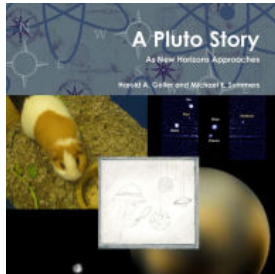


Hands On/Hands Off: Two Approaches for Physics Fundamentals in Physics and Astronomy Classes



By
Dr. Harold Geller, Associate Professor
George Mason University
NASA/JPL Solar System Ambassador
at Randolph Macon College
23 April 2016



ABSTRACT

Attendees will be exposed to a number of fundamental demonstrations and laboratory activities as utilized in physics and astronomy lecture and laboratory sections. The concepts covered include topics from mechanics to electromagnetism. We will also discuss the pros and cons of computer simulations versus hands-on activities.

Computer Simulations

- Different forms
 - “Local” software
 - Computer simulations done in a physics class in lieu of standard physics experiments
 - Examine mechanics and electricity and magnetism
 - Online simulations
 - PhET
 - Examine mechanics and electricity and magnetism

Description of "Local" Software

- Exploration of Physics Volume I
 - Written by Raman Pfaff, University of New Haven and John Di Bartolo, Polytechnic Institute of NYU
 - Published by *Physics Curriculum & Instruction*
 - Publisher is organized to act as both a developer and publisher of physical science educational materials
- Comprehensive software library of physics simulations and labs
 - covers a full year of introductory physics
 - Mechanics, Waves, Heat, Fluids, Optics, and Electricity & Magnetism

Virtual Labs Utilized

- Free fall laboratory
 - In vacuum and with air resistance
- Projectile Motion
- Inclined plane
 - With no friction and with friction
- 1st Law of Thermodynamics
 - Energy conversion
- Electricity and Magnetism
 - Resistive circuits
 - Resistors in series
 - Resistors in parallel
 - Lenz's Law
 - Producing magnetism from electricity
 - Varying number of loops
 - Varying area

Free Fall Laboratory

experiment theory hints exploration of physics

y (m) 20
 v (m/s)
 a (m/s²)

Scaling Factors
position 1
velocity 1
accel. 1

Snapshot On/Off
 Bounce On/Off

position, velocity, acceleration

x = 10.12
y = 15.38

t (s) 20

mass (kg) 0.10 gravity (m/s/s) 9.8
radius (m) 0.18 wind speed (m/s) 0
height (m) 20 air density (kg/m³) 0.0
snapshot time (s) 0.2 delta t (s) 0.05

The image shows a software interface for a free fall experiment. At the top, there are tabs for 'experiment', 'theory', and 'hints', and a logo for 'exploration of physics'. On the left, a vertical toolbar contains icons for home, back, play, pause, stop, help, volume, and a hand cursor. The main area features a coordinate system with a vertical axis labeled 'position, velocity, acceleration' and a horizontal axis labeled 't (s)'. A yellow box in the upper right of the graph displays 'x = 10.12' and 'y = 15.38'. To the left of the graph, there are control panels for 'y (m)', 'v (m/s)', and 'a (m/s²)', a 'Scaling Factors' section for position, velocity, and acceleration, and 'Snapshot On/Off' and 'Bounce On/Off' checkboxes. At the bottom, there are two columns of sliders for parameters: mass (kg), radius (m), height (m), snapshot time (s), gravity (m/s/s), wind speed (m/s), air density (kg/m³), and delta t (s).

Projectile Motion

experiment

theory

hints

exploration of physics



Controls Show/Hide

Grid Snap On/Off

Trails On/Off

Grid Show/Hide

Vectors On/Off

Bounce On/Off

Graph Limit Range

Launch Settings

"g" (m/s²)

v_x (m/s)

v_y (m/s)

