

Pedagogy meets Technology: Optimizing Labs in Large Enrollment Intro Courses



Thank You !

- American Physical Society 
- The PER Community 
- National Science Foundation 
- Research Corporation for Science Advancement 
- University of Illinois 
- Macmillan Publishing 
- Most of all Great Colleagues

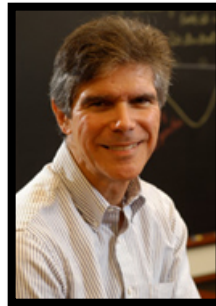
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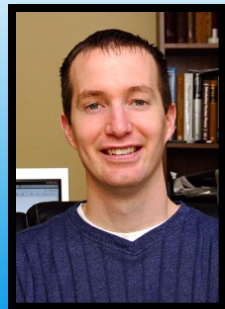


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Affiliates:



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Michael
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Michel
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Vincent
Boucher



Geoffroy
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UIUC Intro Physics Recap:

Infrastructure + Motivation = Improvement

Current Configuration:

Lecture: (50 min) Prelectures, JiTT & Peer Instruction (good)

Discussion: Peer instruction, trained & mentored TA's (good)

Homework: smartPhysics (standard + IE's + mastery) (good)

Exams: Multiple Choice (procedurally good – students struggle)

Labs: Group work (traditional) (not as good – wrong slope)

We are exploring a new approach...

Interactive Online Labs

Hands-on activities delivered & graded online.



The Big Idea:

Each student has their own wireless device (buy cheap).

They are guided through each activity by interactive software.

Timing of activities driven by pedagogy, not space/budget.

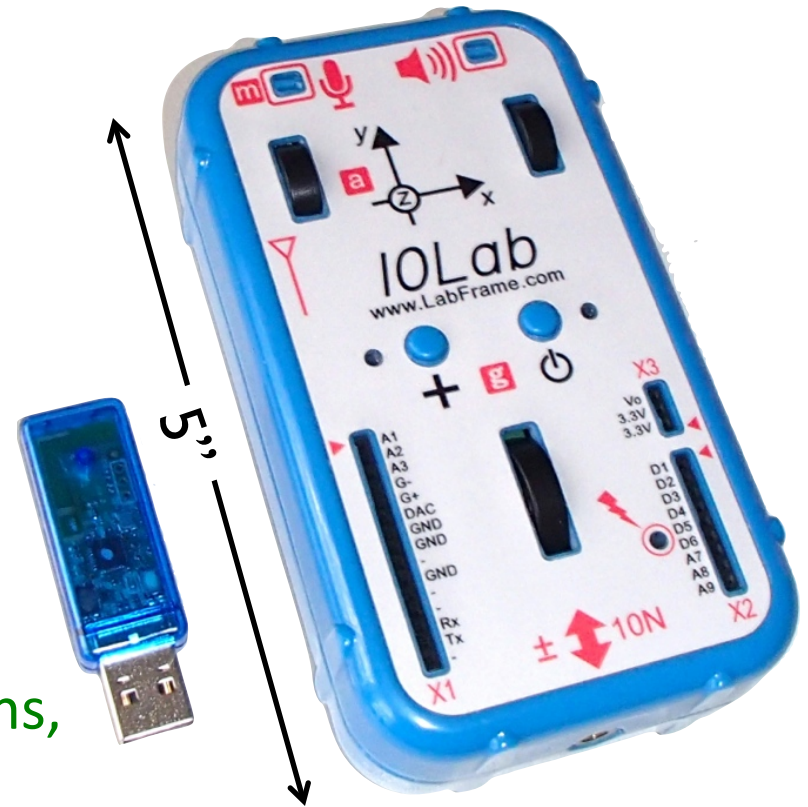


Not just a simulation...

Wireless DAQ hardware

Basics

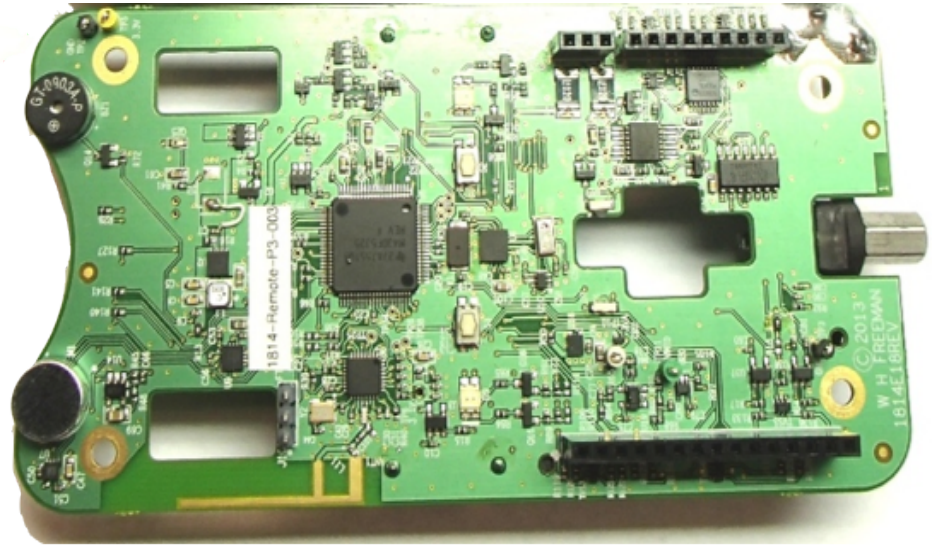
- 2.4 GHz wireless communication with USB dongle (virtual com port).
- Acquires data & sends to PC for display in real time.
- Controlled by PC application which can also display lesson, ask questions, keep score, (think smartPhysics)
- Designed to be opened up, messed with, reprogrammed, (think Arduino)



Inside

Demo

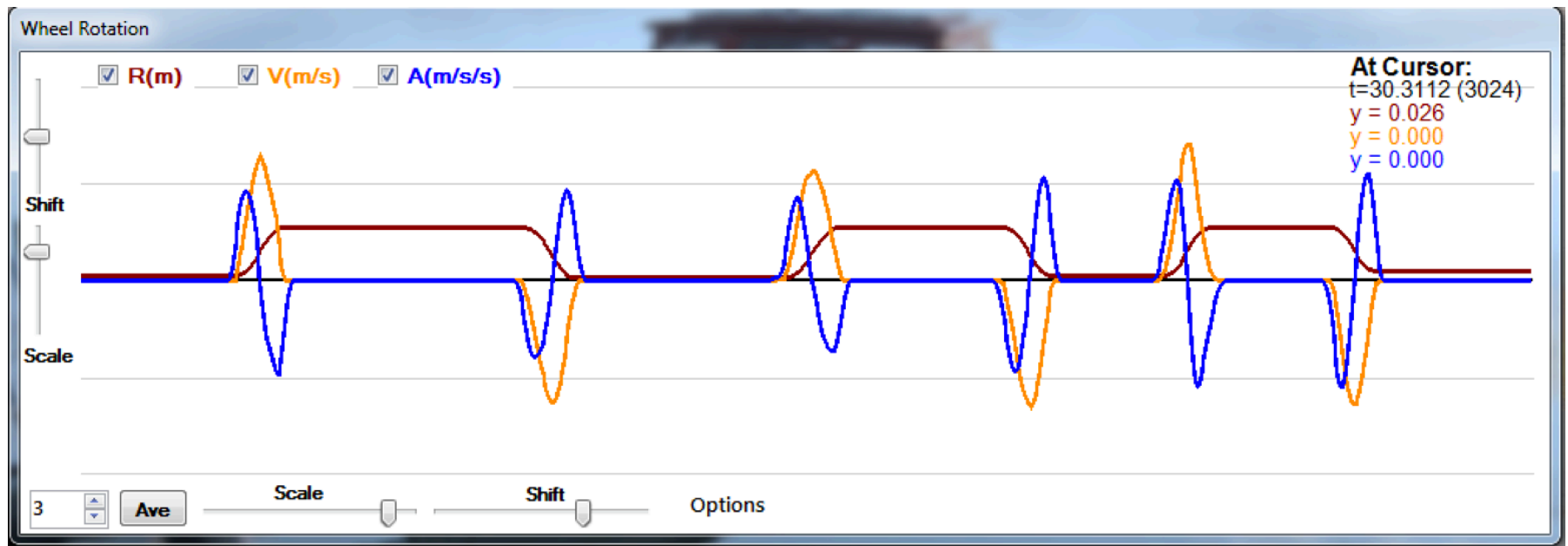
- 3D accelerometer
- 3D magnetometer (.001 B_E)
- 3D gyroscope
- Force probe (± 10 N)
- Position encoder for x, v, a
- Light intensity sensor
- Atmospheric pressure sensor
- Temperature sensor
- Speaker
- Microphone
- DC coupled high gain differential amplifiers w/ external inputs
- Extensive expansion port including ADC in, PIO & DAC out, FTDI (First expansion board: High quality ECG)
- High sample rate (up to 5 kHz) with transfer to PC in real time.



