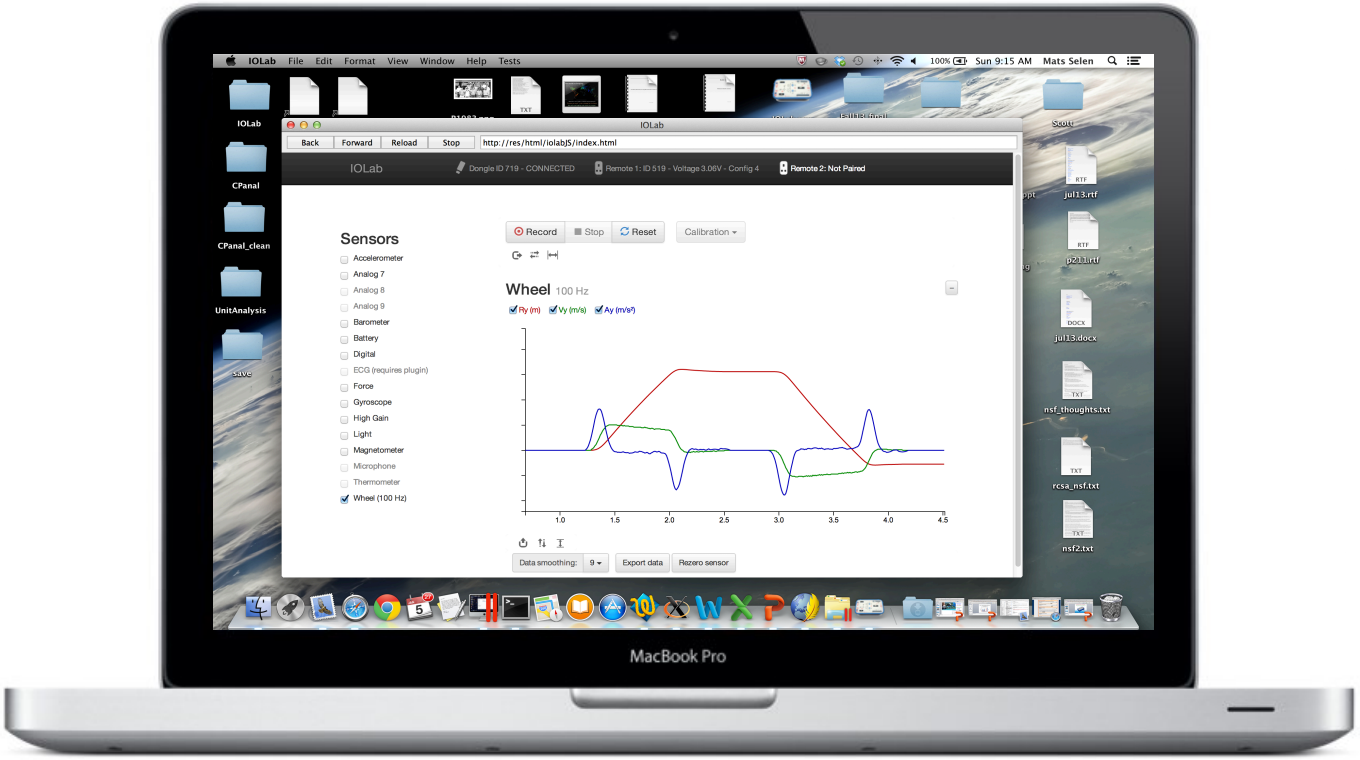
Interactive Online Laboratories:

(Why, How, When, and Where)



Mats Selen
UIUC Physics

Intro Physics at Illinois

Fall 2013
(Calc. based)

PHYS 100: 536
PHYS 211: 986
PHYS 212: 1186
PHYS 213: 600
PHYS 214: 609
PHYS 225: 129
(Total > 4000)

Big Data for PER

Physics Education Research

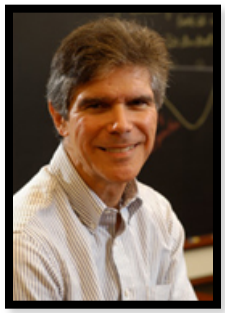
Projects:

Dept. Culture

IE's
i>clickers
Prelectures
smartPhysics
IOLab

Flipping the Classroom


Gary Gladding


Jose Mestre


Mats Selen

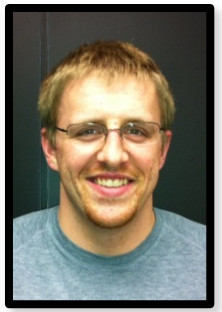

Tim Stelzer


Katie Crimmins


Witat Fakcharoenphol


Brianne Gutmann


Sara Rose


Noah Schroeder

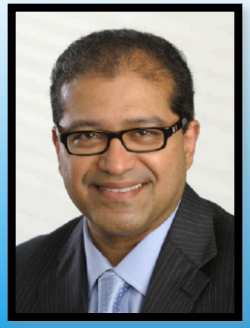

Morten Lundsgaard


Michael Scott

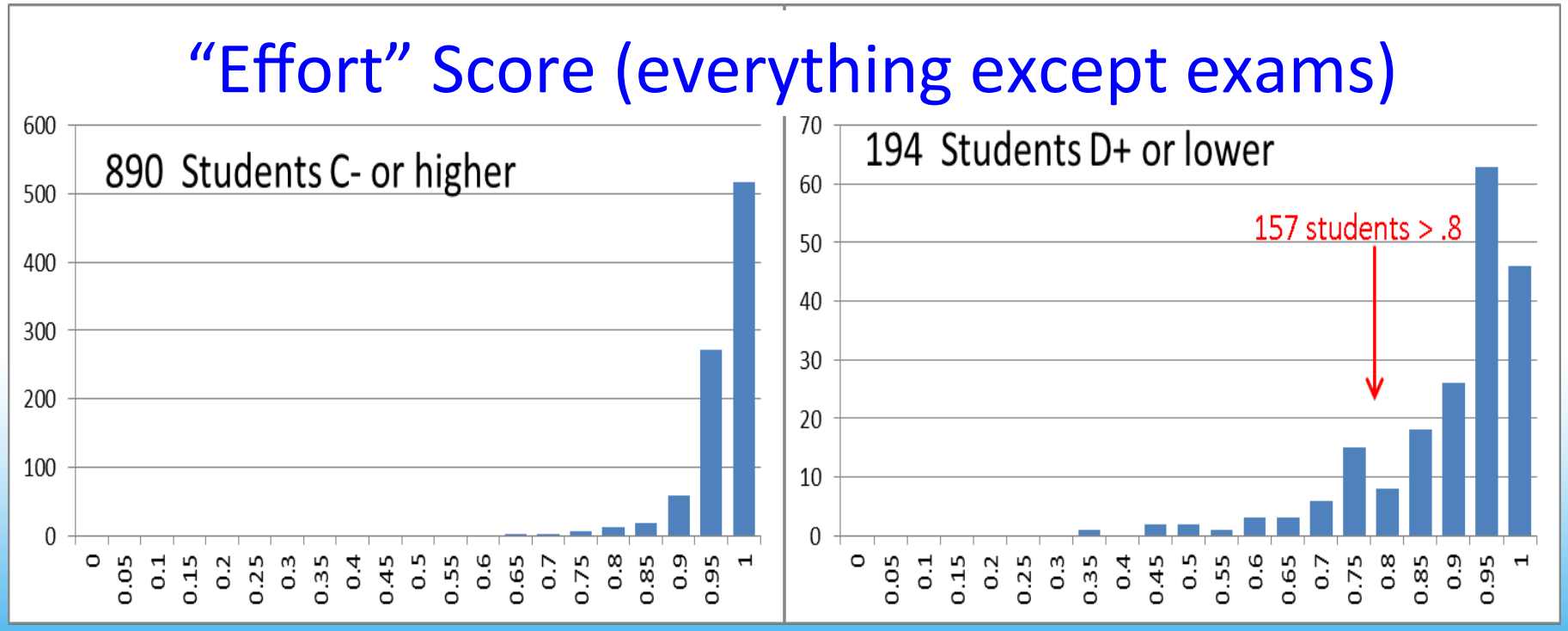

Michel Herquet


Vincent Boucher


Geoffroy Piroux

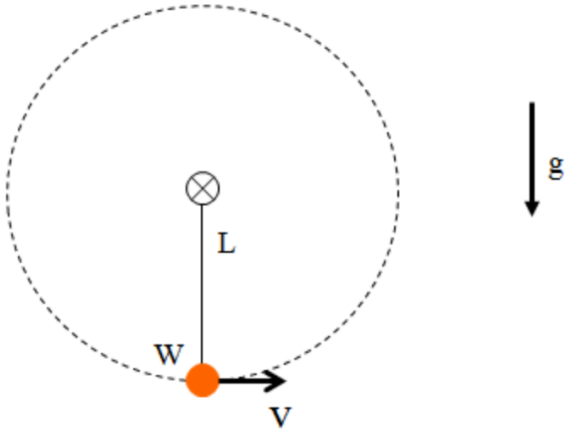

Abe Kocheril

One of our main goals is to help students that try hard and still fail.



Fall/2013 Exam Analysis

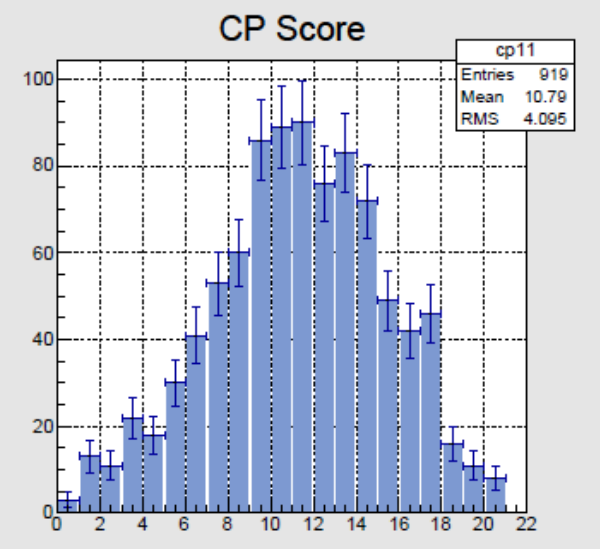
Example: conceptual preparation question



A tennis ball of weight *W* is attached to a rope and swung in a vertical circle. The rope has length *L*.

