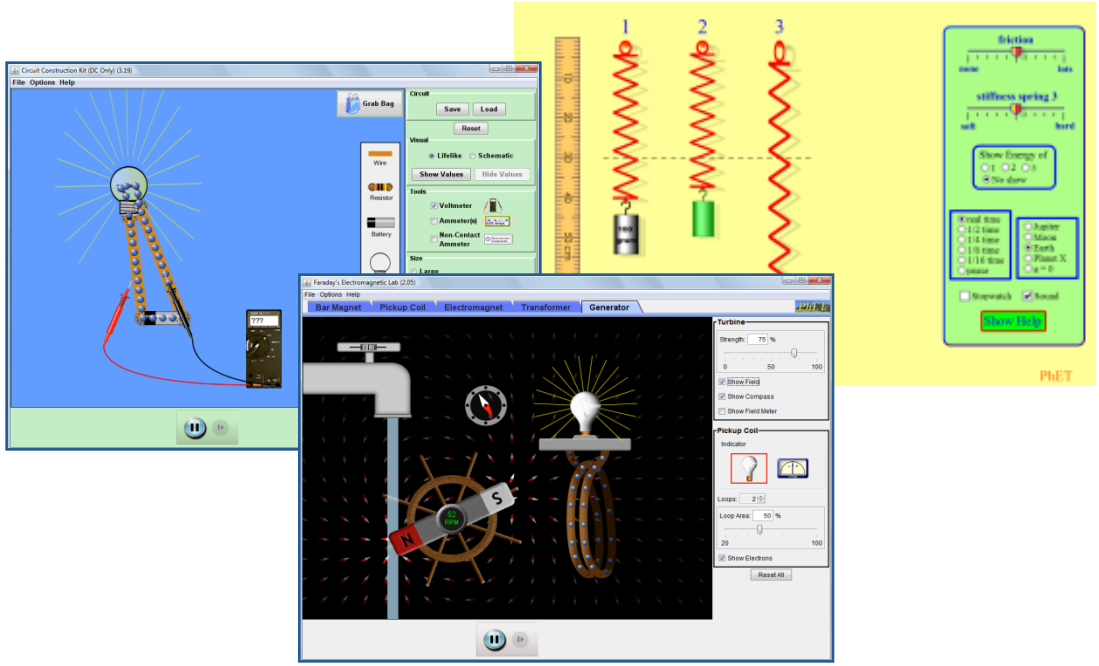
PHET
INTERACTIVE SIMULATIONS
University of Colorado **Boulder**



Teaching Physics with PhET simulations:

Free, researched, web-based resources

Sam McKagan

American Association of Physics Teachers

Seattle Pacific University

(former PhET postdoc, now PhET consultant)

Workshop Learning Goals

Be able to …

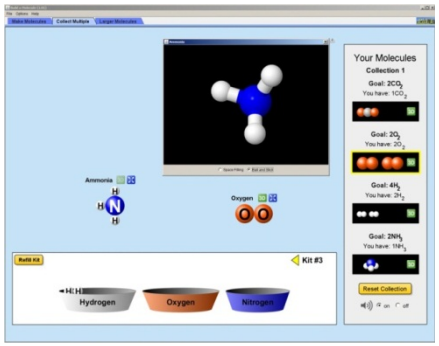
1. Explain key design features of PhET simulations, and when/why you might want to use (or not use) a PhET sim

2. Integrate PhET simulations into instruction in a variety of ways – including in combination with specific teaching strategies (e.g. peer instruction)

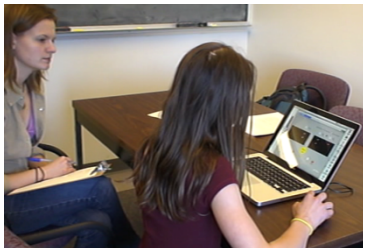
3. Use some key research findings around simulations to guide that use in class.

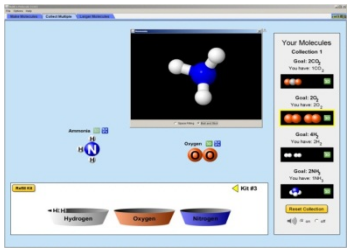
Intro to PhET

Product Development



Research





Classroom

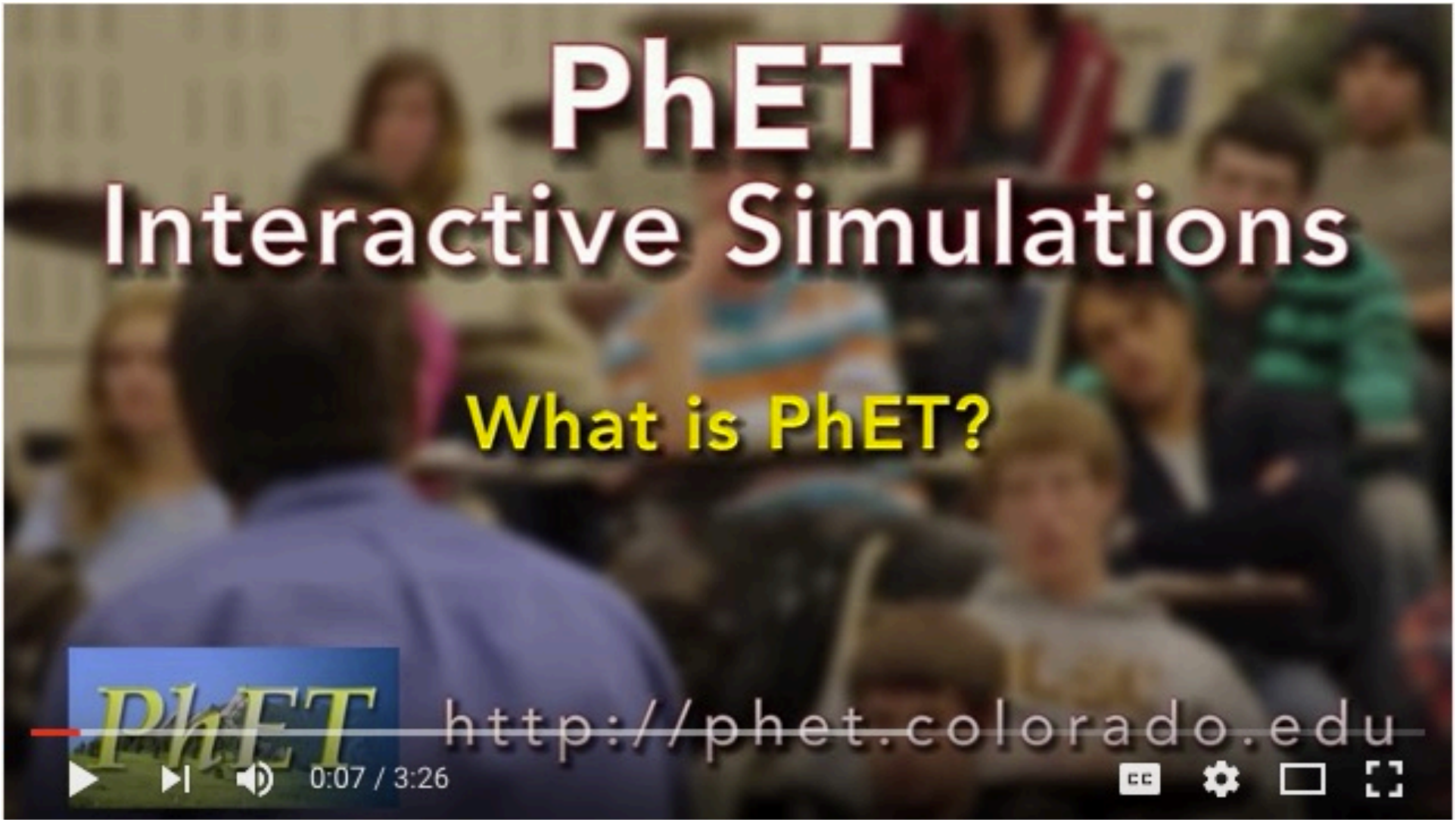
Integration

Teacher

Student ⟷ Student

The PhET Team

Faculty, Education Researcher/Designer,
K-12 Teachers, Students, Software Developers

