INTRODUCTION
Today in 2.000

- Scheduling
- About 2.000
- Evaluation
- Mechanical Engineering
- Understanding Systems
- Sketching
- Homework #1
- Meeting

HANDS ON PROJECTS

VISUAL COMMUNICATION

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Scheduling issues

On the scheduling mixup....

What they had to say: "Amusing"
2.000 Goals

Provide an introduction to Mechanical Engineering
- Careers
- MIT Curriculum

Teach the “Engineering way of thinking”
- Determine important parts of a problem
- Modeling and estimation

Develop Engineering knowledge
- Common elements and systems
- How machines are made and work

Develop Mechanical Engineering skills
- Communication and project management
- Analytic and geometric modeling
- Engineering design process

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I am…. I am not...

What 2.000 is:
- Thinking class
- Course for those who believe in academic citizenship (reciprocation)
- EASY, if you come to class and stay on schedule
- DIFFICULT, if you are lame and not responsible
- FUN

What 2.000 is not:
- High school class on steroids
- Tinkering class (Ooohh lets take things apart 100% of the time)
- Cruise class
- Weed out class
2.000 Policies

2.000 is a VERY FUN course to take, very hard course to teach

○ We must/will run a tight ship to ensure the fun continues....

Grading

○ Tests 30 %
○ Labs 20 %
○ Homework 10 %
○ Projects 25 %
○ Participation 5 %
○ Academic citizenship 10 %

Advanced permission required for:

○ Absence from lab, field trip, guest speaker
○ Late homework submission
○ “Make-ups” not guaranteed, held at instructor convenience

Assignments

○ Verify home dissections (you are responsible for bringing equipment)

Collaboration

○ All submissions must be your own work
○ Team efforts require individual submissions of individual work

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### Grades cont.

<table>
<thead>
<tr>
<th>GRADE</th>
<th>UPPER</th>
<th>LOWER</th>
</tr>
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<tbody>
<tr>
<td>A+</td>
<td>100.00</td>
<td>96.67</td>
</tr>
<tr>
<td>A</td>
<td>96.67</td>
<td>93.33</td>
</tr>
<tr>
<td>A-</td>
<td>93.33</td>
<td>90.00</td>
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<tr>
<td>B+</td>
<td>90.00</td>
<td>86.67</td>
</tr>
<tr>
<td>B</td>
<td>86.67</td>
<td>83.34</td>
</tr>
<tr>
<td>B-</td>
<td>83.34</td>
<td>80.00</td>
</tr>
<tr>
<td>C+</td>
<td>80.00</td>
<td>76.67</td>
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<tr>
<td>C</td>
<td>76.67</td>
<td>73.34</td>
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<tr>
<td>C-</td>
<td>73.34</td>
<td>70.00</td>
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<tr>
<td>D+</td>
<td>70.00</td>
<td>66.67</td>
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<td>D</td>
<td>66.67</td>
<td>63.34</td>
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<tr>
<td>D-</td>
<td>63.34</td>
<td>60.00</td>
</tr>
<tr>
<td>F</td>
<td>60.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

#### 2001 Final Grades for 2.000

![Bar Chart]

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2.000 Resources

2.000 Bio-Unit resources

- Prof. Culpepper
- Prof. Smith
- Patrick Petri
- Guillermo Urquiza
- Nicholas Conway

2.000 Web page

- EVERYTHING runs off the web page!!!!!
  psdam.mit.edu/2.000/start.html

Mechanical Engineering computer labs (Building 3-462 and 35-125)

- CAD
- Microsoft™
- Graphics
- Scanner
- Laser printer

Kits

- Tool kits: 1 each student may be kept if class not dropped
- Lego Design kits: 1 each student must be returned

Electronics

- Digital cameras: 12 for group projects
- Laptop computers: 5 for class use

You need to obtain a 100 MB Zip Disk (before first CAD lecture)
What you will be doing this term

Lecture
- Analytic skills
- Hands-on experiments

Lab
- Hands-on skill and Computer and career skills development
- Held in 3-370 & 3-446 (messy ones)
- Reassembly is part of grade (No mystery pieces)
- Write ups
  - Guide you through critical parts of disassembly
  - Write-ups: 85% finish in Lab!