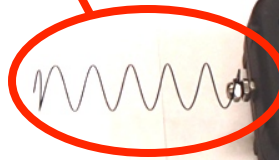
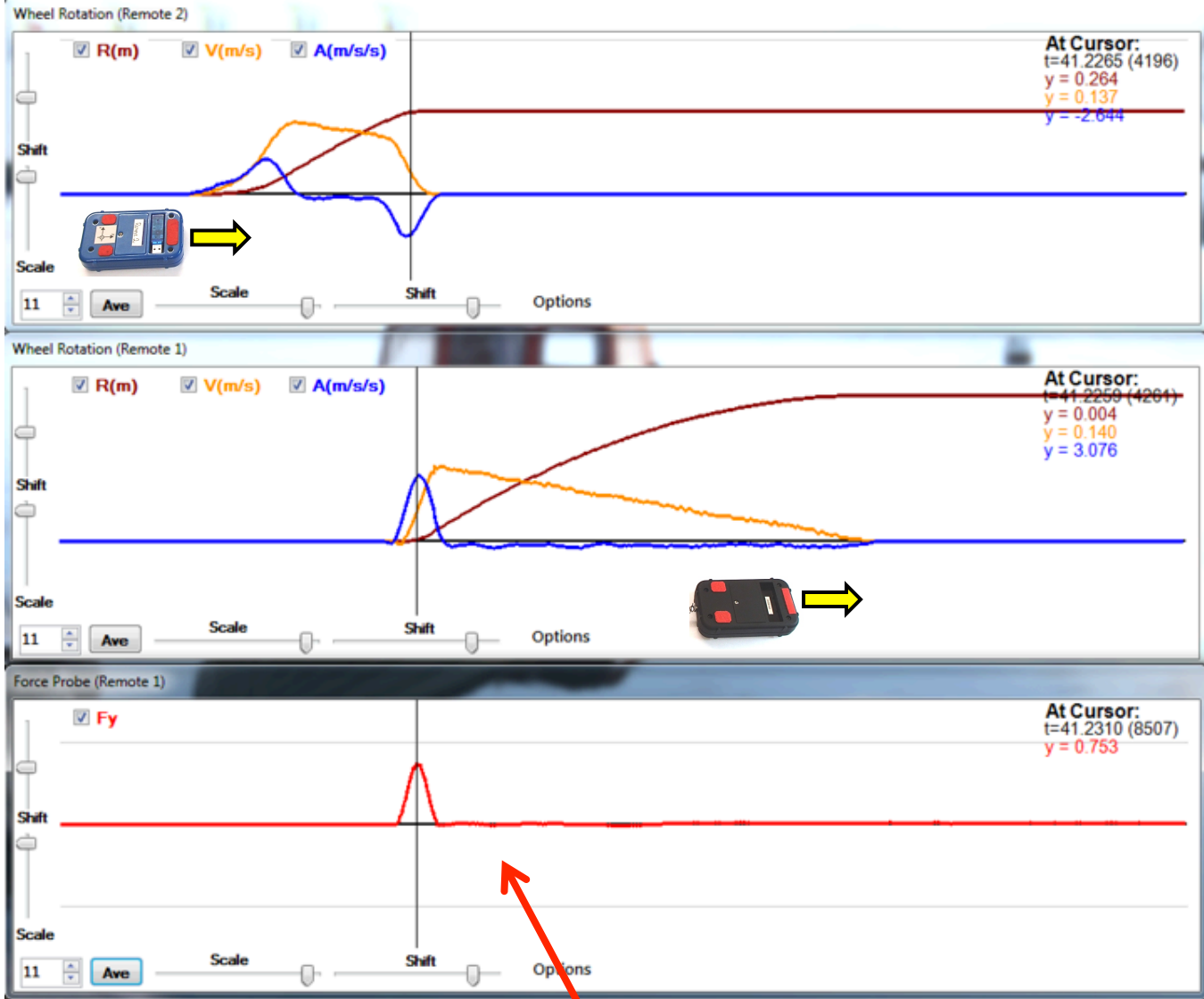
A few examples...

- Orientation
 - Free fall
 - Friction (linear, rotational)
 - Earth field
 - Wire/battery field
 - Oscillation
- Light
 - FFT

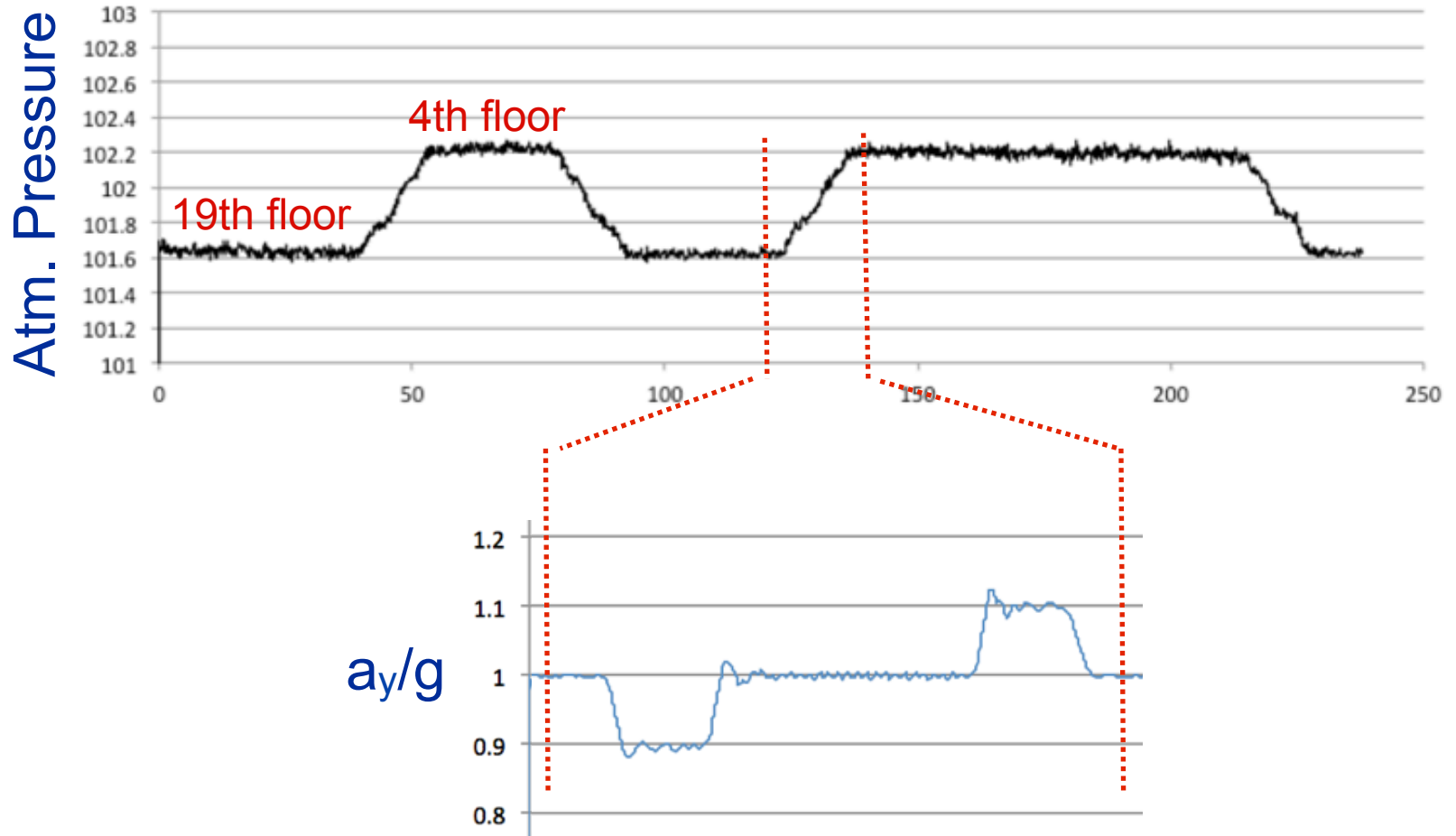
Example: Measurement of position, velocity and acceleration



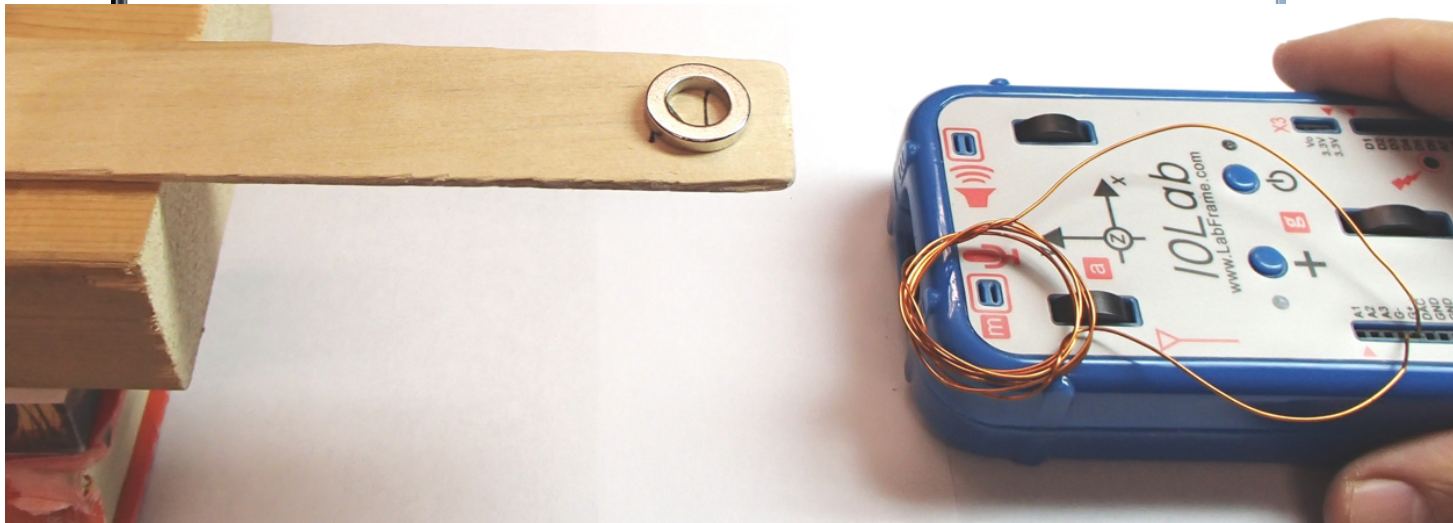
Collision:



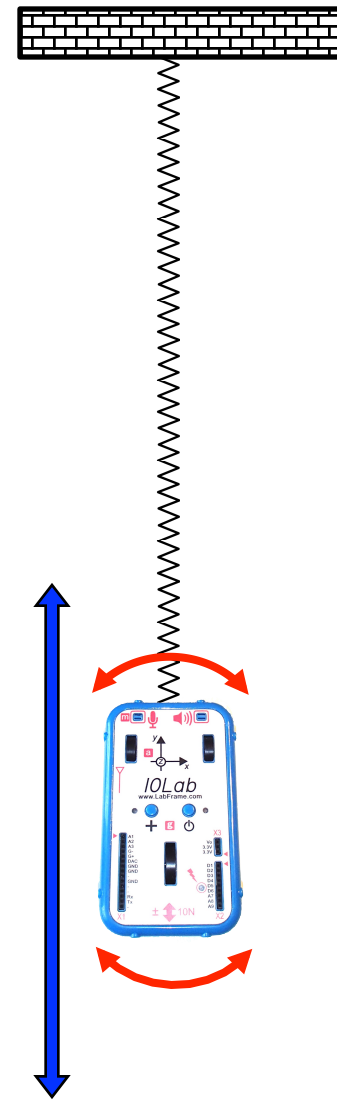
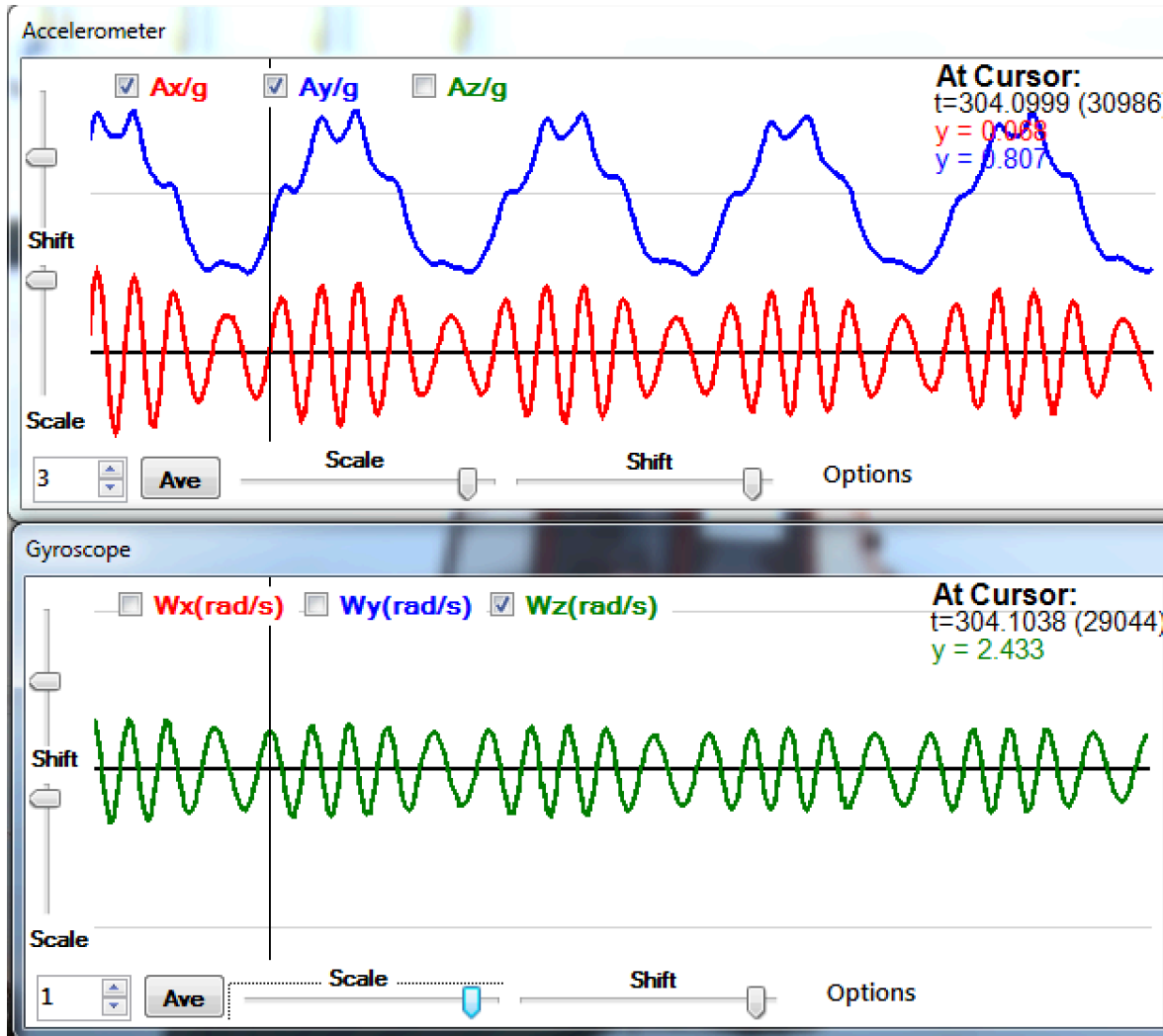
Riding an Elevator



Faraday's Law

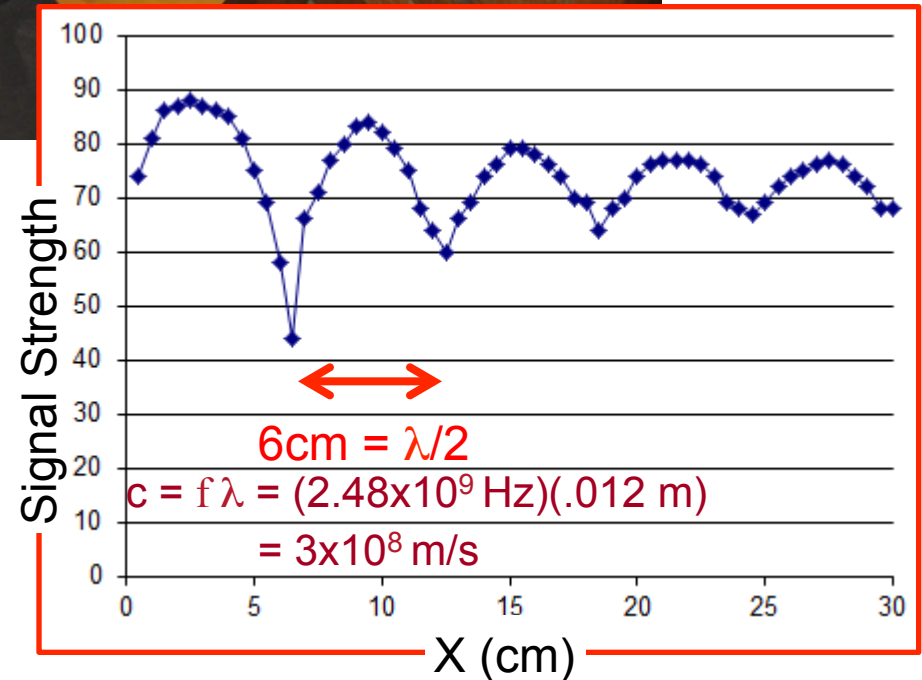
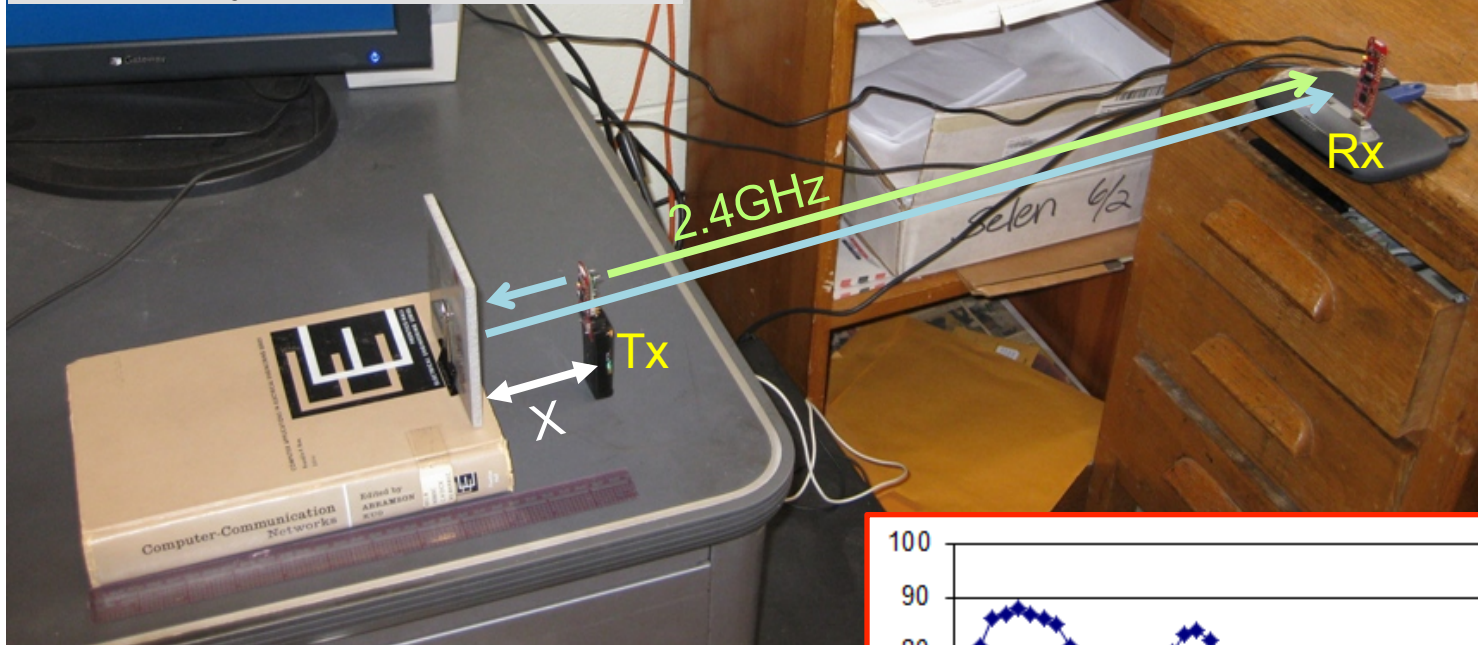


