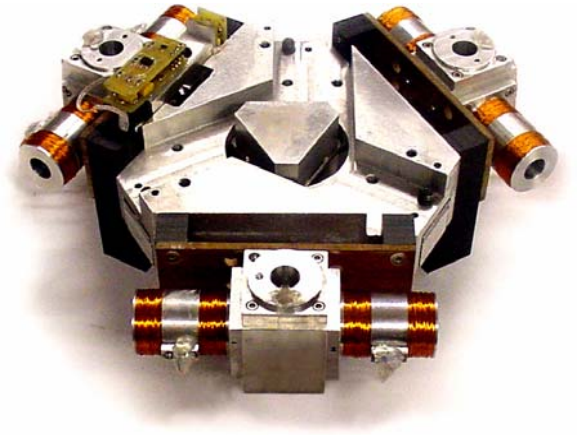
2.76 / 2.760 Lecture 1: Logistics & Intro

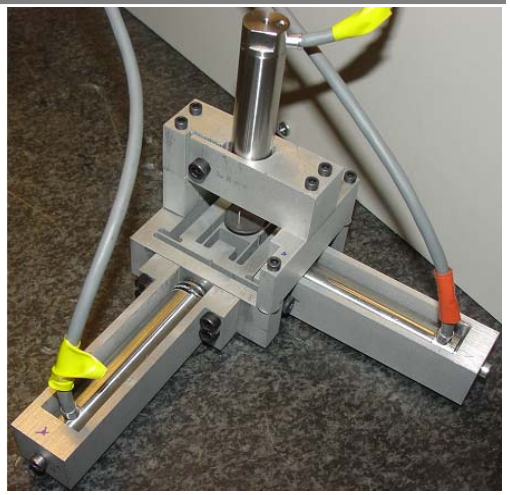
Tablet PCs

Goals

- ❑ Perception
- ❑ Design approach
- ❑ Manufacturing
- ❑ Integration



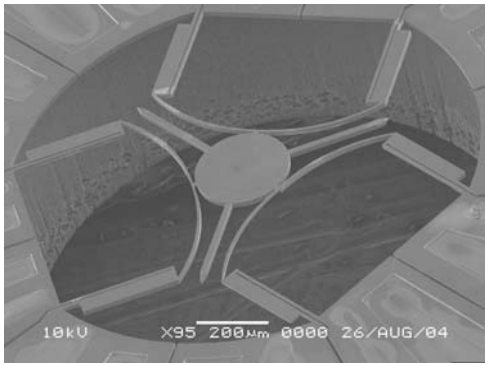
Macro-scale Hexflex Nanomanipulator



Student-built Scanning
Tunneling Microscope (STM)

Activities

- ❑ Topical overview
- ❑ Project overview
- ❑ Literature review



Micro-scale Hexflex Nanomanipulator

Thanks to:
NSF CAREER: Nanomanufacturing Program

Tools and resources

Tablet PCs

- SolidWorks Unigraphics ProE
- Matlab MathCad Excel 2003
- CoMeT CosmosWorks
- OMAX layout
- Word 2003 PPT 2003

To do:

- Wireless set up
- Sign agreement
- Expected to have your Tablets at each class

What is a multi-scale system?

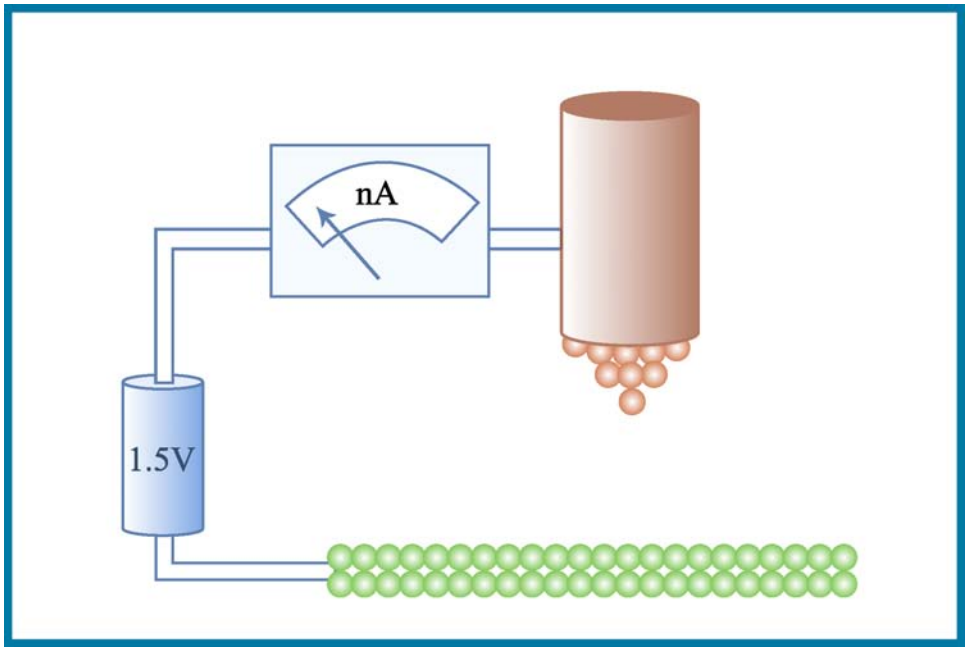
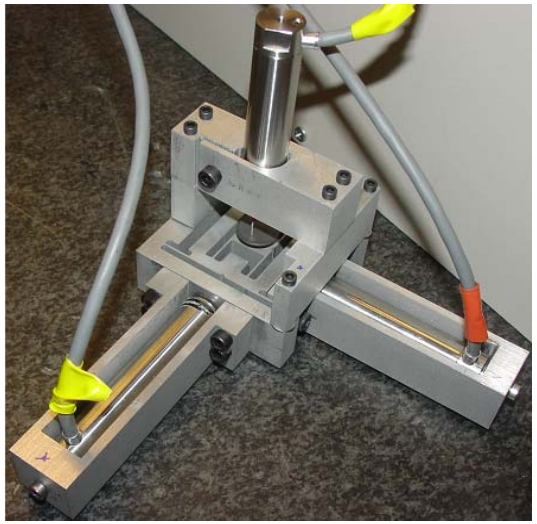


Figure by MIT OCW.



