2.S999 Global Engineering  
Course Info and Syllabus  
Prof. Amos Winter  

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Course Information
Title: Global Engineering
Term: G/H Fall Term
Prereqs: 2.007, 2.008 or permission of instructor
Units: 3-0-9 (12 units)
Lecture: MW 1-2:30 (5-233)
Website: http://stellar.mit.edu/S/course/2/fa13/2.S999/

Description
Combines rigorous engineering theory and user-centered product design to create technologies for developing and emerging markets. Topics covered will include: machine design theory to parametrically analyze technologies; bottom-up/top-down design processes; user-centered product design; engaging stakeholders in the design process; understanding socioeconomic factors that affect adoption of products; and developing/emerging market dynamics and their effect on business and technology. Class material will be complemented by guest speakers who are subject matter experts in relevant fields and case studies on successful and failed technologies. Student teams will apply course material to term-long projects to create new technologies, developed in collaboration with industrial partners and other stakeholders in developing/emerging markets.

**Educational Objectives**

This course will give students a perspective on the technical and socioeconomic factors that are relevant to designing technologies in developing and emerging markets. Engineering theory presented will include mechanical design analysis and bottom-up/top-down product design methodology. Socioeconomic content will include understanding the dynamics and economics of developing/emerging markets and engaging stakeholders in the design process. Students will work in teams to create new technologies by applying theory from the class and partnering closely with international stakeholders, including companies that have a track record of successfully manufacturing and disseminating products in target markets. The educational objective of the course is to train global engineers, who have the tools required to understand, tackle, and solve challenging technical problems in the developing and developed world.