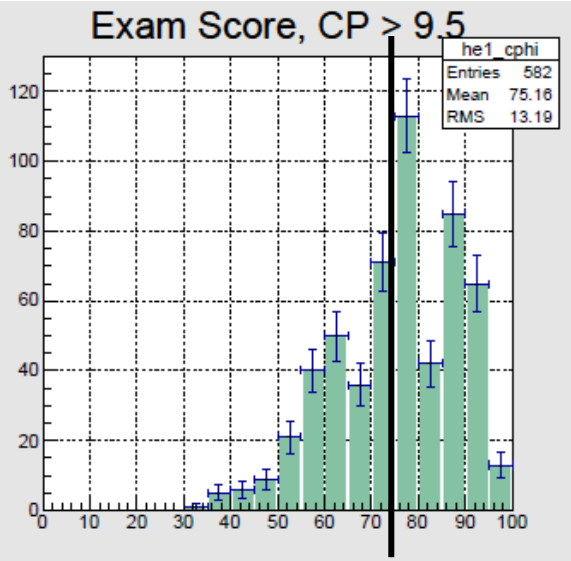
Which of the following describes the tension in the string when the ball is at its **lowest** point moving with speed V?

A) It is equal to W
B) It is greater than W
C) It is less than W

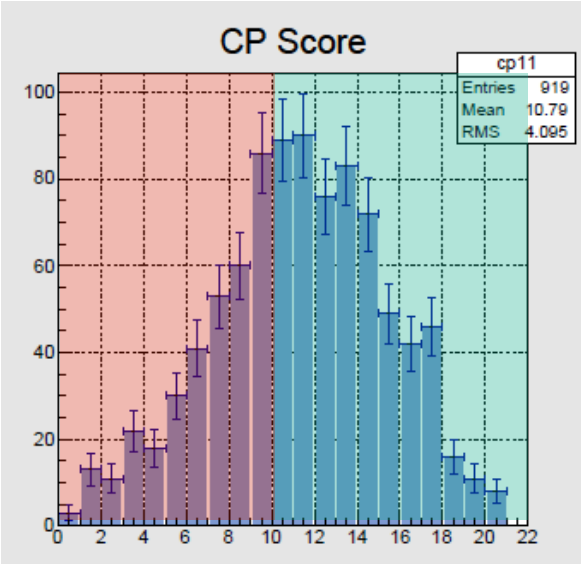


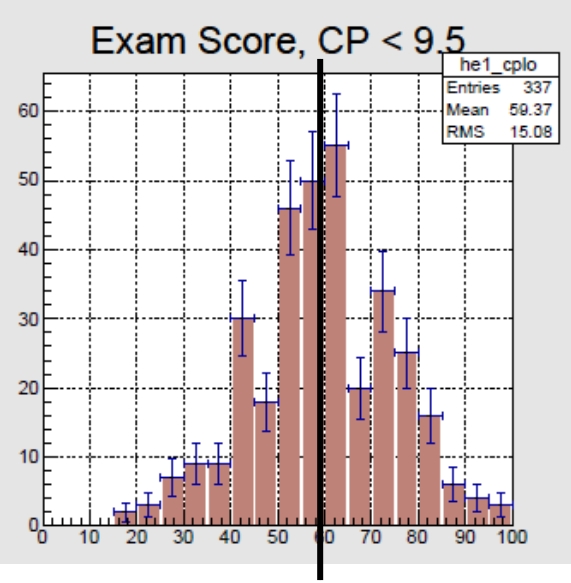
Fall/2013 Exam Analysis

Unscaled Total Exam Score
vs Review Checkpoint Score



Average
= 75%

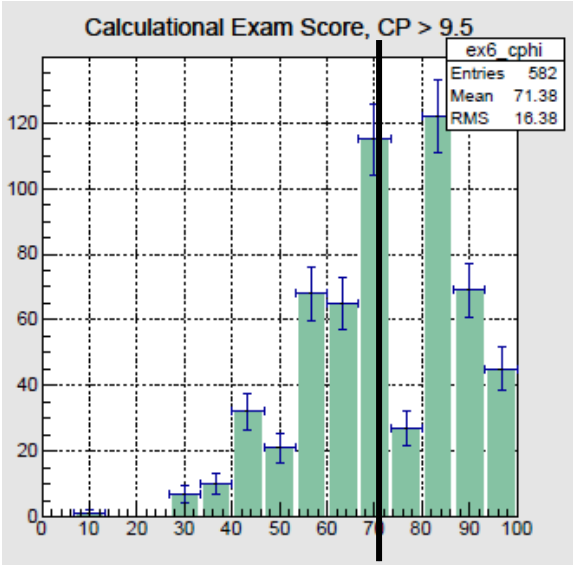




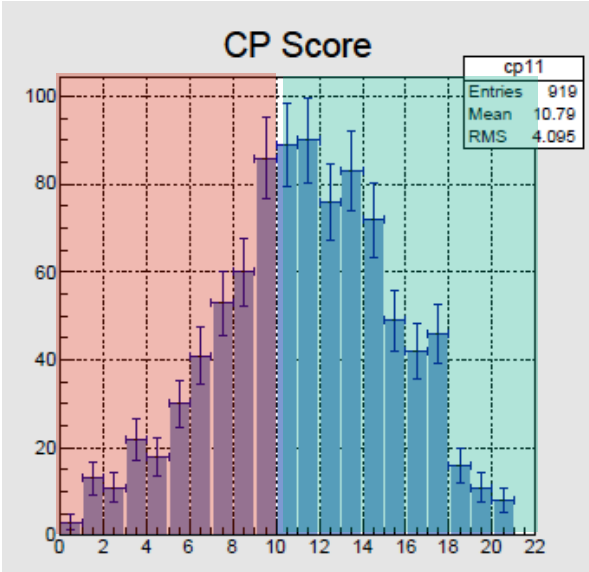
Average
= 59%

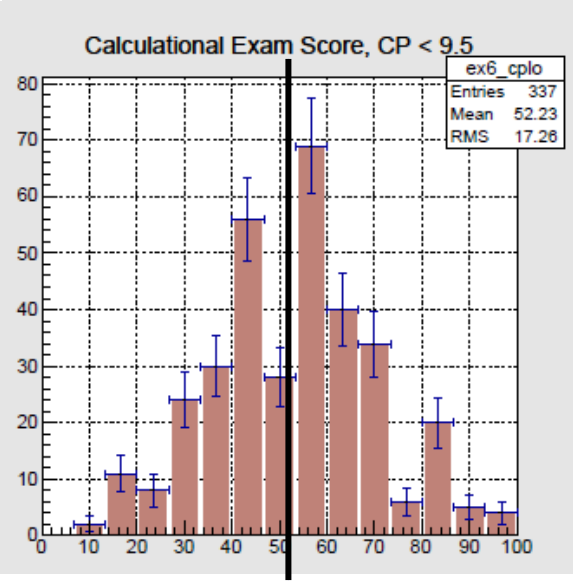
Fall/2013 Exam Analysis

Unscaled *Calculational* Exam Score vs Review Checkpoint Score



Average = 71%

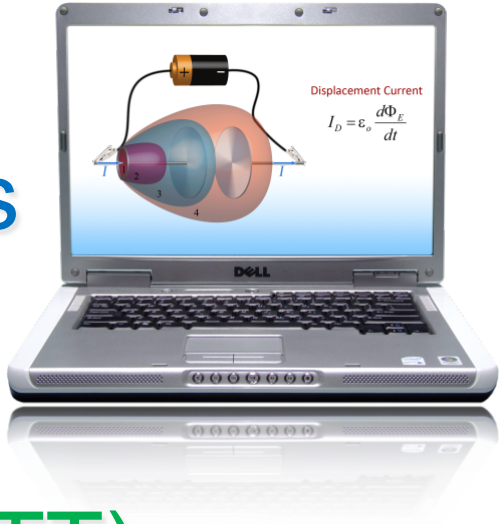


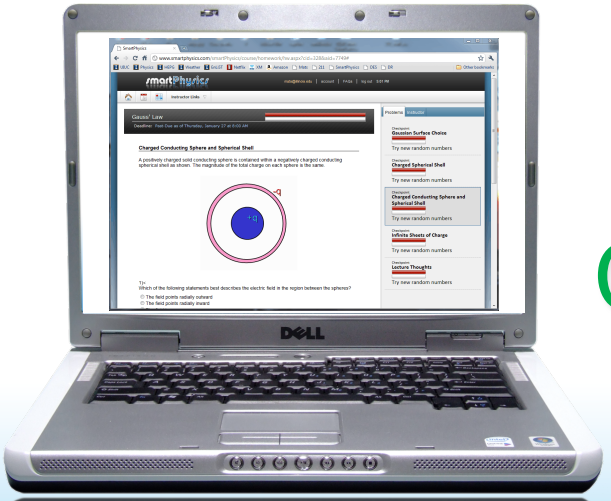


Average = 52%

Started flipping the classroom in 2008

Pre Lectures



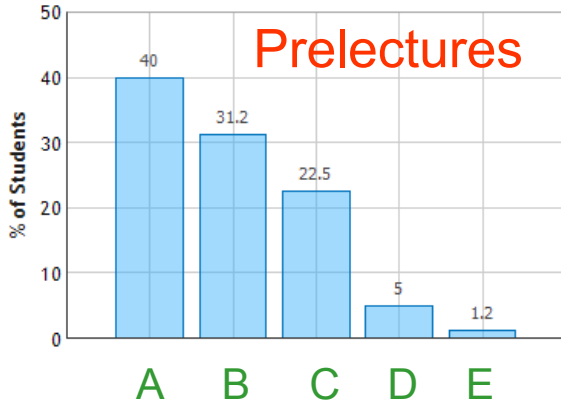


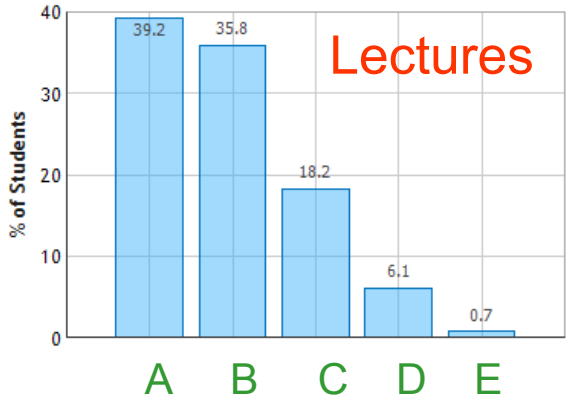
Checkpoints (JiTT)

