

## ME/E105 Product Design

**Professor Ken Pickar, TA: Tom Oliver**  
**First Term 2008 (3,0,6)**  
**Tuesday, Thursday 2:30 to 3:55, New Media Room (Behind Einstein Papers Building on Hill St.)**

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### Course Objectives:

- To study the business and social context for developing products.
- To study how product development is accomplished and to take a product through the early design stages.
- To focus this knowledge on the Developing World
- To learn team and communications skills

*This year we continue our emphasis on Guatemala. We will explore the social context required to develop successful products in general and in Guatemala in particular. In addition there will be a parallel module, with a speakers' series to cover this subject in more detail. Students from Raphael Landivar University, Guatemala City and Art Center in Pasadena will join our teams.*

The purpose of this course will be to expose students to the complete spectrum of product development activities from market research to production and after-market support but in a developing world context. We see that the normative tools are very useful in this new market area. The course will give insight to products developed using a variety of technologies, though technology is not the emphasis of this class. In fact, many useful products can be constructed employing indigenous technologies.

### DFX

For all students, good practices will be presented. Design will be presented as a process whose cost, performance, timing, and quality are measurable. Integral with this approach is the adoption of a series of anticipatory design practices which form the core of this course. (These are sometimes referred to as DFX or Design For "X" methodologies.) For example, researched customer desires are taken into account to assure that the product will have a market. This is difficult enough when the customer belongs to a familiar culture. The problem is multiplied when the customer culture differs profoundly from that of the engineer/designer.

Another concept covered is product economic return, including the practice of design to a specified cost. This is particularly operative when the customer can only afford a product that provides a fast return. The cost of this product is often very low by developed world standards.

An important issue is reliability where we address the question of making products that are robust against use (or misuse) and predictably survive for greater than a specified period.

Manufacturability will be covered where the design enables products to be made in the most cost-effective, reproducible fashion in areas with little or no supporting infrastructure. Sustainability in a resource-limited world will be addressed by considering the effect of our products on limited natural resources. We emphasize the effect on the environment through all phases of the life cycle of a product. This includes manufacture, use and disposal, all considered during the design stage to minimize unhappy surprises.

The human interface is another important consideration. In addition to ease of use, this subject also addresses health and safety concerns. Ethical discussions, using case approaches, will cover occasions when engineers are faced with choices that conflict with personal values. We will present methodologies for addressing these dilemmas, which arise in the life of every engineer, including, most assuredly, those who build developed world products. We consider also that products are made in a social and political context. It is particularly important for engineers to be aware in the design phase of regulatory issues, IP protection, legal restrictions, misuse and other government and social constraints.

*To study these methodologies, there will be a student term project where a student-chosen product concept is developed by a 4-person team. Each of the good practices will be applied to each of the selected projects. The teams will be composed of Caltech students with a Landivar student on each of these teams. Art Center Students will also be assigned to teams.*

In accordance with good design process, there will be an opportunity for rapid prototyping to help develop the concept. It is not expected that a complete ready-to-manufacture design will be completed in the limited time available. However, design studies and drawings will be made and perhaps early prototypes could be developed.

The major challenge in this course is to work through the challenges of understanding the market and designing an appropriate product in the very limited time available. Towards that end we offer some alternative approaches

1. In engineering, the concept of “reuse” is well established. Here we use pre-existing designs as a basis to make necessary improvements without having to redesign from scratch. One approach here is to work on projects which a team in a previous ME/E 105 team has addressed. The new team would make changes as required to bring the product to a higher level of readiness for the market place.
2. Another alternative for a Team which wishes to continue is to register for independent study or work in the summer in Guatemala to implement

## **Mentors**

To assist you, experienced mentors with industry or developing country experience will be assigned to each product team. We are working on assigning entrepreneurs from Guatemala to each team.

## **Designs Appropriate for the Developing World**

In addition to lectures, we will employ real-life studies, using guest speakers to explore several examples of the application of these principles. As mentioned above, for the subject of products for developing countries, there will be a parallel speaker series which will emphasize the special issues associated with this subject. For these projects, we intend to have a fourth team member from the developing country, working under the guidance of an in-country mentor. Because of their higher organizational complexity we will have these teams in place and the subjects vetted prior to the start of class.

This sequence is being developed in collaboration with the Caltech Chapter of Engineers for Sustainable Development (<http://esw.caltech.edu>), students from the CASS student exchange program, USAID's Farmer-to-Farmer program at Florida International University, Universidad Francisco Marroquín, and Design that Matters, an MIT-related organization ([www.designthatmatters.org](http://www.designthatmatters.org))

## **Teams**

To increase the team diversity and benefit from their skills, we are inviting students from the Art Center School of Design in Pasadena to join our teams. To participate in this class, you must take these teams very seriously. You are obligated to attend team meetings and bear your share of the burden. Each team member will receive an identical grade for efforts produced by the team. However, there will be some grade differentiation based on contribution to class discussions. We will form these Teams very early in the quarter, beginning the first day of class. At each class homework may be presented by one or more Team.