Advanced Lab: Oscillations



Advanced Lab: Speed of light

Pre-prototype hardware shown



A few words on development

Version 0



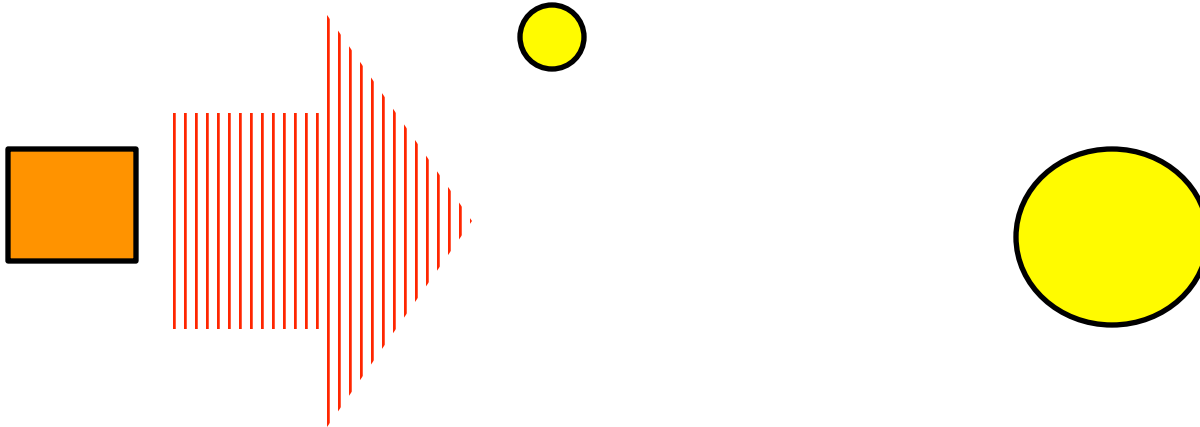


Version 1

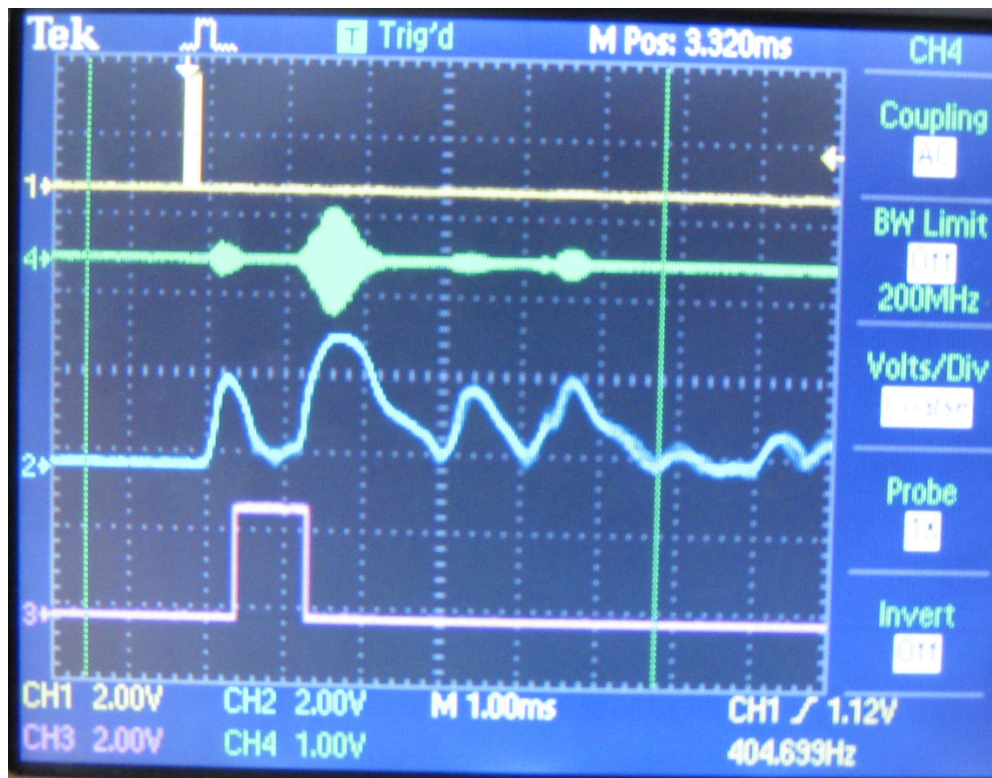
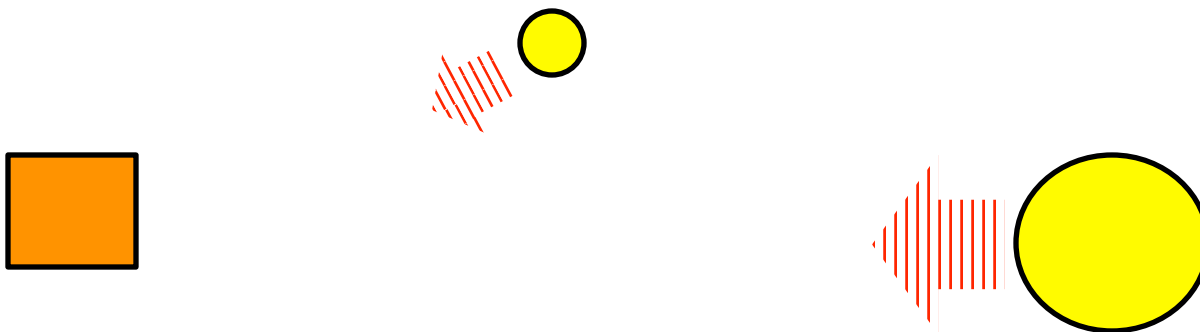
Version 1

- Worked great as “proof of principle”
 - Used in several class tests
 - Convinced our backers to fund Version 2
- Had 2 drawbacks:
 - No force probe (inexpensive solution hard)
 - Ultrasonic ranging so-so (also quite hard)

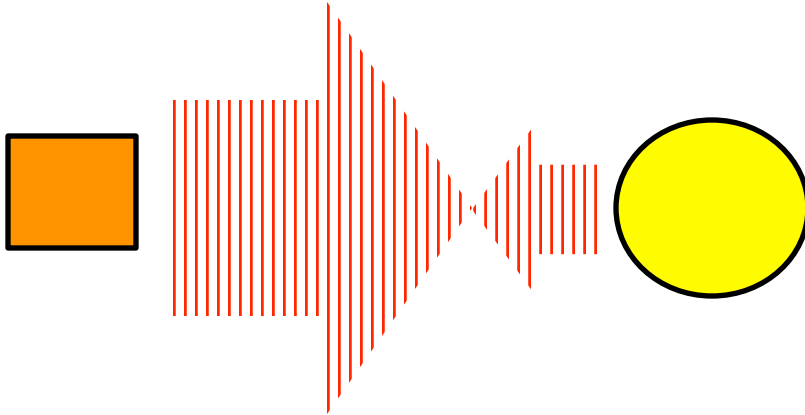
Ultrasonic Ranging



Ultrasonic Ranging

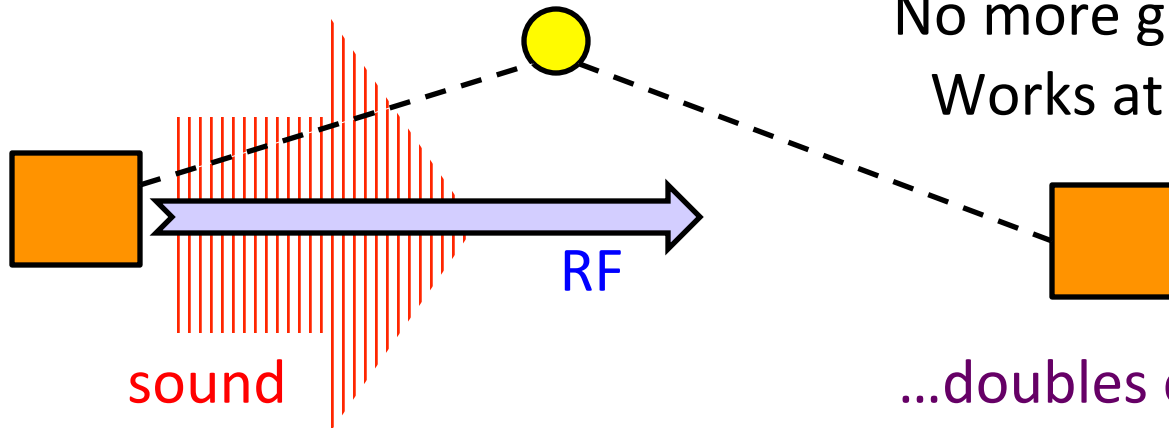


Ultrasonic Ranging

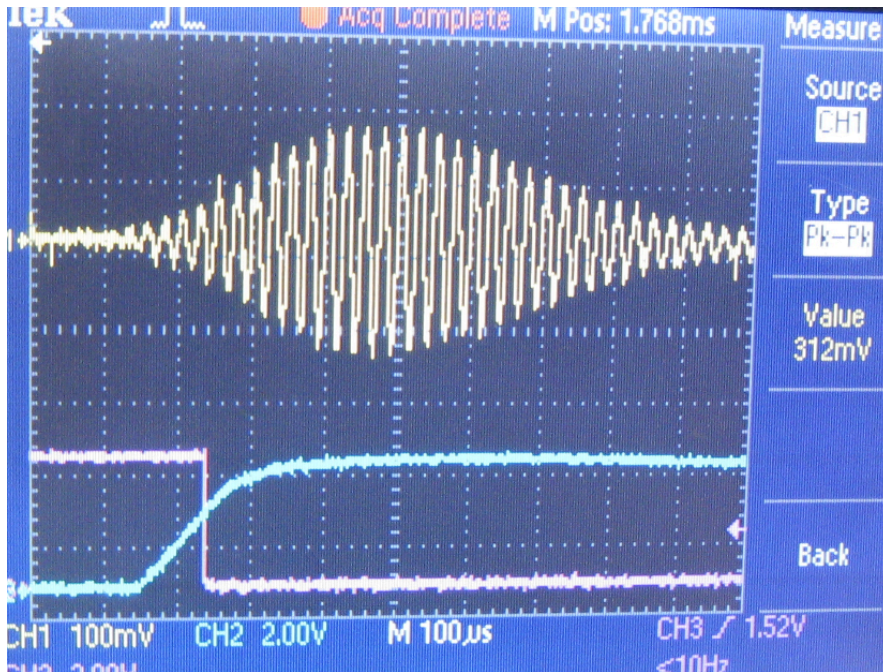


Also can't
measure $R = 0$

Clever Solution (I thought)



Intrinsic problems with ultrasound...