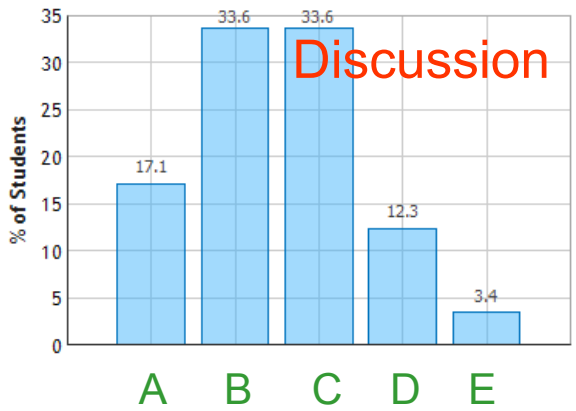
Peer Instruction

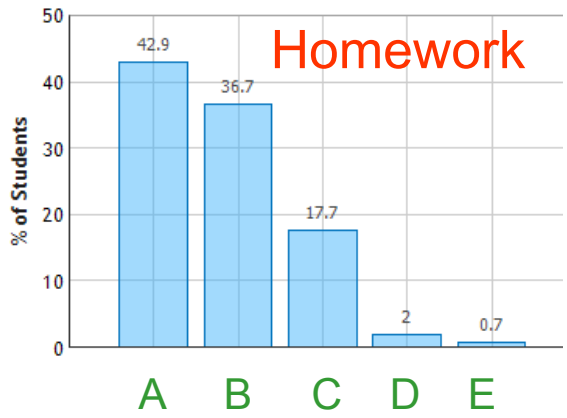
Same semester (Fall 2013)

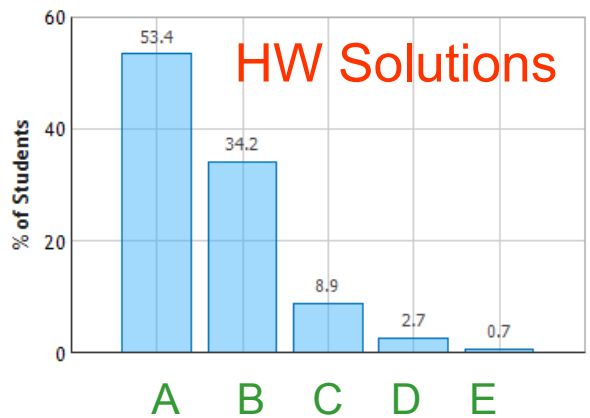
How important were _____ in helping you learn the material

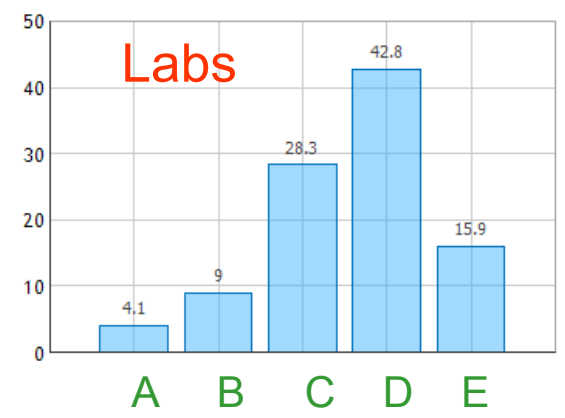












A: Essential, B: Very Important, C: Somewhat Important, D: Not very important, E: Useless

Current status at UIUC:

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

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

Homework: Online, including Interactive Examples (good)

Labs: Group work (traditional) (not so good)

Problem = Opportunity:

Optimize labs to really bolster conceptual knowledge

Reality:

Not so easy due to both financial & pedagogical constraints

Budget, Space Timing

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

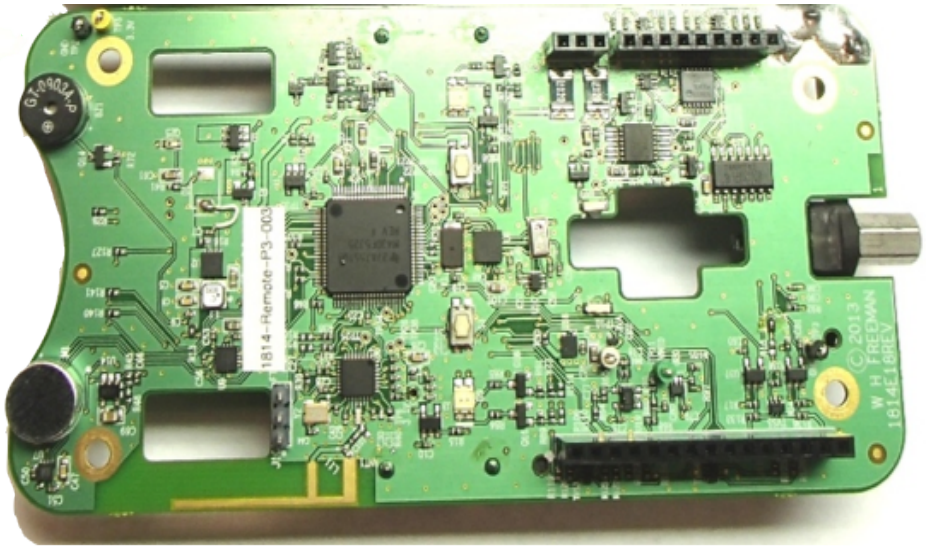
Basics

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

Inside

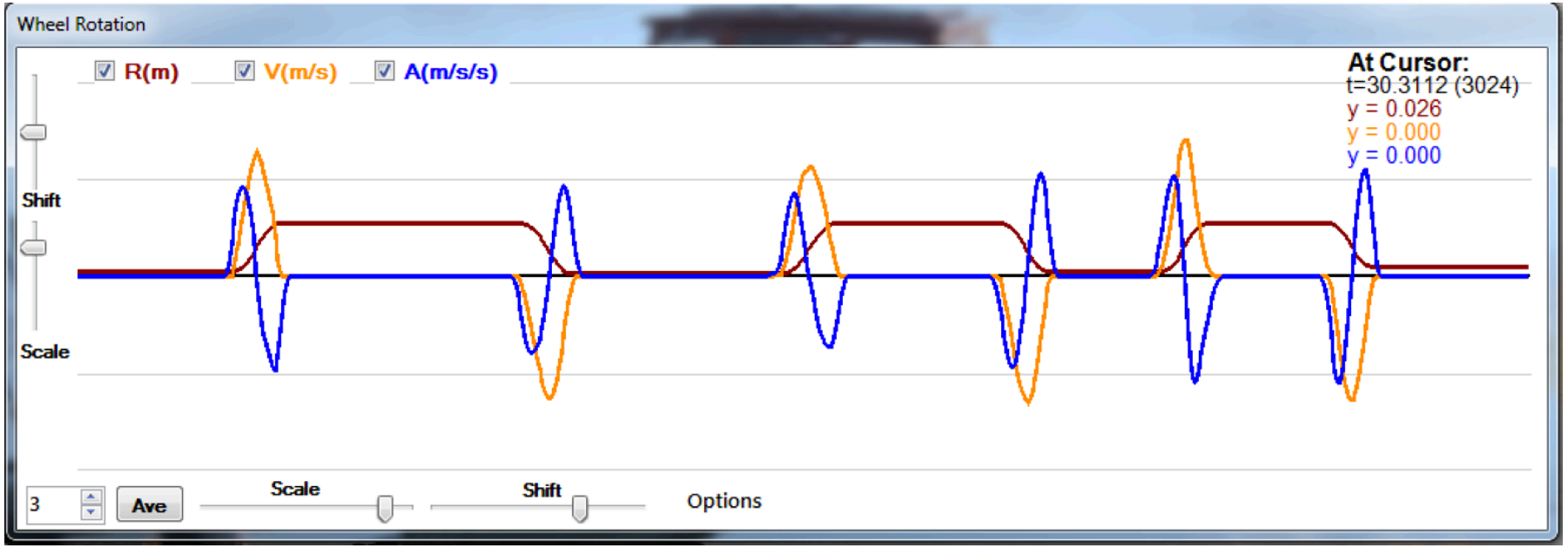
Demo

- 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.