**Syllabus**

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Lecture Topic</th>
<th>Assignment Given</th>
<th>Assignment Due</th>
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</thead>
<tbody>
<tr>
<td>W</td>
<td>9/4/13</td>
<td>Overview of class - what class will cover, syllabus, what is due, why it is</td>
<td>Read Human-Centered Design Toolkit, Read The Frugal Way</td>
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<td>being taught, takeaways</td>
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<tr>
<td>M</td>
<td>9/9/13</td>
<td>Overview of class projects, expected deliverables, start of design process.</td>
<td>Submit info card on major, background, skills, year, project preference.</td>
<td>Read The Frugal Way, Info card due Tuesday morning 9am in 3-449C</td>
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<tr>
<td></td>
<td></td>
<td>30-min from Angie Locknar about research resources</td>
<td>Read LFC Constraint-Driven Innovation Study, LFC Biomechanics Paper</td>
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<tr>
<td>W</td>
<td>9/11/13</td>
<td>Project teams assigned. Continuation of design process - focus on stakeholder</td>
<td>Readings from Reverse Innovation,</td>
<td>Read Human-Center Design Toolkit</td>
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<td></td>
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<td>engagement, where our value added.</td>
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<tr>
<td>M</td>
<td>9/16/13</td>
<td>Case study: LFC - highlight multi-market opportunities</td>
<td>Readings from Jugaad Innovation</td>
<td>Read LFC Constraint-Driven Innovation Study, LFC Biomechanics Paper</td>
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<tr>
<td>W</td>
<td>9/18/13</td>
<td>Defining design requirements and generating strategies from technical and</td>
<td>Read How GE is Disrupting Itself</td>
<td>Readings from Reverse Innovation</td>
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<tr>
<td>Date</td>
<td>Day</td>
<td>Event</td>
<td>Paper/Readings</td>
<td>Notes</td>
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<tr>
<td>9/23/13</td>
<td>M</td>
<td>Guest Speaker - Amy Smith</td>
<td>Readings from Poor Economics</td>
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<tr>
<td>9/25/13</td>
<td>W</td>
<td>Guest Speaker - Navi Radjou, author of <em>Jugaad Innovation</em></td>
<td>Thinking Differently: The State of Innovation in India</td>
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<tr>
<td>9/30/13</td>
<td>M</td>
<td>Guest Speaker – Abhijit Banerjee, author of <em>Poor Economics</em></td>
<td>Readings from Poor Economics</td>
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<tr>
<td>10/2/13</td>
<td>W</td>
<td>Designing for large-scale - factors to consider as an engineer and case studies. Big case study on the AK-47</td>
<td>Read Case Study on Jaipur Foot, Read how Jaipur Foot is made</td>
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<tr>
<td></td>
<td>M</td>
<td>Class discussion about class thus far - reactions on Jugaad, Reverse Innovation, Poor Economics, Thinking Differently, GE Disrupting Itself, as well as guest speakers. Manufacturing and prototyping - Multi-market design, local manufacturing, design for expendability, design for repair, techniques on making quick prototypes, empirical validation. Ben on shop resources at MIT</td>
<td></td>
<td>Read Case Study on Jaipur Foot, Read how Jaipur Foot is made</td>
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<tr>
<td>10/9/13</td>
<td>W</td>
<td>Guest Speaker: Ratan Tata visit for 1hr. Strategy Presentations for half hour.</td>
<td>Read case study about Kickstart, Readings from Out of Poverty</td>
<td>Strategy Presentations - 10min full presentation and 2-minute, single slide summary</td>
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<tr>
<td>10/14/13</td>
<td>M</td>
<td>No class - Columbus Day</td>
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<tr>
<td>10/16/13</td>
<td>W</td>
<td>Finish strategy presentations. Concept development, turbo example, if there is time. 30 min presentation from the TLO on IP protection</td>
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<tr>
<td>10/21/13</td>
<td>M</td>
<td>Case study: Treadle Pump</td>
<td>Read paper on low-pressure drip irrigation</td>
<td>Read case study about Kickstart, Readings from Out of Poverty</td>
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<tr>
<td>10/23/13</td>
<td>W</td>
<td>Concept Presentations</td>
<td>Concept Presentations</td>
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<tr>
<td>10/28/13</td>
<td>M</td>
<td>Most Critical Module and Prototype development</td>
<td>Read paper on low-pressure drip irrigation</td>
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<tr>
<td>10/30/13</td>
<td>W</td>
<td>Take-apart/product teardowns</td>
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<tr>
<td>11/4/13</td>
<td>M</td>
<td>Class presentations on take-aparts/teardowns</td>
<td>Read Up In Smoke, Readings about Darfur Stove</td>
<td>Class presentations on take-aparts/teardowns</td>
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<tr>
<td>11/6/13</td>
<td>W</td>
<td>Guest Speaker - Bob Hauke from GE Medical</td>
<td>Readings about low-cost diagnostics from the Whitesides group</td>
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<tr>
<td>11/11/13</td>
<td>M</td>
<td>No class - Veterans Day</td>
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<tr>
<td>11/13/13</td>
<td>W</td>
<td>MCM Presentation - class design reviews</td>
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<tr>
<td>Day</td>
<td>Date</td>
<td>Activity</td>
<td>Readings/Assignments</td>
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<tr>
<td>M</td>
<td>11/18/13</td>
<td>Case study: cookstoves</td>
<td>Read Up In Smoke, Readings about Darfur Stove</td>
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<tr>
<td>W</td>
<td>11/20/13</td>
<td>Guest Speaker - George Whitesides</td>
<td>Readings about low-cost diagnostics from the Whitesides group</td>
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<tr>
<td>M</td>
<td>11/25/13</td>
<td>Open class time - work on projects</td>
<td>Draft paper due to team mentors</td>
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<tr>
<td>W</td>
<td>11/27/13</td>
<td>Work on projects - no lecture - day before Thanksgiving</td>
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<tr>
<td>M</td>
<td>12/2/13</td>
<td>Engineer's toolbox - review of important theory for design engineer. Backup would be patent process or work on projects</td>
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<tr>
<td>W</td>
<td>12/4/13</td>
<td>Guest Speaker - Vijay Govindarajan</td>
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<tr>
<td>M</td>
<td>12/9/13</td>
<td>Engineer's toolbox - review of important theory for design engineer. Backup would be patent process or work on projects</td>
<td>Final Presentation in the evening of 12/12. Final Paper due by midnight on 12/15</td>
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<tr>
<td>W</td>
<td>12/11/13</td>
<td>Guest Speaker – Ashok Gadgil</td>
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**Texts and Readings**

**Required Texts**

**Recommended Texts**

Students are expected to complete all of the assigned class readings. This material will be used to complement lecture content and is an important element of the class. Students will be expected to discuss/compare/contrast lecture content with the
readings as part of in-class discussions. The reading load has been paced throughout the semester to balance the ramp-up of the class projects.

**Guest Lectures**
Global Engineering will have some of the most highly regarded thought leaders in development technology delivering guest lectures. These lectures form a major intellectual component of the course. Most of the guest lecturers will also deliver a Tata Center proseminar on the same day they visit class, which is also recommended for the Global Engineering students.