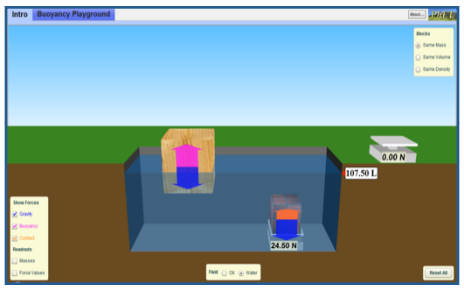


Video: https://www.youtube.com/watch?v=4Hj6GqBRpA0

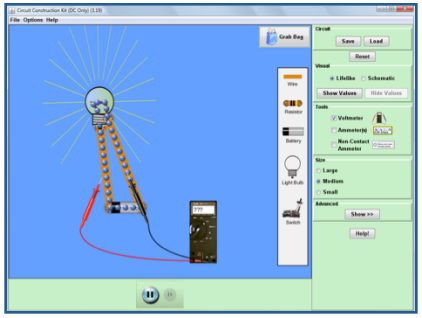
PhET for College Physics

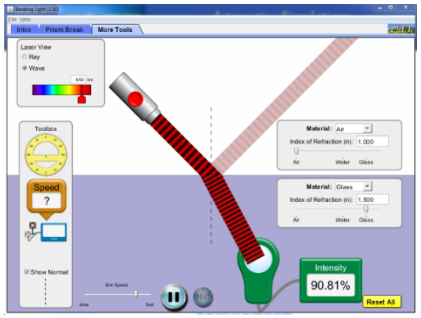
Total of **130 interactive sims** with **91 for college physics**
Most Java and Flash → Moving to HTML5 (slowly)