Projects
- I: Pump (group)
- II: Lego (group)

Homework
- Individual exploration/disassembly

Test
- Test I: Analytic & CAD
- Test II: Hands-on

Tours and guest speakers

Tutorials available for
- Project Management
- Microsoft Excel
- Technical Writing
- Microsoft Power Point
- HTML
- FTP
- CAD
- Graphics
- DXF Files

PROJECT I  TOUR: MIT MEMS LAB

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2.000 Setting the pace

Sources of variability
8.01  Physics I
8.012 Physics I
8.01L Physics I
8.01X Physics I
8.02  Physics II
8.022 Physics II
8.02T Physics II
8.02X Physics II

In past years, student capabilities have varied widely

When one teaches to the average:

\[ \frac{1}{3} = \text{lost} \quad \frac{1}{3} = \text{OK} \quad \frac{1}{3} = \text{bored} \]

Semester pace

- We will pace to allow lower \( \frac{1}{3} \) to “catch up” in first 3 weeks
- Pace will increase by \( \sim 50\% \) until end of 5 weeks to “catch up” lower \( \frac{2}{3} \)
- Pace reach nominal in early March
Project I – Pump (Group project)

Study

Plan/manage project

\[ D = \pi \times (R_o^2 - R_i^2) \]

Plan

Design

Model

Make

Build

Test

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Project II: Working joystick

- touch sensor
- crown gear
- FB rotation sensor
- differential LR rotation sensor
- 185 mm full height
- 87 mm
- 90 mm

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Project II: X-Y Plotter (3 axis machine)
Integrating Virtual Take Apart (VTA)

screwanim.avi

Notes, instructions, video

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Geometry manipulation tools
EVALUATION
Pre-2.000 Assessment

Part of your academic citizenship will include assessment exercises:

- Last year automotive and Ford grant
- This year, beginning of class book

✓ We need to assess your incoming state of knowledge/skill

Sketches for problem 2

Top

Left

Front

Right

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What is Mechanical Engineering?

Mechanical Engineering (ME):

- Develop/support mechanical solutions using basic, applied, & experimental means.
- Also develop solutions that are of a mechanical nature:
  - Robotics
  - Automotive
  - Biomedical
  - Aerospace
  - Software
  - Electronics
  - Environmental
  - MEMs
  - Structural
  - Info. Technology

Core MIT ME Divisions

- Mechanics and Materials 2.001, 2.002
- Systems, Controls, Information 2.003, 2.004
- Fluids and Energy 2.005, 2.006
- Design and Manufacturing 2.007, 2.008
- Bio-Engineering 2.791, 2.792, 2.797
Mechanical Engineering: Career choices

MEs are have a broad knowledge/skill

MEs are flexible human resources, flexible = valuable

Motivating factors:

- Portability and flexibility of capabilities
  - Knowledge/skill makes you marketable in many areas
- Job Security
  - Mechanical problems will always exist
- Management
  - Lead multi-disciplinary teams
- Medical/Bio-Engineering
  - The body is a machine.....
- Consulting
  - Handle multi-disciplinary projects
- Academia
  - Teaching & research in: ME, CE, EE, AE
- Entrepreneurs
  - Broad knowledge base = more options, more applications for creativity
## “Famous” Mechanical Engineers

<table>
<thead>
<tr>
<th>Name</th>
<th>Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charles Vest</td>
<td>President of MIT</td>
</tr>
<tr>
<td>Alex d'Arbeloff</td>
<td>Chairman of MIT Corporation</td>
</tr>
<tr>
<td>Soichiro Honda</td>
<td>Founded the Honda Motor Company</td>
</tr>
<tr>
<td>Wright Brothers</td>
<td>First practical airplane</td>
</tr>
<tr>
<td>Leonardo da Vinci</td>
<td>Tank, Helicopter, Sculpture, Art</td>
</tr>
<tr>
<td>Thomas Edison</td>
<td>1\textsuperscript{st} practical light bulb + 1,093 patents</td>
</tr>
<tr>
<td>Henry Ford</td>
<td>First affordable car</td>
</tr>
<tr>
<td>Herbert Hoover</td>
<td>31\textsuperscript{st} president of the United States</td>
</tr>
</tbody>
</table>
UHTW MODEL
Purpose:
- Purpose is to provide you with an organized starting point for investigating machine
- With experience, you will learn to identify what is important with a “crutch”

Benefits of systematic thinking:
- Remove experience barriers
- Reduce errors and missing important information
- Make you consider all important areas

Limitations of systematic thinking
- You become BORG / automaton!
- You may start to think “inside the box”
- Do not be afraid to add to the model (you should probably not detract at this stage)

The 2.000 System
- Five “F” words will help you recognize what is important
The 5 “F” words you should know

To understand an engineering system, you must know the following:

- **Function**: What is purpose and why is it needed?
  You should include who, what, when, and where.
- **Form**: What the device looks like and how it moves?
- **Physics**: What are the physics that characterize and limit performance?
- **Flows**: What flows, how does it flow, and where does it flow?
- **Fabrication**: How was the device made & how does this affect performance?