**Attendance**
Attendance of each class is highly encouraged. In-class discussions will be an important part of learning in Global Engineering. Attendance will be factored into the individual performance component of each student’s grade.

**Grading**

- Strategy Presentation: 10%
- Concept Presentation: 10%
- Most Critical Module (MCM) Presentation: 10%
- Final Presentation: 20%
- Product Take-apart Presentation: 5%
- Final Report: 25%
- Individual Performance: 20%

During the strategy, concept, MCM, Final, and Take-Apart presentations, the audience will fill out rating sheets to score each team. These ratings will be taken under consideration when grades are assigned by the teaching staff. The final report will be graded by Prof. Winter. Each member on a team will receive the same grades for that team’s presentations and final report. The individual performance grade will be determined by the teaching staff with consideration of the following: peer reviews of each team member by his or her fellow team members; team mentor’s assessment of his or her team members’ participation; and class participation judged by Prof. Winter (which includes attendance).

**Team Projects**

**Overview**
The term-long team projects and resulting reports are major learning components of Global Engineering. The purpose of the projects is to develop an engineering solution to a developing/emerging market problem, and articulate the technical and socioeconomic factors behind the problem and solution. The class will be split into teams of four to five students. During the second lecture, projects will be presented. Each student will fill out an info card with their background, skills, interests, and desired project. The teaching staff will use these cards to assemble teams with balanced skill sets, trying to give priority to project preference.
Each team will work with a mentor. Teams are required to meet with their mentors for ~3hrs/week. This is effectively the lab component of the class. Each team will also be partnered with a point of contact at the organization that defined the project scope. It is the team’s responsibility to hold regular meeting/Skype/phone calls with the point of contacts and share information and ideas about the project. The intent is for the team to work with the partners, not solve a problem for them. The partners are an excellent source for background information and motivation for the projects – they are all established players in the markets for which we are creating technology. Learning how to work with partners halfway around the world is an important lesson of the class. Demonstration of effective communication with the partners will be a graded component, assessed during the milestone presentations.

**Project Deliverables**

Each team will be expected to produce a working proof-of-concept prototype for their project that satisfies the design requirements of the problem they are addressing. Additionally, teams need to produce the engineering theory behind how their technology operates, and collect data that validates the theory and the technology’s performance. “Hacking” together solutions will not be acceptable in Global Engineering. The point of the class is to combine rigorous engineering theory with the important socioeconomic factors in developing/emerging markets to create high-impact, disruptive technologies.

Projects will be developed through four milestones in the class. Each milestone corresponds with one of the class presentations. The following deliverables are expected for each milestone.

- **Strategy Presentation** – In this presentation, teams will present a focused scope of the problems they are going to solve. This information will not be provided during the project overview presentations during the second lecture. Teams will have to work with their partners to fully understand the problem and where they should focus their efforts. Background information and motivation for the problem will be expected. The “strategy” the team defines should be an articulation of the path it will take during the semester. High-level conceptualizations (such as how a consumer may interact with a product) and first-order analysis will be expected during this presentation.

- **Concept Presentation** – While the strategy presentations are focused on what the team is going to do, the concept presentations should tell how the team is going to do it. This will include physical depictions of the proposed solution, which may take the form of looks-like models of how a consumer may interact with a product, analysis and theory for possible solutions, and sketches of overall concept architecture. The team should have an overall plan for what its problem is and what the final solution is going to be. At this
point, the team should identify the core technical challenge behind the problem and where it will focus its efforts for the remainder of the semester.

- **Most Critical Module (MCM) Presentation** – The most critical module is the technological keystone of the concept; it is the element of the problem that will most greatly determine success or failure of a solution, and it is often the trickiest to solve. In this presentation, teams will present the solution to their MCM. This will most likely be a bench-level prototype that demonstrates the feasibility of an idea. Teams should support this feasibility with theory and data. In this presentation, the teams should also outline the remaining modules that need to be developed to construct a proof-of-concept prototype of their concept.

- **Final Presentation** – There is full month between the MCM and final presentations. During this period, teams will develop the remaining modules of their projects and assemble them into the full proof-of-concept prototype. During the final presentation, teams will review the overall scope of their projects including background/motivation and the specific problems on which they focused. The presentation should include a demonstration of the resulting technology (ideally in person, otherwise in video) with theory and data that backs up its performance. This presentation should be of the quality that would be expected at an academic conference.