Mechanics

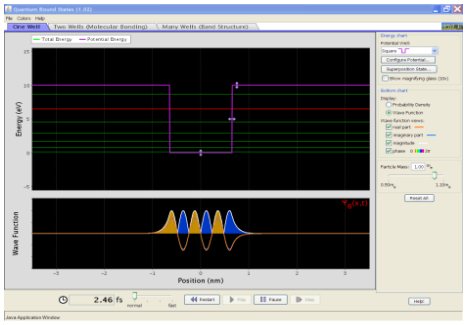


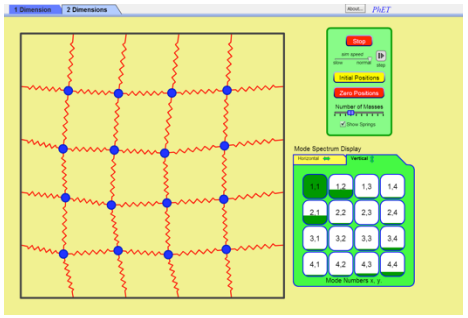
E&M



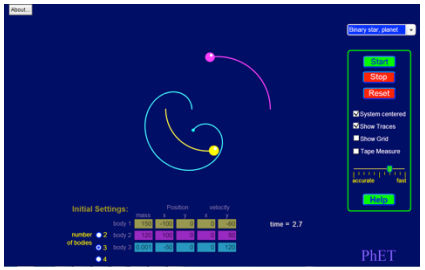


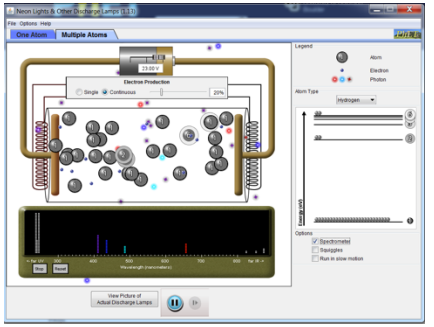
Upper Division





Astronomy

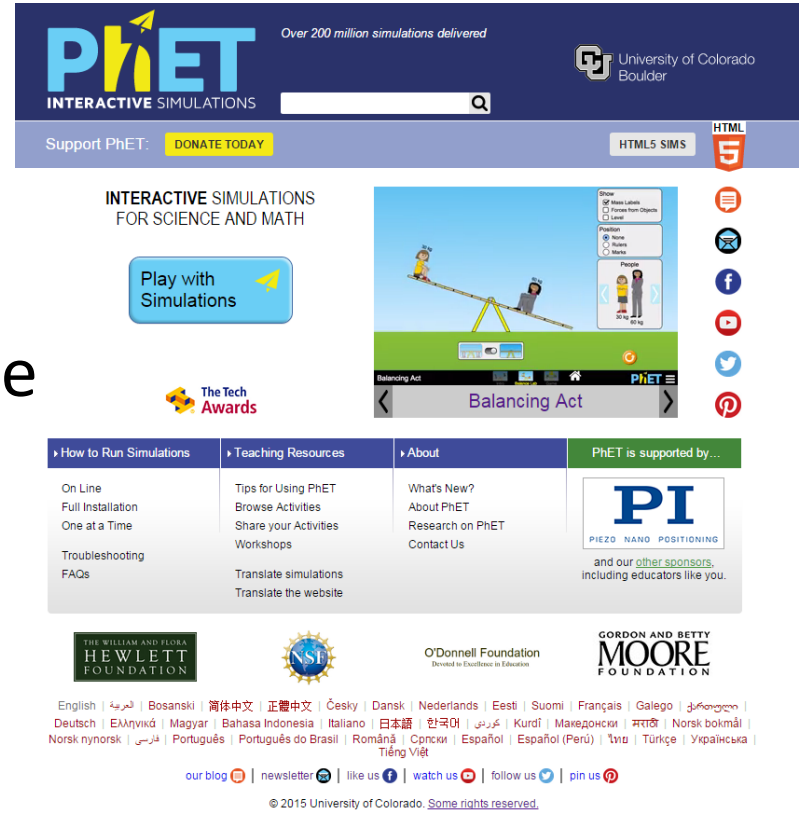




Finding PhET

- **Open-use License:** Creative Commons – Attribution

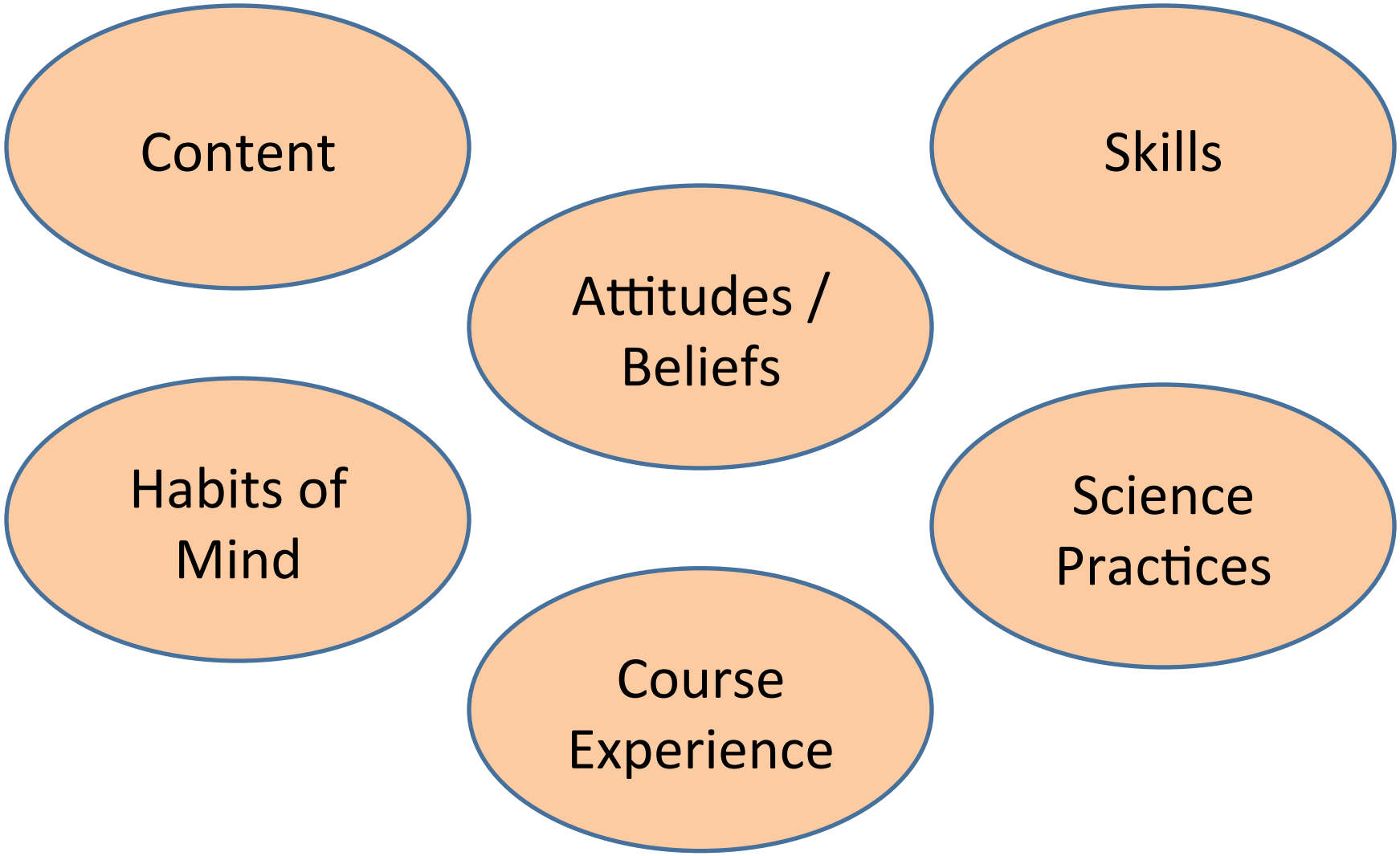
Use online



Or download!
(~300 MB)

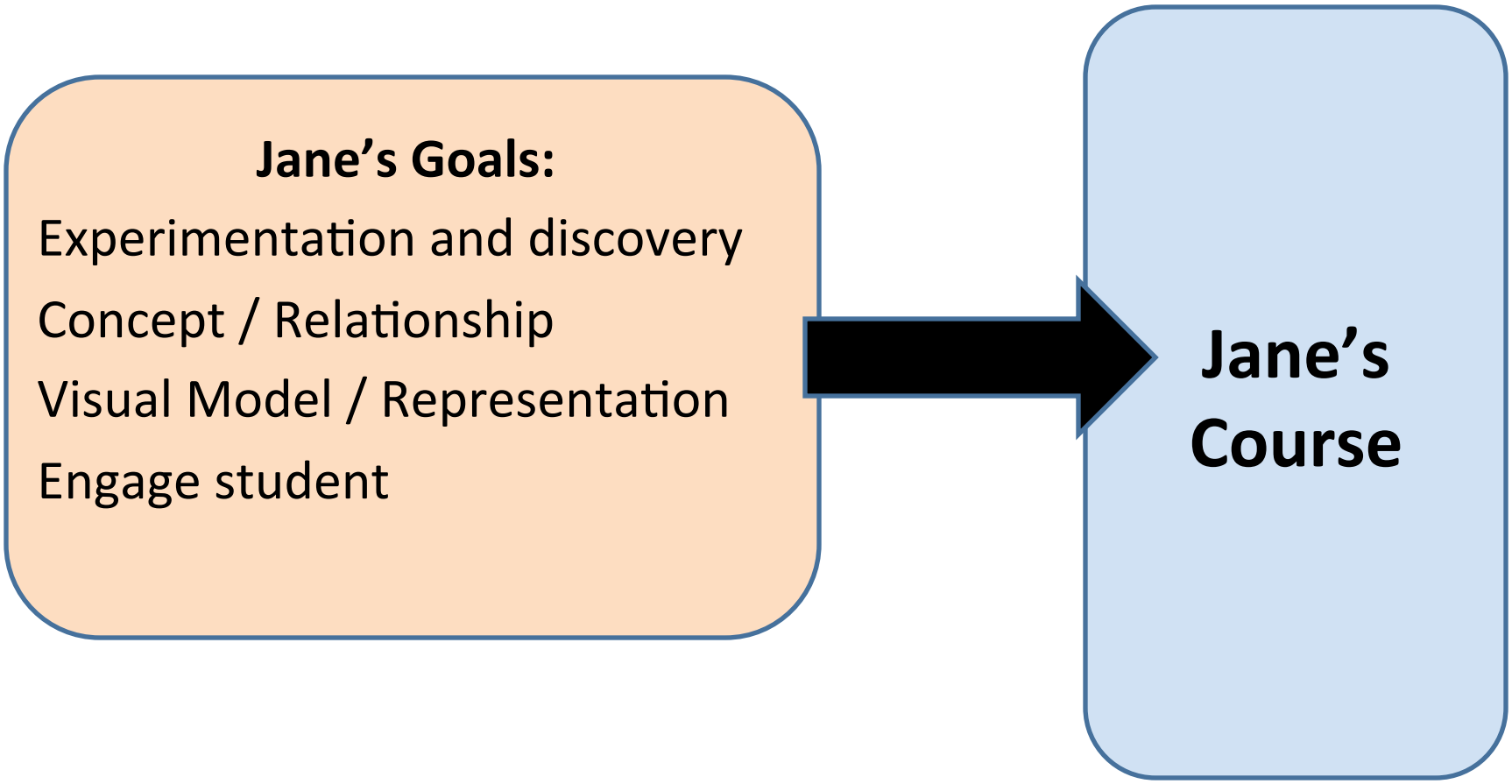
http://phet.colorado.edu

Thoughts: How might PhET help **your goals**?