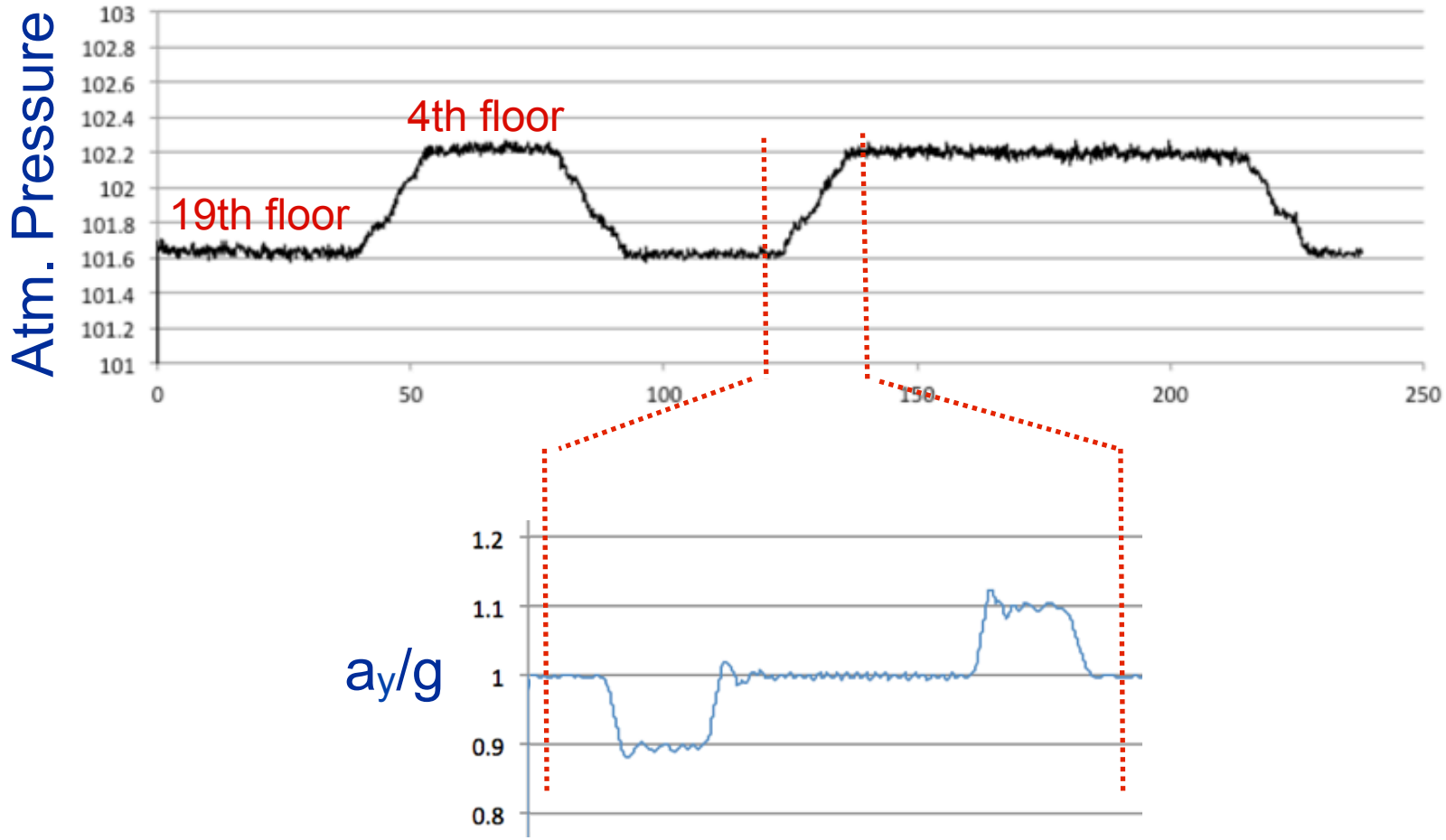
Example: Measurement of position, velocity and acceleration



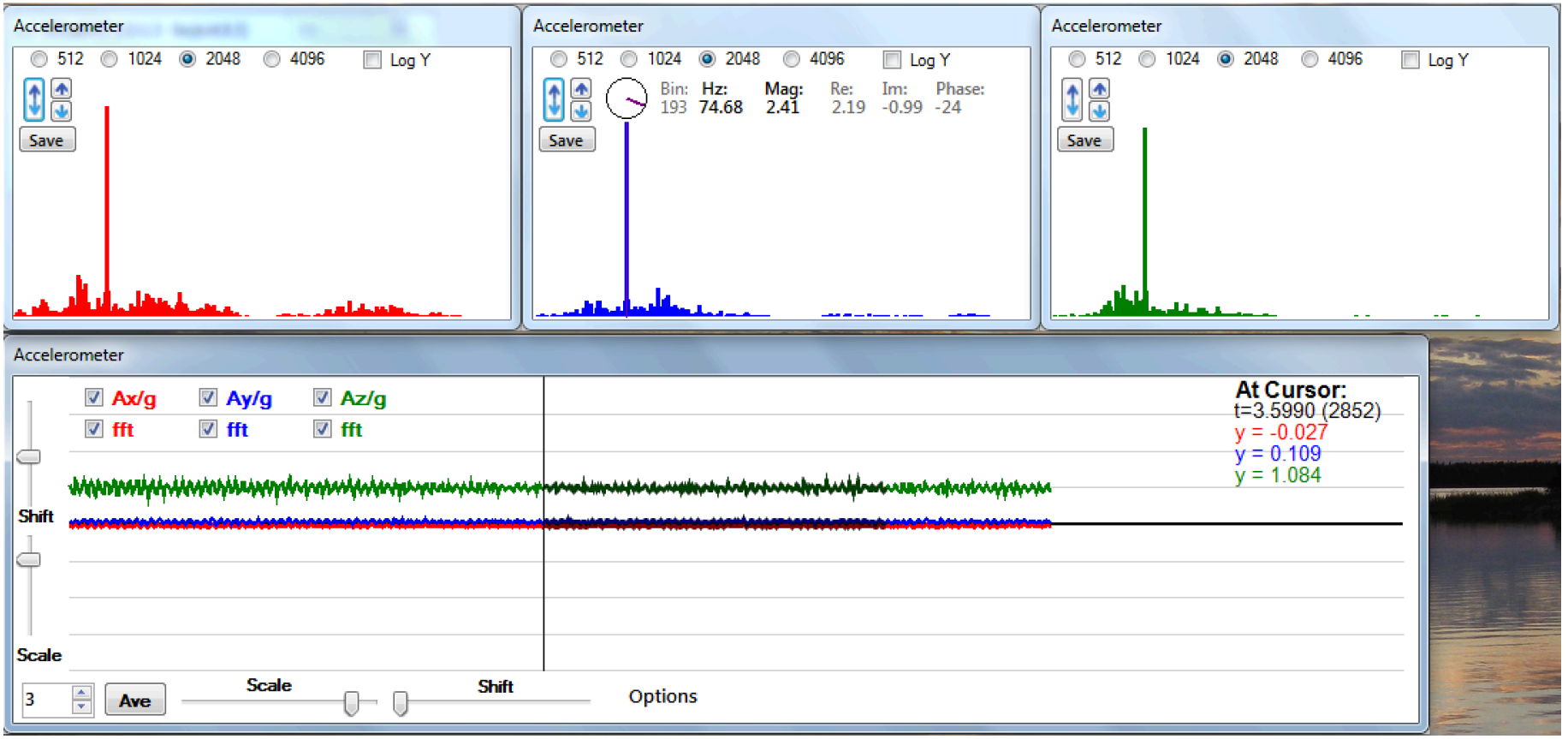
Example: Collisions


Wheel Rotation (Remote 1)
R(m)
V(m/s)
A(m/s/s)
At Cursor:
t=35.3036 (3545)
y = 0.166
y = 0.312
y = -4.288
Shift
8
Ave
Scale
Shift
Options
Force Probe (Remote 1)
Fy (N)
At Cursor:
t=35.3097 (7072)
y = -1.383 (2053.0)
Shift
5
Ave
Scale
Shift
Options
Wheel Rotation (Remote 2)
R(m)
V(m/s)
A(m/s/s)
At Cursor:
t=35.3119 (3544)
y = 0.009
y = 0.226
y = 4.453
Shift
7
Ave
Scale
Shift
Options
Force Probe (Remote 2)
Fy (N)
At Cursor:
t=35.3080 (7068)
y = 1.375 (2082.0)
Shift
Scale
Shift

