise noted. Late assignments are discouraged but accepted, heavily penalized at 20% of the total score (20 points out of 100) for each day for late.

ALL INDIVIDUAL ASSIGNMENTS ARE TO BE SUBMITTED VIA THE BCOURSES "ASSIGNMENTS" TAB UNDER THE APPROPRIATE HEADING PRIOR TO THE START OF CLASS ON THE DAY THEY ARE DUE. YOU MAY WANT TO BRING ONE COPY OF YOUR HOMEWORK TO CLASS, AS WE WILL FREQUENTLY ASK YOU TO SHARE YOUR RESULTS (DIGITAL SHARING IS FINE).

WEBSITE USE:

We will make extensive use of the course Website to both communicate information to you and to converse with you about your homework and your projects.   You will find the course listed on http://bCourses.berkeley.edu/.   Once you have formed your project groups, we will set up email lists and folders where we expect you to store your working documents for your project.   The faculty will review the group pages regularly to provide feedback on your work.   Our research shows that teams that heavily use their shared documents and email connections do better in the class, so we strongly encourage you to use these group function.

JOURNAL

Each individual in the class is **required** to maintain a design journal throughout the semester, to be turned in at the end of instruction for the semester,on the day of your team's final presentation during RRR week.   It counts 10% towards your individual grade. The journal will be returned at the end of the Spring Semester. This journal should include your individual thinking (both imagery and words) pertaining to your project. Think of it as a diary of sorts. You may sketch pictures, paste in pictures or business cards, write words, create mindmaps, or choose any other approach that works for you to capture your ideas, thoughts, and reflections about your product and your project.   The journal should be used both to **capture ideas** about the product itself as you move through the process, but also to **document thoughts, reflections and insights** on the process of product development, group dynamics, project process, etc.   Inventors use journals as it helps to document when they came up with an original idea (useful in the patenting process); engineers do this to work out complex technical details; and designers do this to generate lots of ideas (as ideas feed off of one another); project managers use journals as a management tool to generate "lessons learned" and "best practices" to help run future product development projects more effectively. You can tailor your journal to your own working style and your unique role within your project team. There are copies of exemplary design journals on the bCourses website if you would like to see what one might look like.   Only the faculty will see these journals; no

one else will see them unless you choose to share. Your design journal will count towards your individual assignments grade.

LAPTOP, TABLET AND SMARTPHONE POLICY

Class time will focus almost entirely on in-class exercises to bring to life project-based learning. You will need to give your full attention to your teammates, to the work you are being asked to do together, and to what you are taking away from that work. Please do not use your laptops or smart phones in class, unless it is for a class exercise or to take notes (no email, texting, web browsing, Facebook, etc.) Any violation of this policy will lead to a reduction in your participation grade. We love the way Adaptive Path, one of the design firms we work with, describes its policy along these lines:

__HONOR THE GATHERING.__ In this ever more interrupt-driven digital world, it's a challenge to bring together all the right people at the same time to think, make and solve problems that are too complex for just a few people to figure out. Gatherings of this magnitude need opening ceremonies to acknowledge the value of the time we are about to spend together. Typically these ceremonies don't include marching bands or fireworks (although that would be cool), but there are small and simple actions that help us all recognize that this is a sacred time. These small things include sending out invitations ahead of time, providing food and drink, creating an environment where people can focus without laptops or smart phones, welcoming and orienting people to our day together, and having the client sponsor begin the workshop with essentially an opening blessing for the people gathered and the work we will accomplish. (www.adaptivepath.com)

PROJECT BACKGROUND AND GENERAL INFORMATION

The goal of the class project is to learn principles and methodologies of product development in a real world context. Most product development professionals work under tremendous time pressure and do not have an opportunity to reflect on the development process. In this course, the stress level will be low enough to allow time to experiment and learn. You will be asked to form project teams of 4 to 5 students. Some teams will have the opportunity to work with students from multiple disciplines. You will have opportunities during the first two weeks of class to scope out the possible projects and get to know potential teammates.

PROJECT BACKGROUND

Your challenge in the project portion of this course is to design a new product (a physical product, piece of software or service, business model), test it on a consumer group, and produce an early prototype version of it. The goal of this exercise is to learn principles and methodologies of product development in a realistic context.

Guidelines (not rules) for successful projects are as follows. These arise from constraints due to the classroom setting, and observations of successful teams in past semesters.

- There should be a demonstrable market need for your product. One good way to verify a market need is to perform a competitive review and to identify existing products that try to meet the need. Your product need not be a variant of an existing product, but the market need addressed by your product should be clearly evident. The product does not have to have a tremendous economic potential, but should at least be an attractive opportunity for a small firm.

- Avoid products in over-worked areas. In the past, teams who have worked on over-worked areas (better bicycle locks, lost items finder, better backpacks) find that it is really hard to find an angle that has not already been covered in the market or by previous classes.