Thoughts: How might PhET help **your goals**?

Integrating PhET into Instruction



How might you use these sims in your course?

Ideas for Implementations:

Designed for versatile use

- Pre-lecture assignment (e.g. Just-in-time-teaching)
- Interactive Lecture Demonstration
- Concept Questions and Peer Instruction
- In-class activity
- Lab or Recitation
- Homework

Use in lecture

Use in lecture:

- Lecture Demonstration / Visualization

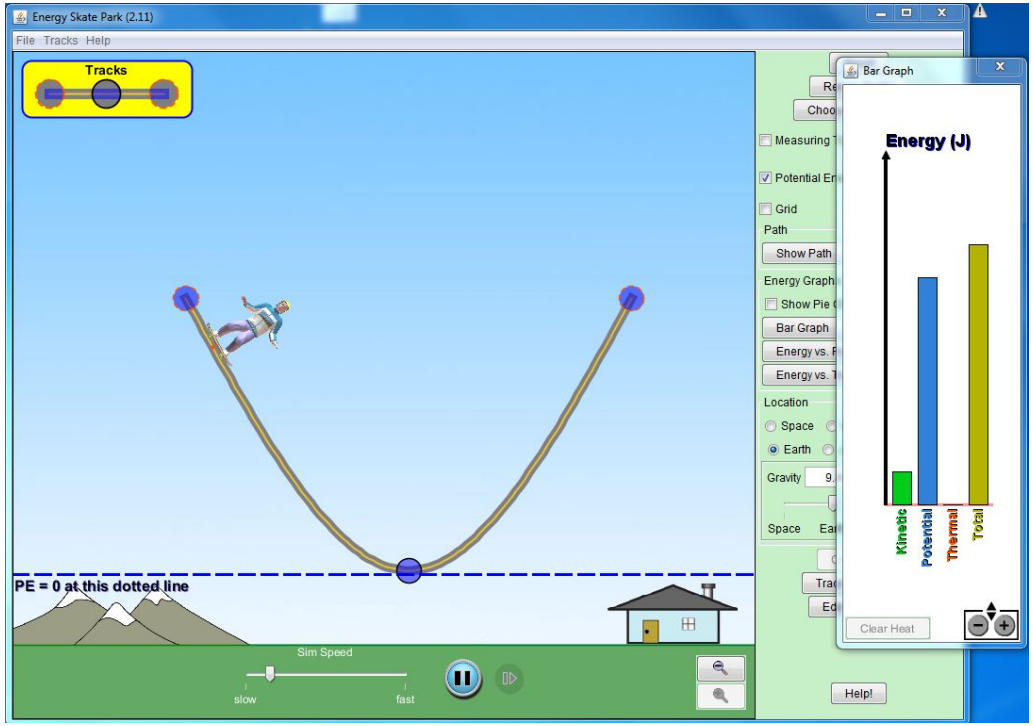
Going beyond demos:

- Coupled with Concept Tests and Peer Instruction
- Interactive Lecture Demos
- Interactive Discussion with Predications
- Whole Class Inquiry (student-suggested experimentation)

See Teaching Resources for helpful videos:

http://phet.colorado.edu/en/teaching-resources/usingPhetInLecture

Example Concept Test



I move the zero of PE up to the starting point of the Skateboarder (skateboarder still starts from rest).

The total energy of the system is now:

A) Zero

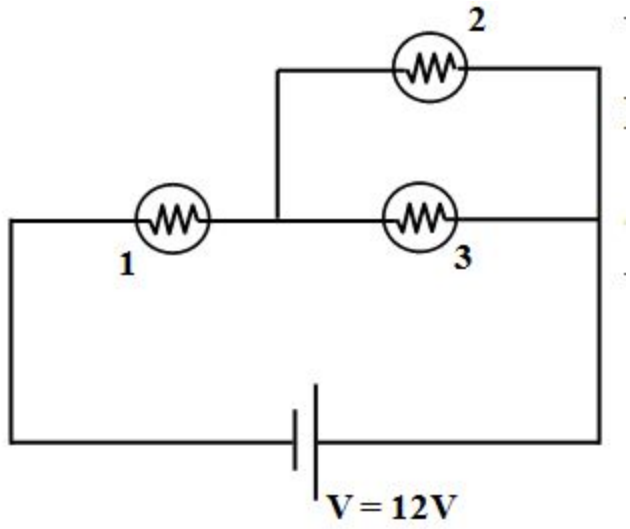
B) Positive

C) Negative

D) Depends on the position of the skateboarder

Energy Skate Park

Example Concept Test



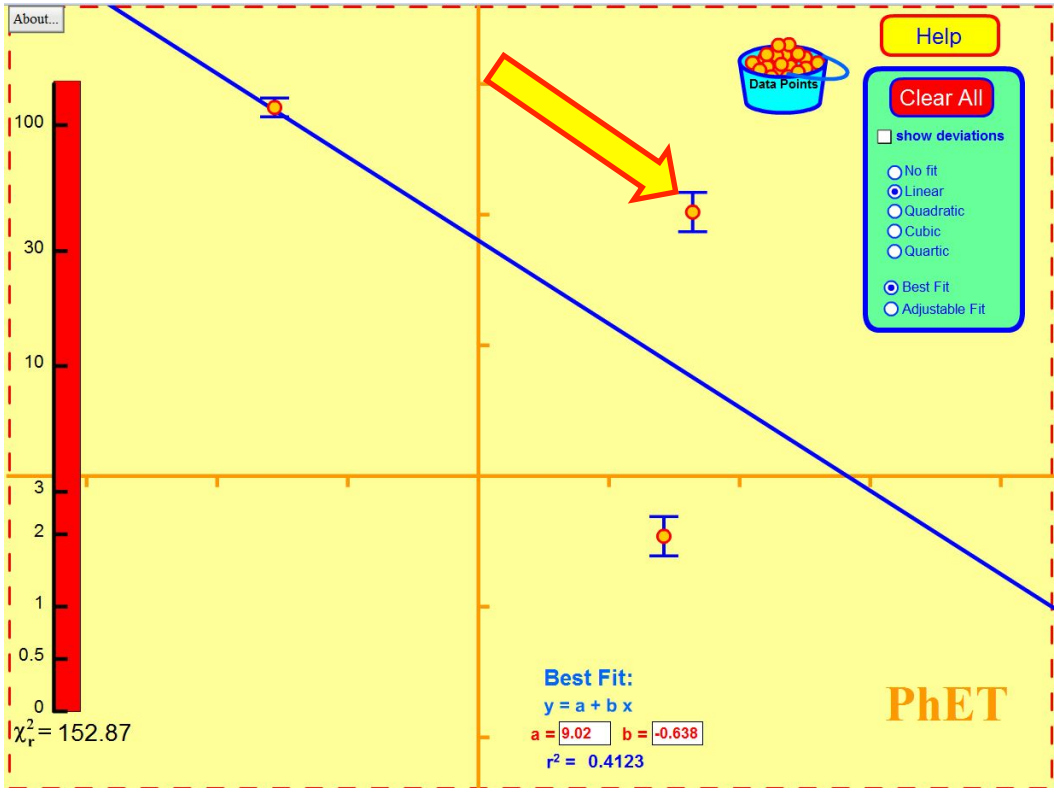
In the circuit, what happens to the brightness of bulb 1, when bulb 2 burns out?
(When a bulb burns out, its resistance becomes infinite.)