- 1) Receiver is a driven oscillator
- 2) 40 kHz \rightarrow 25 μ S \rightarrow 8 mm
- 3) Differentiate to get v & a

Better Solution



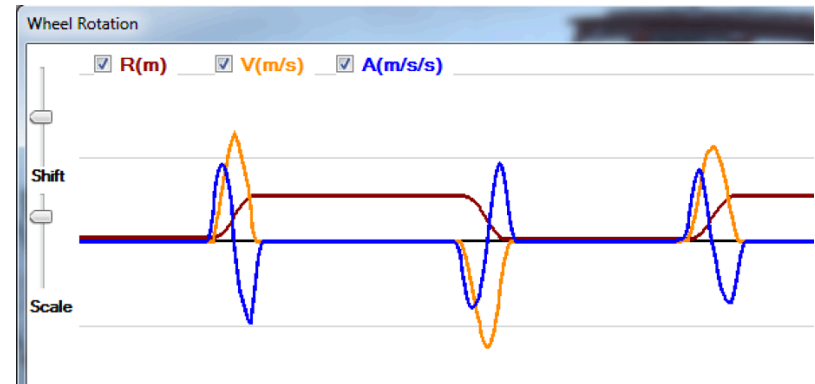
Cheaper & much more reliable

1 mm resolution

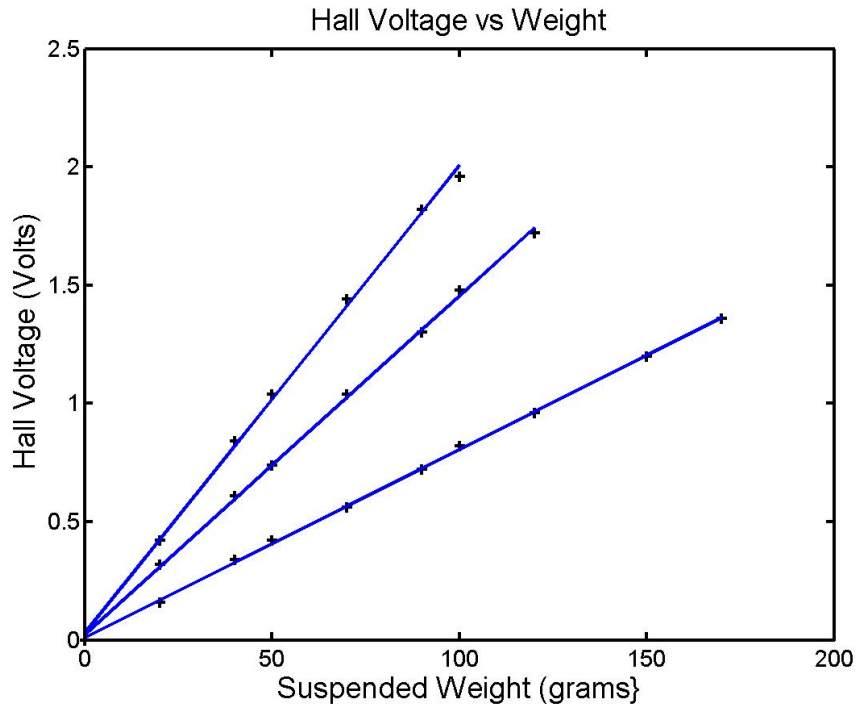
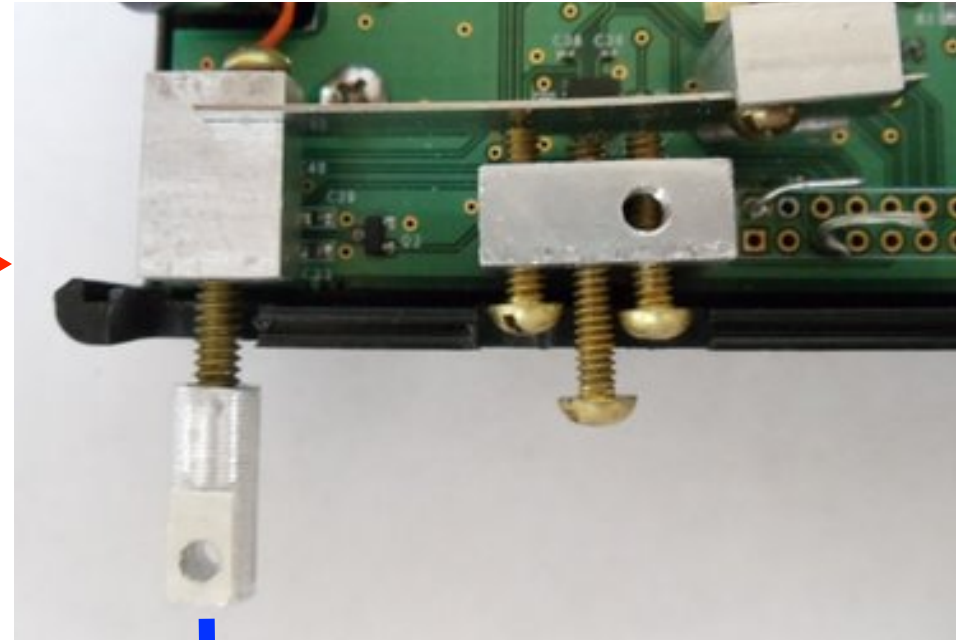
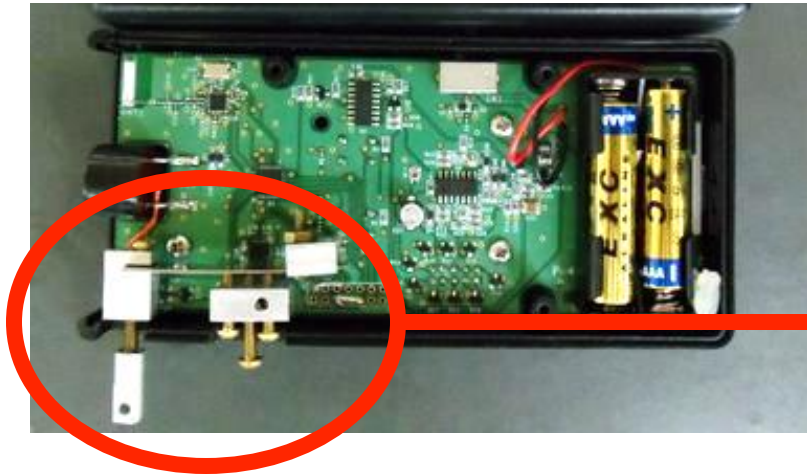
Measures velocity