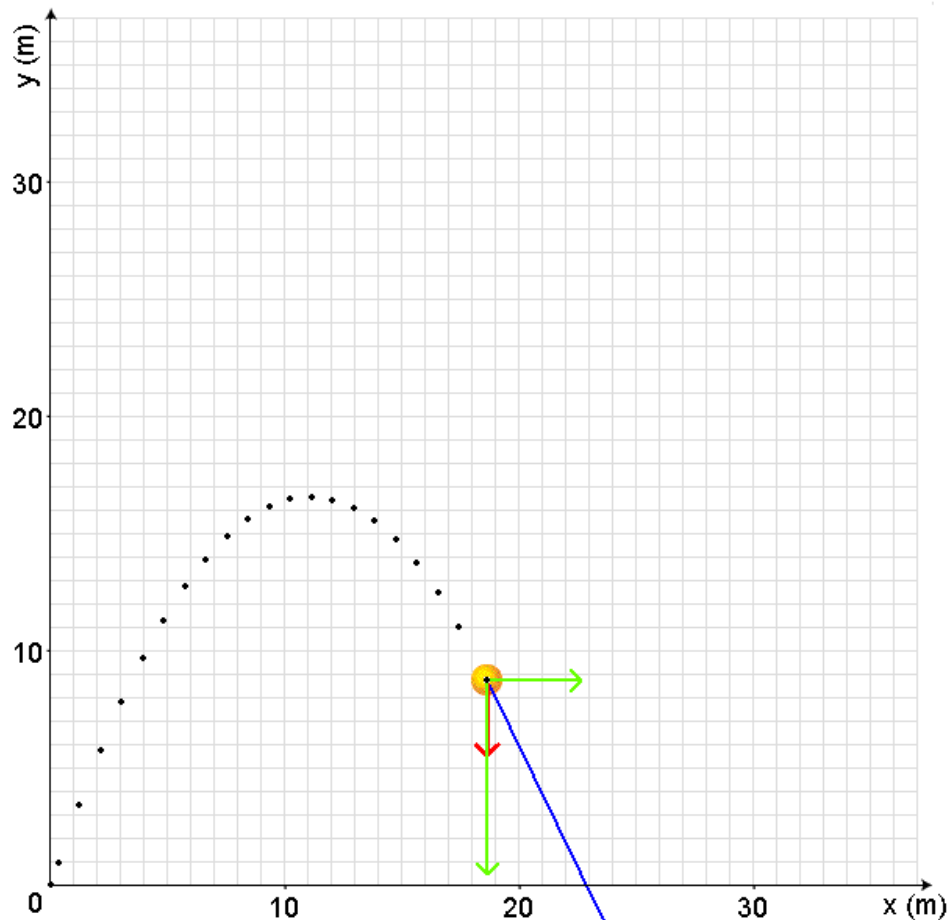
v (m/s)

θ_i (deg)

mouse pos. (-- m, -- m)

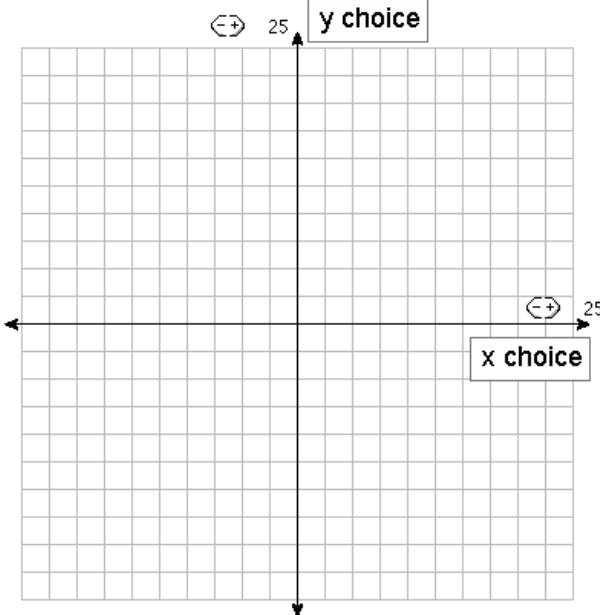
Plot full trail

x = 18.6 m
y = 8.7 m
v_x = 6.0 m/s
v_y = -12.4 m/s
v = 13.8 m/s
a_x = 0.0 m/s/s
a_y = -9.8 m/s/s
t = 3.1 s



