Inquiry-Based Labs for Introductory Physics

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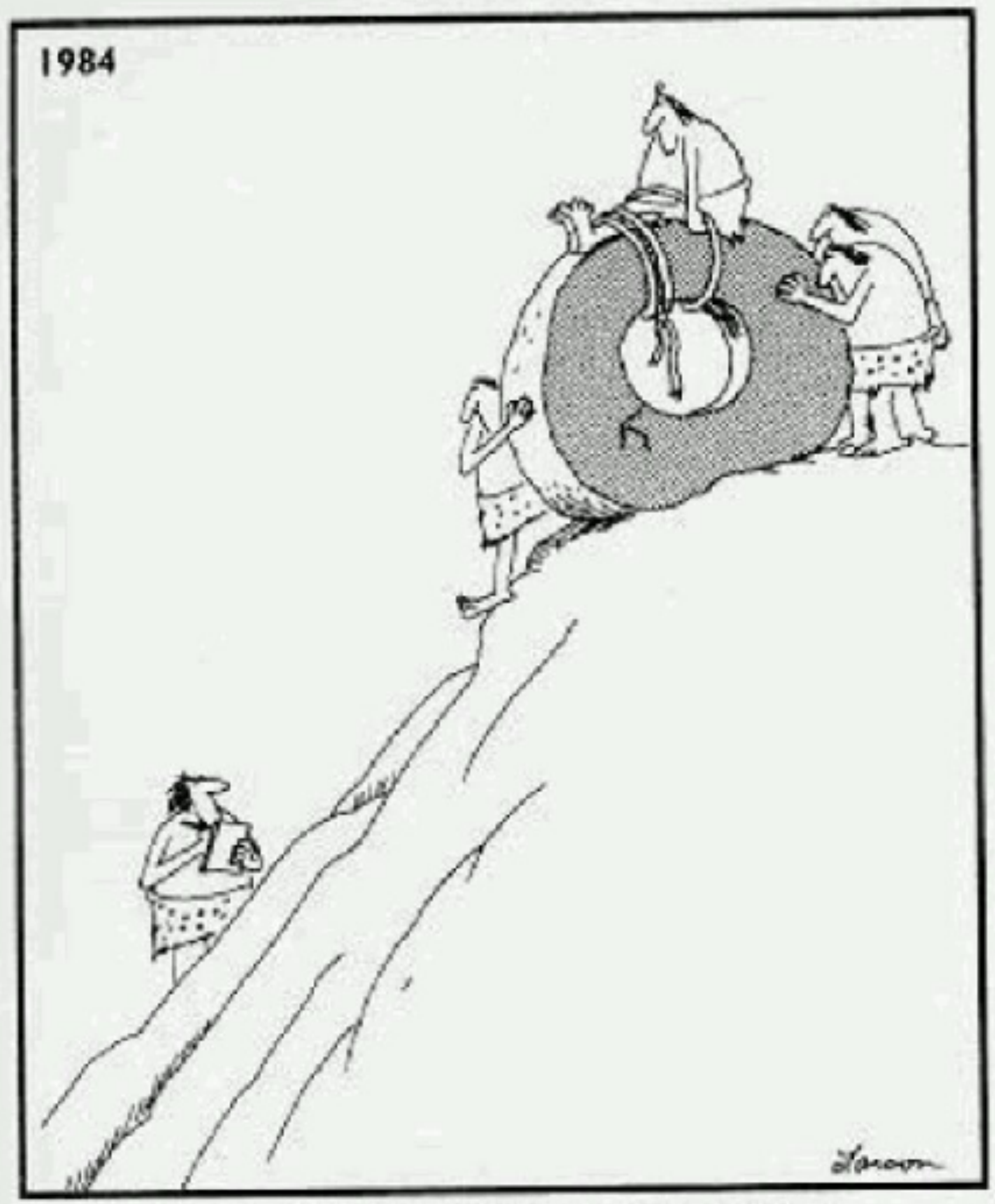