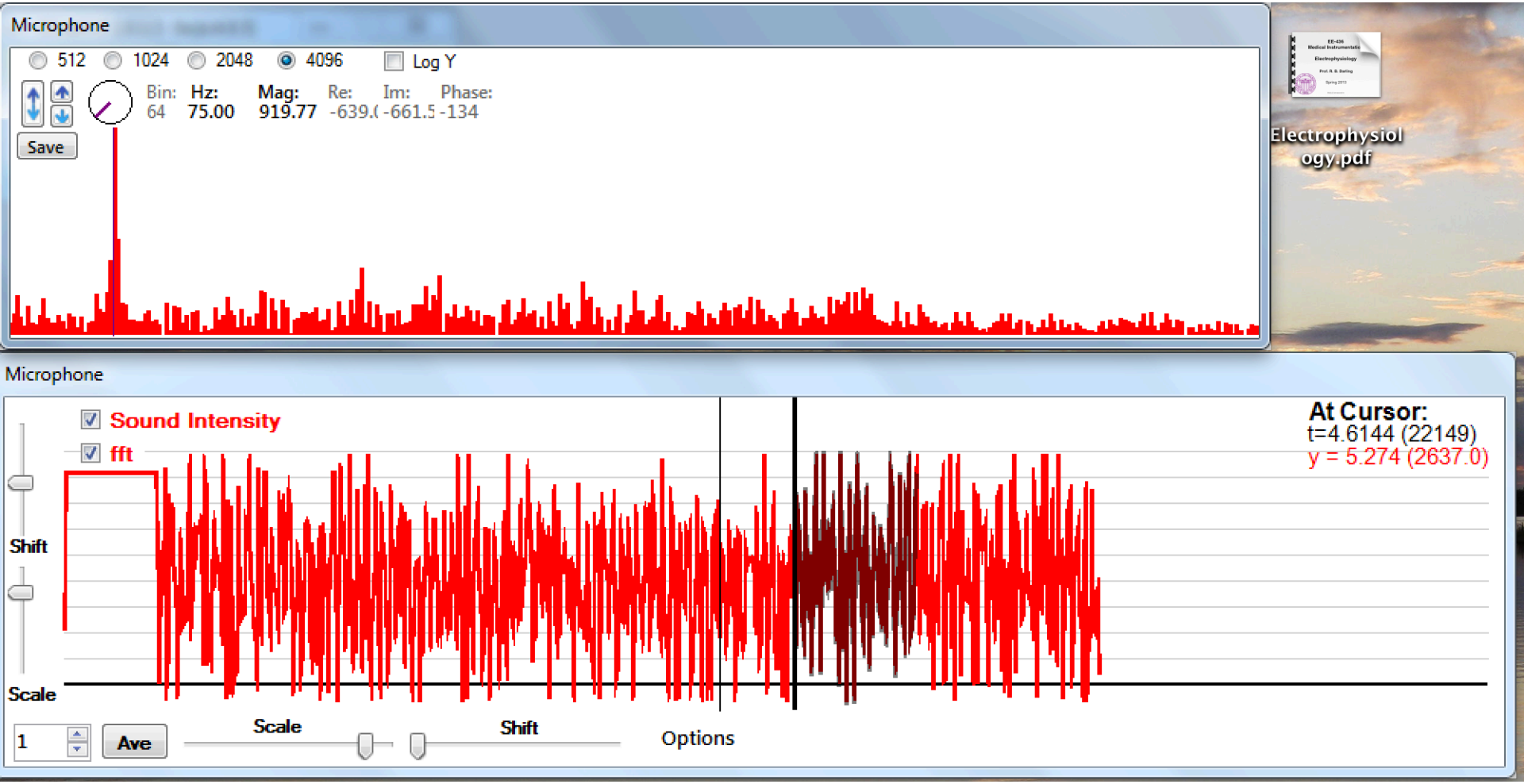
Riding an Elevator



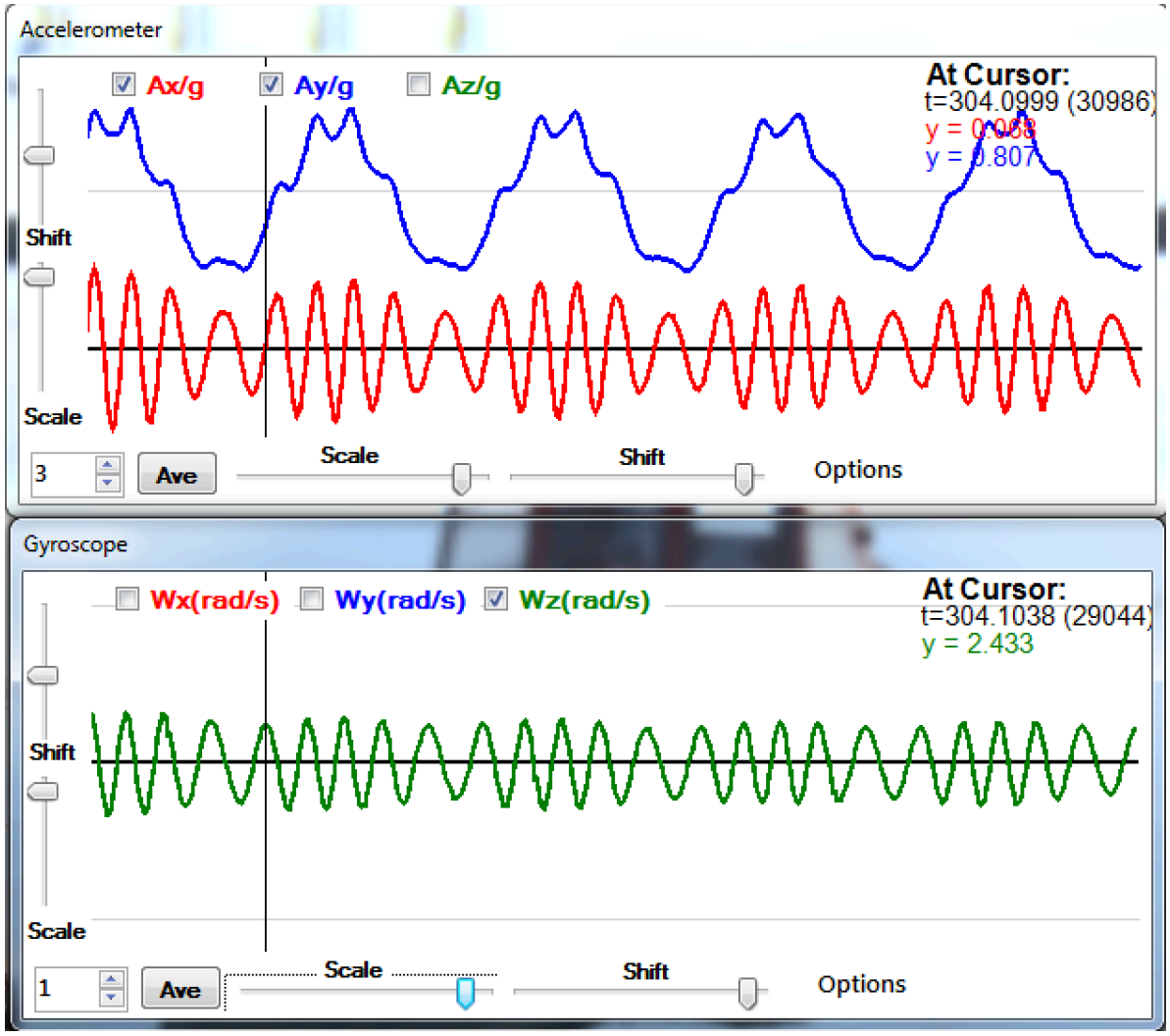
On plane to AAPT (FFT - accelerometer)

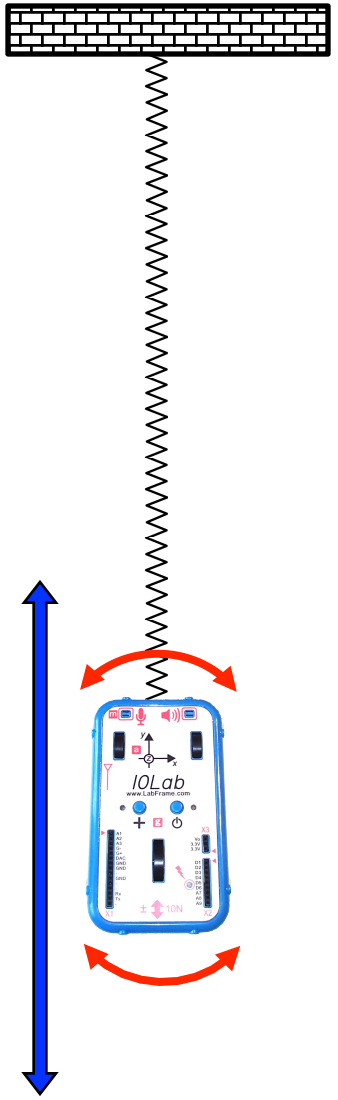


On plane to AAPT (FFT - microphone)