Systems are characterized by:

- Component functions
- Component interfaces
- Component arrangements (parallel, series, sub-systems)
- For MuSS, not well understood /covered in literature

Multi-scale systems

- Span size scales of several orders of magnitude (OOM)

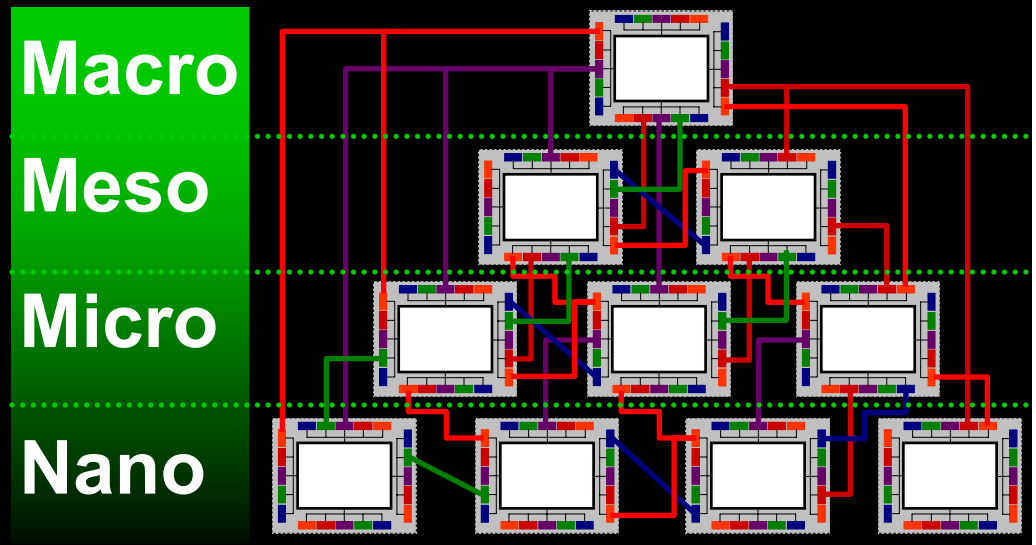
What can be coupled?

Is it as simple as saying connection pts?