Early experiments in transportation

Motivations

- ***encourage creativity & learning from failure***
- ***avoid cookbook experiences***
- ***limit cost to students***
- ***facilitate more in-depth lab reports***

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~~*Use a source and a discharge resistor in the circuit as before. Choose the dimension of R such that you obtain reasonable times. The capacitors made available to you may have different values of capacitance. Adjust the resistors accordingly.*~~ skip

Decide how many voltage reference points you need to find all charges. Show and name the reference points in the diagram above. skip

1 source	voltage [V]	~~theoretical~~ measured C (postlab)	charge Q (postlab)	theor. Q (postlab)

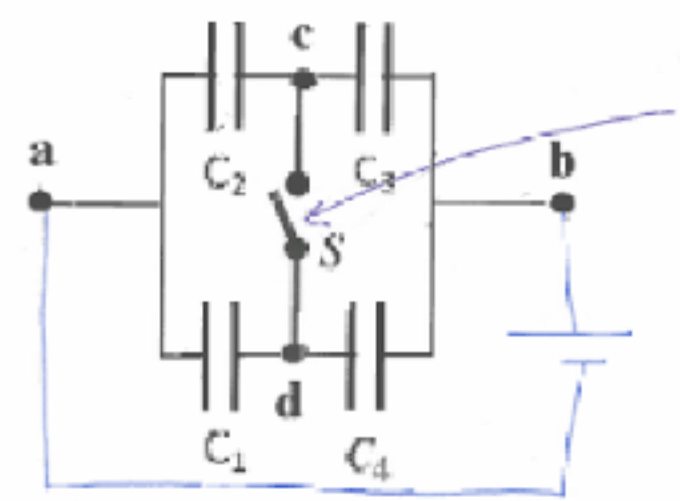
Activity 2.2: Mixed Capacitor Circuit II ??

Set up the circuit shown below. Use four capacitors, two pairs as in the figure with C as close as possible to the actual values in the figure and to the ratio of the values in the figure.

Question: Before you proceed, predict what will happen to C_{eq}, V_{ad}, V_{db} and V_{ab} when you close switch S. What happens to the respective charges on the capacitors? Prediction:

~~Now calculate the charge/ discharge time for S open and closed:~~ skip

$R \cdot C_{eq}$:



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parallel 1 source	voltage [V]	theoretical C (postlab)	charge Q (postlab)	theor. Q (postlab)
V_{ad}				
V_{ac}				
V_{db}				
V_{cb}				
V_{ab}				
V_{dc}				

with switch open or closed??

Initial Reflections

2-3 hours per lab for scoping out a plan

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Plan on reviewing errors, uncertainties, and propagation of errors multiple times

Lab 1: Specific Heat

Background
Your firm has been hired to design a steam heating system for UW's new engineering building. You will determine which of three selected materials would be best for constructing the pipe network.

Technical details
Determine the identity of three separate cubes of different materials by devising an experiment to measure their specific heat values. You may choose which three cubes to study. The website engineeringtoolbox.com may prove useful.

Specific Heat

Lab 2: Ideal Gas Law

Background

You are on an interstellar voyage to Kepler-186f, an Earth-size planet 500 light years away in the Cygnus constellation. Your crew consists of an atmospheric scientist, a chemical engineer, a mechanical engineer, and an astronomer. Kepler-186f is in the "habitable zone" where water would be in the liquid phase. Your first task is to **characterize the atmosphere** (find its molar mass). Your second task is to **calibrate the volume of your gardyloo** (a glass flask plus rubber tubing connected to the pressure sensor), a critical piece of equipment for further analyzing the atmosphere.

Technical details

Available tools include the gardyloo, a GPS unit, a thermometer, and a pressure sensor. Note: a gardyloo will melt if exposed to liquid! You must find a non-liquid-based calibration technique.