A) Bulb 1 gets brighter
B) Bulb 1 gets dimmer.
C) Its brightness remains the same.

(Hint: What happens to the current from the battery when bulb 2 burns out.)

Circuit Construction Kit

Example Concept Test



If we increase the error bar on the data point shown, what happens to the slope of the best-fit line?

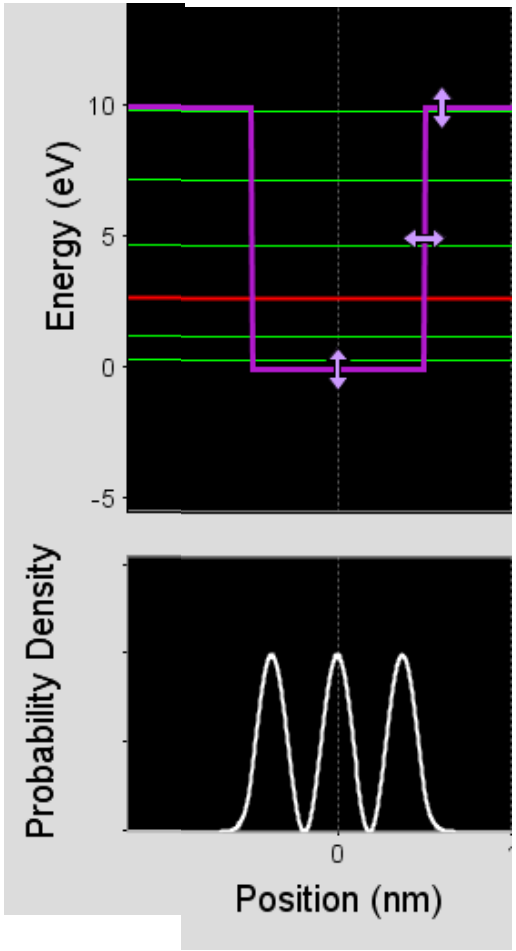
A) It becomes more negative (line tilts CW).

B) It becomes less negative (line tilts CCW).

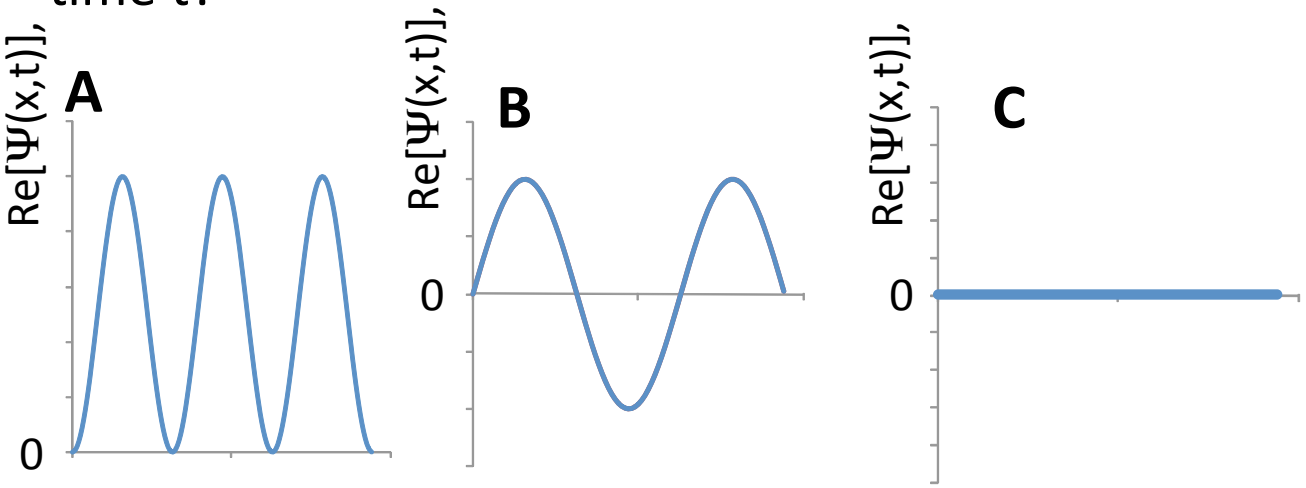
C) It does not change.