These may depend on different times/states of a machine

- **Example**: Airplane (high speed, low speed, on the ground)
- **Example**: Car (idle, high speed, in a crash)

**Learn these words, your grade will depend upon using this model**

- You may answer in sketches, words, equations and variables
- Consider your audience to be your peers
- Do what you think is necessary to explain this so that I KNOW that you understand
Automotive braking system: Function

Description of function should include the 4 Ws
- **Who**
- **What**
- **When**
- **Where** (when applicable)

**Good example:**
- Provide the means for a car’s driver to reduce the speed of an automobile. The braking system should work at all times, in all conditions.

**Bad examples:**
- Slow the car down
- Dissipate energy via friction in brakes
- Stop the car
  - Ignores
  - Specific to type of brake
  - What about slow down?
Automotive braking system: Form

Master Cylinder (MC)
- Back left
- Back right
- Front right

\[ \dot{m}_{MC} \]
\[ \dot{m}_{BL} \]
\[ \dot{m}_{BR} \]
\[ \dot{m}_{FR} \]

Tire
Caliper
Rotor
Rim

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### Automotive braking system: Flows

**Master Cylinder (MC)**

**Flows:**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>Brief description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>Fluid flows to calipers&lt;br&gt;See arrows for description</td>
</tr>
<tr>
<td>Energy</td>
<td>Master Cylinder does work on fluid&lt;br&gt;Fluid does work on caliper pistons</td>
</tr>
<tr>
<td>Momentum</td>
<td>Momentum transfer to fluid by MC&lt;br&gt;Momentum transfer from fluid to CP</td>
</tr>
<tr>
<td>Information</td>
<td>Master cylinder position transferred&lt;br&gt;Known from caliper piston position</td>
</tr>
</tbody>
</table>

Caliper piston (CP)
## Automotive braking system: Physics

<table>
<thead>
<tr>
<th>Type</th>
<th>Equation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>$\Sigma m_{in} = \Sigma m_{out} + \Sigma m_{stored}$</td>
<td>Fluid mass remains constant, fluid out of master cylinder = fluid into calipers</td>
</tr>
<tr>
<td>Energy</td>
<td>$W_{MC on fluid} = \int F_{MC} \cdot dx_{MC}$</td>
<td>Piston in master cylinder exerts force on fluid over some distance ($x_{MC}$), does work on fluid</td>
</tr>
<tr>
<td>Energy</td>
<td>$W_{fluid on CP} = \int F_{CP} \cdot dx_{CP}$</td>
<td>Fluid exerts pressure force on caliper piston over some distance ($x_{CP}$), does work on piston</td>
</tr>
<tr>
<td>Energy</td>
<td>$\Sigma E_{in} = \Sigma E_{out} + \Sigma E_{stored}$</td>
<td>Energy is conserved, assuming energy is dissipated in the system, work master cylinder does on fluid equals work on caliper pistons by fluid</td>
</tr>
<tr>
<td>Information</td>
<td>$x_{MC} = \text{constant} \times x_{CP}$</td>
<td>Information about the change in position of the master cylinder piston ($x_{MC}$) can be determined by measuring position of the caliper pistons ($x_{CP}$)</td>
</tr>
</tbody>
</table>
## Automotive braking system: Fabrication

<table>
<thead>
<tr>
<th>Component</th>
<th>Mfg. Process(es)</th>
<th>Clues</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pistons</td>
<td>Turned and ground</td>
<td>Turned – axi-symmetric part</td>
<td>Stainless</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ground – smooth finish, no turning marks</td>
<td>Steel</td>
</tr>
<tr>
<td>Caliper</td>
<td>Cast and machined</td>
<td>Cast – rough surface finish, rounded edges,</td>
<td>Cast iron</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Machined – Well defined surfaces with machining marks</td>
<td></td>
</tr>
<tr>
<td>Rotor</td>
<td>Formed/Cast &amp; turned</td>
<td>Formed/Cast – Moderately rough surface, large, heavy part</td>
<td>Steel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turned – Rotor surfaces are flat and show machining marks</td>
<td></td>
</tr>
<tr>
<td>Brake pad</td>
<td>Formed &amp; bonded to caliper</td>
<td>Formed – Irregular shape with smooth edges, on machining marks</td>
<td>Metal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bonded – Assembled to caliper with no signs of welding, fasteners, or snap fits</td>
<td></td>
</tr>
</tbody>
</table>
ASSIGNMENT

Syllabus

Camera: You should at least have this disassembled by next lecture

Reading: Project Management tutorial (see web page)