INTRODUCTION

2.000 How and Why Machines Work, Lecture # 1

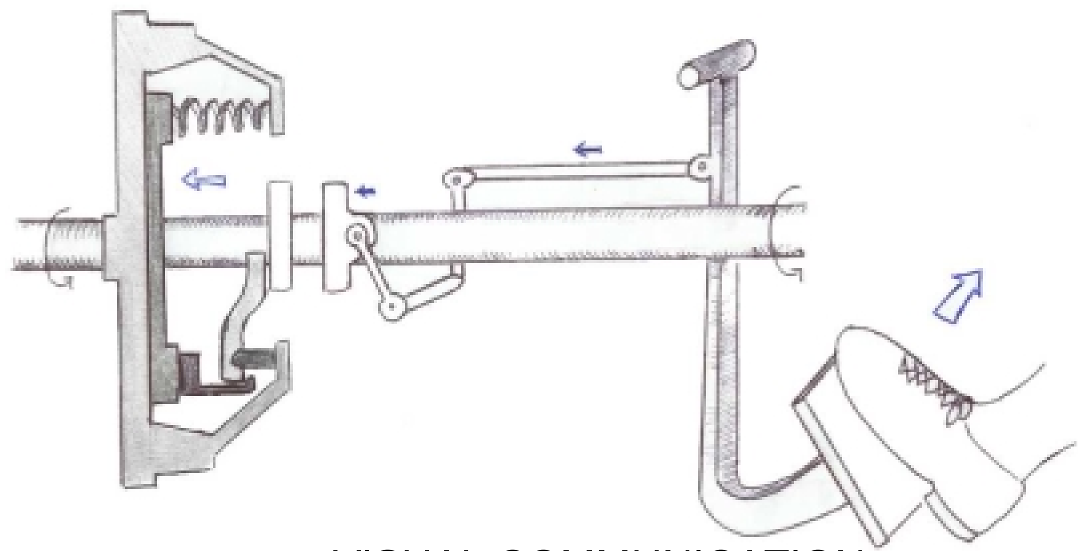
Today in 2.000

~Time

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

WWII JET ENGINES

HANDS ON PROJECTS



VISUAL COMMUNICATION

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

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

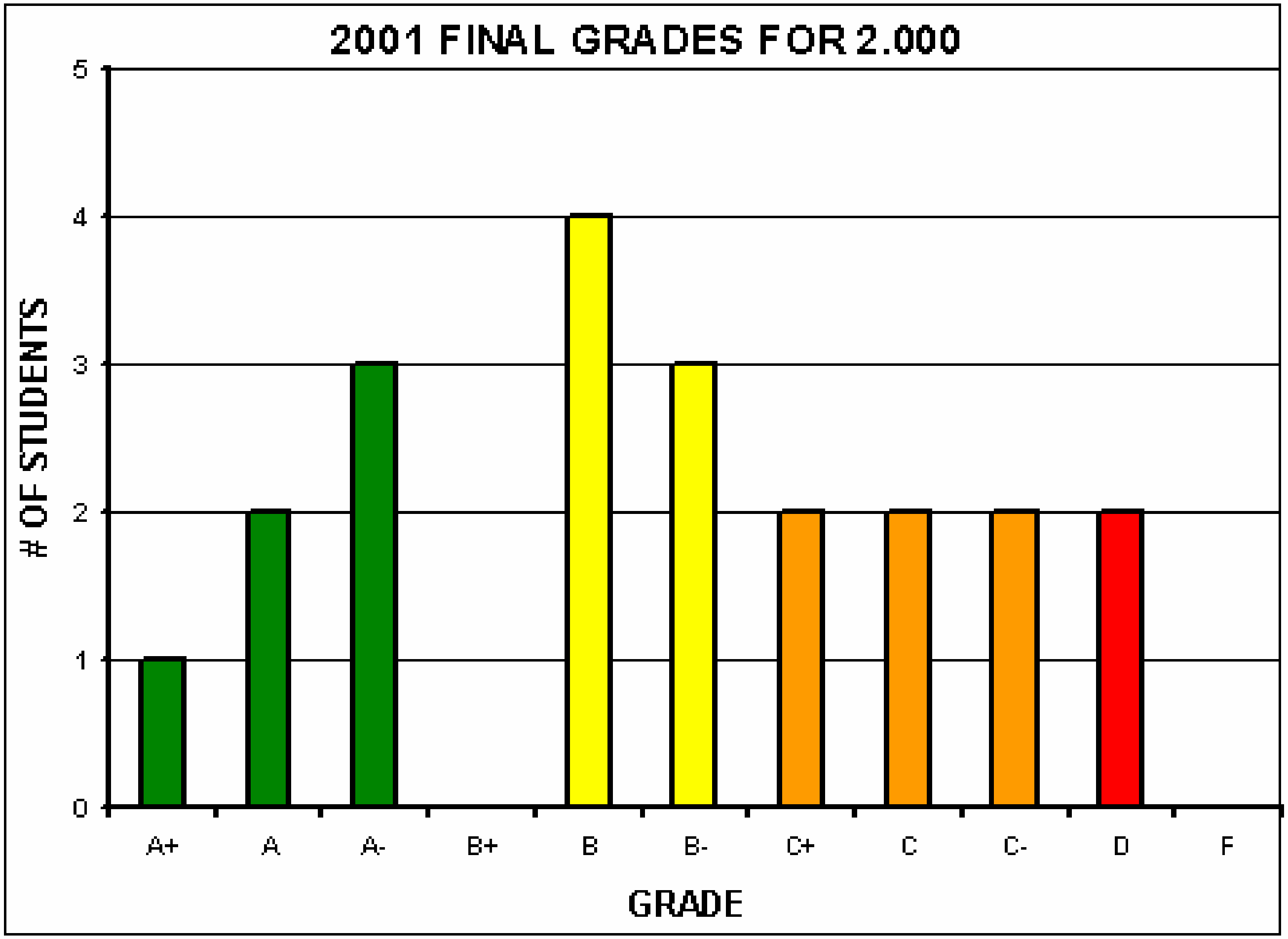
- Verify home dissections (you are responsible for bringing equipment)