Example Concept tests

Probability Density for n=3

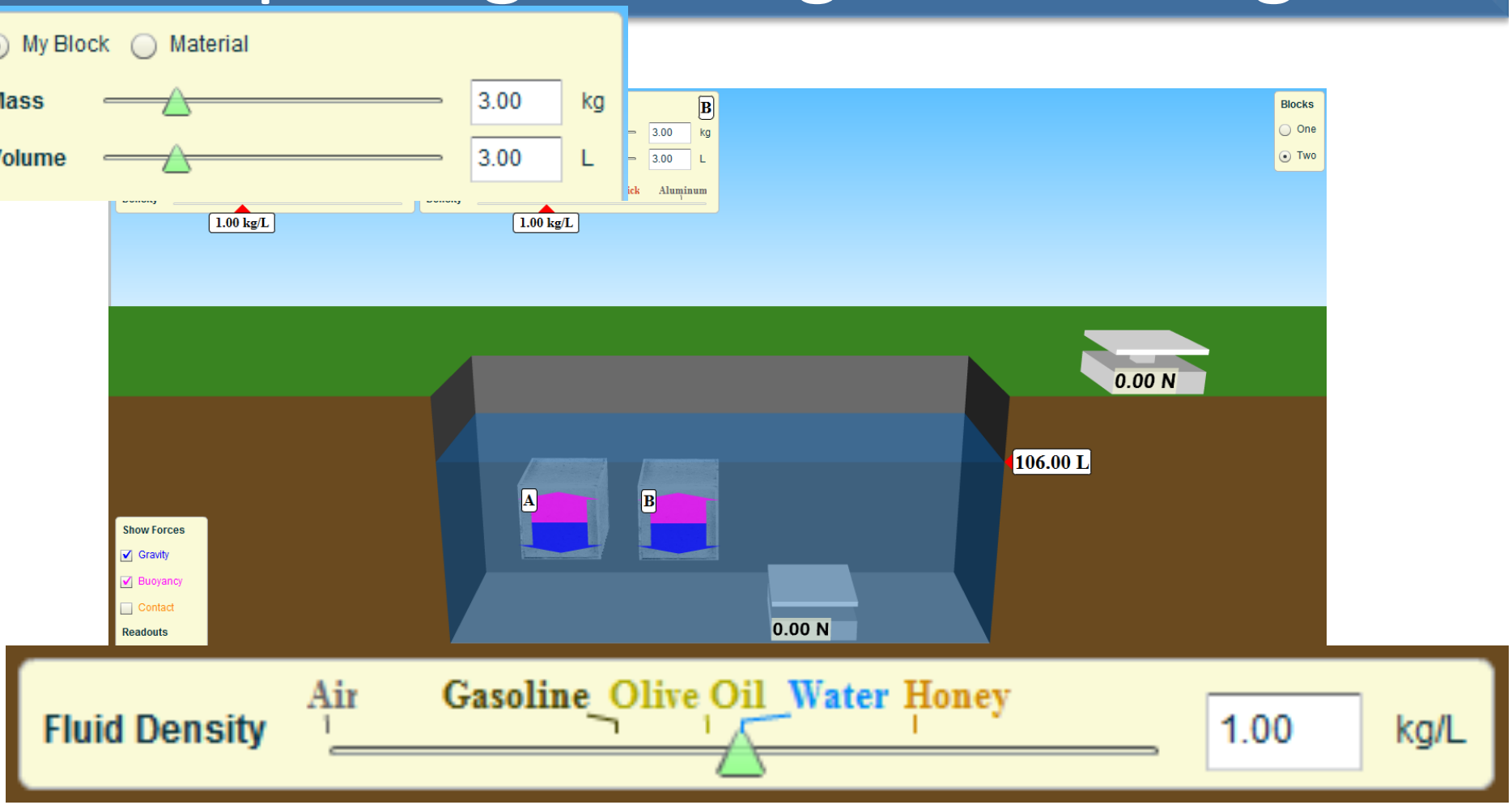


Which of the following are possible graphs of the **real-part** of the wave-function, Re[Ψ(x,t)], at some time t?



D. B and C are both possible

Exploring floating and sinking



What change would make these blocks float?

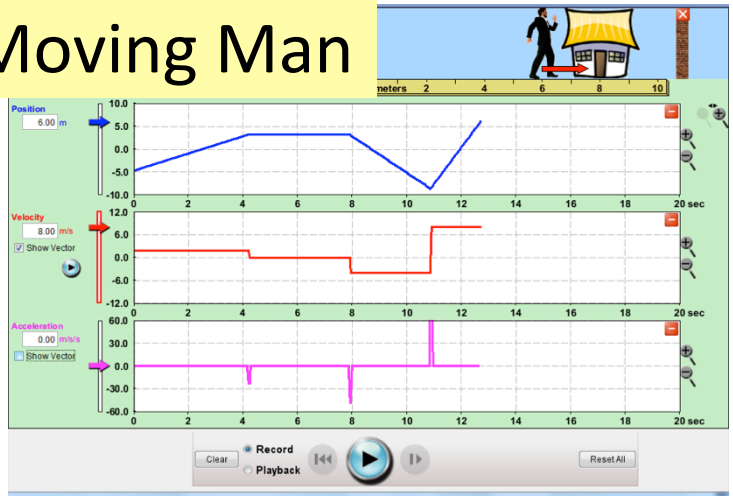
And why?

(How many strategies can you find!)

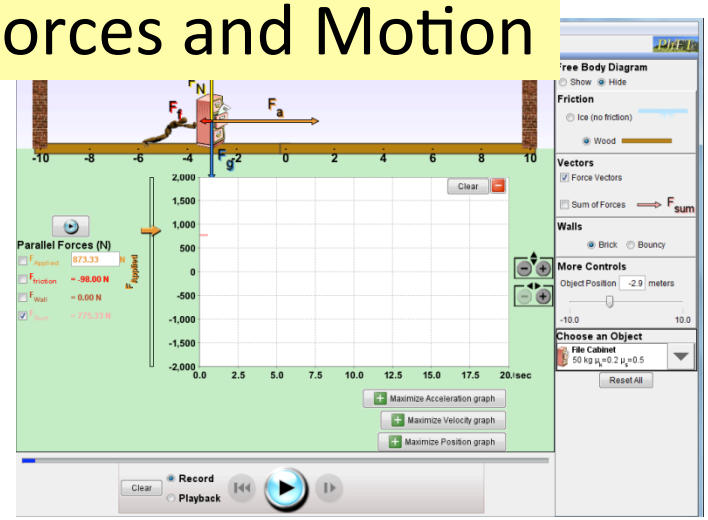
Buoyancy

Interactive Lecture Demo (ILD) mode

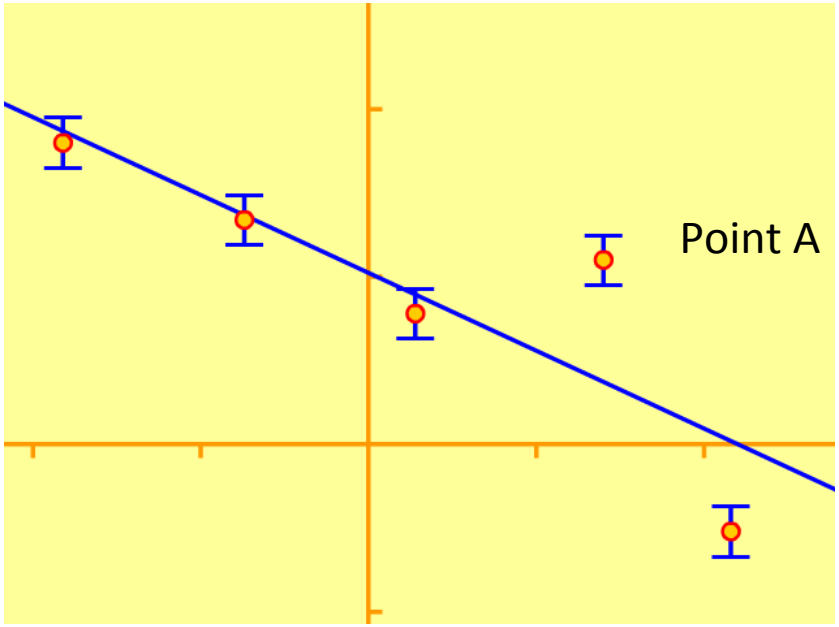
Moving Man



Forces and Motion

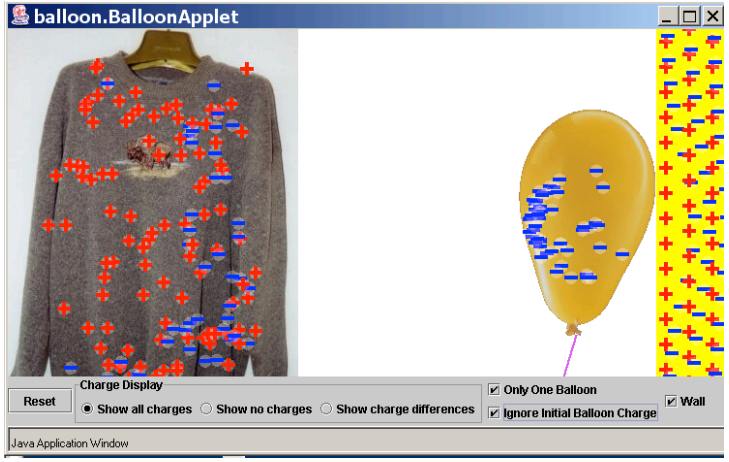


Predict how the best fit line will change if the error bars on data point A increase. (Draw your answers)



Impact on Discussion

Many More Questions and Class-led Exploration:



1) If you rub the sweater on the balloon will electrons transfer the other way?
2) Can you polarize something where the protons move?
3) Are there <u>any</u> situations in which the +'s move?
4) In an insulator, are the charges stuck?

