Productive and FUN use of lab time!

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- Faculty work hard to create labs that encourage students to investigate important concepts.
- Outcome
 - Students rush through lab
 - Get correct answer once and are satisfied even if several other trials produced the same different answer!



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 - Students rush through lab
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 - Students divide and conquer
 - Much grumbling little engagement
 - "Remember in lab when you ..."
 - Blank look from entire class!
 - Complaint: Lab doesn't coincide with class

Previous Work

- CCK vs. Real circuits.
- Demonstrated improved performance on exam questions 2 months later.
- Simulation groups more facile with real equipment challenge.
- Students less dependent on lab instructor.





Finkelstein, Adams, Perkins, KellerWieman, Adams, Perkins (2008)(2005)Science

Previous Project – 2011/2012 Algebra-based Labs

Explore the concepts with the simulation.
 Calculations with the simulation.
 <u>III. Test with real equipment.</u>



What did we learn

- Faculty buy-in (maybe not...)
- Still have the problem that students want to finish up and leave.
- Incorporating a sim into the lab seemed to have a synergistic effect.
 - A combination lab sim and real equipment received a more consistent effort over 2 + hours from students
 (compared to either all sim or all real equipment)
- "Real" hands-on materials were most popular over "physics" real equipment or sims (intro lab).

Fall 2012/2013

1/2 recitation, 1/2 lab

- Recitation
 - Knight, Jones and Field workbooks
 - Individual work turned in (work in groups)
 - Goal: conceptual understanding (this is where the work happens)
- Lab
 - Designed for divide and conquer
 - Goal: Have fun, relate physics to life, maybe learn something



Fall 2012/2013

• Inspired by a talk by Duane Merrell at BYU



Projectile Motion

- Materials and equipment: Instructor Demonstration Pasco Projectile Launcher, wooden hoops, string, tape.
- Each group will be assigned a distance from the Projectile Launcher. Your challenge is to hang a wooden hoop at your assigned distance such that the projectile will fly through the middle of your hoop when launched.

PHYS 220 - PROJECTILE MOTION

Materials and equipment: Instructor Demonstration Pasco Projectile Launcher, wooden hoops, string, tape.

Each group will be assigned a distance from the Projectile Launcher. Your challenge is to hang a wooden hoop at your assigned distance such that the projectile will fly through the middle of your hoop when launched.

Group 1:	1.50 m
Group 2:	3.00 m
Group 3:	6.00 m
Group 4:	7.50 m
Group 5:	10.00 m
Group 6:	4.50 m
Group 7:	9.00 m

The projectile will not be launched until every group is satisfied with their hoop position. 30% of your lab grade is based on the ball successfully going through your group's hoop. The remainder of your lab grade will be based on a brief description of your approach to this problem including all calculations.

Your instructor painstakingly collected data from multiple launches of the projectile and calculated the launch speed of the projectile for your use.

When launched from the "X-LONG Range" setting at an angle of 30°, the launch speed was found to be 12.107 m/s (how fast is this in miles per hour?). During launch trials the projectile's final position varied by a maximum of 1.7 cm which is very precise!

WARNING: ONLY THE INSTRUCTOR IS AUTHORIZED TO LAUNCH THE PROJECTILE

Useful Equations:

 $x_f = x_i + v_i \Delta t + \frac{1}{2} a(\Delta t)^2$ $v_f = v_i + a \Delta t$ $v_f^2 = v_i^2 + 2a(\Delta x)$



Projectile Motion



Force Vectors

Materials and equipment: 5 sheets of newspaper, blue 2 inch painter's tape, ring stand and a 2 ounce Snicker's bar.

Your group's challenge is to use only the 5 sheets of newspaper and tape to get your Snicker's bar as far from your ring stand as possible. The group with the largest distance receives 5 bonus points.



- 1. The ring stand must stand upright, as designed, flat on the table or floor.
- 2. You can only attach your materials to the post part of the ring stand, not the base of the stand, the table, ceiling or any other item.
- 3. The Snicker's bar must be suspended only by the materials described above.
- 4. No distance below the base of the ring stand will count.
- 5. The suspended Snicker's must be in equilibrium. No motion for a full minute.
- 6. The minimum distance between the closest portion of the post to the Snicker's bar will be measured.











Good motivation and questions

People stayed to see who won!!

Why did theirs work? What is wrong with ours? Is it too heavy? Lots of tape was not a good plan was it?

Winners!



Standing Waves

• Old lab



- Listed masses, asked students to collect several data points and then graph to find the density of the string. (often students cheated and massed the string so they knew the answer)
- New lab
 - Relevant equations given.
 - Task: find density of the string.
 - Challenge: Make as many loops as you can!

Physics 221 - Standing Waves

Waves on a String

The speed of a wave is determined by the medium in which it travels. For a wave traveling on a string, the speed depends on the string tension and its density (mass/length). As you know, the speed of the wave determines the relationship between wavelength and frequency.

$$v = \sqrt{\frac{T}{\mu}} \qquad \qquad v = \lambda f,$$

Investigate

Materials and equipment: string, wave driver, function generator, weights, weight hanger, meter stick, digital balance

Attach the string to the wave driver (basically a speaker that vibrates a post as well as air) and lay the other end of the string over the pulley. Attach a weight hanger to the end of the string nearest the pulley and then add some weight (as much or little as you like) to the hanger. Connect the banana plug cables to the wave driver and then to the function generator. Select the sinusoidal output on the function generator. The function generator powers the wave driver; using the frequency control on the function generator you can vary the frequency of vibration of the string. Make sure that the wave driver is unlocked.

Vary the frequency of the function generator to find frequencies that are just right to create standing waves on the string.

Challenge

Create a standing wave with as many loops as you can. When you've found the maximum number of clear loops possible, write you result on the board.

Task

Use an experimental technique of your choosing to determine the mass density, μ , of your string. Write your value on the board along with a very short (10 words or less) description of how you found μ .

Plan

After seeing other lab groups' values for linear mass density and considering how you found your value today, what would be a more accurate way to find μ ? You don't have to do the experiment but please describe carefully how you could have performed a more careful experiment to come up with a more accurate value.

How did it work

- Most tried to use the equations but with one data point.
- Didn't think to measure it directly
- Wildly different numbers on the board
- Motivated students to figure out what went wrong (added about 30 minutes of engaged activity)
- Suggested plan to make a better measurement had a lot of the right things in it!
- Some students chose to work on getting the largest number of loops.

What seems to work

- Balanced Challenges
 - Not too hard OR too long
 - Challenge or competition between lab groups
- Student choice
 - One of the hardest things for me to let go of!
- Real life materials
 - Force lab, rotational motion demo lab, elastic properties of plastic spoons, straw instruments, lenses, mirrors, tape lab, EKG, ...

How do I know?

- Measure engagement by:
 - If they stick around after they finish their lab
 - Time spent on iPhone



How do I know?

- Measure engagement by:
 - If they stick around after they finish their lab
 - Time spent on iPhone
- Measure understanding by:
 - Quality of questions during lab
 - "Why did theirs work?"
 - "No... that won't help. If you add mass it'll increase the wave speed and that increases the size of the loop!"
 - Comments during class or in office hours:
 - Not only do they remember lab, they bring it up. "It's like in lab when we did this..."

Still figuring things out

- Too hard once students brains are tired lose em!
- Some directions can't be written down
 for example lenses and mirrors
- Almost impossible to have a successful lab after an exam

Conclusion

- Split lab into two 1½ hour chunks (recitation and lab)
- Lab goals: fun, student choice, real life connections
- Faculty buy-in (?)

Labs are posted <u>here</u>