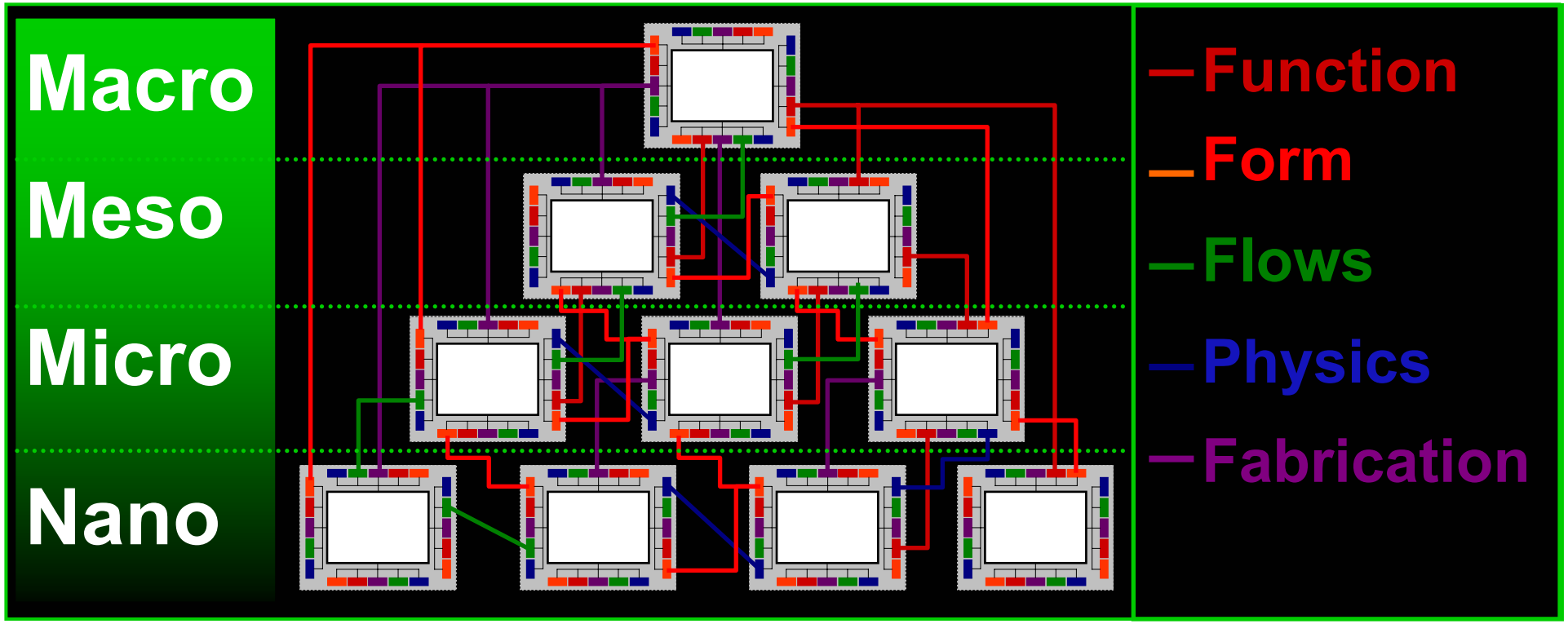
Connecting points important but not all

Cross-scale interactions

- Function
- Form
- Flows
- Physics
- Fabrication

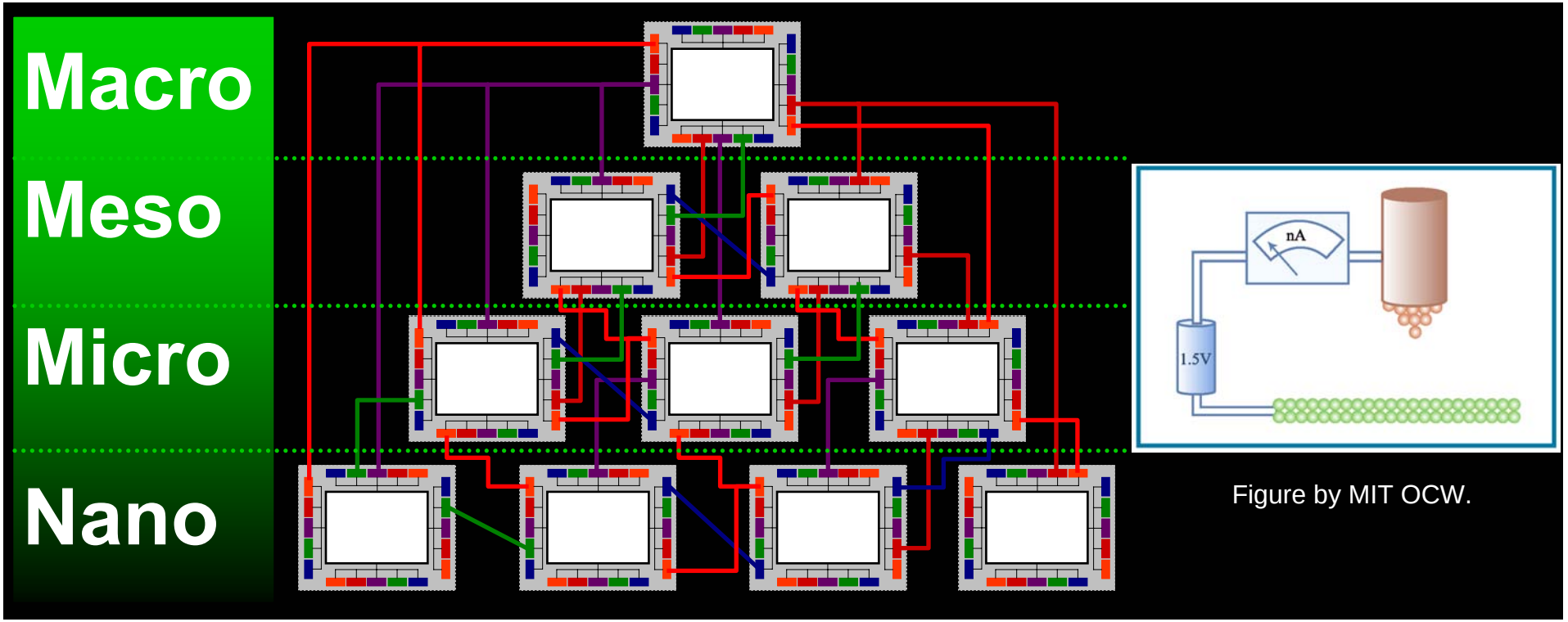


Cross-scale coupling



Function	Form	Flow	Physics	Fabrication
What	Geometry	Mass	Application	Compatibility
Who	Motion	Momentum	Modeling	Quality
Why	Interfaces	Energy	Limiting	Rate
Where	Constraints	Information	Dominant	Cost
Etc…	Etc…	Etc…	Etc…	Etc…

Cross-scale coupling



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Where	Constraints	Information	Dominant	Cost
Etc…	Etc…	Etc…	Etc…	Etc…

Why 2.76 / 2.760?

Components

- Machine elements
- Electronics
- Fabrication

http://www.stephensonmarine.i12.com/

Diagram of engine components removed for copyright reasons.

Integration

- No MS integration edu
- No MS mfg. edu

Range: .05 nm – 10cm
Ratio: 2 000 000 000

Range: .01 mm – 500mm
Ratio: 50 000

What are the consequences of this?

E.g. say errors which scale with size?

Thermal, vibration, gravity, electrical, sound, noise, etc…

Why now?

Graph removed for copyright reasons. Growth in global government investment in nanotechnology, 2001-2003 (source: nABACUS).

Isn't this "careful" design of each part & & using precision assembly (PA)?

Careful design with the wrong perspective leads to bad FRs and CSs?

PA often needed to cross scales, BUT goal is to eliminate need for PE!!!