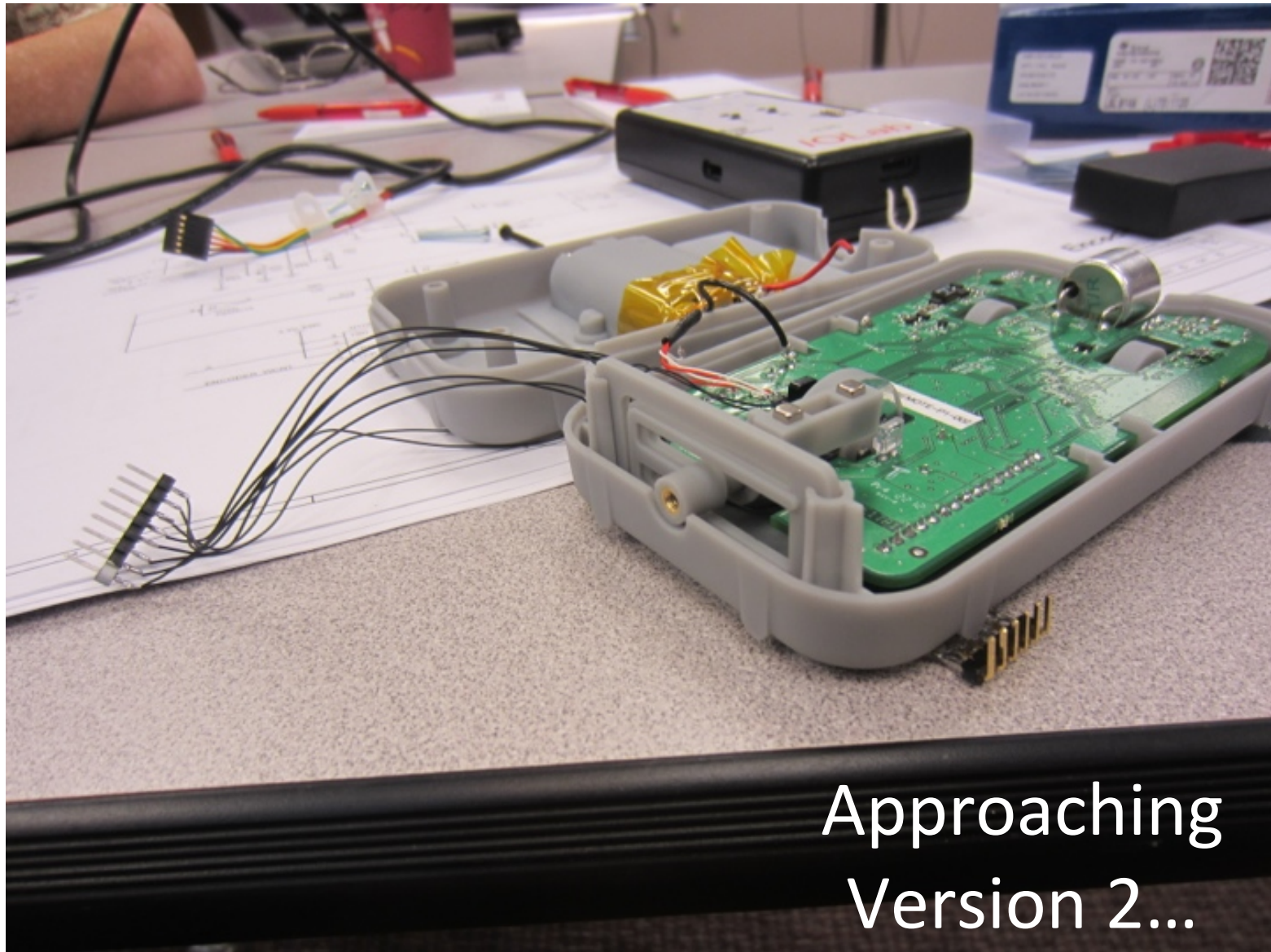
$$a = dv/dt$$

$$dx = vdt$$

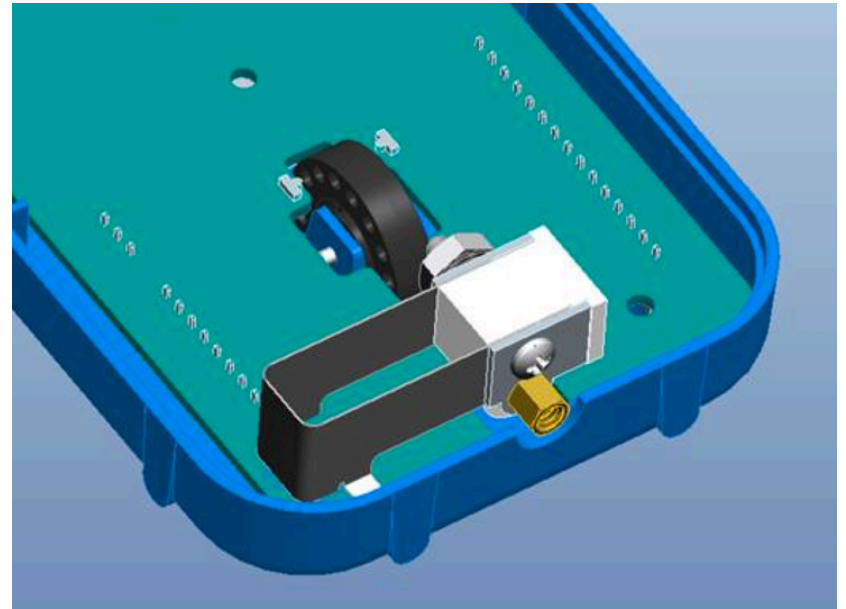
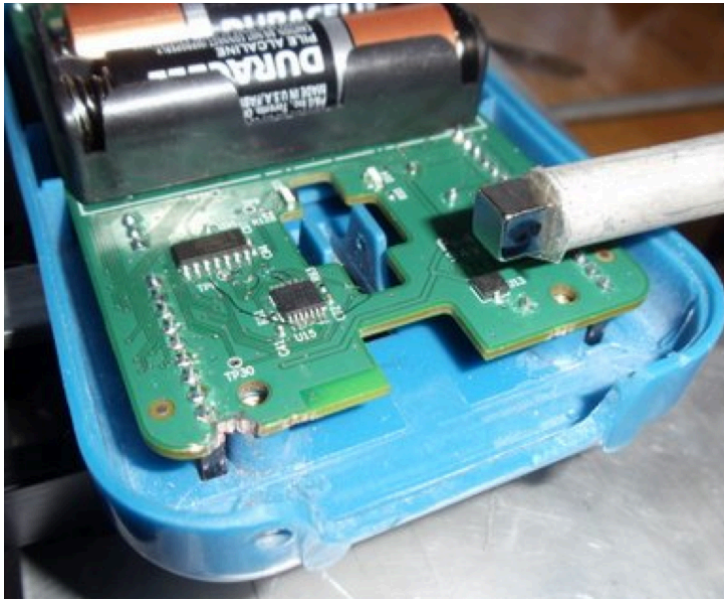
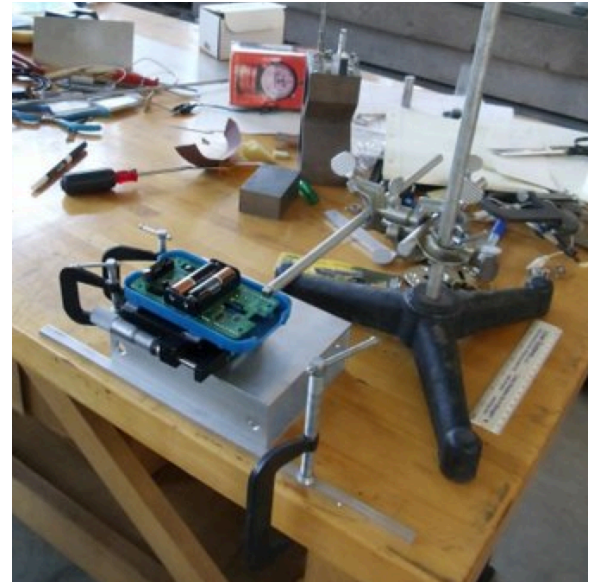
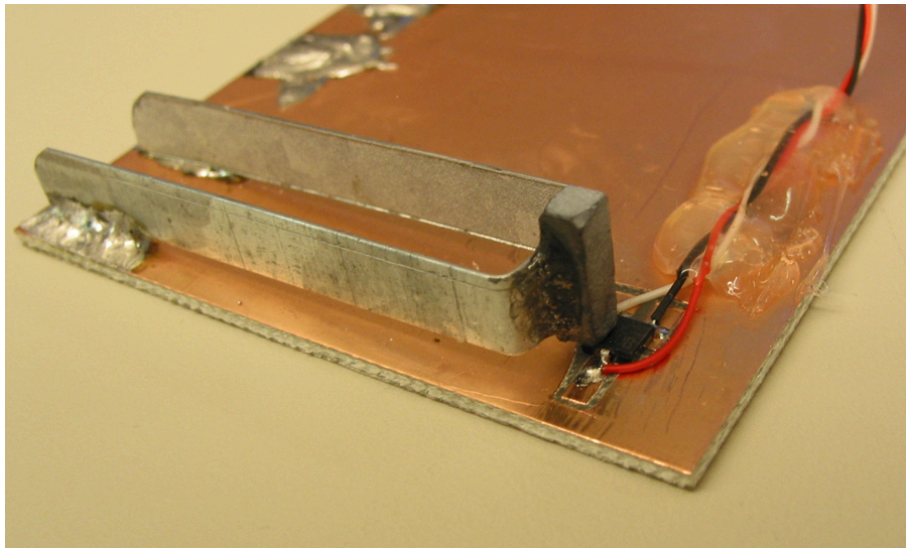


Cheap & Elegant Force Probe Solution: Thanks to Lee Holloway

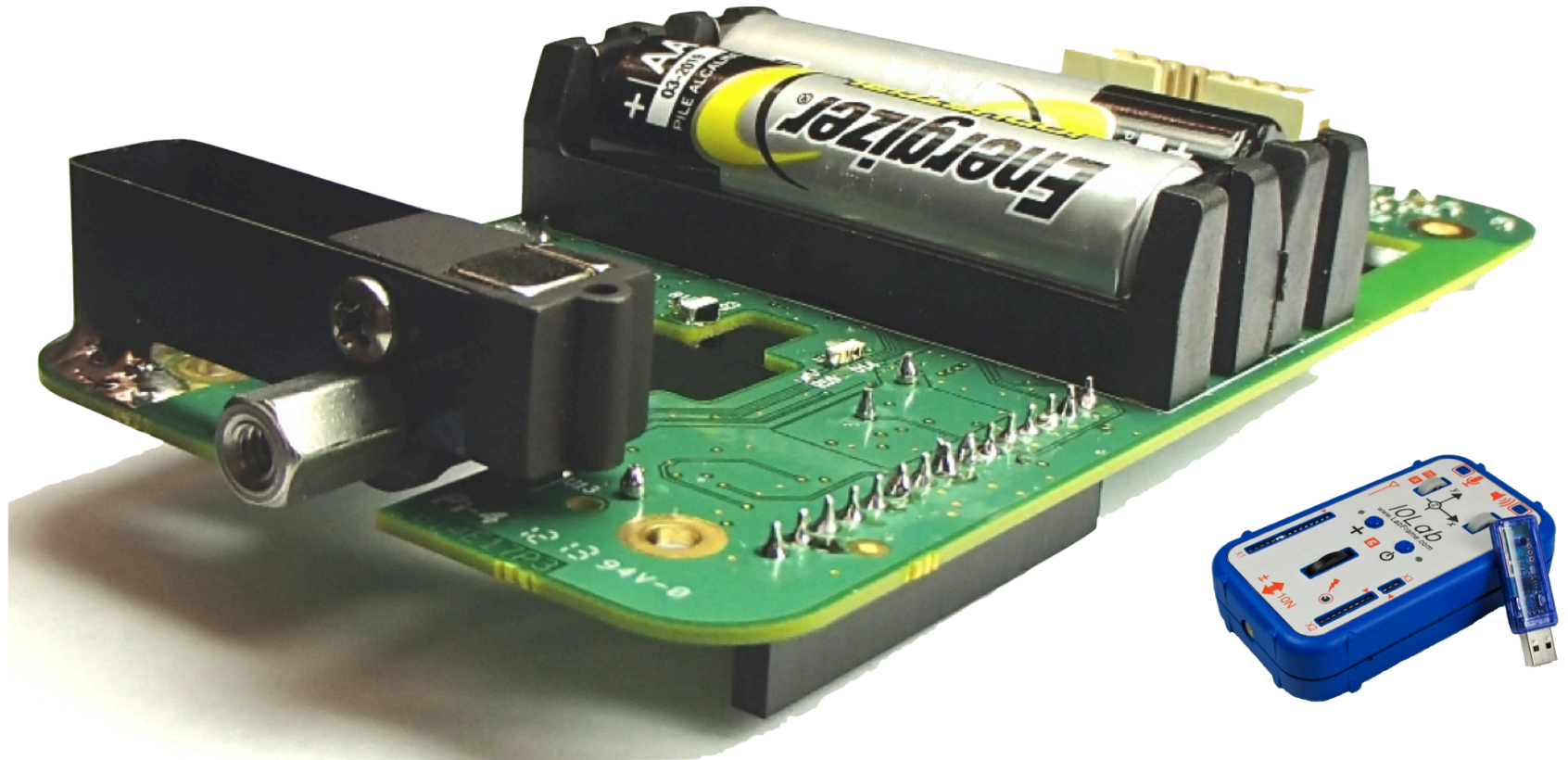




Approaching
Version 2...



Version 2 (have 70 prototypes)



Will build 3000 more for a fall/2013 content development push (need colleagues)...