Collaboration

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

Grades cont.

GRADE	UPPER	LOWER
A+	100.00	96.67
A	96.67	93.33
A-	93.33	90.00
B+	90.00	86.67
B	86.67	83.34
B-	83.34	80.00
C+	80.00	76.67
C	76.67	73.34
C-	73.34	70.00
D+	70.00	66.67
D	66.67	63.34
D-	63.34	60.00
F	60.00	0.00



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

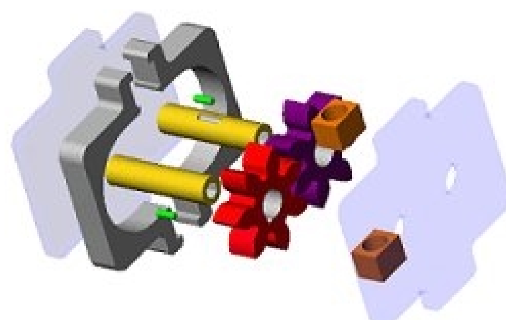
Test

- 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



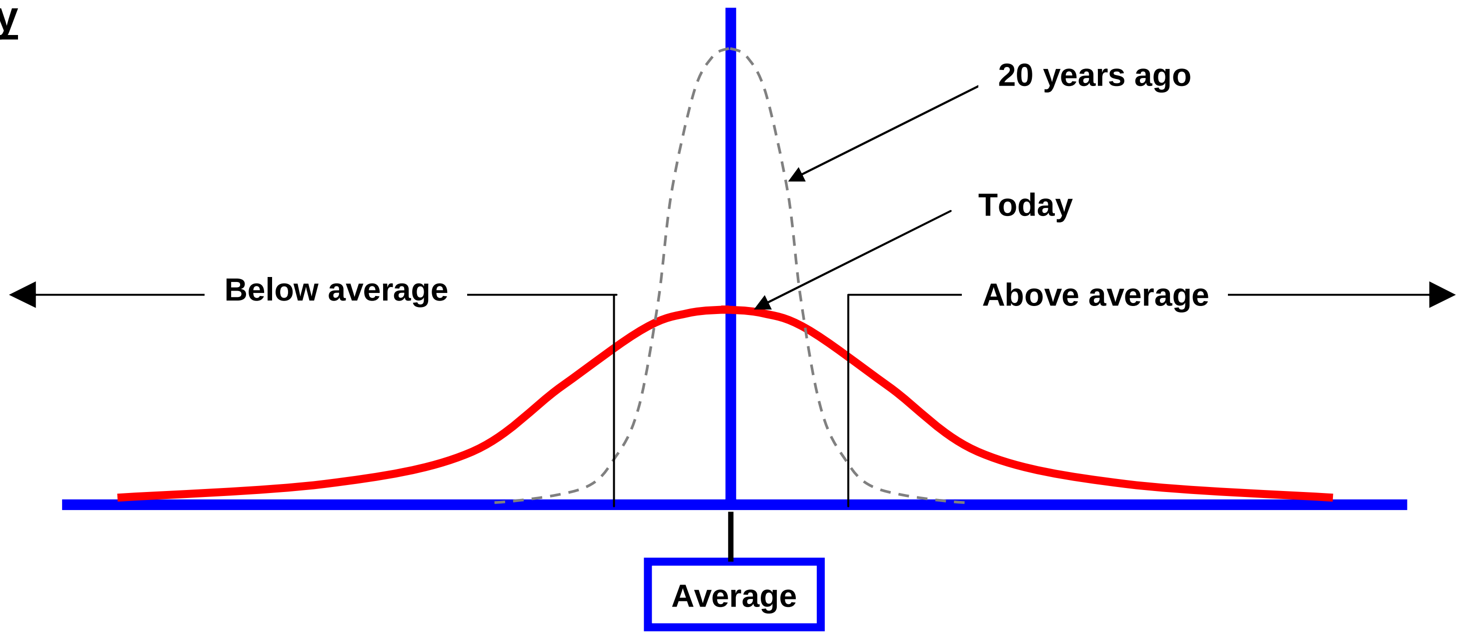
PROJECT I

TOUR: MIT MEMS LAB

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:

$^1/_3$ = lost **$^1/_3$ = OK** **$^1/_3$ = bored**

Semester pace

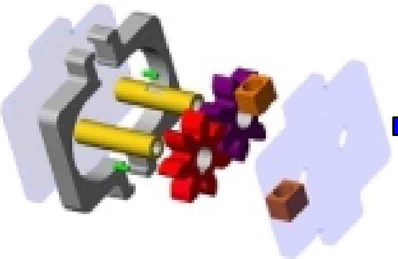
- **We will pace to allow lower $^1/_3$ to "catch up" in first 3 weeks**
- **Pace will increase by ~ 50% until end of 5 weeks to "catch up" lower $^2/_3$**
- **Pace reach nominal in early March**

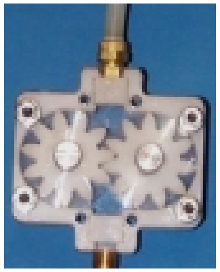
Project I – Pump (Group project)

