2.009 Product engineering processes

powered garden cart automatically follows user
Welcome!

powered garden cart automatically follows user
2.009 Product engineering processes

A mini quiz

Put your name on the top of an index card

Which object is different from all the others?
Which object is different from all the others?

b

Congratulations!
The only one with all straight lines
2.009 Product engineering processes

A mini quiz

Which object is different from all the others?

\begin{itemize}
  \item \text{c}
\end{itemize}

Congratulations!
The only one that is asymmetric
2.009 Product engineering processes
A mini quiz

Which object is different from all the others?

Congratulations!
The only one with no points
Which object is different from all the others?

Congratulations!
The only one made with line and arc
2.009 Product engineering processes
A mini quiz

Which object is different from all the others?

Congratulations!
The only one that is the projection of a triangle onto a curved surface
Welcome!

to product engineering processes
a place where there are many right answers

products for the developmentally disabled
Welcome!

there are many right answers
… and even more wrong answers
there are many right answers

... and even more wrong answers
it’s not easy, but...
we are here to help you succeed

course instructor  teaching assistants  administrative assistant

lab instructors

communication instructors

technical instructors  meta yodas  librarians

+ 30 mentors!
information/staff menu
building a machine for innovation

motivation
+ creativity
+ informed craft
+ process

= innovation
Machine for technical innovation

What’s the recipe?

- motivation
  - design
  - process

= innovation
2.009: developing/engineering products

design

Creativity to see many unique viewpoints/framing

Capability to understand/analyze/model/test viewpoints

Creativity to generate solutions from a viewpoint

C1: lateral thinking (mini quiz: more than one answer)
C2: informed (most of your formal education) + craft
C3: synthesis from a viewpoint (constraints)
a mini quiz for the ‘3rd C’: generating solutions!

put your name on the top of an index card

think of a way to place a sheet of paper so that when two people stand on it, facing towards each other, it is impossible to touch.

some rules:
cutting or tearing the paper is not allowed
tyling up the people is not allowed

one solution:

another solution? hang …challenge assumptions

another solution? use two people that cannot move
2.009 Developing/engineering products

design

C reativity to see many unique viewpoints/framing
C apability to understand/analyze/model/test viewpoints
C reativity *generate solutions* from a viewpoint
Machine for technical innovation

What’s the recipe?

motivation

+ design

+ process

= innovation
2.009 developing/engineering products

process(es)

a collection of strategies to help ensure that you have a high likelihood of being successful

on time, every time
2.009 Product engineering processes

the class

Develop new product ideas
Provide teams of ~20 students with the opportunity to experience the need/opportunity finding, innovating, prototyping, and business development cycle in a simulated but very realistic environment. Fully functional alpha prototypes are designed and fabricated by the teams.

Improve our 3Cs (design)
Practice being creative and constructing physical and analytical models for reasoning about creative alternatives.

Processes
Learn strategies for the 3Cs and apply them to product development and working in large teams.
2.009 Product engineering processes

goals for today

how is the course organized?

what will I experience?

what are the milestones (grading)?
Product engineering processes

how is the class organized?

<table>
<thead>
<tr>
<th>lab (product development activity)</th>
<th>technical managers</th>
<th>consultants</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 instructors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-24 students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mentors: ~4 design 1 comm.</td>
<td></td>
<td>consultants</td>
</tr>
<tr>
<td>2 instructors</td>
<td></td>
<td>consultants</td>
</tr>
<tr>
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<td></td>
<td>consultants</td>
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<tr>
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<td></td>
<td>consultants</td>
</tr>
</tbody>
</table>

| discipline-specific mentors | |
| course librarians           | |
| lab staff                   | |

<table>
<thead>
<tr>
<th>class (development process and design methods)</th>
<th>CEO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 course instructor</td>
<td>aides</td>
</tr>
<tr>
<td>course TAs</td>
<td></td>
</tr>
</tbody>
</table>
Product engineering processes
how is the class organized?
Product engineering processes
beyond 2.009: opportunities to keep learning!

Braille label maker
“the home”

inexpensive, high quality printing, fast
after 2.009: patents
started company (6dot)
funded on kickstarter
Product engineering processes

how is the class organized?

process

design techniques

product definition

physical modeling
What will I experience?