- Don't use cost-reduction as the motivating driver. Rarely are innovative products created by the goal of reducing costs alone. The driver should be to meet a compelling unmet need.

- The product should require no basic technological breakthroughs, but you can use new innovations originating on or off campus as the basis for your idea. If you choose a physical hardware product (rather than a software user interface design or service), the product should contain fewer than 10 parts. We do not have time to deal with large technological uncertainties; we are more concerned that you have a product that people really want, applying existing technologies, even if those technologies are new.

- You should be confident of being able to build a reasonable prototype of the product. If you choose to make a hardware product, you must have access to prototyping capabilities such as machining processes and the skill sets to run them. In some cases a combination of a non-functioning "appearance" type model and a rough mechanical or electrical "working" prototype may be acceptable.

- Prototyping Facilities: With the new Jacobs Hall we have a wide range of prototyping capabilities, but all require prior safety training before use.

  - Your ME team member should have access to ME shop facilities. We recommend that all interested students sign up for the student shop training during the early part of the semester, if you have not already done so. The Mechanical Engineering Student Access Machine Shop is available for students who will be working on projects and research related to our academic mission. If any student hasn't received the safety orientation training and needs to use the Mechanical Engineering Student Access Machine Shop this semester, they need to go through our safety orientation training in the early part of the semester. Training in another shop or location does not qualify the student to work in the ME shop. Students will need to visit the shop in 1166 Etcheverry Hall to schedule their training. The shop is open Monday through Friday 8:00-11:30 and 1:00- 4:30 for safety orientation enrollment. The safety orientation training is for education and safety purposes and consists of three 1- hour instructional/ hands-on sessions and a final 2 hour hands-on demonstration of safe work practices and machine tool competency. It is recommended that interested students sign up early during the first 3 weeks of the semester. Training is on a first come-first served basis. The staff cannot guarantee a slot in the schedule for students who don't sign up early. We will start the scheduling process at 9:00 AM on Wednesday January 20, 2016. The actual safety orientation training will occur during the period from January 27, 2016 through March 18, 2016. More information ME shop website at: http://www.me.berkeley.edu/new/Shop/.

  - Another option is the CITRIS Invention Lab, which provides knowledge, tools and support to rapidly design and prototype novel interactive products, embedded sensing systems and integrated mobile devices. The Invention Lab offers a variety of prototyping equipment ranging from basic craft tools to electronics workbenches, CAD stations and professional digital fabrication machines. Key equipment includes a laser cutter, professional and entry level 3D printers, Vinyl cutter, and circuit board mill. Common prototyping materials and supplies are available for purchase in the lab. Lab staff provides additional guidance and support for design and equipment use. Fees for use of the lab per semester is $125 for individual student use (more if working with a research group). More at: inventionlab.org.

  - For software user interface products, you should have access to proficiency in Web design tools or other software prototyping tools.

- o Jacobs Hall Maker Pass and equipment training for the semester (3D printers, hammers, large-format printer, etc). The Maker Pass is optional, but highly recommended if you are interested in prototyping. To get a Maker Pass, complete all steps as early as possible to gain access. Here is more information as to how you can get a maker pass:
    1. *Training:* New users must pass the General Workshop Safety (GWS) training; trainings from past semesters carry over, so if you passed GWS last semester, you do not need to retake it, unless it is deemed necessary by Jacobs staff, on a case-by-case basis.
    2. *Fees:* Starting this semester, the Jacobs Hall Maker Pass fee is $75 for the semester, payable by credit card via this online form, or check made out to "UC Regents," brought to 234 Jacobs Hall. Fee waivers are available to students with financial need and requestable via this form. For more information on fee payment, contact Aleta Martinez at aleta@berkeley.edu.
    3. *Equipment Training Bootcamp.* On January 12th and 14th, Jacobs is offering all-day training "bootcamps", featuring all 7 available equipment hands-on trainings, including some new ones that were not available in the fall. Though trainings will still be offered throughout the semester, this is your chance to get them done before classes start, and start using equipment right away. To register for bootcamp, enroll in the General Workshop Safety bCourse first, then click "2016 Bootcamp Schedule and Sign-ups". As usual, you must pass the online quiz component before attending the hands-on training. If you have questions, please to check this FAQ or feel free to contact Amy Dinh at amydinh@berkeley.edu.

- You should have access to more than five potential users of the product (more than 20 would be nice.) You will need to talk with them or observe them when you launch your product and visit them with your product mock-ups or prototypes.

- Save any highly proprietary ideas for another context, as we will be open in discussing the projects in class and do not wish to be constrained by proprietary information. By contrast, novel business ideas are generally not proprietary, benefit from exposure and feedback, and depend generally on execution for differentiation.