We want to manufacture not fabricate

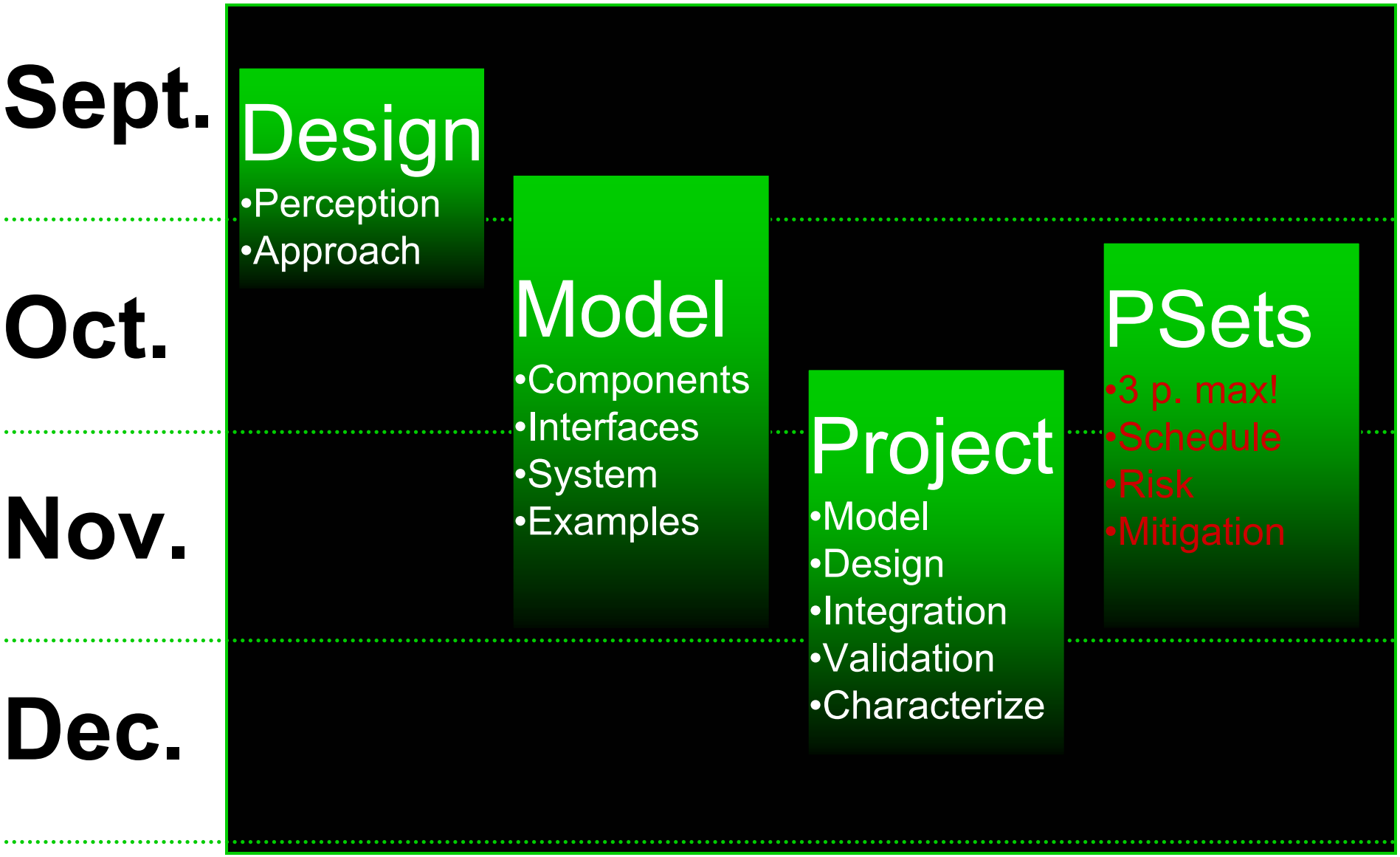
George Patton had his perspective right

"No “body” ever won a war by dying for his country. He won it by making the other poor dumb “guy” die for his country.“

Get everything you want with minimal effort while maintaining future productivity:

- Maximize use/re-use of complimentary parts
- Minimize conflicts / incompatibilities