Hardware is useless w/o content & pedagogy

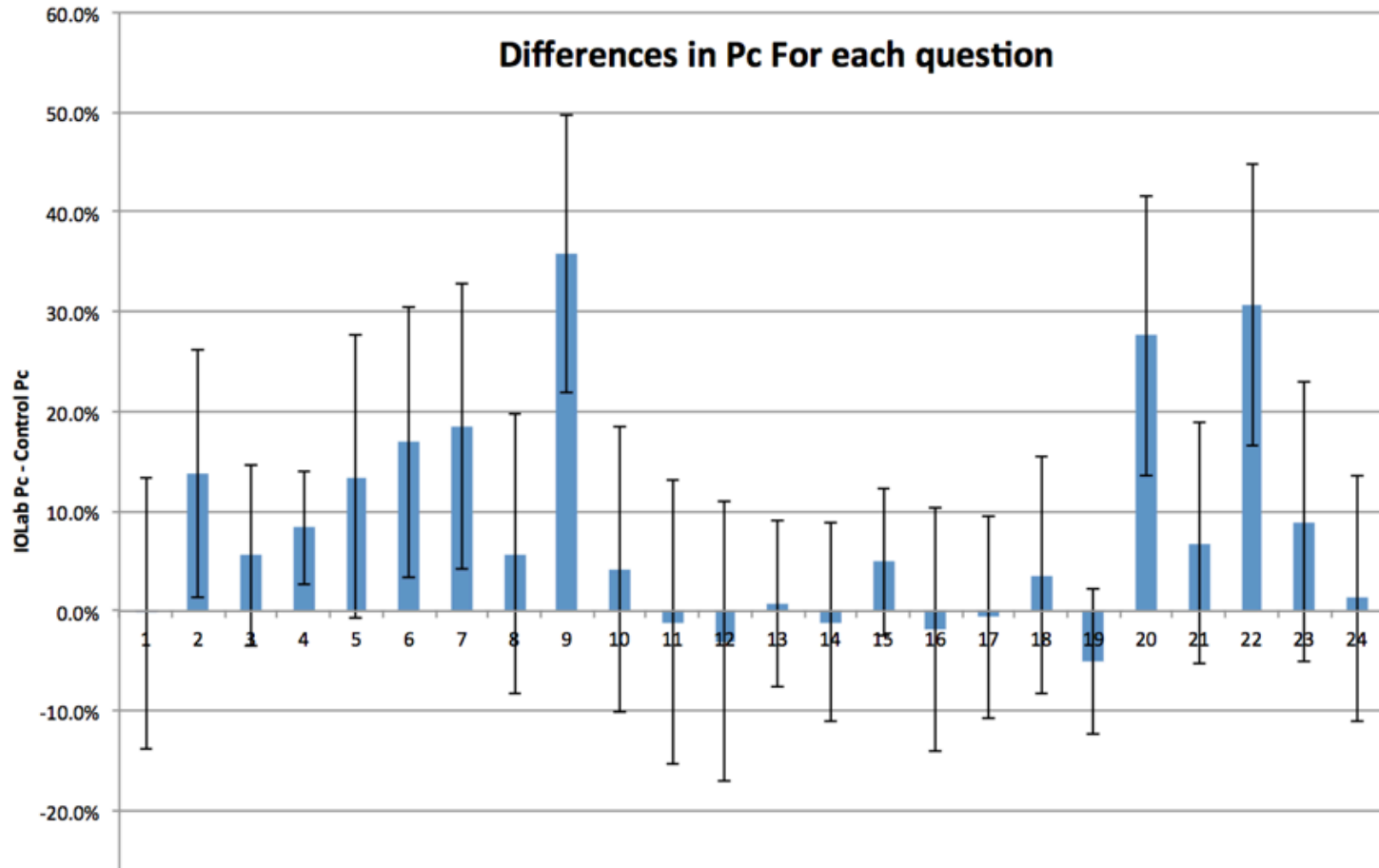
NSF/TUES research program to study possible pedagogical approaches

- Recent clinical study of 50 UIUC students learning kinematics.
- Half of the students read Tipler for 30 minutes.
- The other half did individual self paced IOLab activities which took, on average, 15-20 minutes.
- Both groups took the same 24 question post-activity quiz.



Show mini-lesson

- Preliminary results indicate that the IOLab group learned more in less time (having more fun).



Pedagogy

- We are particularly interested in the effect of having students do short hands-on activities as they are introduced to the concepts by the Prelectures (i.e. before lecture).

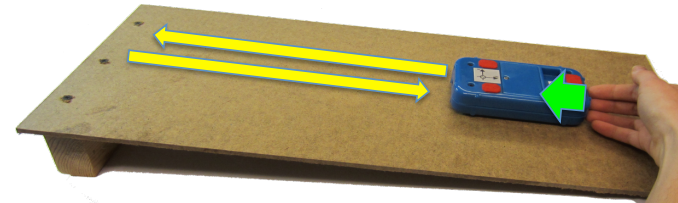
- This work will be
Katie Crimmins PhD Thesis:



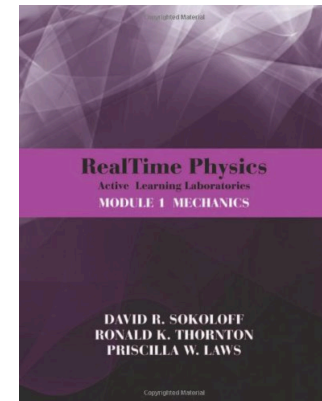
“Interactive Online Laboratories in Prelectures:
Adjusting the timing of hands on activities to move
toward a constructivist learning experience”

Short Term Plan

Designing activities to test at UIUC this fall.



Leverage off great existing MBL activities like *RealTime Physics*, (Sokoloff, Thornton, Laws).



Possibilities: Before lecture; in lecture; combined with discussion; before labs, on paper. Depends on the purpose of “lab” !

This could also have a big impact in online courses (part of our TUES proposal)



Working with colleagues at PSU and at a local CC. (should have something to show at winter AAPT meeting)

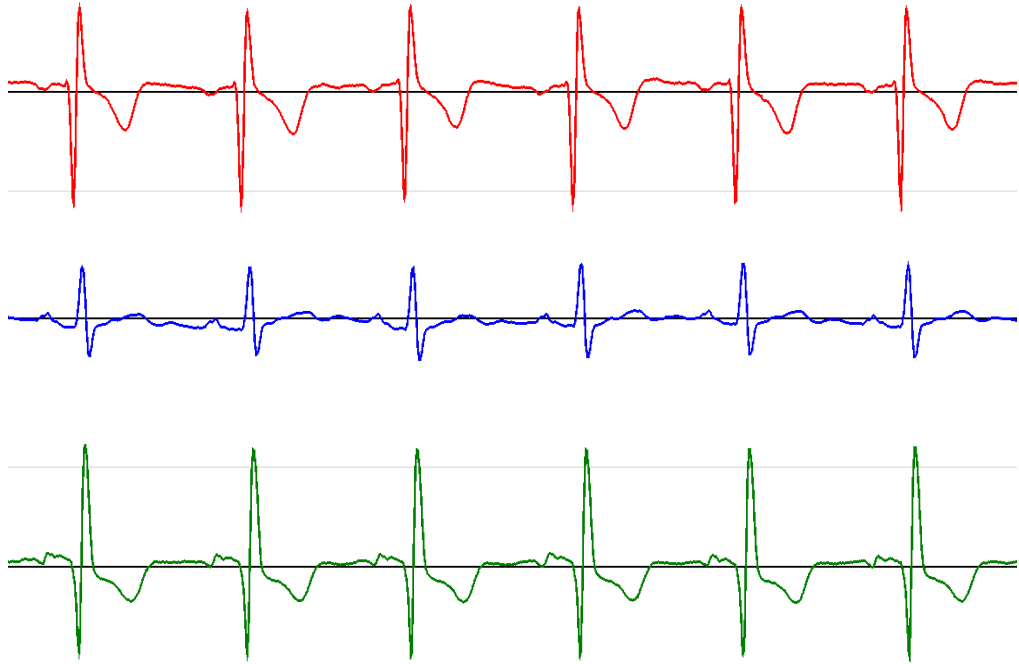
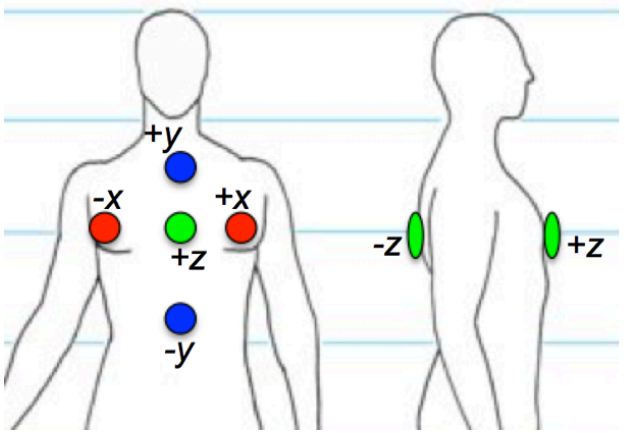
We are very excited about the educational possibilities enabled by this tool.

Detour:



Other Research:

With U of I
Med School &
varsity athletic
department



New OD-ECG approach:
High bandwidth sampling of
3 orthogonal differential channels

Simple
& cheap
& low noise

Standard 12-lead ECG

D.O.B.:
Dr:
Tech:

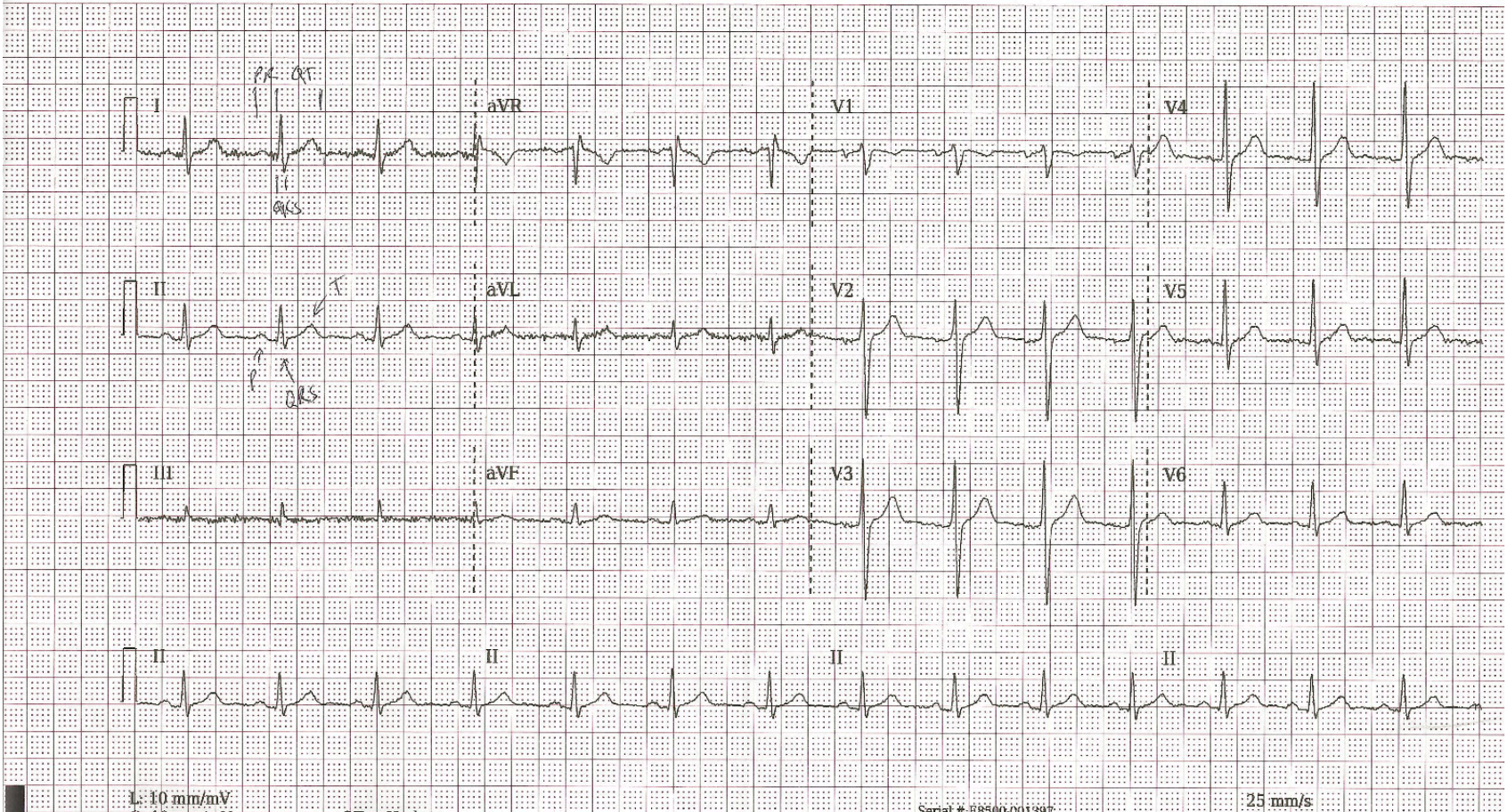
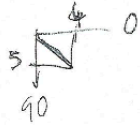
Vent. Rate:	86 bpm
RR Interval:	697 ms
PR Interval:	154 ms
QRS Duration:	92 ms
QT Interval:	354 ms
QTc Interval:	399 ms
QT Dispersion:	82 ms
P Axis:	43 deg
QRS Axis:	54 deg
T Axis:	22 deg