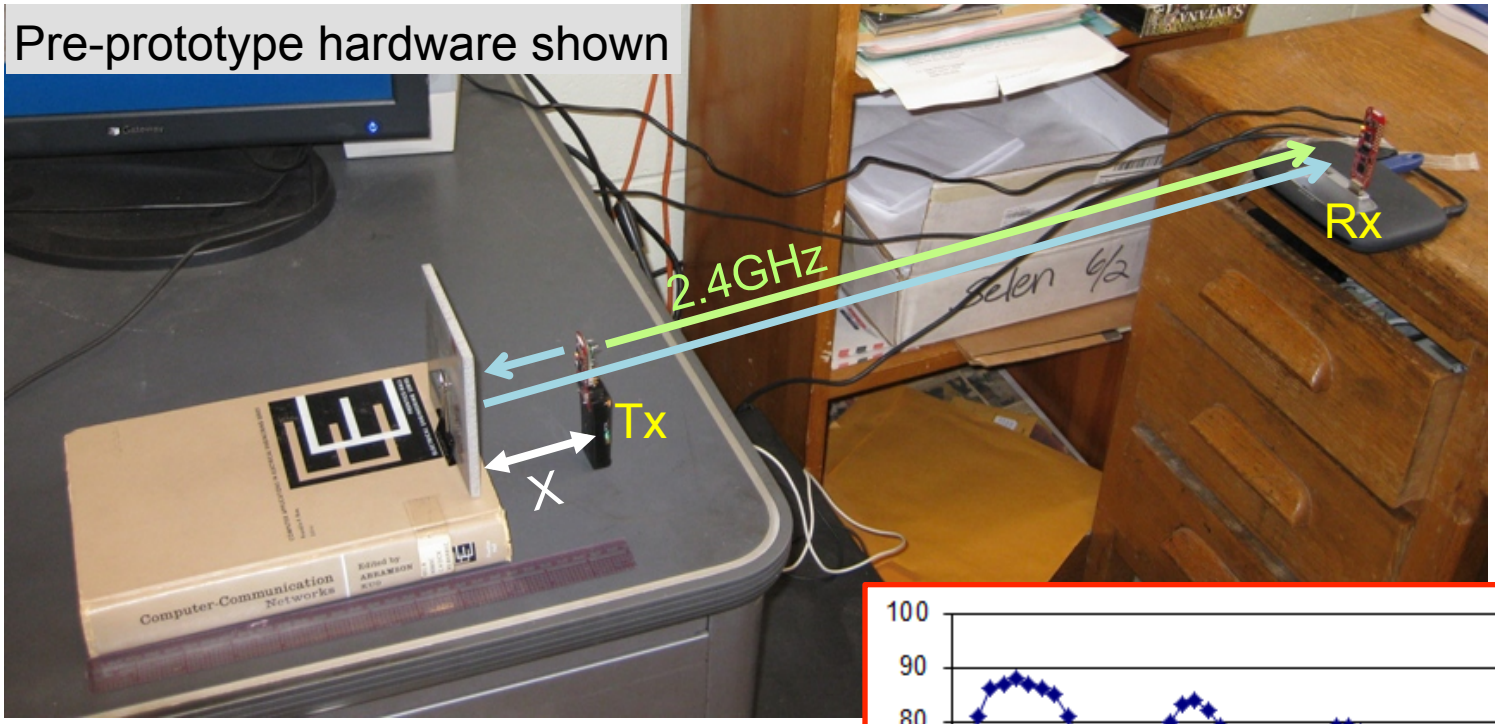


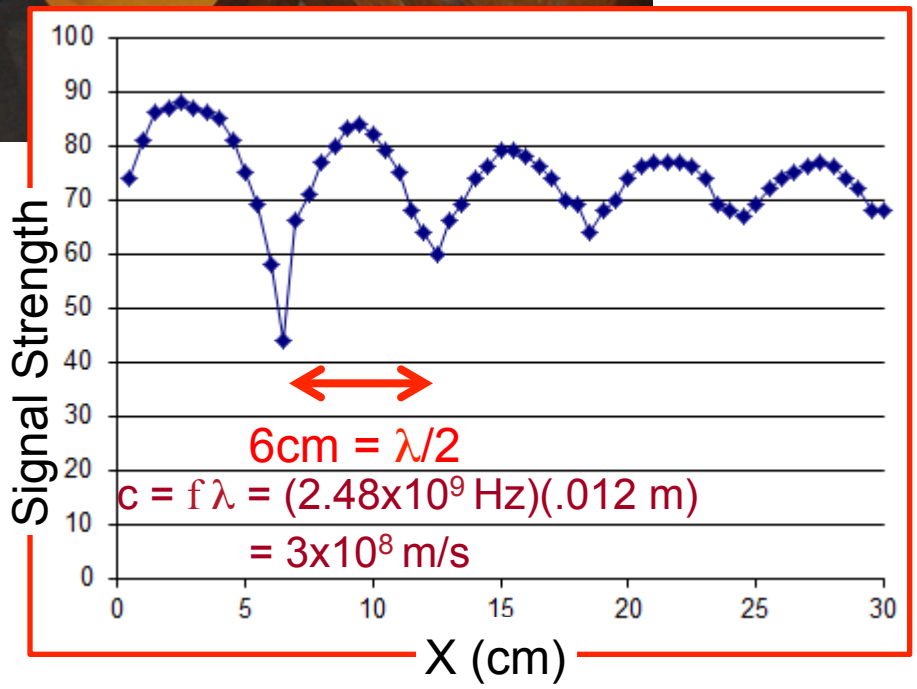
Advanced Lab: Oscillations



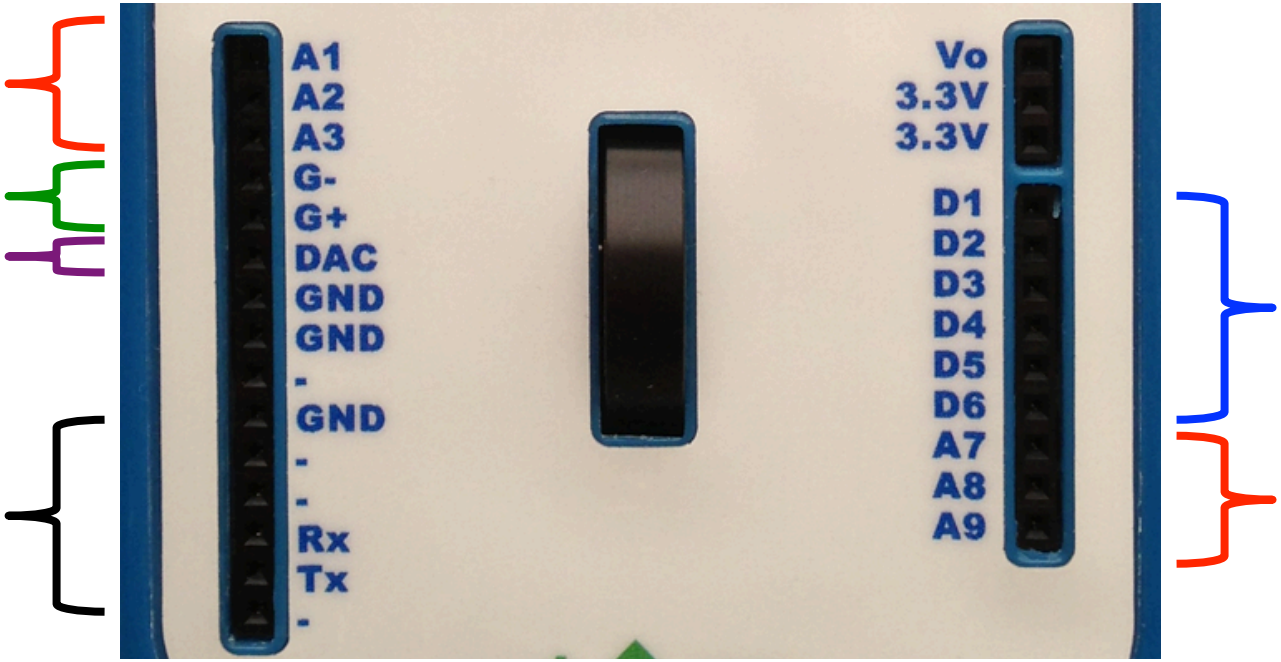


Advanced Lab: Speed of light





Top Connector



6 analog inputs

1 High Gain DC coupled differential input

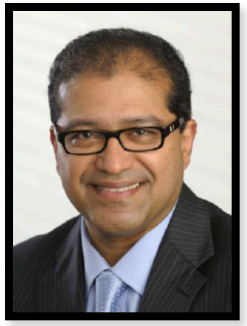
6 digital input/outputs

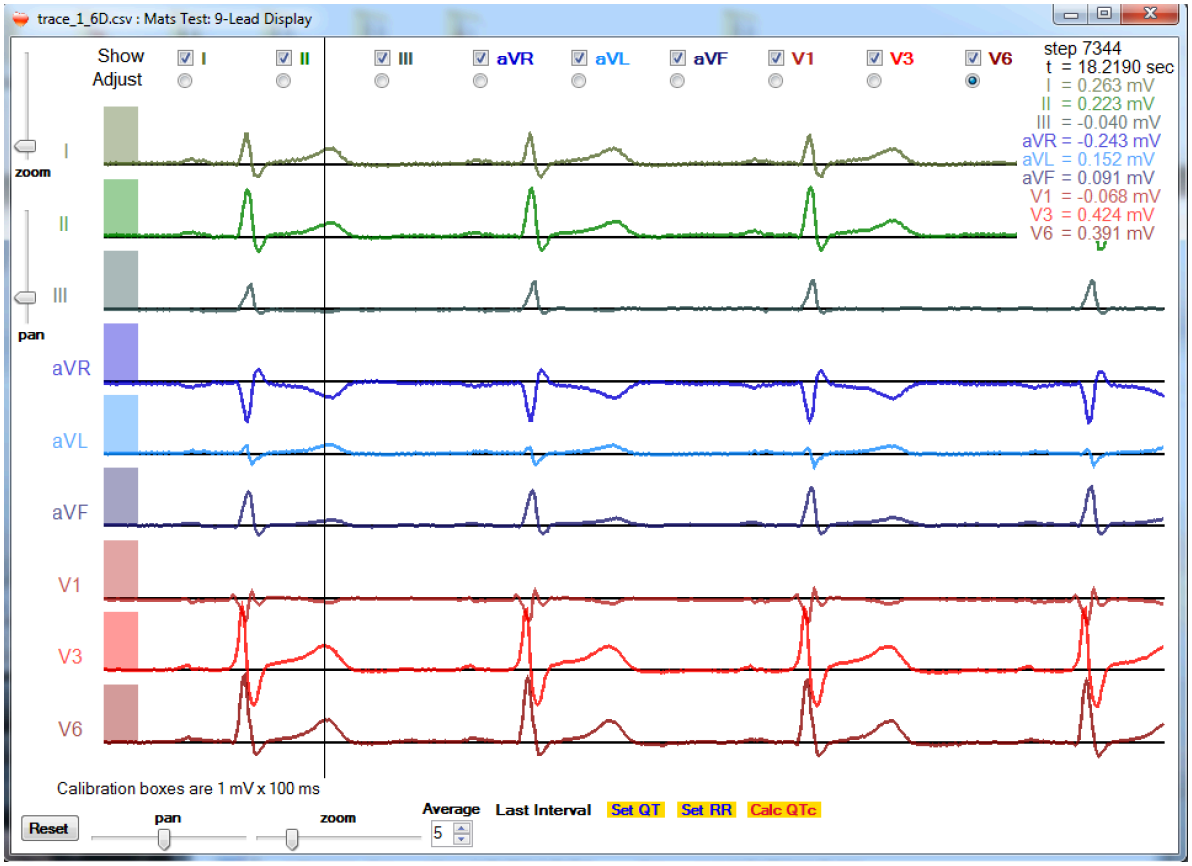
1 DAC output (8 bit)

1 FTDI header

ECG:

With U of I Med School & varsity athletic department





Simple
& cheap
& low noise

Playing is fun, but we also need to study the best way to use this tool (NSF/TUES).

Our studies are focused on students working independently on hands-on activities.