Semester at a glance



Course goals

Inter and intra-scale perspective

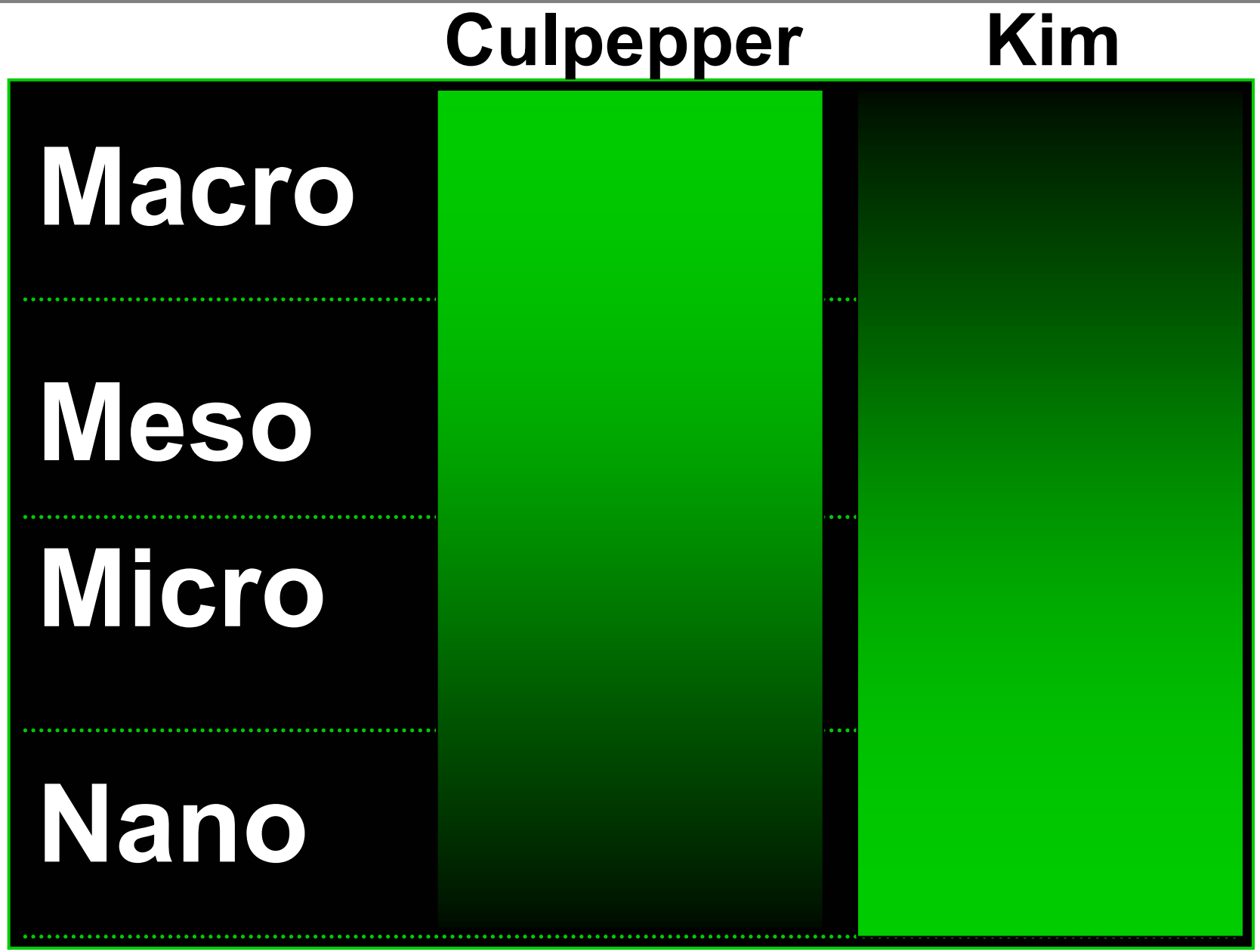
- MoSS modeling
- MuSS modeling
- Error modeling
- Cross-scale interfacing
- Application & examples

Our focus is on mechanical aspects

Fabricating MuSS

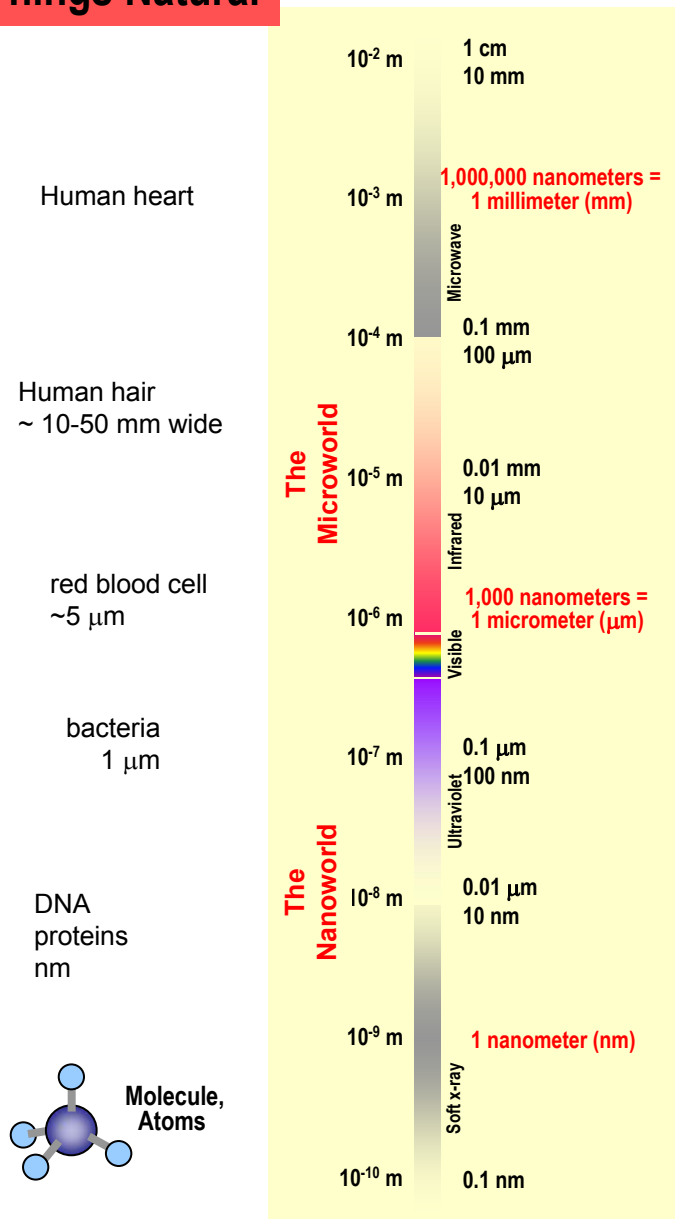
- MuSS DFM
- Process compatibility
- Characterization
- Calibration
- Integration

Our Research



Examples

Things Natural



RF Switch

Nanopipette

Biomedical Manipulators

Nano manipulation

Diagrams removed
for copyright reasons.

How can you engineer (not just model!) the small-scale with no experience?