*All Homework will be done by all teams and submitted to the TA and myself on the date due; your grade ("HW") will be based on these analyses. All other members of the class who are not presenting are required to do the Homework and be prepared to comment. However, only one team will orally present the assignment. You will know in advance when your team will present. The responsibility to present your results will be rotated with each team presenting at least once. This discussion simulates how business profit or non-profit is actually conducted; most business information is transmitted orally through presentation and discussion. Therefore, I will require all students to contribute. I know some students are not comfortable with this and I will make some allowances. However, I do want all to join in and 20% of the grade will be dependent upon this participation.*

*Please e-mail the instructor and TA all your assignments as well as provide hard copies in the class when the assignment is due.*

### **Expectations**

The above only works if the teams work as teams with everybody contributing. No free rides. The Caltech honor code applies here. Everyone in the class, presenting or not, does the homework. Everyone (or almost everyone) attends each class, showing up on time. If you have to unavoidably miss a class, I would like an e-mail or telephone message in advance informing me of the fact. There will be periodic team assessments to assure that the teams are functioning well. If there are irresolvable issues, teams can be broken up and the members re-assigned. This should be a rare occurrence.

This is the kind of learning where looking up lectures on the web or just doing the assigned readings will not suffice. The student needs to follow the arguments made and participate in arriving at an acceptable conclusion. The journey in getting there is part of the learning experience. Mathematically, the formula is as follows:

Learning = f(team effectiveness + team preparation + rest-of-class preparation) X (class attendance)}

### **Guest Speakers**

We will also hear some guest speakers who will discuss how these principles apply in their industries. There will be a parallel speaker Series which will present additional materials related to building products for a sustainable world. Each student will be required to attend at least two of these lectures and write one page (double-spaced, 12 pt. font) about what they learned from the lecture and how they can apply it to their project. If you absolutely cannot make it to any of the lectures, let Prof. Pickar or the TA know why.

### **Term Product Design Assignment**

1. Choose a Team. Optimum is 3-4 people. If you don't know other people in the class, don't despair, we can assist in team formation. Teams will be formed during the first week.
2. Choose a product to design  
Examples:  
Product ideas presented to you the first day of class  
Other Projects designed to satisfy basic needs (clean water, simple transportation, energy, etc.) in the developing world

Use tools described in Class including at least 8 of the following tools  
Design for appropriateness in the chosen market (e.g. Culture)

Design for Sustainability (Business and technology)

Design for the Environment

ROI and Financial Considerations

Design for extremely low cost

Design for Manufacturability and Assembly

Systems Architecture Considerations

Product Platforms

Risk Mitigation Analysis

Test and Testability

Design for Maintainability

Human Interface- Ergonomic Design

Quality Design

*Invent your own based upon principles taught in class*

Design a “virtual product using these tools”. It is advantageous to build an engineering model which demonstrates functionality. The ME shop is available for your assistance. Please contact John Van Deusen. ([jvand@caltech.edu](mailto:jvand@caltech.edu), X4120). Another possibility is to use rapid prototyping to create a mock up of your product. Realistically, given time constraints, your results might be limited to “paper analysis”.

There will be a paper and presentation at the Midterm and Final.

### **Timetable to be adjusted and coordinated with syllabus**

Teams formed	September 30
Lecture on Teams	October 4
Term project Proposal due	October 4
Term projects Accepted	October 11
First team meeting	October 21-28
Mid-course Report due	November 3
Team Report due	November 17
Final Report due	December 2
Presentation due	December 2

The Final report should be a maximum of 20 pages double-spaced. It should include the Design plus the thinking that went into creating this Design. We will have a poster session after the Final Presentations. Interested members of the community will be invited to hear your talk and to discuss your results.

The Midterm Presentation should take about 20 minutes (~ 10 PowerPoint slides). The Final presentation should take also about 30 minutes or 15 Slides. An outline of the contents will be discussed in the Class.

The TA and I are available continuously for counseling on this assignment. Please feel free to call on us.

### **Grades**

30% HW, 20% Midterm Assignment 35% Final Term Assignment, 15% class participation.

Your HW grade will be based on your written answers submitted to me and the TA. In my grading, I look for understanding of the material and originality.

Your Midterm and Final assignments grades are also based on these criteria. We will not grade on your presentation style; however we will give you feedback on how well I thought you organized and presented the material.

### **Auditing**

Although auditors are welcome, it is clear from the above that the amount of learning accomplished is directly proportional to the effort expended. Naturally, this is true of anything you would want to learn. In this course, merely perusing notes or lecture slides after the fact is not as useful as you would think unless have a position of knowledge of what the discussion is all about. Auditors might consider forming teams with other auditors.

### **We need to get this in bookstore! Tom, can you handle? At least on reserve**

#### Course Text

Ulrich and Eppinger “Product Design and Development, Third Edition” in bookstore.