Addressing Conceptual Problems in 1D Kinematics Using Interactive Online Laboratories

Katie Ansell

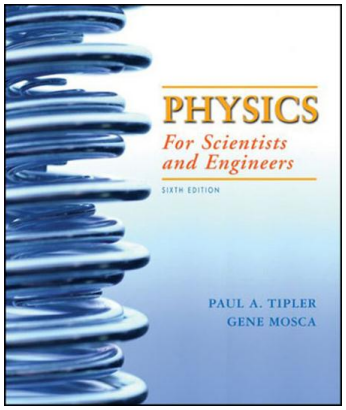
AAPT Summer Meeting

July 15, 2013

Study - 1D Kinematics Review

Reading Group

N=25



Mathematical explanations

14 numerical examples

Figures of graphed motion

30-35 minutes

IOLab Group

N=22

Training plus three guided activities

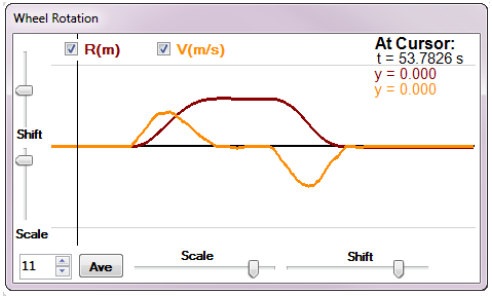
Students asked to make predictions

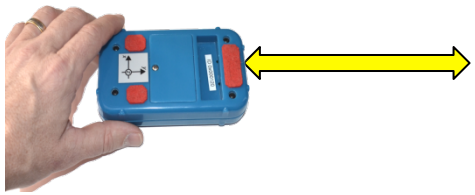
Integration tool

10-15 minutes

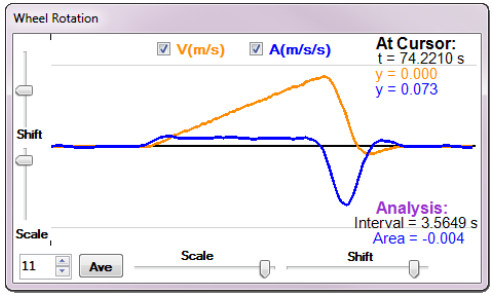
Goal 1: Address Situational Difficulties

Turning Around 1

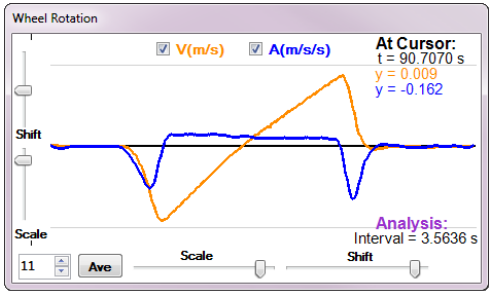


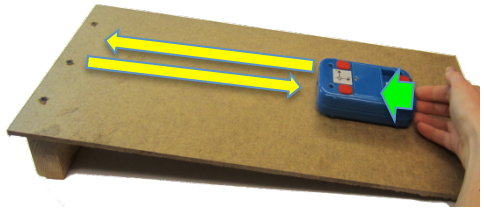


Speeding Up
(constant a)

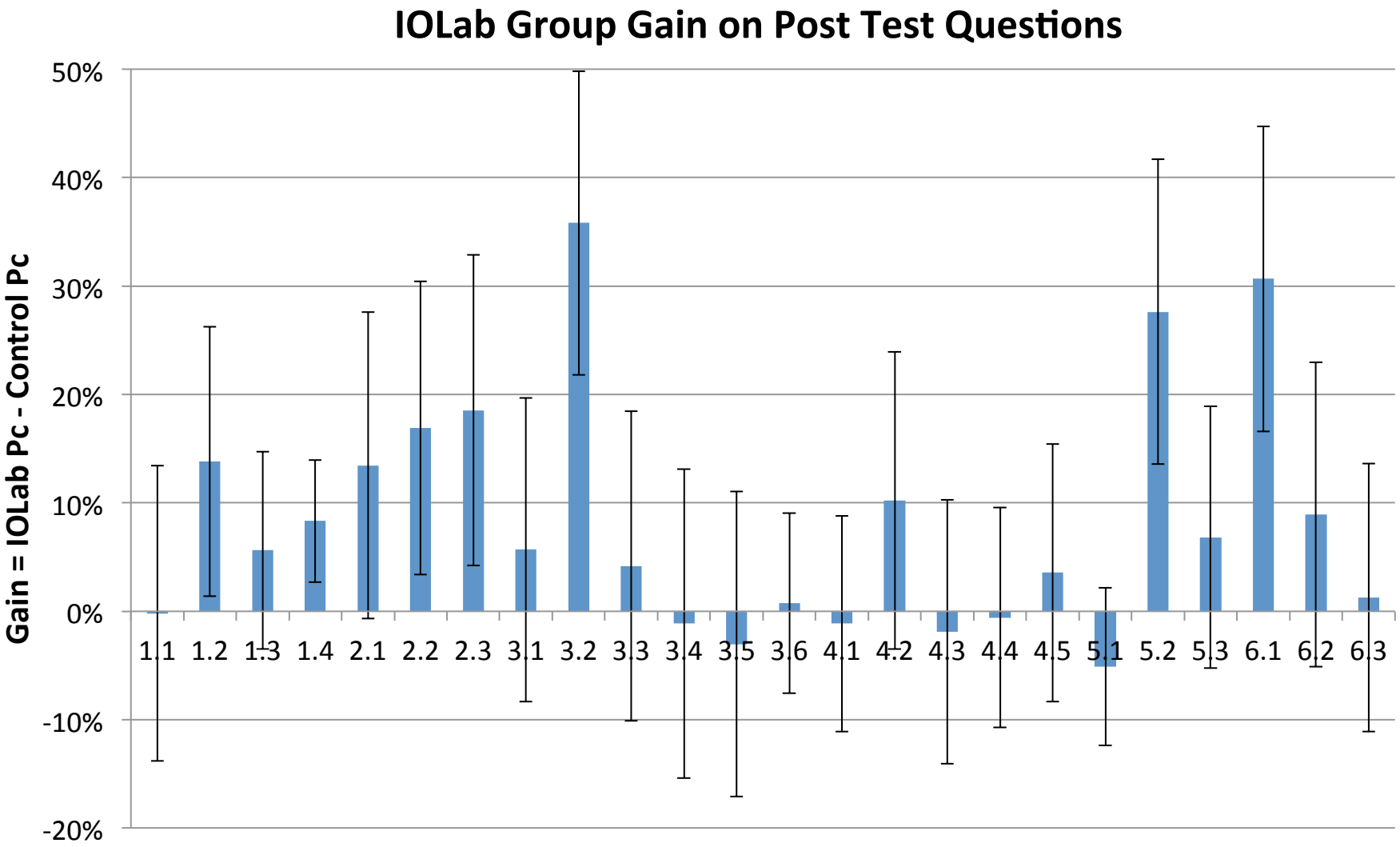


Turning Around 2
(constant a)