Should we:

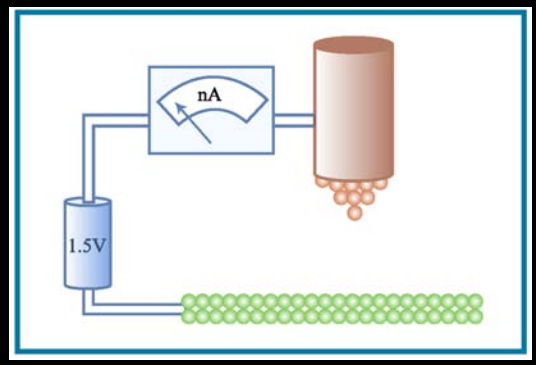
Applied math & modeling = "idea"

Or should we:

Do fundamentals

Learn to design small to large

Use the STM to learn about the small!!!



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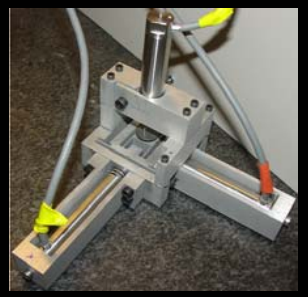


Examples: STM

Bias voltage (mV – few volts) applied between tip and sample

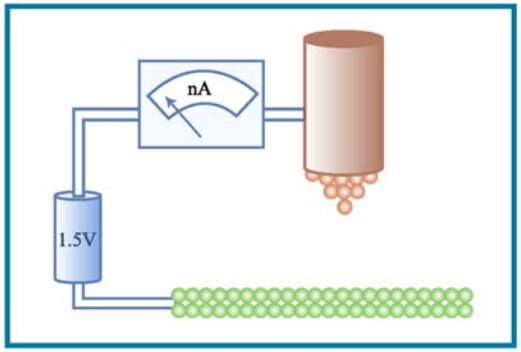


Figure by MIT OCW.

At ~10 Ångstroms current (nA) flows

Overlapping tip-sample atom wave functions

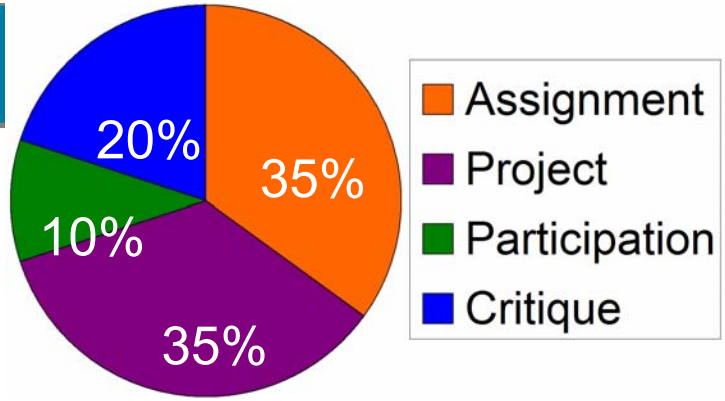
Electrons "tunnel" across the gap

$$i(gap) \sim e^{(-2\ K\ gap)}$$

Two images removed for copyright reasons.
Source: IBM Almaden Research Center
http://www.almaden.ibm.com

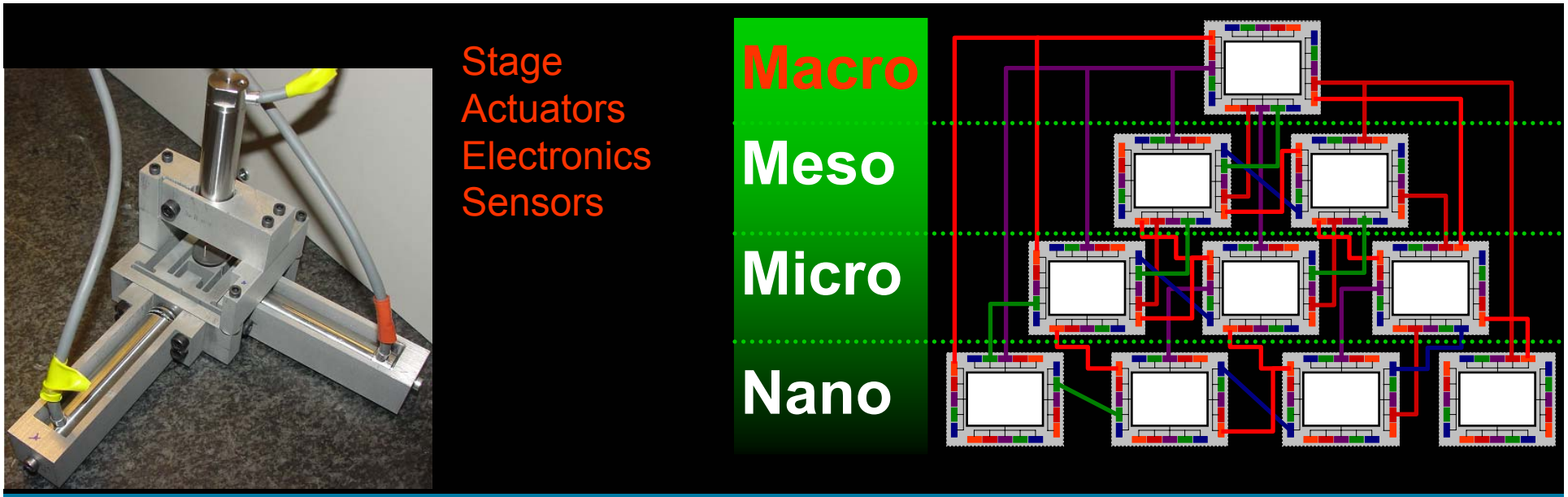
Examples: STM

i(gap) ~ $e^{(-2\ K\ gap)}$ drives coupled scale ratio



Why this project

- ❑ Learn how to model/apply lecture
- ❑ Investigate small-scale (get a feel for small-scale)
- ❑ Prepare you for research/experiment/industry