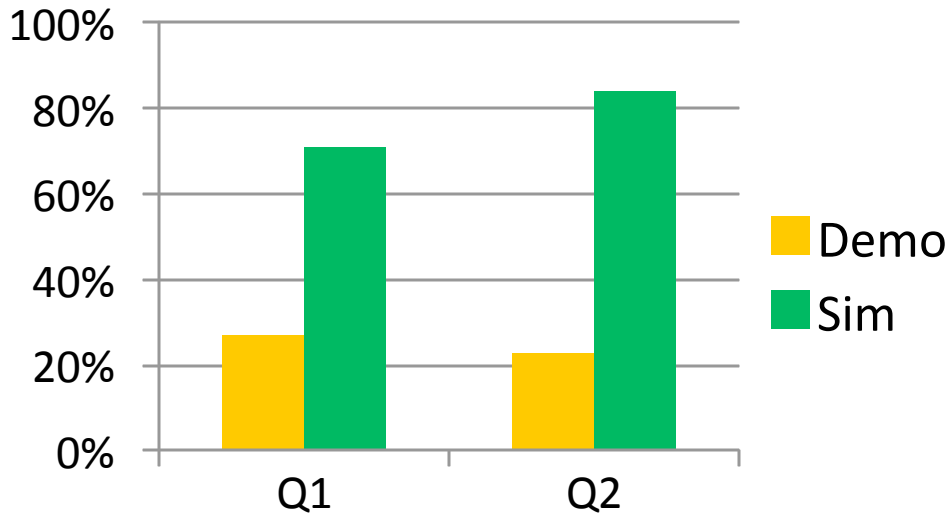
…

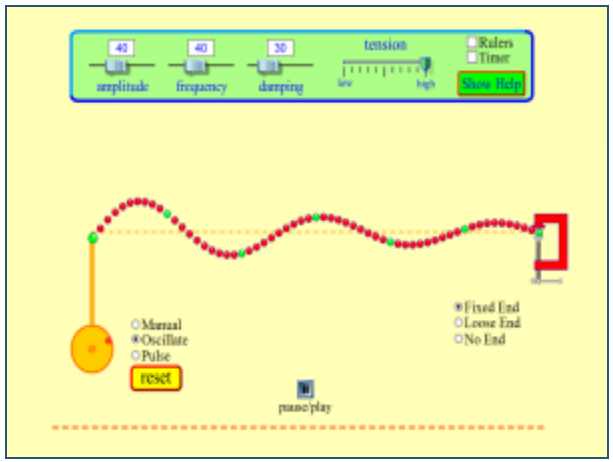
Impact on Visualization

Common expert visualization - **Wave-on-string simulation vs. Tygon tube demo**

Follow-up Concept Test:

Questions about velocity of different points on the string.





Instructor vs Student Control

Designed to support inquiry learning

Use accurate, dynamic visual representations

Show the invisible

Create a game-like environment

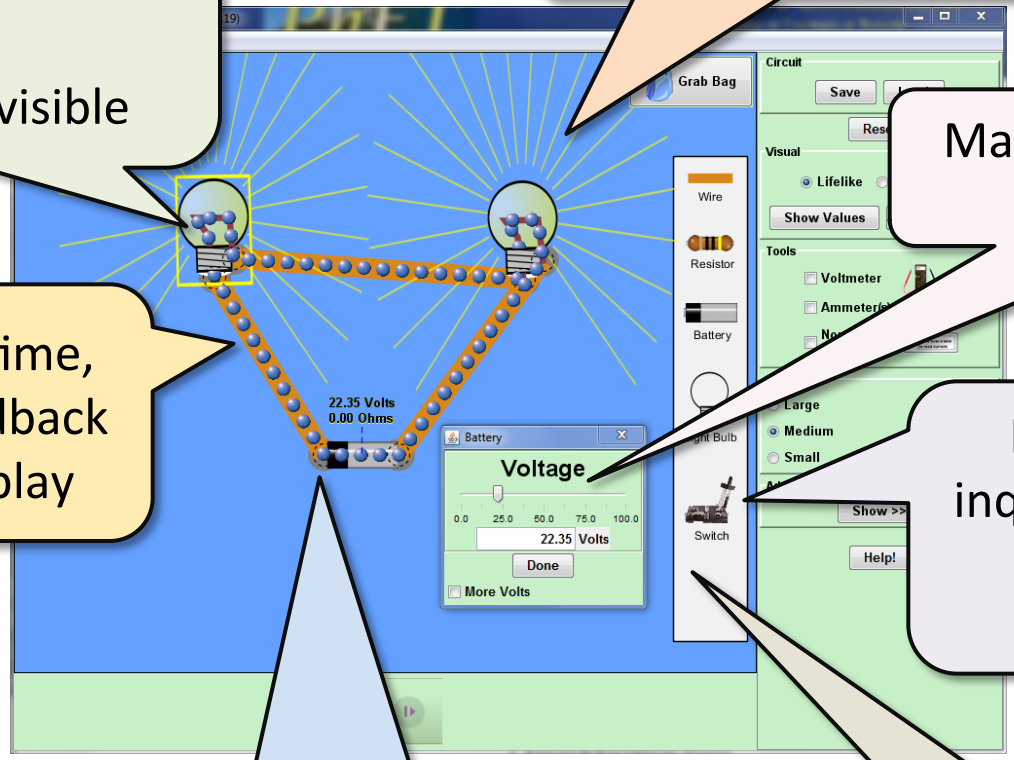
Make simulations highly interactive

Provide real-time, animated feedback as students play

Implicitly scaffold inquiry through design of controls and representations

Allow actions that would be difficult or impossible in the real world

Provide an intuitive interface, usable without instructions

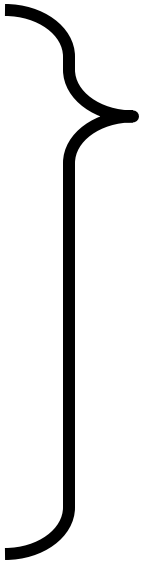


Use of PhET sims

Lecture

Lab

Homework



Opportunity for student scientist-like exploration

But, no silver bullet:
Context and Activity critical

Do students learn if I just tell them to play with a sim?

- They can. **But, better with guided inquiry / accountability.**
- Large database of classroom-tested activities available on the PhET site.

What makes a good sim activity?

- ***Minimum*** instruction.

  Detailed procedures *inhibit* student exploration.

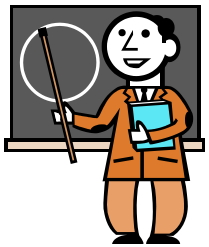
- Clear Learning Goals

  Give students the *goal*, not the procedure.