Study

Plan/manage project

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





Design

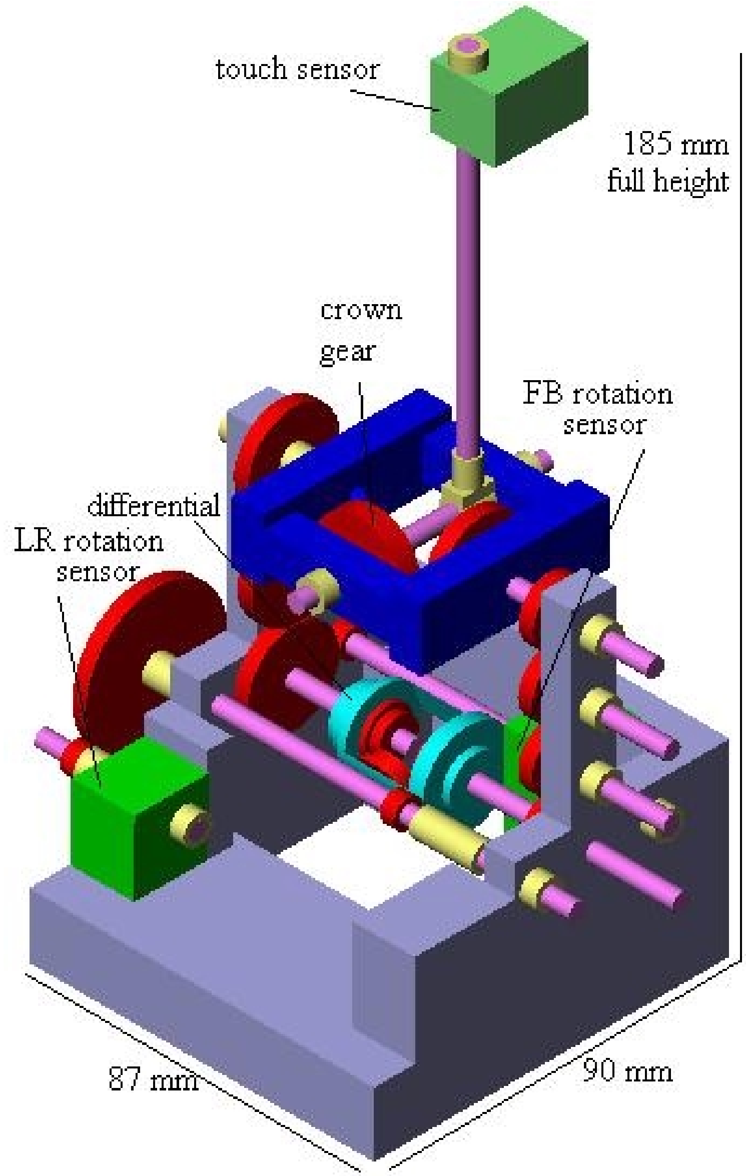
Model

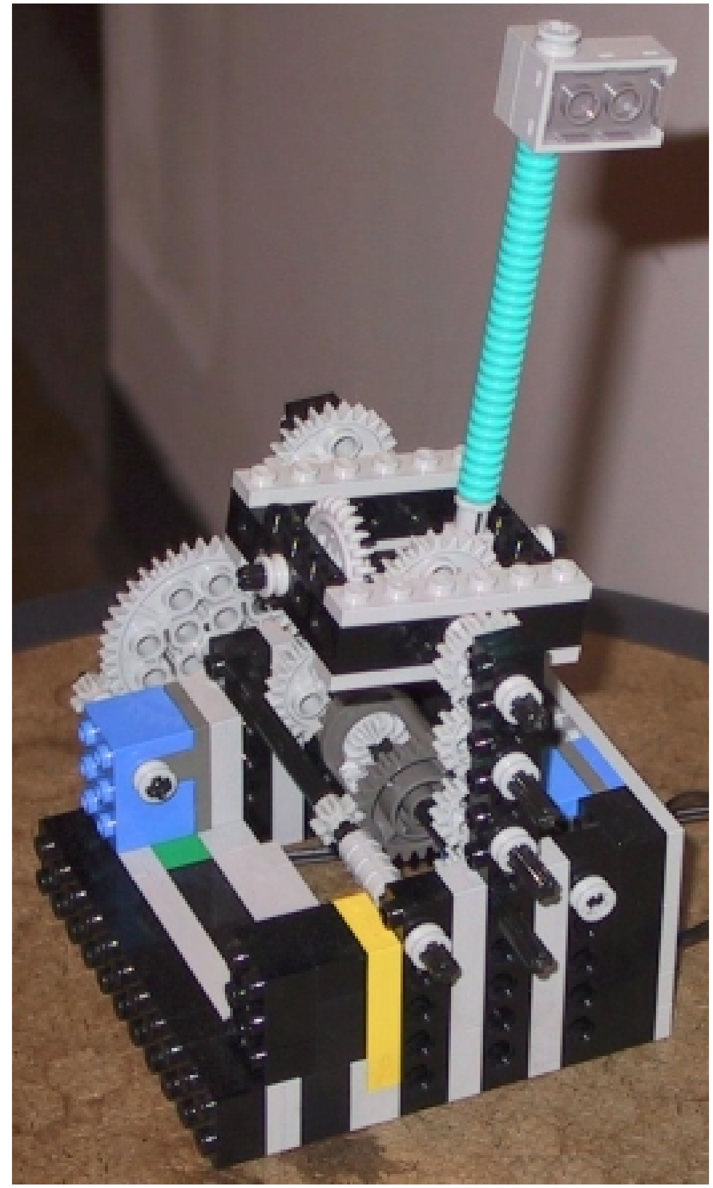
Make

Build