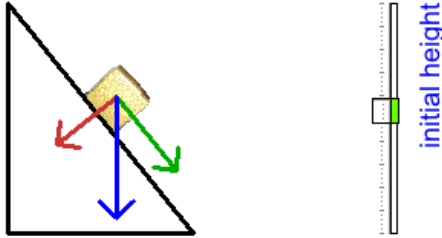
Inclined Plane

experiment
theory
hints
exploration of physics



Bouncing
 On/Off

x = 2.9 m	✓
y = 5.0 m	✓
v _x = 0.00 m/s	
v _y = 0.00 m/s	
v = 0.00 m/s	
a = 0.00 m/s/s	
t = 0.00 s	



mass (kg) 7.9

angle (deg) 51.0

vel. down plane (m/s) 0.0

coef of friction 0.00

x (m)	v _x (m/s)	a _x (m/s ²)
y (m)	v _y (m/s)	a _y (m/s ²)
t (s)	v (m/s)	a (m/s ²)
KE (J)	PE (J)	E (J)

8

Electric Circuits

experiment

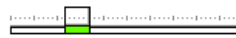
theory

hints

exploration of physics



Resistor 1 (ohms)



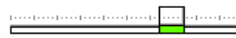
30

Resistor 2 (ohms)



50

Resistor 3 (ohms)



70

Resistor 4 (ohms)



50

battery voltage (V)

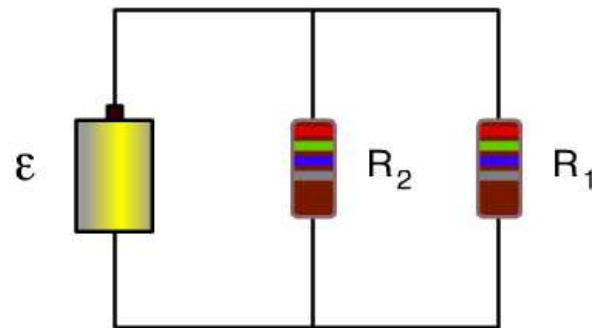
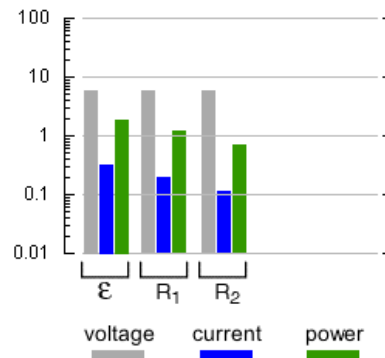
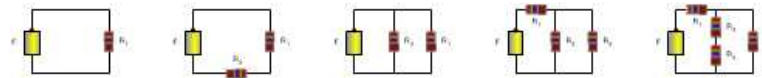


6.0

Show/Hide Information

	volts (V)	current (A)	power (W)
R ₁	6.00	0.20	1.20
R ₂	6.00	0.12	0.72
R ₃			
R ₄			
\mathcal{E}	6.00	0.32	1.92

Select a circuit



Magnetism and Lenz's Law

experiment theory hints exploration of physics

galvanometer

Magnet Motion On/Off

number of loops 10

loop area 4

magnet strength 10

PhET for Mechanics

Mail - Harold Geller - ... (151) Twitter Facebook Forces and Motion: Basics Harold

https://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_en.html

Sum of Forces
 Values

Refresh Mute

Forces and Motion: Basics

Net Force Motion Friction Acceleration

PHET

PhET for Electricity

$V = IR$

1.5 V 1.5 V 1.5 V

current = 9.0 mA

V voltage 4.5 V

R resistance 500 Ω

Ohm's Law

PhET

PhET for Magnetism

Browser tabs: Mail - Harold Geller - C, (171) Twitter, Facebook, Faraday's Law 1.1.4

Address bar: https://phet.colorado.edu/sims/html/faradays-law/latest/faradays-law_en.html