On Reserve: “Contemporary Engineering Economics” Chan S. Park

### **This needs work!**

#### Suggested Readings:

1. UN: The Millennium Development Goals Report 2005
2. Excerpts from E.F. Schumacher. Small is Beautiful: Economics as if People Mattered.
3. David French. “The Ten Commandments of Project Planning”, The AT Reader, ed. Marilyn Carr. London: Intermediate Technology Press, 1985. pp 407-412

4. McDonough, W. and M. Braungart. "The NEXT Industrial Revolution." The Atlantic Monthly, October 1998.
5. Sky Marsen. "Organizational Communication"
6. Monique Maddy. "Dream Deferred: The Story of a High-Tech Entrepreneur in a Low-Tech World" Harvard Business Review, May-June 2000.
7. C. K. Prahalad and Allen Hammond. "Serving the World's Poor, Profitably." Harvard Business Review, September 2002.
8. Ford advertisement from New Yorker
9. Carly Fiorina's 2004 commencement speech

Additional reading and references can be found on the course webpage.

Course Follow-on

For those students interested in continuing with their product through to the next stage, your work can be pursued in the next Class in the sequence: E 102 Entrepreneurial Development where we can pursue a business plan to commercialize your product. Other flexible, independent study alternatives will also be possible for those who desire to continue product design through to manufacturing models and beyond.

**The 2008 Schedule tentative!**

Date	Subject	in Class
09/30 Tue	Introduction Luzmi Delgado	Caltech, Art Center, Landivar Course objectives, expectations, introductions.

10/2 Thur	Process, Mission statement	The Product Development Process. Introduction to DFX methodologies. Importance of design and importance of process. Mission Statement Criteria for Choosing a product Candidate product topics Teams 101 Team Formation Exercise
10/7 Tue	Mission Statements Introduction to marketing	Teams present their Mission Statements How do you size and understand the market. Primary and secondary research. Role of field coordinator, Guatemalan Team members
10/9 Thur* *Wed Noon	Marketing with Developing World Focus <i>Class moved to noon, Wed, Oct 8</i>	Rest of Teams present mission statement Lecture: How do we know what the market wants or needs? What about products in developing countries? What is our goal (profit, development). What are possible business models.
10/14 Tue	Product Specifications	Team Presentations of Market Research Plan Who is the customer, what is the size of the market, what does the customer want? Lecture: How to determine the optimum specs for your products and convert into engineering requirements
10/16 Thur	Luzmi Delgado Design for Culture	Team Presentations of Market Research Plan The Guatemalan Culture. Appropriateness of Design

10/21 Tue	Lecture Product Architecture	Product	Team Presentations of Product Specs How to architect a system. Is there a structured way of thinking about partition of function?
10/23 Thur	Oscar Arce Human Factors and industrial Design	Human Factors	Team Presentations of Product Specs How are products designed to be human friendly? What special considerations are there for Guatemala?
10/28 Tue	Lecture Detailed Design	Detailed	Team Presentations on candidate architectures How do you build a product that will satisfy the market and product specs
10/30 Thur Ken Away	Lecture Ovidio Morales	Morales	Team Presentations of Market Research Plan Contextualization" and "Social Responsibility"
11/04 Tue	Lecture Reliability, Failure Modes and Effects	Reliability, Failure Modes and Effects	Tools to design products, robust against unintended uses as well as against flaws that can cause early failure

11/06 Thur	Midterm Presentations	20 Minute Presentations on Accomplishments to date; Include detailed design, plans for the rest of the course, expectations, quality of Team interactions
11/11 Tue	Lecture Design for Mfg Factory operations DF Assembly, Building device model for demonstration	Team Presentations on Cultural Design How do factories actually work? How can you avoid designing the unbuildable? Outsourcing challenges and limitations. Manufacturing/Assembly challenges in developing countries.
11/13 Thur	Financial Considerations	Team Presentations on Cultural Design Lecture: NPV, Pro forma, Payback time, design to Cost, Bill of Materials. Applications to developed and developing worlds
11/18 Tue	Lecture on Rapid Prototyping	Team Presentation on Business Context Prototyping to test ideas
11/20 Thur	Team perspective	Team Presentation on Business Context and on Team Learnings Team Report due.

<b>11/25</b> <b>Tue</b>	<b>Ethical</b> <b>Consideration</b>	<b>Other Constraints on Developing products in the</b> <b>Developing World. Government and Law.</b>
<b>11/27</b> <b>Thur</b>	<b>Thanksgiving</b> <b>holiday</b>	<b>No Class</b>
<b>12/2-</b> <b>Tue</b>	<b>Review of what we</b> <b>have learned</b>	<b>Guatemalan Students join us</b>
<b>12/4</b> <b>Thur</b>	<b>No class</b>	
<b>12/8</b> <b>Monday</b>	<b>Final</b> <b>Presentations</b>	<b>Final Presentations and Final Reports</b> <b>Poster Session and Prototype demonstrated</b>