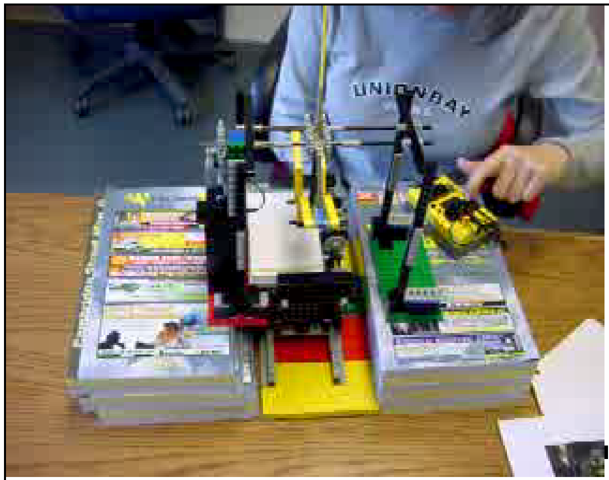
Test

Project II: Working joystick



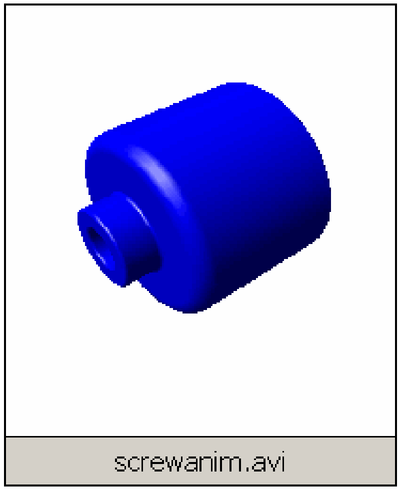


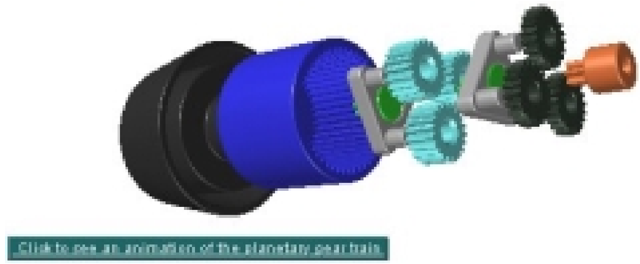
Project II: X-Y Plotter (3 axis machine)