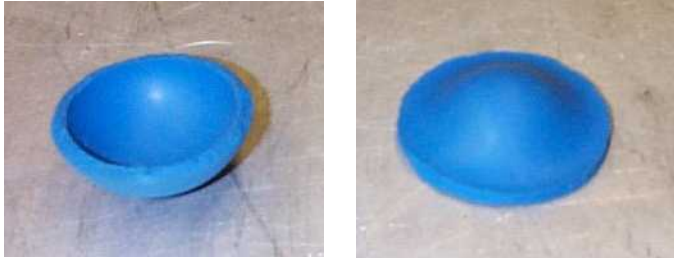
Simulation components:

- Voltmeter: Labeled "voltage", showing a scale from - to +.
- Light bulb: Connected in the circuit.
- Coil of wire: Connected to the voltmeter and light bulb.
- Bar magnet: Labeled "N" (North) and "S" (South).
- Control panels: Includes a checkbox for "Field lines", buttons for coil rotation, magnet movement, and a refresh button.

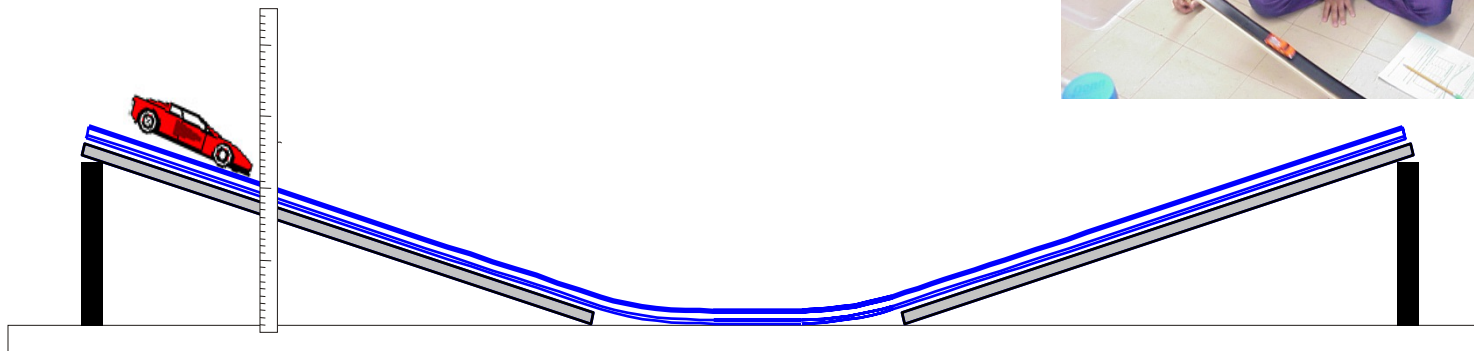
Faraday's Law

PhET

Activity with Half Ball and Hot Wheels