In-Class activity or Lab

Worse:

- Give directions on how to use the sim



- **Result:**
  Students are nervous, reluctant to try things, ask lots of questions about sim use, as opposed to learning goals.

Better:

- Provide activity and do not offer any pointers on the sim itself

- **Result:**
  Students explore uninhibitedly, quickly find/learn all the controls, become the "owner" of the sim.

"Factors promoting engaged exploration with computer simulations", N. S. Podolefsky, K. K. Perkins, and W. K. Adams, *Phys. Rev. ST Phys. Educ. Res.* **6**, 020117, 2010.

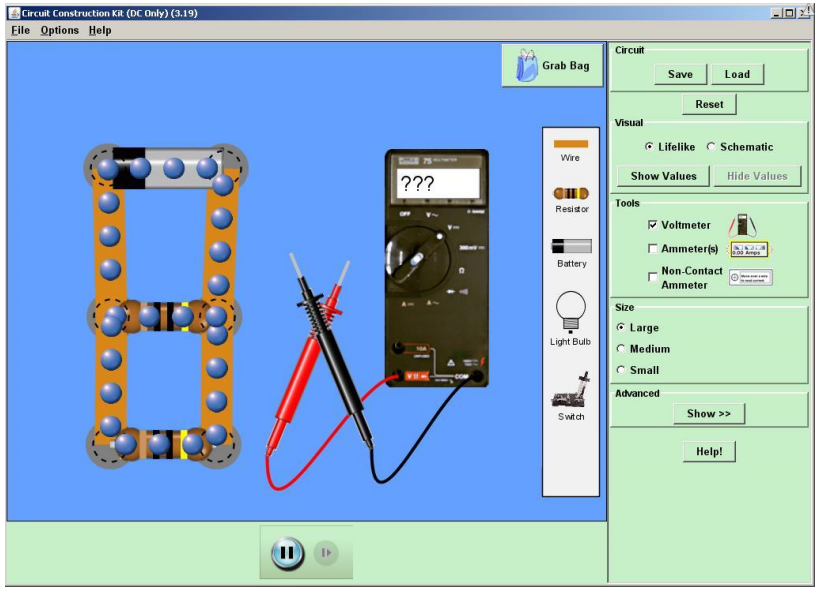
Example Activity: Masses and Springs

- 5-10 minutes of play – No instructions.
- **Challenge 1:**
  Using data from the sim, make a graph that shows whether or not the springs obey Hooke's Law.
- **Challenge 2:**
  What is the mass of the red weight?
- **Challenge 3:**
  Determine the spring constant in two different ways: with your graph from (1) and with the stopwatch.

Cookbook directions (NOT effective):

- Watch me while I show you the controls.
- Measure the equilibrium extension of spring 1, for each of the 3 different known masses, and make a graph of stretch of the spring (on y-axis) vs. mass (on x-axis).
  From this, determine the spring constant k of the spring. Recall that $F_{spring} = -kx$, where x is the stretch of the spring. Don't forget that weight is mg, where $g = 9.8\ m/s^2$.

Compare these tools:



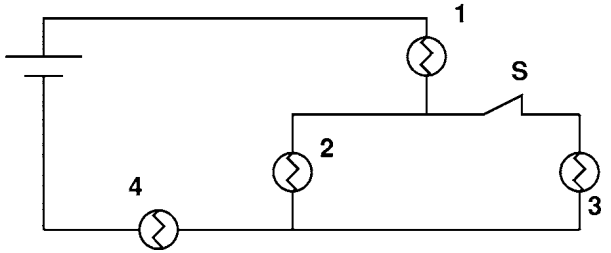
Can PhET sims replace real equipment?

- They can, but we don't think they should.
- Meant to compliment, not replace with lab equipment.
- Sims lack real-world "dirt" effects, allow students to focus on physics concepts.

Circuit Construction Kit vs. real circuits

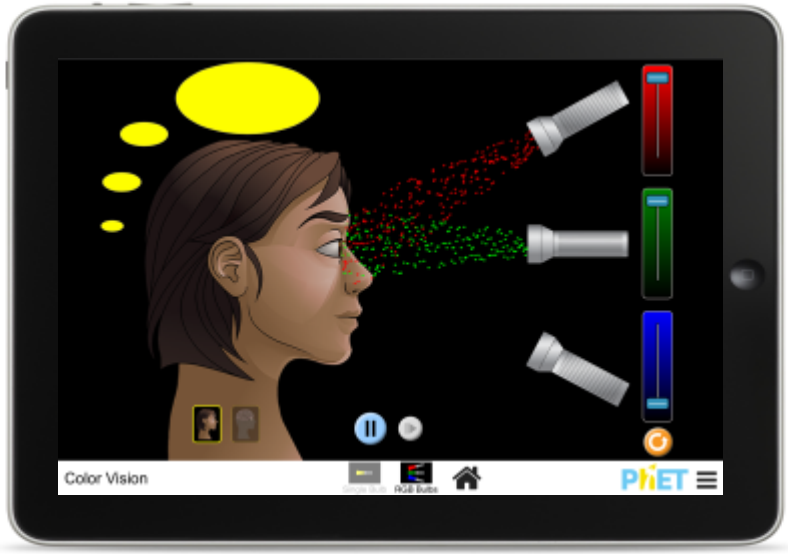
"When learning about the real world is better done virtually..", N.D. Finkelstein et al., *Phys. Rev. ST Phys. Educ. Res.* **1**, 010103, 2005.

- Students who only used virtual circuits, did equally well on building real circuits.
- Better on final exam.
- Sims allow risk-free, rapid inquiry cycle.



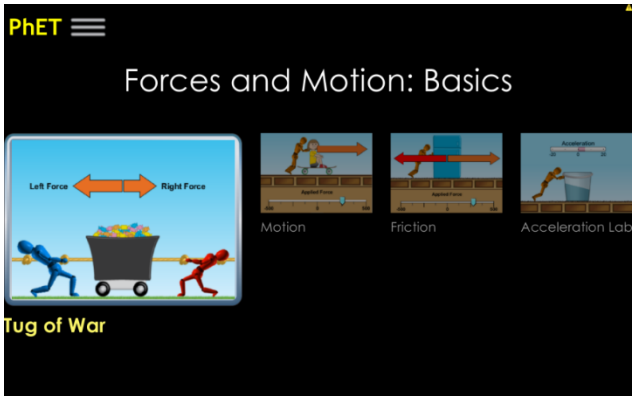
Next Generation HTML5 Sims

- HTML5 – 24 sims so far, many more to come!
- Cross-platform design
- Touch and mouse interaction



Next Generation Sims: Advancing Capabilities

- **Interoperability** (e.g. embedding, communication)
- **Customization** (e.g. start-up configuration)
- **Data Collection** (e.g. user actions, record/playback, etc)
- **Accessibility for Students with Disabilities**



What would you like to see in PhET?

- Sim ideas? New features? ??

Door Prize! : You can see NEW sims in development, before they are published, at

http://www.colorado.edu/physics/phet/dev

How can PhET be *free*?
(a $8 million resource)

NSF

Hewlett Foundation

The O'Donnell Foundation

Collaborative agreement with King Saud University

University of Colorado


Carl Wieman and Sarah Gilbert