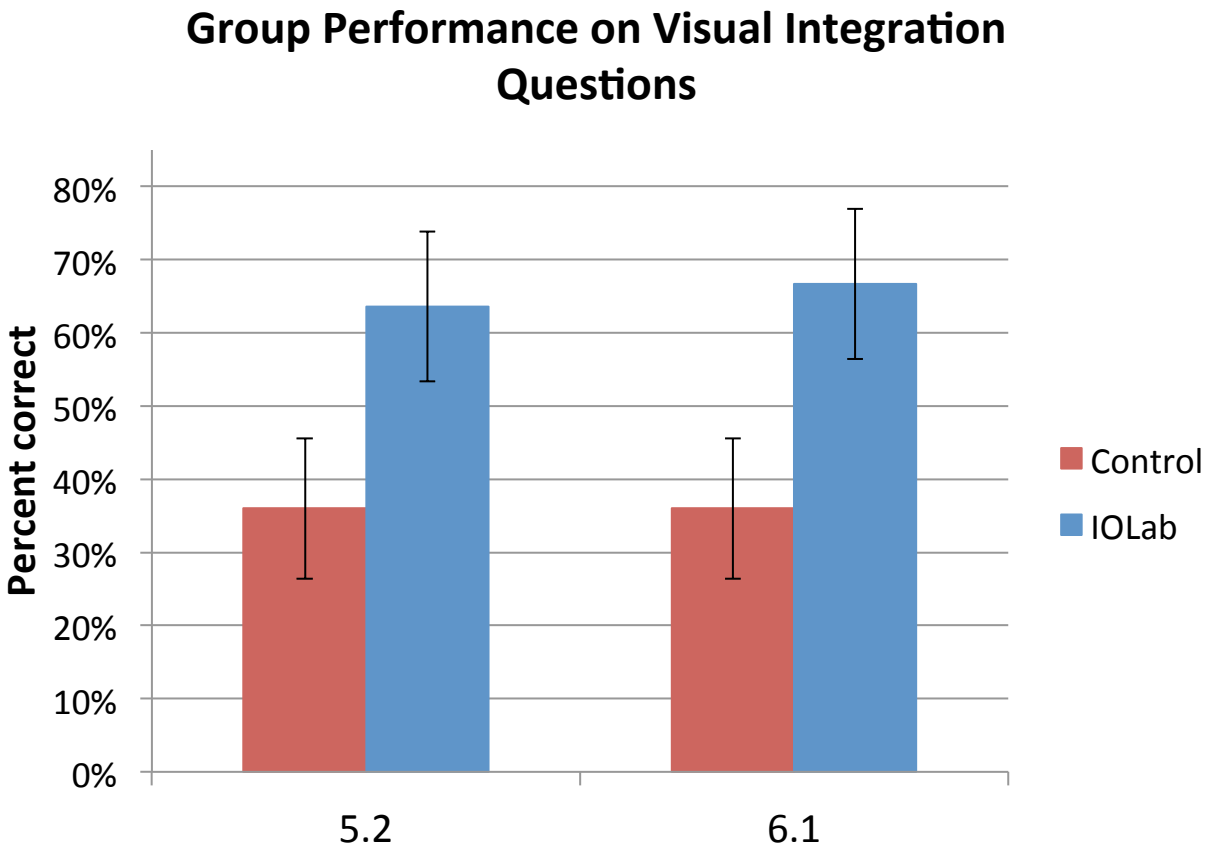




Post Test – Overall Learning Gains



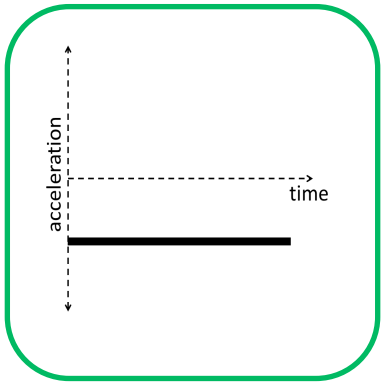
Improved Graph Interpretation

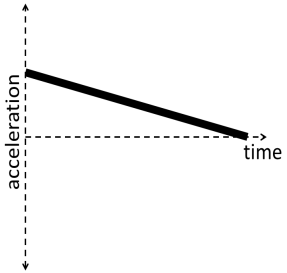


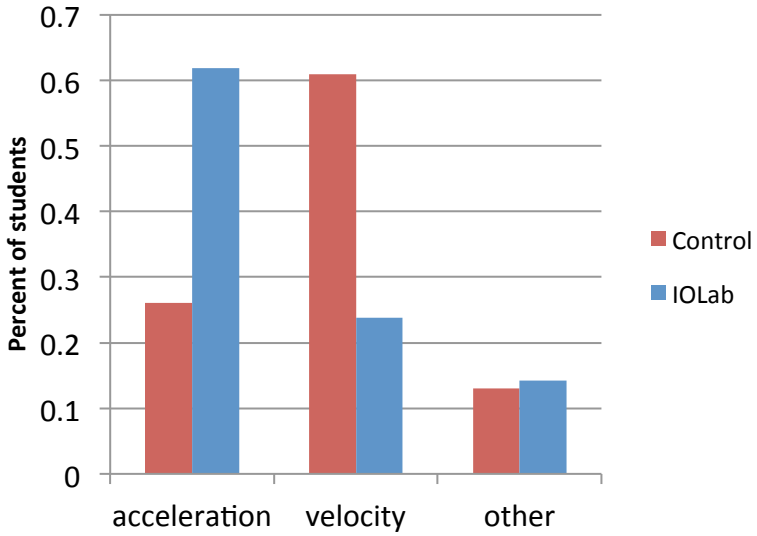
Less likely to confuse velocity & accel.

*Choose **acceleration vs time** graph which corresponds to the motion of the car:*

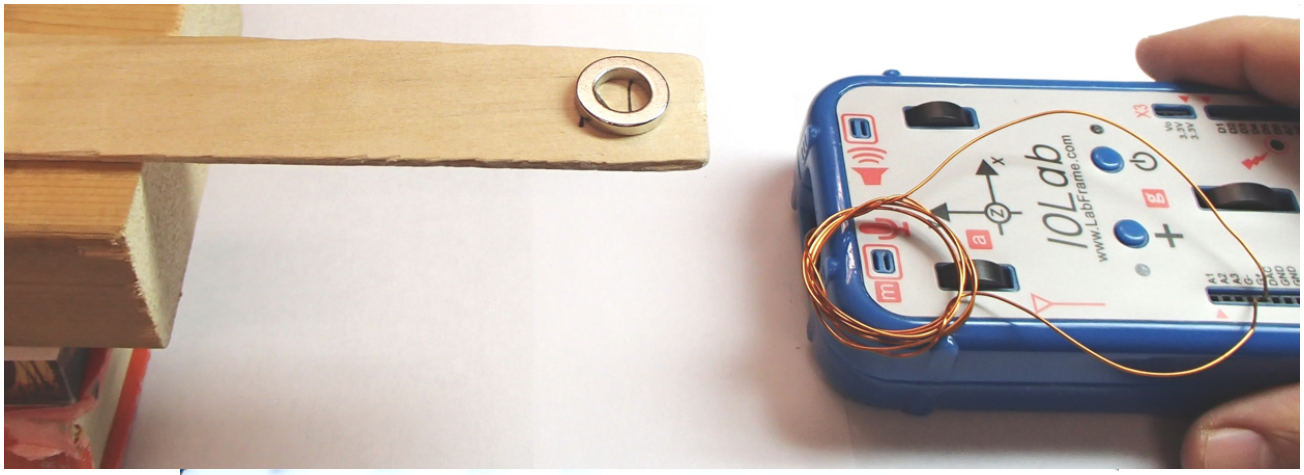
The car moves toward the right, slowing down at a steady rate.

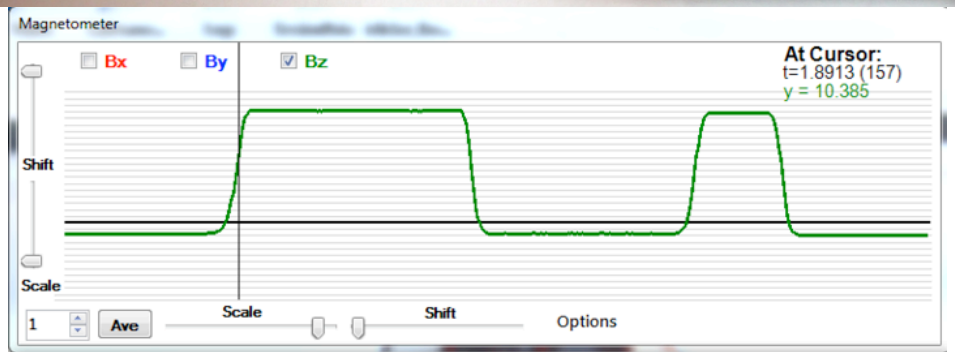


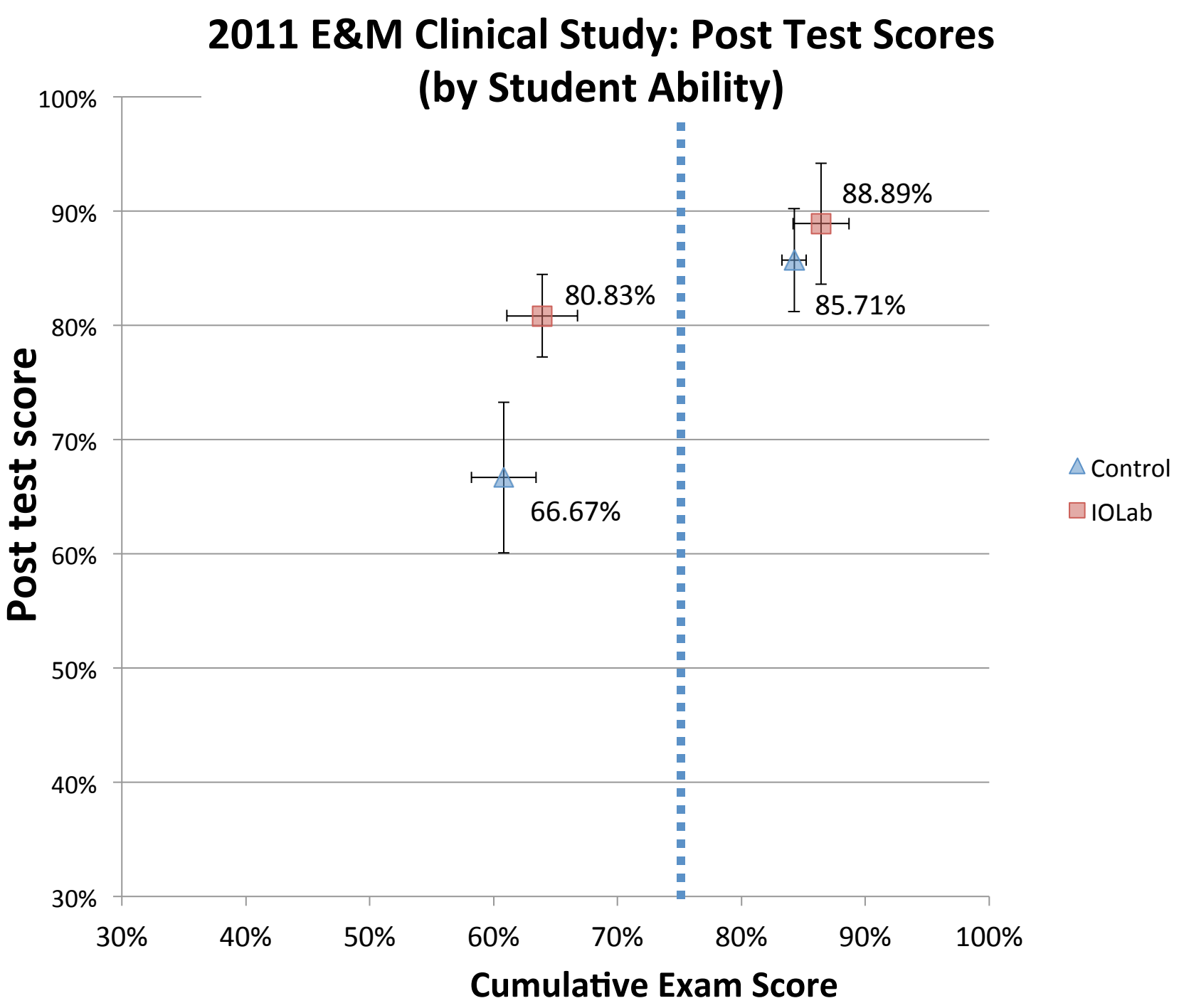




Not just mechanics:






2011 E&M Clinical Study: Post Test Scores (by Student Ability)
100%
90%
80%
70%
60%
50%
40%
30%
Post test score
88.89%
80.83%
85.71%
66.67%
Control
IOLab
30%
40%
50%
60%
70%
80%
90%
100%
Cumulative Exam Score

Future Research (Spring 2014):

- Select two groups of about 50 weaker students from calc. based mechanics class.
- Have them do hands on “dorm room” IOLab activities as part of their smartPhysics Pre-Lectures.
- Assess performance using conceptual questions developed last semester.

Physics Education Research

Software Status

- Original Windows only software
  - Full lesson driver capability
  - Used for our first 2 studies at Illinois
  - Highly capable, clunky implementation, bad developer (me)
  - MS Visual Studio/C#

- First version of new Mac/Windows software
  - Written by the developers of smartPhysics
  - Basic functionality now, sF integration to come.
  - Cross platform C++ library (public API available)
  - GUI based on AngularJS web framework running on the chromium rendering engine.

Physics Education Research

Hardware Status

- We are building 300 new devices “now”.
  - Received the first 4 last week & the rest should arrive later this month.
  - We will have enough devices to finish our own research and support several interested colleagues.
- We have a meeting with Macmillan later this week to discuss future manufacturing plans.
- As we plan the next manufacturing run we will need to figure out how many to build (so please talk to me).