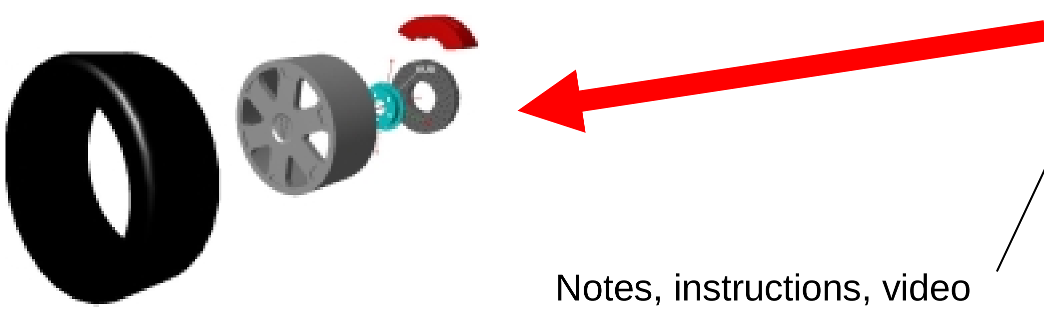


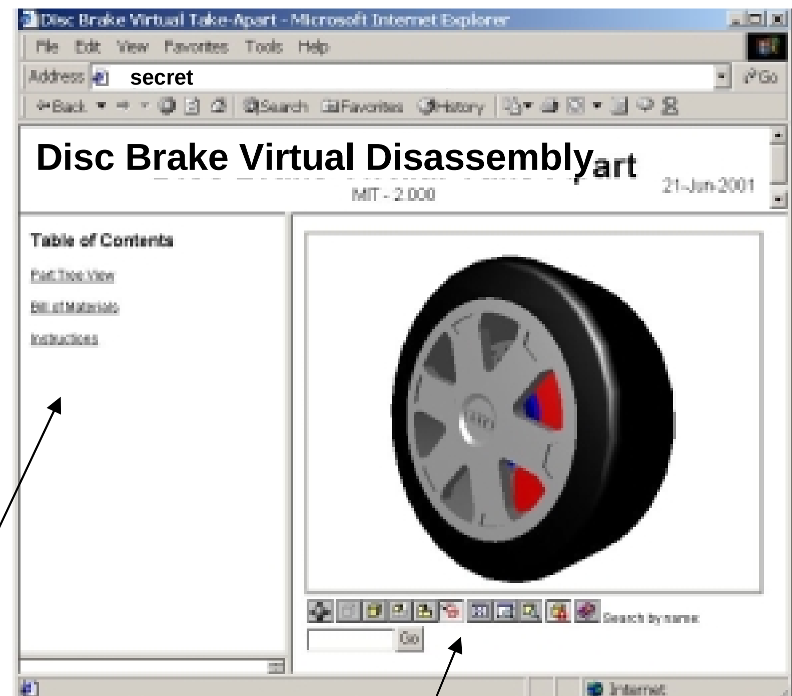
[x-y-z-plotter]-angela-chen.MPG

Integrating Virtual Take Apart (VTA)









Notes, instructions, video

Geometry manipulation tools

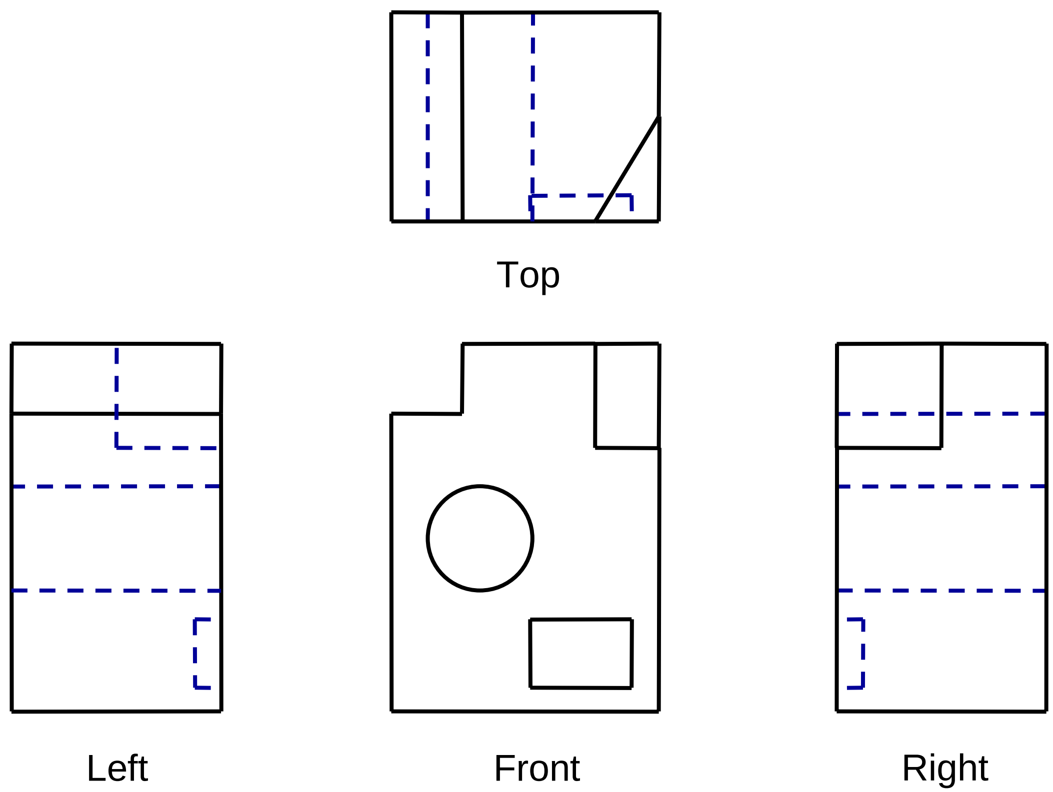
EVALUATION

Pre-2.000 Assessment

Part of your academic citizenship will include assessment excercises

- **Last year automotive and Ford grant**
- **This year, beginning of class book**
  - ✓ We need to asses your incoming state of knowledge/skill

Sketches for problem 2



ABOUT MECHANICAL ENGINEERING

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

Charles Vest	President of MIT
Alex d'Arbeloff	Chairman of MIT Corporation
Soichiro Honda	Founded the Honda Motor Company
Wright Brothers	First practical airplane
Leonardo da Vinci	Tank, Helicopter, Sculpture, Art
Thomas Edison	1st practical light bulb + 1,093 patents
Henry Ford	First affordable car
Herbert Hoover	31st president of the United States