- The most successful projects tend to have at least one team member with strong personal interest in the target market. We strongly encourage those of you thinking about starting your own companies to bring your ideas to the class.

- Most products are really not very well designed. (See, for example, the badly designed products listed at http://www.baddesigns.com/examples.html.) Thus, if you pick almost any product that satisfies the general guidelines in this list, you will likely be able to develop a product that is superior to everything currently on the market.

Projects adhering to these guidelines will have the greatest probability of success.

PROJECT ASSIGNMENTS

Project assignments are intended to pace the development process for your product. There is little slack in this schedule and so assignments must be completed on or before the scheduled due date in order to maintain the project schedule. All project assignments are clearly spelled out in the class syllabus. Please post the items to be reviewed on bCourses.

All project deliverables (except the project proposal and the sketchbook/journal) are to be completed as a team. Please deliver all assignments according to the following format:

- Submit all project assignments and deliverables electronically. Unlike individual assignments that are to be submitted through the assignments tab on bCourses on the due date

for the assignment, Project Assignments and Deliverables should be posted to **your group's page** on the class Web site where they will be visible to all members of your group as well as all faculty members (and coaches if you choose to include them on your site).

- Maintain a history of your project deliverables on your group Web site so that the faculty can review your progress over time, not just your most recent output. You should save formal project deliverables as well as interim documents on the site.

- Be concise. We like project deliverables that are 2-5 pages in length when possible. The exception to this guideline is concept sketches where one concept per page is preferred.

- Please develop a naming scheme for documents posted to your group website; this scheme should make it obvious to us what the documents are. Name files intended for faculty review should begin with the letters DEL (short for deliverable). Follow DEL with an indication of what the document is. For example, when you submit your mission statement for faculty review, name the link DEL-missionstmt.

DESIGN COACHES

We are privileged to offer you the opportunity to collaborate with some of the leading experts in product development from prominent firms in the Bay Area. The design coach is tasked with giving you a practitioner's viewpoint and advice on all aspects of your product and product development progress. Given the coaches' many years of experience in product development and coaching design teams for this course, you will find their input invaluable.

WORKING WITH YOUR TEAM

Many of you have worked on *group* projects before. The goal of this class is to develop high performance *team* skills. We hope that through this course you will learn to differentiate between *groups* and *teams*. Teamwork and effective communication are vital to successful projects in academic and professional settings.

There are two reasons, among many, why learning to work effectively on a team is germane to your success. (1) There is definitive evidence that effective teams outperform groups on ambiguous, complex and interdependent tasks (of which new product development is an example). (2) Studies have found that most organizations regularly use cross-functional teams. It is critical to understand the nature of cross-functional teams, and to learn about them through participation in them. This course is designed to have you take on various roles at different points in the semester, and to assess patterns of cooperation and team dynamics. It is also important to reflect on how they impact your team's performance.

Over the years of offering this course, we have found that some basic team practices greatly benefit both the tangible and intangible outcomes of the team projects. Here are a few recommended best practices for you and your team:

1. Commit to regular meeting times. Face-to-face meetings are optimal, but virtual conferences (video-conference, tele-conference and email chats) are good alternatives when they are not possible. Structure meetings with a clearly assigned agenda, an end-time, and with specificied desired outcomes from that meeting (next steps, decisions, other actions), for which specific individuals are responsible. Reserve five minutes at the end of each team meeting to do a wrap up of decisions, assignments and next steps. This will make the meetings and the work in between meetings more productive. (i.e. higher quality outputs with less time used over the course of the semester).

2. Please use the team bCourses e-mail alias to communicate with your team. It will also archive and thread your e-mails so that you can review past conversations. Store shared documents on the group page on the website.

3. <u>Work together, not separately for team assignments, except where noted.</u> Get to know each other's strengths so that your team can leverage them (e.g., who are the CAD, Matlab, controls, drawing gurus, who's good at organizing and running meetings, who's good at eliciting feedback from customers, etc.)   There are wide gaps in results between teams that truly collaborate versus   groups that split up the work and staple it together when assignments are due. By design, there are many decisions and outputs you must work through as a team.
4. <u>Open and candid communication will serve your team the best.</u> Discuss the means by which you wish to resolve problems as a team (like all teams, you will have problems).   Also discuss what strategies you will use if problems persist.   Decide, for example, when you want to involve the faculty or your design coaches in helping you resolve problems.
5. <u>Use your mission statement/ value proposition canvas to create a shared vision that will allow your team to stay engaged and focused.</u>   Make explicit your learning goals up front – both subject matter and experiential.   Share them with your teammates so they can support you in those goals throughout the semester.   Speak up early if your goals are not being met.   Corrective actions early on are typically more valuable to you and your team than end-of-semester adjustments.
6. *<u>Have fun!</u>*