Bounce
"half" ball

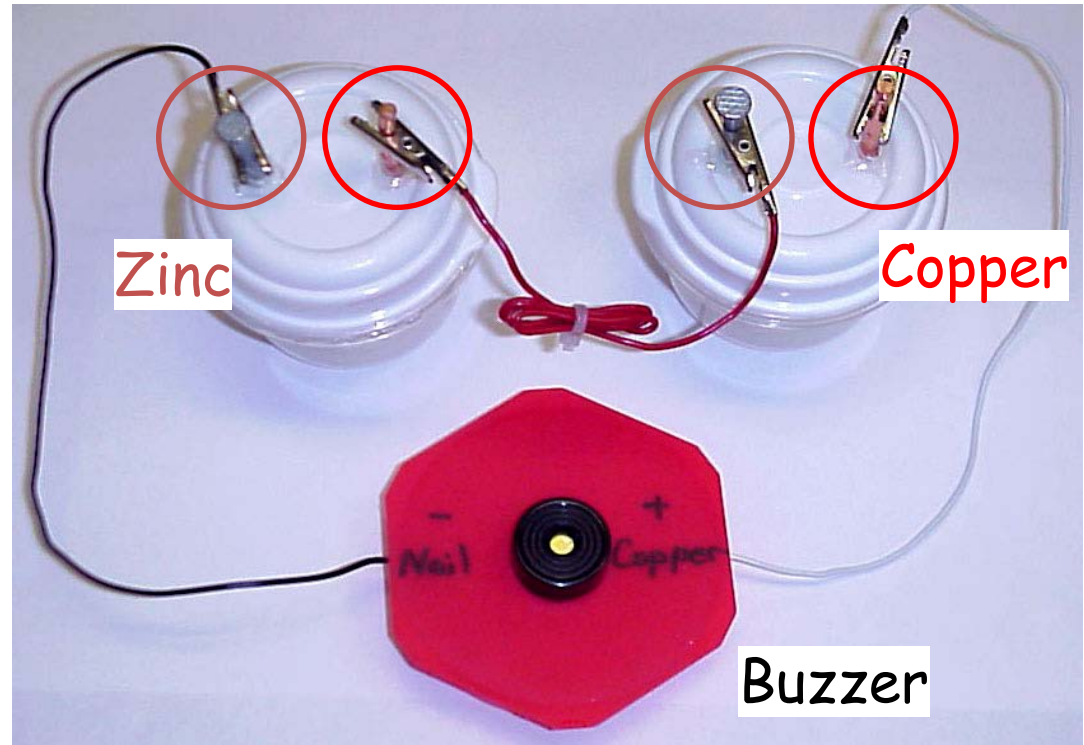
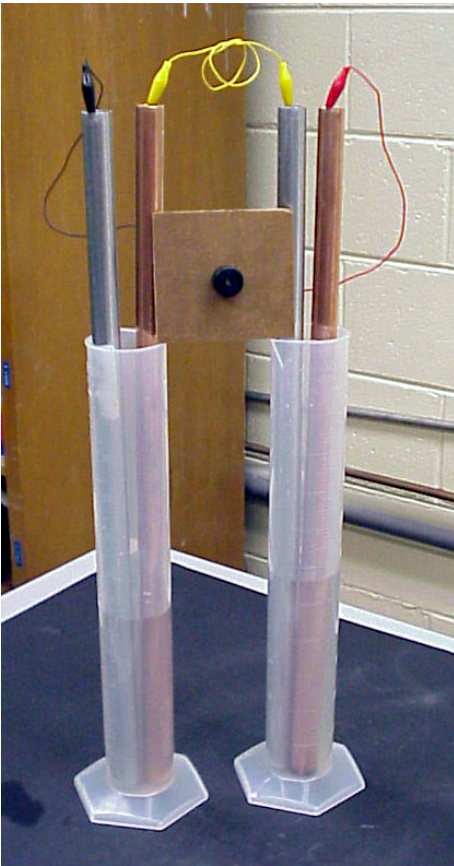


Beginning
Height

Measure Ending Height

- Develop teamwork, graphing, and prediction skills.
- Measure **beginning** and **ending heights** of released car to discover **loss of energy**.

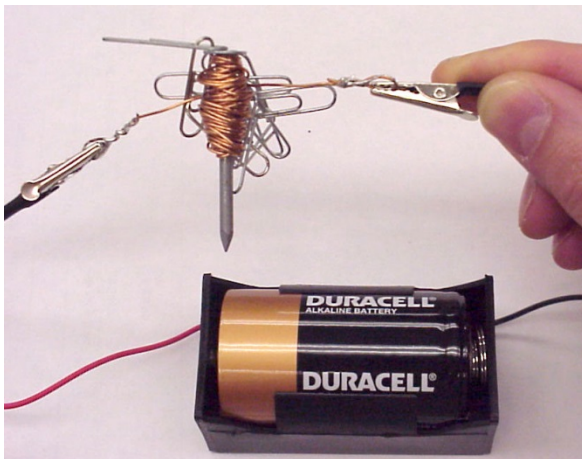
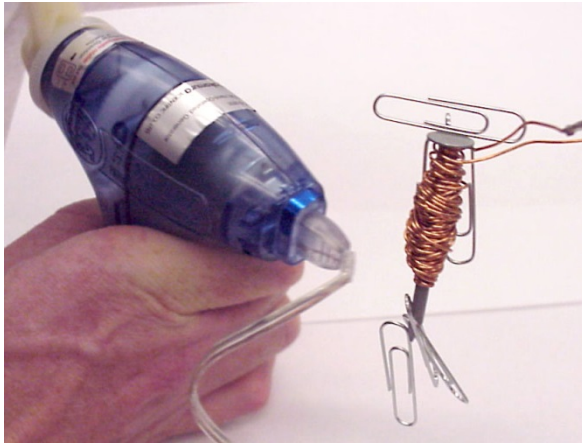
Activity with Salt Battery



- Construct **salt-water** battery using **copper** and **zinc electrodes** to make **buzzer** work!