Normal ECG

— Beat to beat

— QT/RR

— Longest - shortest QT

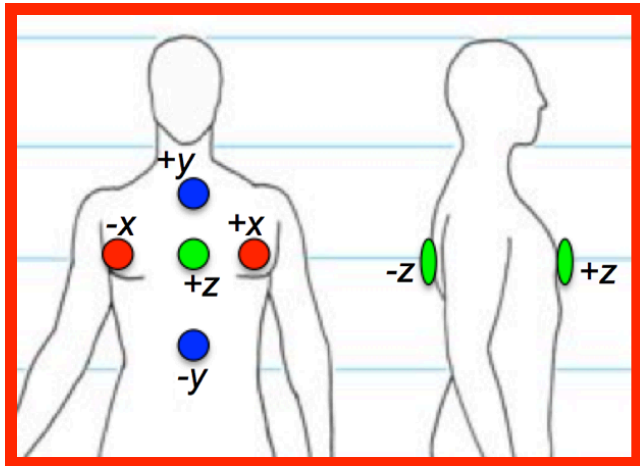


L: 10 mm/mV
C: 10 mm/mV
BURDICK

Qt: Hodges
BURDICK REORDER NO/REF 716-0237-00

Serial #: E8500-001397
E8500 Ref #20110822 7.3

25 mm/s
~STABLE 40 Hz

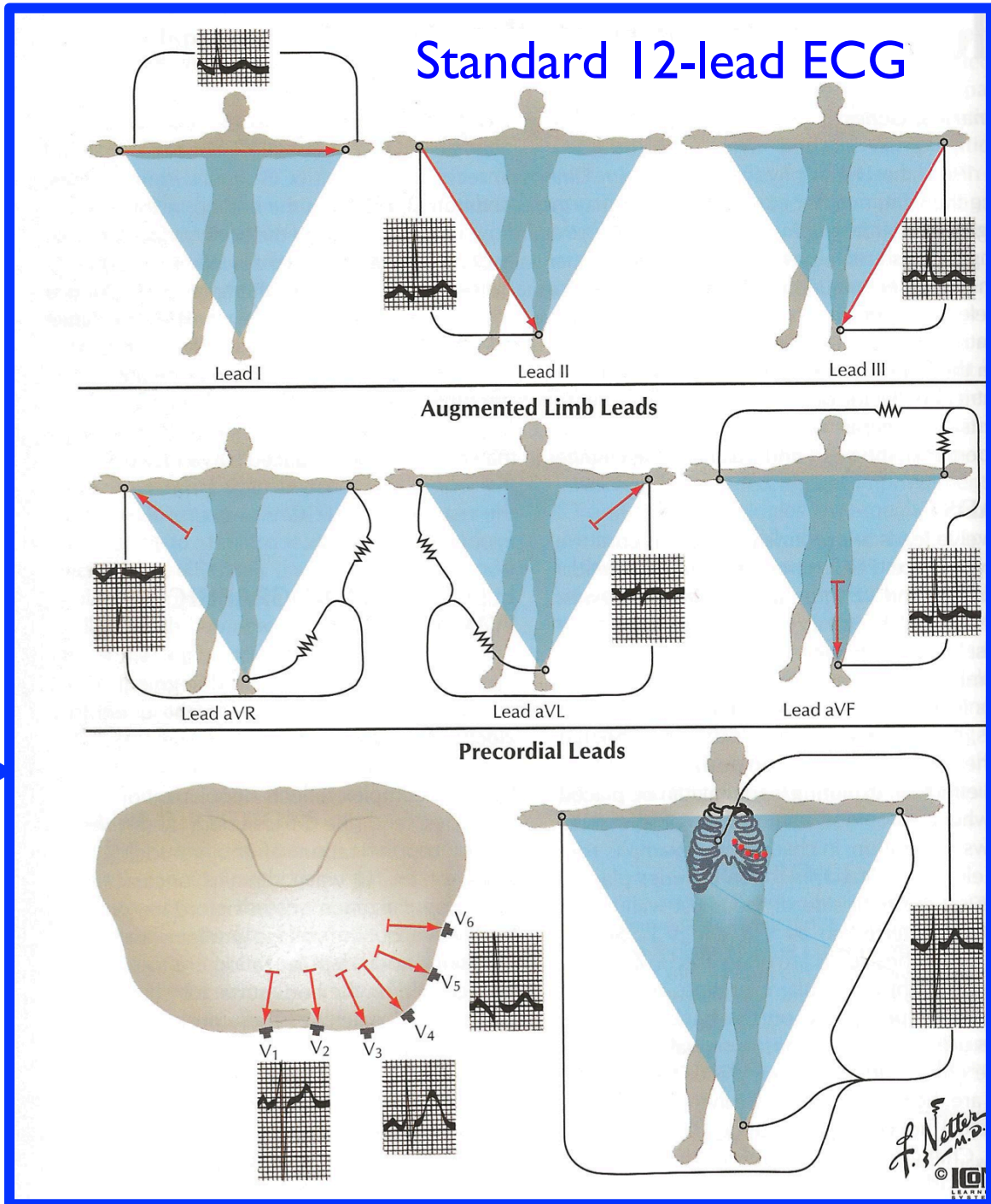


Our Approach

Can we map this



onto this?



Show analysis tool

Why are we doing this?



high school athlete deaths

Web

Images

Maps

Shopping

More ▾

Search tools

About 201,000,000 results (0.29 seconds)

[Teen athletes' deaths spur call for heart screening - TODAY Health ...](#)

[www.today.com/.../teen-athletes-sudden-deaths-spur-call-heart...](#)

Reggie Garrett, a Texas **high school** senior, **died** in September when his ... teen **athletes** has renewed the debate over heart screening for **high school** players.

[High School Football Player Dies; Sixth Athlete Death This Summer ...](#)

[abcnews.go.com > Health](#)

Sep 3, 2011 – For the sixth time this summer, a **high school** football player has collapsed and **died** after practicing in scorching heat.

[High School Athlete Mourned After Sudden Death « CBS Sacramento](#)

[sacramento.cbslocal.com/.../high-school-athlete-mourned-after...](#)

Mar 7, 2013 – A local **high school** is mourning the loss of an **athlete** who **died** while working out on campus.

Current Estimate: About one death / 50,000 student athletes / year

Many can be prevented with a simple ECG screening.

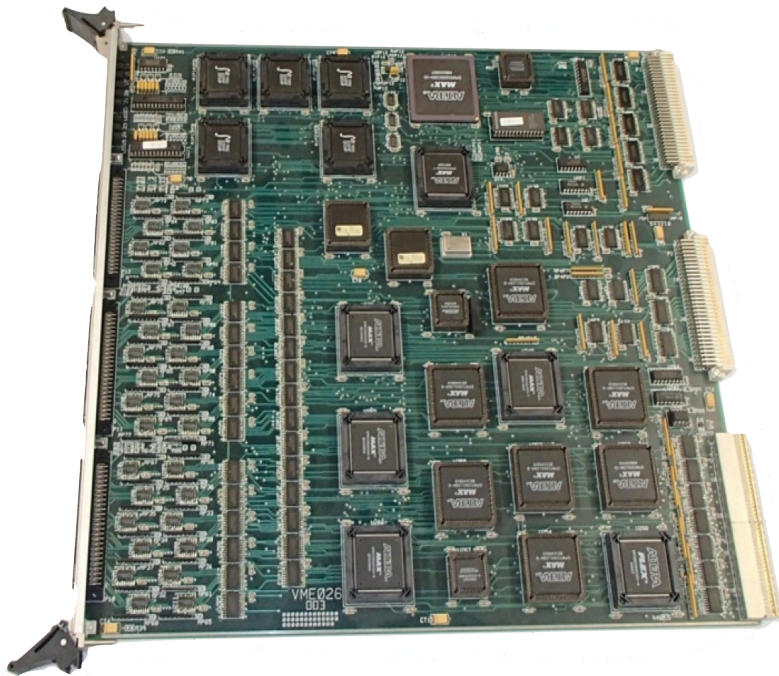
Need something cheap & simple...

Current ECG Study

- Acquired both IOLab and Standard 12-Lead ECG's for 32 University of Illinois Student Athletes (interesting IRB).
- Using this to validate the OD-ECG approach (currently under way).
- Once validated, study large number of athletes.
- Develop database & online analysis software (think particle physics).
- Hide from lawyers.

End of Detour

- As a community, we might have the right tools at the right time, now, to really improve the way we teach.
- PER is exiting – feels like HEP felt when I was young.
- We are very fortunate to have a second careers doing something this interesting...



And this one is easier
to explain to my mother.