**idea development**

### Modeling activities

- **idea generation/sketches**
- **market and customer estimates**
- **sketch models**

### First order energy feasibility

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Assume</strong> 12.5 mph <strong>For</strong> with user weight of 165 lbs and <strong>Total</strong> 0</td>
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<tr>
<td></td>
<td><strong>Rolling resistance of 1.5% (including wheels and bearings)</strong></td>
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<tr>
<td></td>
<td><strong>Wind resistance of 7.5 square feet frontal area</strong></td>
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<td></td>
<td><strong>Minimum drive train efficiency allowable</strong></td>
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<td></td>
<td><strong>Current efficiency goals</strong></td>
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<td></td>
<td>85%</td>
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<td></td>
<td>94%</td>
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<td></td>
<td>77%</td>
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<tr>
<td></td>
<td>72%</td>
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<tr>
<td></td>
<td>67%</td>
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<tr>
<td></td>
<td>62%</td>
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<tr>
<td></td>
<td>57%</td>
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</tr>
</tbody>
</table>

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To meet the weight constraint of less than 30 lbs, the battery weight must be less than 13 lbs, and the motor efficiency is 77%. The gearbox efficiency is 94%.
Idea generation
4 minute exercise
write your name on a blank sheet of paper

generate as many ideas as possible to mitigate…

your ideas will be collected at the end of 4 minutes
What will I experience?

**idea development**

<table>
<thead>
<tr>
<th>Modeling activities</th>
<th>idea generation</th>
<th>market and customer estimates</th>
<th>sketch models</th>
<th>feasibility estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>To meet weight constraint of less than 30 lbs.</td>
<td>With user weight of 165 lbs and counterweight of 9 lbs.</td>
<td>Energy constraint must be less than 13 lbs.</td>
<td>12.5 mph (including wheels and bearings)</td>
<td>1.5% (including wheels and bearings)</td>
</tr>
<tr>
<td>Assume 12.5 mph For</td>
<td>with energy 1</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Rolling resistance of 1.5%</td>
<td>Wind resistance of 7.5 square feet</td>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current efficiency goals</td>
<td>Minimum drivetrain efficiency allowable</td>
<td>Motor: 85%</td>
<td>Gearbox: 94%</td>
<td></td>
</tr>
<tr>
<td>85%</td>
<td>77%</td>
<td>0.8 lbs+</td>
<td>72%</td>
<td>1.8</td>
</tr>
</tbody>
</table>
What will I experience?

concept development

Modeling activities
mockups
market analysis
feasibility analysis
What will I experience?
detailed development

making it really work

Modeling activities
detail design
detailed analysis
user testing
prototype fabrication
A set of modeling activities
rigor in breadth and depth

estimation to detailed analysis

sketching to solid modeling and CAE

soft, sketch models to alpha prototypes
the experience/process is gated by milestones

What are the milestones?

3-ideas presentation (September 26)

4 minutes for 6 ideas

defines team's focus area for the rest of the term!

elevator speech scenario
http://web.mit.edu/2.009/www/keyDates.html
What are the milestones?

**sketch model presentation (October 7)**

6 design concepts, quick and dirty
technical, market, and customer needs data

efficient exploration of concepts
What are the milestones?

mockup presentation (October 20)

4 product concepts per team
technical feasibility/operational principles

identify and resolve critical issues
Process check!
Oct. 20! the term is half over and we still have not made our final idea selection?

Why waste all this time exploring ideas? Just tell us what the design problem is and we will do the detailed engineering.

One of the 3 Cs

The C that is also being outsourced!
see the “creativity crisis” link on the course home page

Creative thinking is key to technical innovation

A series of exploration, experiments and learning that develops the insight to know what to do
What are the milestones?

**technical review (November 17)**

demonstrate functional alpha prototype
discuss remaining areas for improvement

detailed engineering assessment
What are the milestones?

**final public presentation (December 12)**

presentation to a wide audience: classmates, academics, and industry

a complete package: presentation quality, product design, business case

product launch
What are the milestones?

schedule and details

**Key Dates**

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project idea fair</td>
<td>Monday, September 12</td>
<td>7-8 PM</td>
</tr>
<tr>
<td>3 ideas presentation</td>
<td>Monday, September 26</td>
<td>during class</td>
</tr>
<tr>
<td>Sketch model review</td>
<td>Thursday, October 6</td>
<td>7-10 PM</td>
</tr>
<tr>
<td>Mockup review</td>
<td>Thursday, October 20</td>
<td>7-10 PM</td>
</tr>
<tr>
<td>Selection of final product idea</td>
<td>Week of October 24</td>
<td>during team lab</td>
</tr>
<tr>
<td>Assembly review</td>
<td>Wed. Nov. 2 and, Fri. Nov. 4</td>
<td>during class</td>
</tr>
<tr>
<td>Technical review</td>
<td>Thursday, November 17</td>
<td>7-10 PM</td>
</tr>
<tr>
<td>Final design review</td>
<td>Monday, November 21</td>
<td>1-5 PM</td>
</tr>
<tr>
<td>Thanksgiving</td>
<td>Thursday, November 24</td>
<td>all day long!</td>
</tr>
<tr>
<td>Final presentation practice session</td>
<td>Friday, December 9</td>
<td>5-9 PM</td>
</tr>
<tr>
<td>Final presentation</td>
<td>Monday, December 12</td>
<td>7:00-10:30 PM</td>
</tr>
<tr>
<td>Instructor grades meeting</td>
<td>Tuesday, December 20</td>
<td>noon</td>
</tr>
</tbody>
</table>
What are the milestones?
the point: feedback to improve the design!