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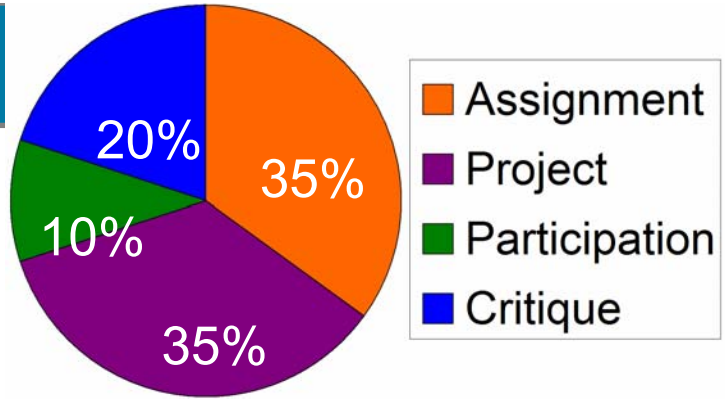

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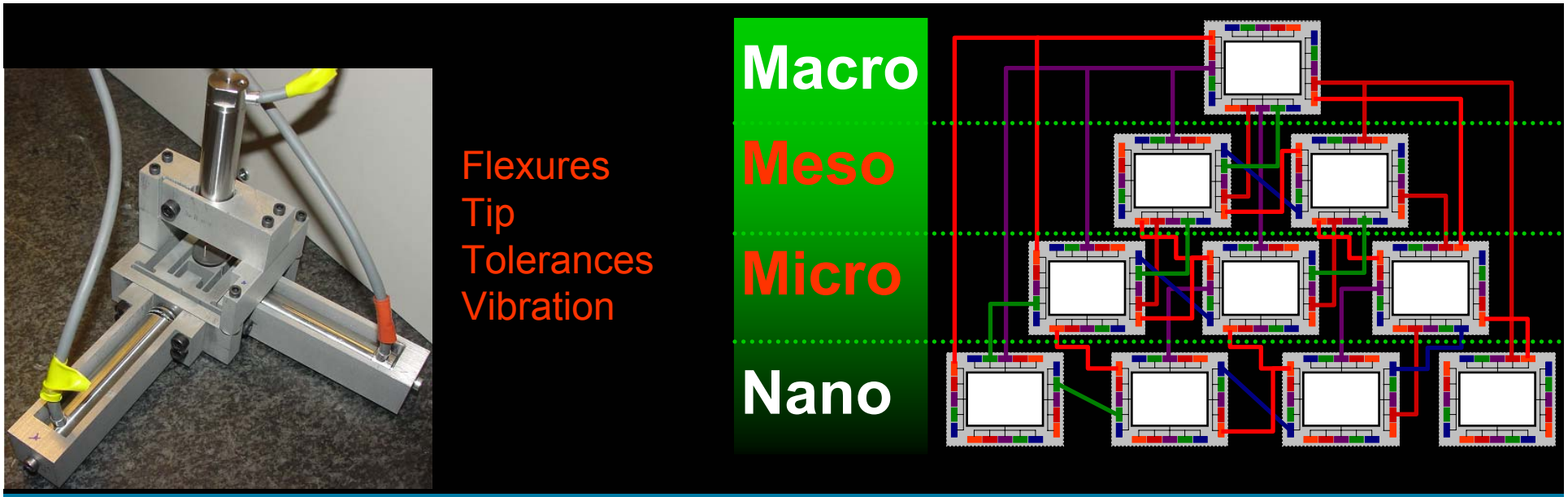

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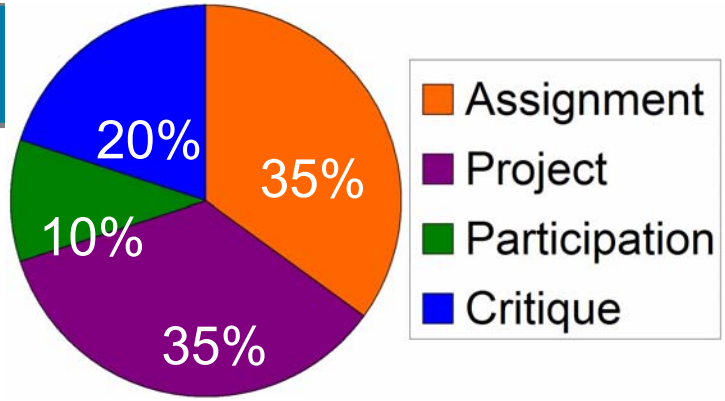