**Final Report**

Each team will produce a final report for their project. The report will be written as an article for the American Society of Mechanical Engineers (ASME) International Design Engineering Technical Conferences (IDETC) and Computers and Information in Engineering Conference (CIE). This is the preeminent design-focused conference offered by ASME and the ideal place to showcase your work. Finishing the article for the class will position each team nicely for meeting the deadline for submission to the conference, which is in January or February. A draft of the paper is due to the team’s mentor the Wednesday before Thanksgiving. The final paper is due the Sunday before finals. These dates are in the syllabus.

For acceptability in the IDETC conference, as well as in Global Engineering, the paper should include the following elements:

- **Background/Motivation** – teams will have to conduct background research and prior art review on their problems. Relevant data and statistics, as well as relevant work of others should be cited. This is typically included in the introduction section.

- **Analysis** – Engineering/scientific theory needs to be presented that supports and justifies the presented work. You need to explain *how* the technology

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behaves so you can teach others how it can be adapted to their specific situation.

- **Materials and Methods** – Describe how the prototype was designed/manufactured and how it was tested.

- **Results** – This section should show how the presented theory predicts the behavior of the technology.

- **Ramifications** – Why does your work matter? Contextualize its impact and why it matters. What are the learnings from the work? What, if any, future work remains? This information is usually presented in the conclusions section.

Two example ASME IDETC papers have been posted on the Global Engineering Stellar page. These papers are of similar depth and scope as what is expected for the class projects. Both of these projects were completed with a similar amount of time and effort as a class team would allocate in a semester.

**MIT Library Support**
Angie Locknar, the MIT Libraries rep for ME, has set up a resource page for our class: [http://libguides.mit.edu/2s999](http://libguides.mit.edu/2s999). There are links to relevant information for your projects here, including research articles and info about India. Don’t hesitate to contact Angie for further information – she can typically help you find whatever you need.

**Intellectual Property**
Many (if not all) teams will produce intellectual property from their projects in Global Engineering! Our goal is to have every team get a publication and patent from their project! MIT’s policy, by and large, is that IP created by students in a class is owned by the students. If MIT resources are heavily used, MIT may own the IP, but the inventors would still receive a royalty if the IP is licensed. If the IP is created in conjunction with an outside partner, the ownership would be shared. A representative from MIT’s Technology Licensing Office (TLO) will be visiting class to describe MIT’s IP policies. They can also be found here: [http://web.mit.edu/tlo/](http://web.mit.edu/tlo/). Do not disclose any IP related to your work before you have protected it – disclosure will also be covered in the TLO’s lecture.

**Fabrication Facilities**
Teams will be expected to seek out their own fabrication facilities and areas where they can store/develop/build their projects. There are many open access fabrication facilities on campus: Hobby Shop (which will be closed until Oct. 2013), Edgerton Shop, ME Graduate Machine Shop, and the LMP Shop. These shops typically have
training requirements, so please find out what these requirements are before you need to build something. The best way to piss off a shop manager is to barge in and say you need something made at the 11th hour, especially if you are not a member of the shop. Students on a team will also have access to the facilities in their own labs, including GEAR Lab’s shop, the AI machine shop, the IDC shop, and the Media Lab. Only use these private labs if one of your team members or your project mentor has access. ALWAYS LEAVE A SHOP CLEANER THAN HOW YOU FOUND IT!

Ben Peters is a fantastic resource for “maker spaces” around campus, and is a guru for many fabrication techniques. He will be the class’s main point of contact for fabrication questions. Prof. Winter, and the project mentors, are also good resources. Outsourcing machining is also a viable option; please work with your mentors, Ben, and Prof. Winter for suggestions on where to send parts.

**Budget/Purchasing**

Each team has a budget of $5,000 for its project. The team is responsible for allocating and budgeting these funds accordingly. Each team should have a treasurer who keeps track of spending in a spreadsheet. Funds should be spent solely for project-related expense, not on food or entertainment. Paying for Hobby Shop membership is an acceptable expense.

Ben Peters will be in charge of purchasing for the class. If you need something bought, you can do it via one of the following ways:

- Contact Ben and tell him what you need, where to buy it, and how much. He will place the order on his procard.
- Buy the item yourself and submit your receipt to Ben for reimbursement.
- If someone on your team has a procard, or wants to get a procard, you are welcome to use it. Please coordinate with Prof. Winter to set this up so your verifier knows to which account purchases should be posted.