all course staff review each team
results discussed in class
## What are the milestones?

**grading**

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>% Course Grade</th>
<th>Assigned To ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brainstorming</td>
<td>5</td>
<td>Individual</td>
</tr>
<tr>
<td>Design notebook</td>
<td>10</td>
<td>Individual</td>
</tr>
<tr>
<td>Peer review</td>
<td>10</td>
<td>Individual</td>
</tr>
<tr>
<td>Instructor leverage</td>
<td>5</td>
<td>Individual</td>
</tr>
<tr>
<td>3-Ideas review</td>
<td>5</td>
<td>Section</td>
</tr>
<tr>
<td>Sketch model review</td>
<td>15</td>
<td>Section</td>
</tr>
<tr>
<td>Mockup review</td>
<td>15</td>
<td>Section</td>
</tr>
<tr>
<td>Assembly model</td>
<td>5</td>
<td>Team</td>
</tr>
<tr>
<td>Technical review</td>
<td>20</td>
<td>Team</td>
</tr>
<tr>
<td>Final presentation</td>
<td>10</td>
<td>Team</td>
</tr>
</tbody>
</table>
Where do I find course information?

http://web.mit.edu/2.009  not a stellar site!

Welcome to 2.009! Fall 2016
What's up? This week in 2.009
See the key dates for 2016

This home page is updated daily, so you can follow it to easily keep on top of what is coming up and what needs to be done when. We don't use stellar.

by 5 PM Saturday! Signup with your lab time preferences — absolutely required by all students in the class as we do not use the registrar's lab sections. Lab assignments will be posted on the website no later than 8 PM Sunday. Labs start next week!

Of interest: (archive)
- sketching tutorial: 5 PM this Friday to help with project brainstorming
- 2015 build challenge: once upon and idea
- secret of success: grit
- creativity crisis
- fast food restaurant ice!

For class Friday
- obtain your design notebook
- read chapters 1&2 in the course textbook. If you don't have the text, you can download chapters 1&2 (certs and class registration required)

The course text is Product design and development by Ulrich and Eppinger
**Where do I find course information?**

**schedule and details**

**Class and Lab Schedule (Syllabus)**

<table>
<thead>
<tr>
<th>Date</th>
<th>Class</th>
<th>Lab</th>
<th>Assigned</th>
<th>Due, or on this day</th>
<th>Due in your lab</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wed. Sept. 7</strong></td>
<td>2.009 Introduction (.pdf)</td>
<td>No lab this week</td>
<td>Lab section signup (absolutely required: registrar section assignments are not used!)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Failed prototype test (.mpeg)</td>
<td></td>
<td>Design notebook</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Reading: Read chapters 1 and 2 in textbook (Introduction and development processes)</td>
<td></td>
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</tr>
<tr>
<td><strong>Fri. Sept. 9</strong></td>
<td>Creativity and product development challenge (.pdf)</td>
<td>Brainstorming</td>
<td>Special tutorial on idea sketching by product designer Roger Zhu. All students welcome. Sketching materials will be provided. 5-6 PM, room 3-370. This tutorial will be quite useful for the brainstorming assignment and sketching materials will be provided for participants!</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Creativity strategies cheat-sheet (.pdf)</td>
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<td>Group brainstorming tutorial (.pdf)</td>
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<td>Theme reveal video</td>
<td>Brainstorming</td>
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</tr>
<tr>
<td><strong>Sat. Sept. 10</strong></td>
<td>Lab section signup (due at 5 PM)</td>
<td>Idea fair</td>
<td>Idea fair</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.009 Product engineering processes
preparation for this Friday

lab section registration:
You MUST register online for a lab section before Saturday at 5 PM—see the 2.009 home page
Please help each other not miss this deadline

review: course goals and syllabus

read chapters 1 and 2 in text

buy a design notebook
Friday
the project theme