Activity with Electromagnets

Mini-electromagnet



Loudspeaker

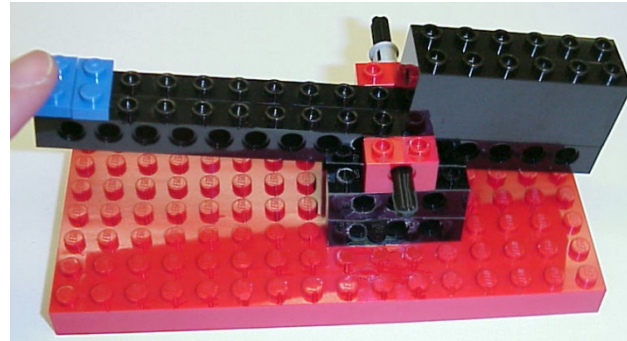


- Make **electromagnet** with **wire** wrapped around **nail** and "power" with generator or battery.
- Make **loudspeaker** using electromagnet, cup, and radio.

Activity with Simple Machines



Pulley System



Construct Lego Lever

Identify Tools as Simple Machines



Activity with Electrical Circuits



Series Circuit



Parallel Circuit



- Build series and parallel circuits with lightbulbs and measure voltage using a meter.
 - What happens when one bulb is unscrewed?
 - Which bulbs are brighter?

Activity with Magnets



- Predict whether items are magnetic or not.



- ⌘ Draw magnetic "field" lines formed by iron filings around a magnet.

Published Comments

- "...this study provide[s] evidence of the advantages of computer-based practical classes over traditional ones..."
- "...both virtual and physical manipulatives can be effective in developing conceptual understanding."
- "...school laboratory activities have special potential as media for learning that can promote important science learning outcomes for students..."
- "Researchers must examine the goals of science teaching and learning with care to identify optimal activities and experiences from all modes of instruction that will best facilitate these goals."
- "...there is no simple answer to the dilemma which laboratory is the best..."
- "Perhaps with the proper mix of technologies we can find solutions that meet the economic constraints of laboratories...while at the same time providing enough open-ended interaction to teach design."

Summary and Conclusion

- Hands on; remote; or computer simulation labs
- What is best for the money?
- What is best for the teacher?
- What is best for the students?
- Is all of physics just a computer simulation?
- At times, administrators only hear what they want to hear
- FINAL THOUGHTS
 - Would you want a surgeon who only did computer simulated surgery?
 - Or someone who only worked with virtual diapers?
 - BEWARE COMPUTER INDUSTRIAL COMPLEX

References

- "Virtual and Remote Labs in Physics Education" by Ulrich Harms
- "Remote Laboratories Versus Virtual and Real Laboratories" by Nedic, Machotka and Nafalski
- "Role of Laboratory Education in Power Engineering: Is the Virtual Laboratory Feasible" by Karady, Heydt, Iwamoto, Olejniczak, Mantooth, and Crow
- "Computer Simulations Improve University Instructional Laboratories" by Gibbons, Evans, Payne, Shah, and Griffin
- "The Role of the Laboratory in Science Teaching: Neglected Aspects of Research" by Hofstein and Lunetta
- "The Laboratory in Science Education: The State of the Art" by Hofstein and Mamlok-Naaman
- "The Laboratory in Science Education: Foundations for the Twenty-First Century" by Hofstein and Lunetta
- "Hands-On, Simulated, and Remote Laboratories: A Comparative Literature Review" by Ma and Nickerson
- "Comparing the influence of physical and virtual manipulatives in the context of the Physics by Inquiry curriculum: The case of undergraduate students' conceptual understanding of heat and temperature" by Zacharia and Constantinou