UHTW MODEL

2.000 system of machine investigation

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)**

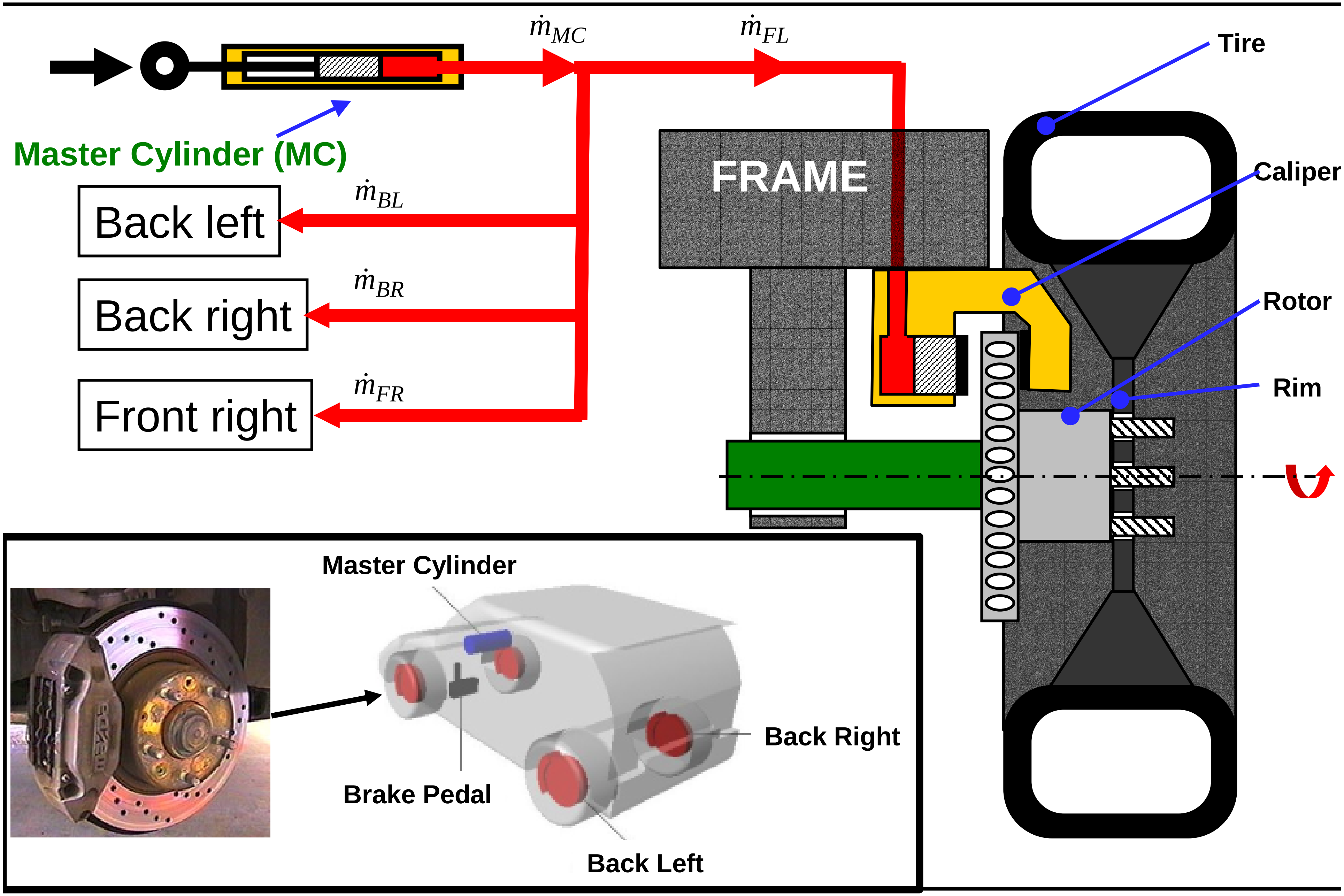
Good example:

- **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.**

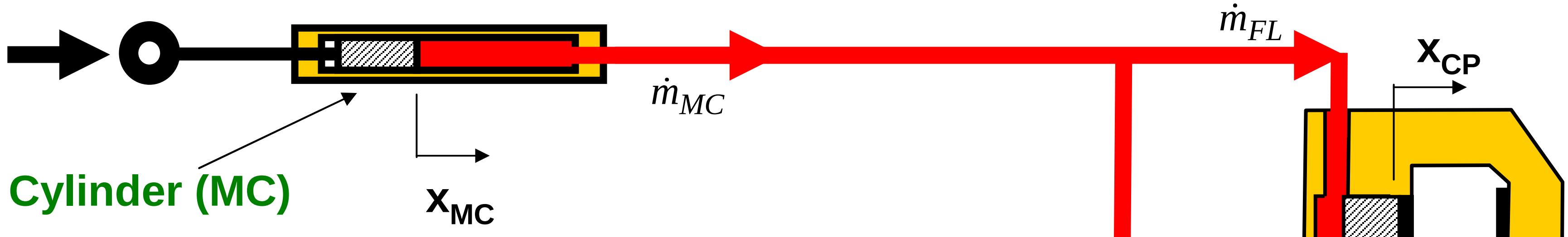
Bad examples:

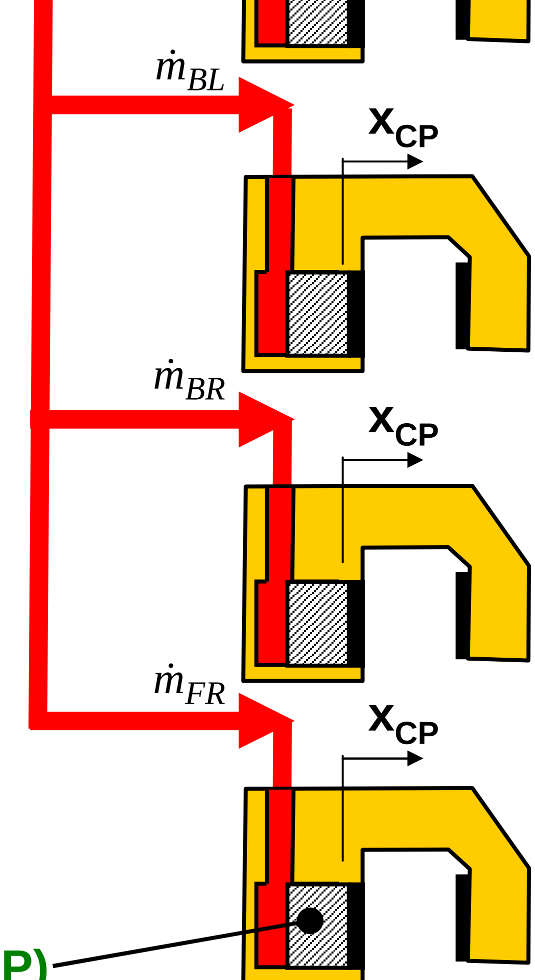
Slow the car down	Ignores
Dissipate energy via friction in brakes	Specific to type of brake
Stop the car	What about slow down?

Automotive braking system: Form



Automotive braking system: Flows





Flows:

TYPE	Brief description
⊙ Mass	Fluid flows to calipers See arrows for description
⊙ Energy	Master Cylinder does work on fluid Fluid does work on caliper pistons
⊙ Momentum	Momentum transfer to fluid by MC Momentum transfer from fluid to CP
⊙ Information	Master cylinder position transferred Known from caliper piston position

Automotive braking system: Physics

Type	Equation	Description
Mass	$\Sigma\dot{m}_{in} = \Sigma\dot{m}_{out} + \Sigma\dot{m}_{stored}$	Fluid mass remains constant, fluid out of master cylinder = fluid into calipers
Energy	$W_{MC\,on\,fluid} = \int F_{MC} \cdot dx_{MC}$	Piston in master cylinder exerts force on fluid over some distance (x_{MC}), does work on fluid
Energy	$W_{fluid\,on\,CP} = \int F_{CP} \cdot dx_{CP}$	Fluid exerts pressure force on caliper piston over some distance (x_{CP}), does work on piston
Energy	$\Sigma E_{in} = \Sigma E_{out} + \Sigma E_{stored}$	Energy is conserved, assuming energy is dissipated in the system, work master cylinder does on fluid equals work on caliper pistons by fluid
Information	$x_{MC} = \text{constant} \times x_{CP}$	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})

Automotive braking system: Fabrication

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

ASSIGNMENT

Syllabus

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

Reading: Project Management tutorial (see web page)