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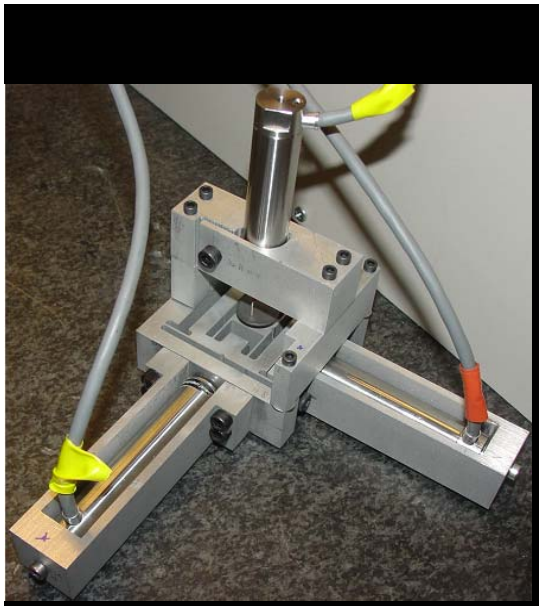
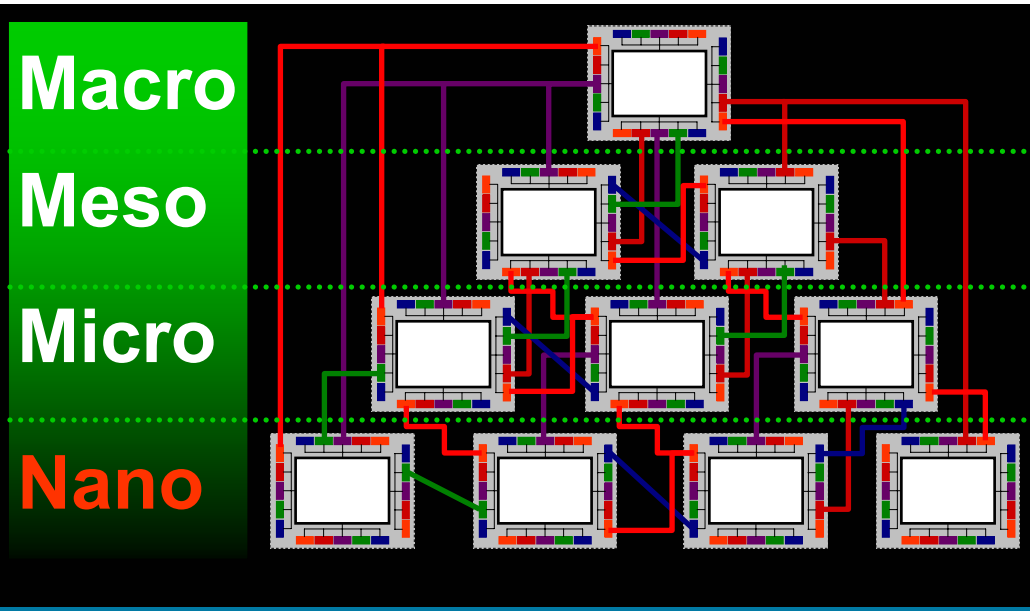


Sample
Motions
Gap
Features



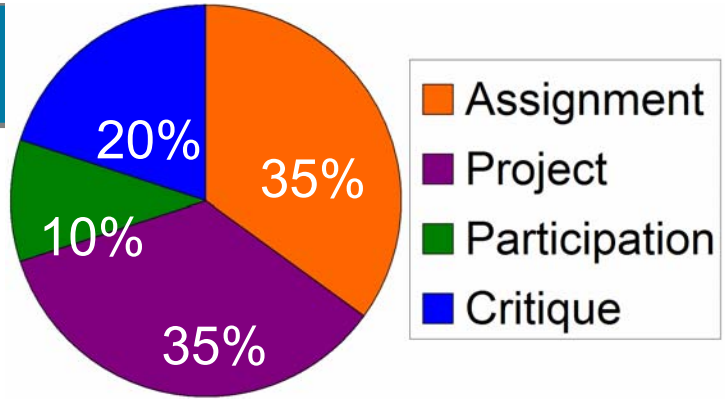
Examples: STM

Is this an overly ambitious project?

Yes, but…
our freshman engineering students do…

Photos removed for copyright reasons.

Problem sets



Two birds with one stone

- Ambitious project
- Problem set = project steps

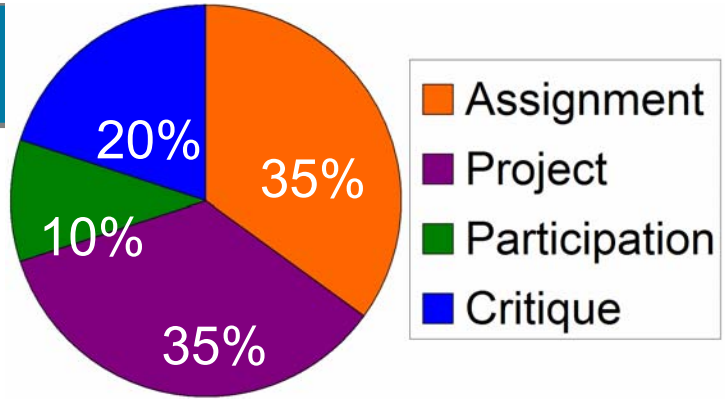
Quality:

- Typed, stapled, neat sketches
- 3 page maximum

On time, every time

- No late work for credit
- Must hand in all work to pass
- Submission

Literature critique



Logistics

- 3 papers per team, 2 papers per student
- 3 page critique per paper
- 10 minute presentation

Guidelines

- Scientific/scholarly merit
- Impact and importance
- Scientific and engineering approaches

Purpose

- Extend knowledge beyond pure mechanical
- Project suggestions
- Professional preparation

What is important for 2.76 / career?

Identifying & prioritizing importance

Nice vs. necessary & moving fast

Qualitative, but rational modeling

Quantitative modeling

Concise communication (3 pagers)

Assessment test

?

Assignment

E-mail resume to Course Secretary

Don’t forget tablet agreement form!!

Reading: Design & Complexity