Lab 3: Applied & Induced Charge Distributions

Due Date: March 23

Challenge
Devise *two* ways to measure the charge on a metal ball.

Available materials:

aluminum foil	string	fur scraps
insulating rod	protractor	your phone's camera
ring stand with clamps	mass scale	charge sensor
metal pail & plastic disk	Faraday cage	charge separators
grounding wires & wrist strap	ground plate	*Logger Pro* software

Technical details
Before attempting to measure the charge on a metal ball, familiarize yourself with the Vernier equipment and *Logger Pro* software. For example, measure the net charge created by rubbing your feet against carpet. Also, test the claim that when two charge separators are rubbed against each other they will have equal and opposite charges.

Lab 4: Capacitance

Due Date: April 11

Scenario

You shipwreck on a coral reef next to an uninhabited island. Being the brilliant leader of the surviving group, you assert that a good way to flag down a passing ship is to run a large, brief current through some conducting filamentary wire to create a momentary but bright flash of light. So you set out to construct some capacitors with the materials that washed ashore with you.

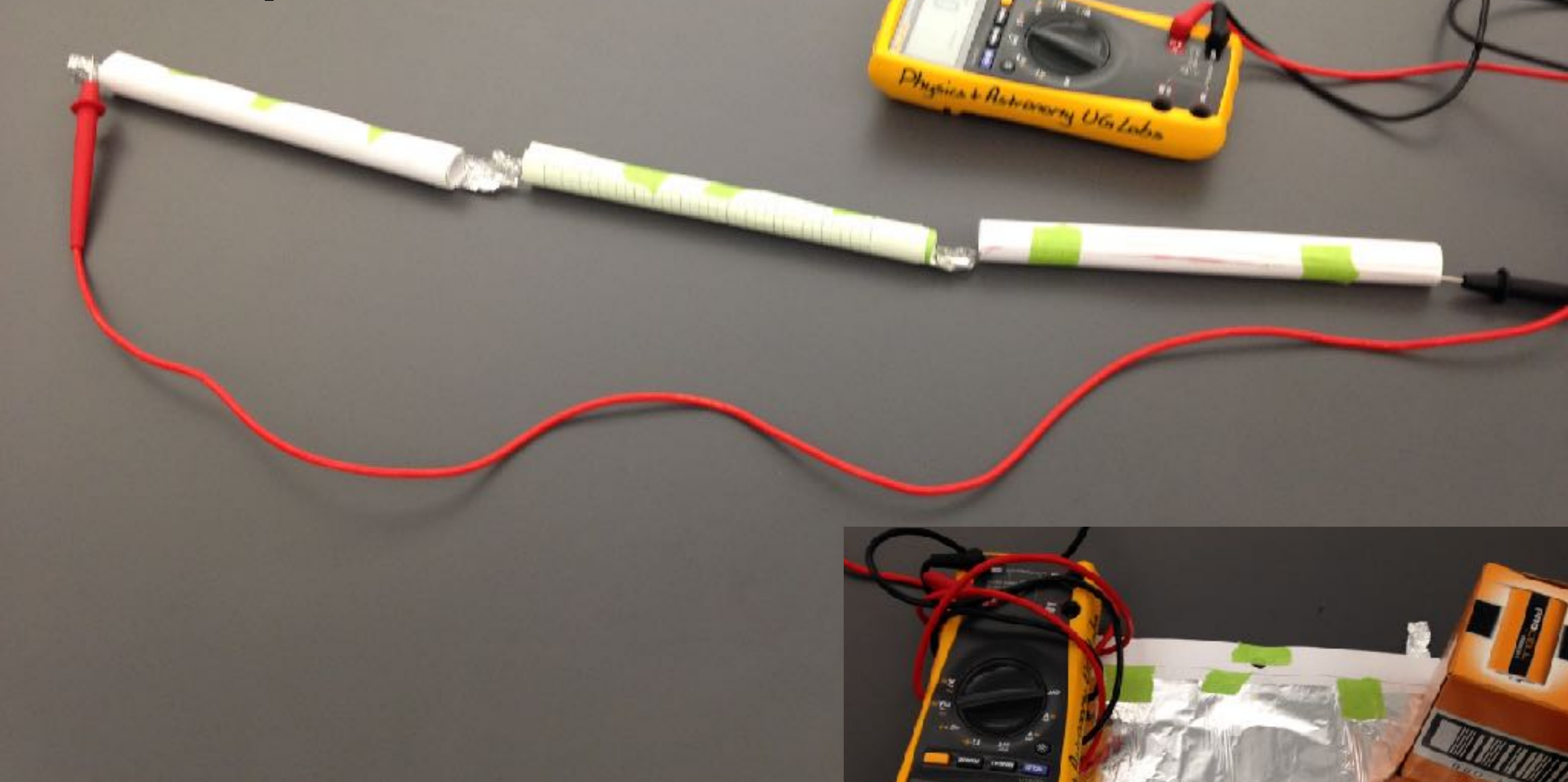
Challenge

1. Construct three capacitors with paper dielectrics. Measure their capacitances and infer the paper's dielectric constant in each case. Compare the estimated paper's dielectric constant to accepted value(s).
2. Place the capacitors in series and quantify how well the measured equivalent capacitance matches the expected value based on the results from Part 1.

Available materials:

aluminum foil	paper	scissors
dowel (long cylinder)	multimeter & probes	tape
ruler	caliper	

Capacitors in series



Construction of a capacitor

Lab 5: *RC* Time Constant

Due Date: April 20

Challenge

Devise *two* ways to measure the product of resistance and capacitance (*RC*) for a DC circuit.

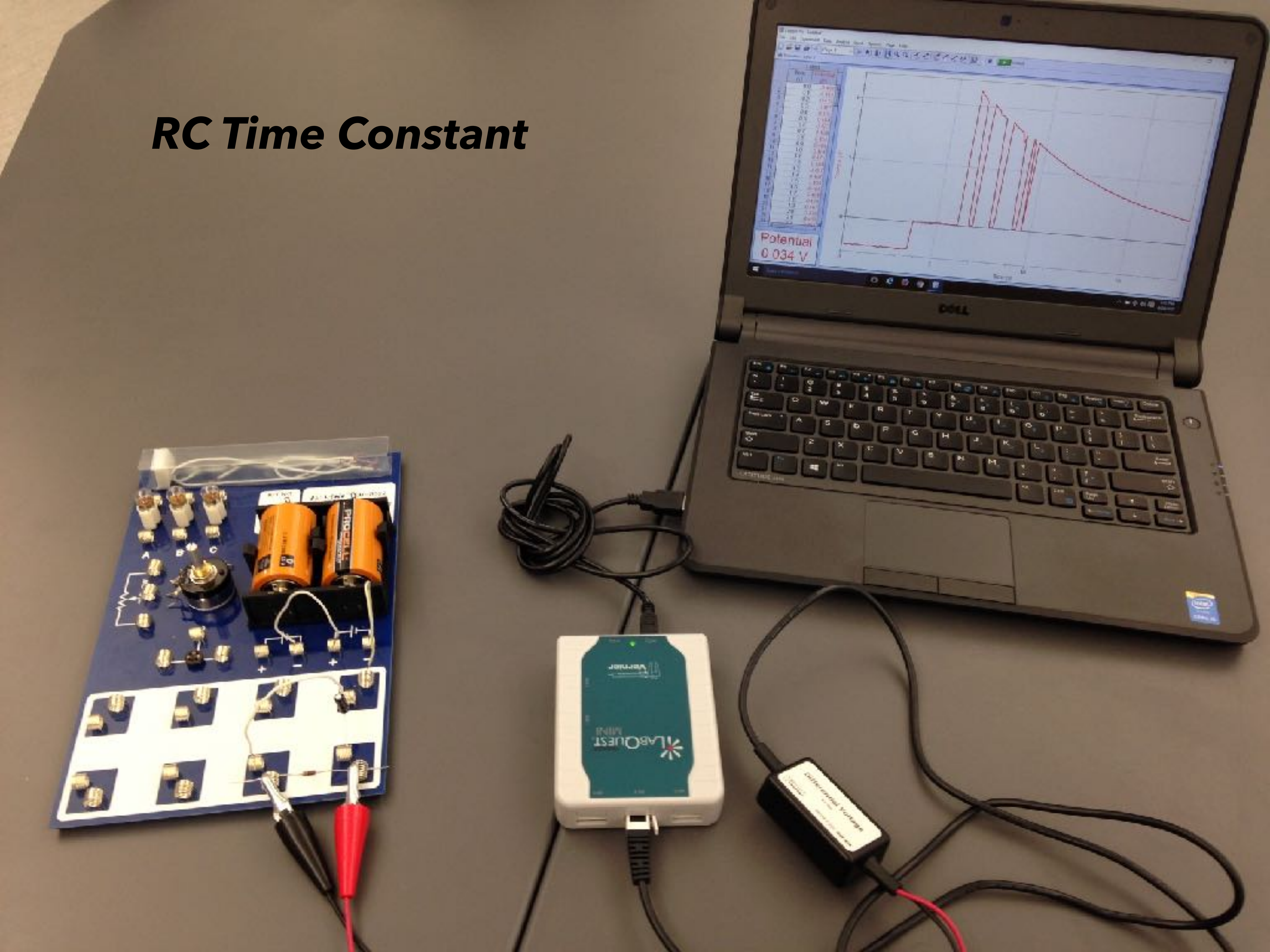
Available materials:

multimeter & probes	resistors	capacitors
Logger Pro software	current sensor	voltage sensor
circuit board, wires, batteries	your phone's camera	

Technical details

Before attempting to measure *RC*, familiarize yourself with the Vernier equipment and *Logger Pro* software. For example, measure the resistance of a resistor by using both a multimeter and Ohm's Law.

RC Time Constant



Lab 6: Magnetic Fields

Due Date: May 04

Background

During your interstellar voyage to Kepler-186f, one of your crew members smacks their noggin during a game of *Pokémon Go* gone horribly wrong. You quickly cobble together a simple MRI machine to assess the severity of the injury.

Challenge

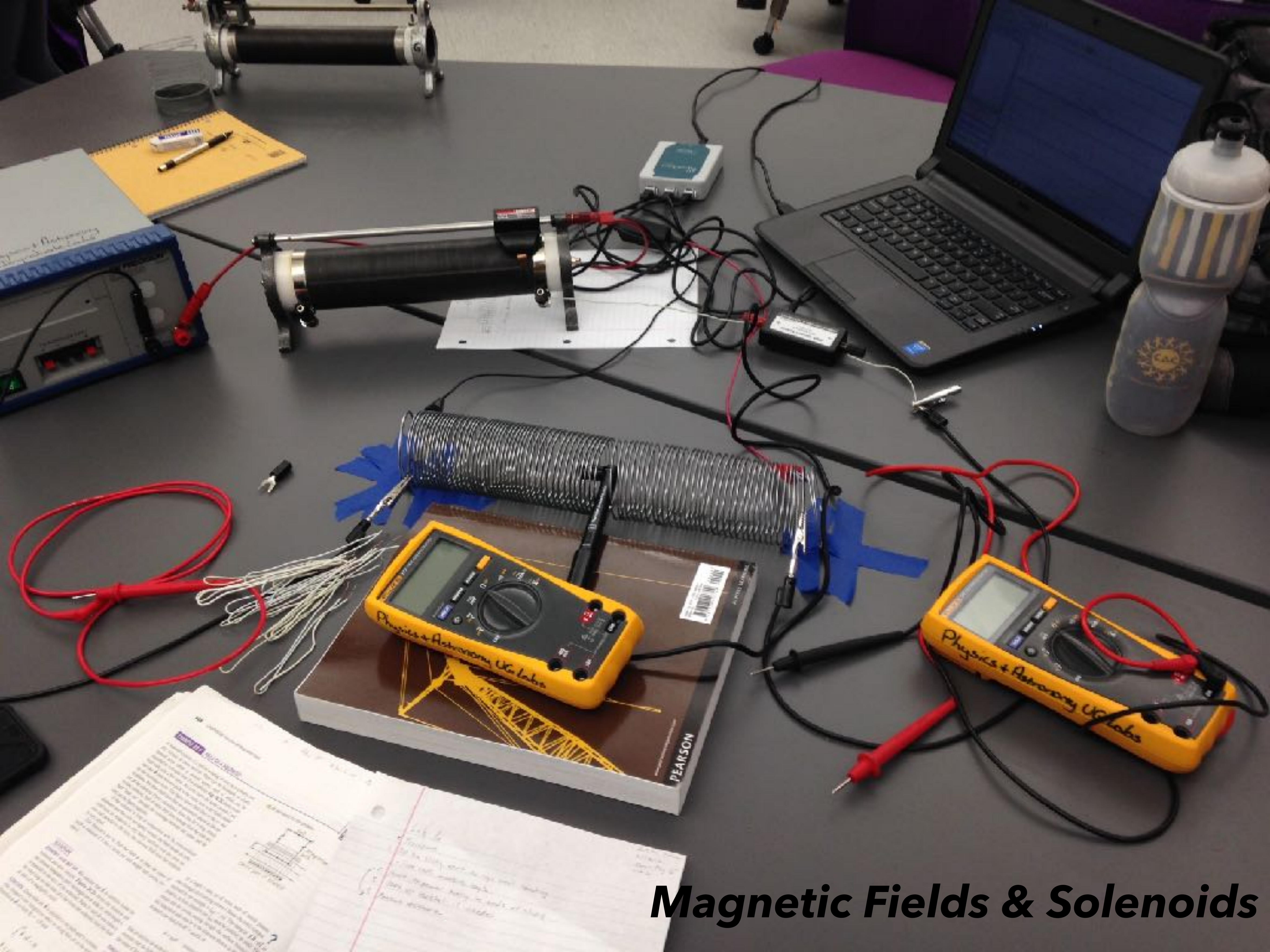
Devise an apparatus that will generate magnetic fields of approximately 1.0 mT, 1.25 mT, and 1.5 mT. Compare your results to those expected from theoretical considerations.

Available materials:

multimeter & probes	rheostat	*B* field sensor
Logger Pro software	wires, voltage source	your phone's camera
metal slinky	ruler	tape

Technical details

Before attempting to measure a magnetic field, familiarize yourself with the equipment and software. For example, measure the current through the slinky by using both a multimeter and Ohm's Law.



Magnetic Fields & Solenoids

Lessons Learned

- ***The lab write-ups are in fact quite simple***
- ***Require XX minutes at the beginning for thinking***
- ***There can be much more student ownership***
- ***Creative avenues are boundless***
- ***Inferior lab plans are ok – failure can be a powerful route to learning!***
- ***Do fewer labs; require more detailed reports***
- ***Training TAs especially important***
- ***The actual data taking is ~5 min, but allot 120 min***
- ***Surprising that they don't immediately check error***
- ***[Students may naturally pursue shortcuts]***
- ***[Some will finish sooner; have back-up activities]***

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Labs: Do you think you learn more from the inquiry-based format adopted this semester, or from a more traditional format that provides more step-by-step guidance?

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I tend to learn best when I'm shown how everything works and it's pointed out to me how things work together so I can visualize and understand what's going on.

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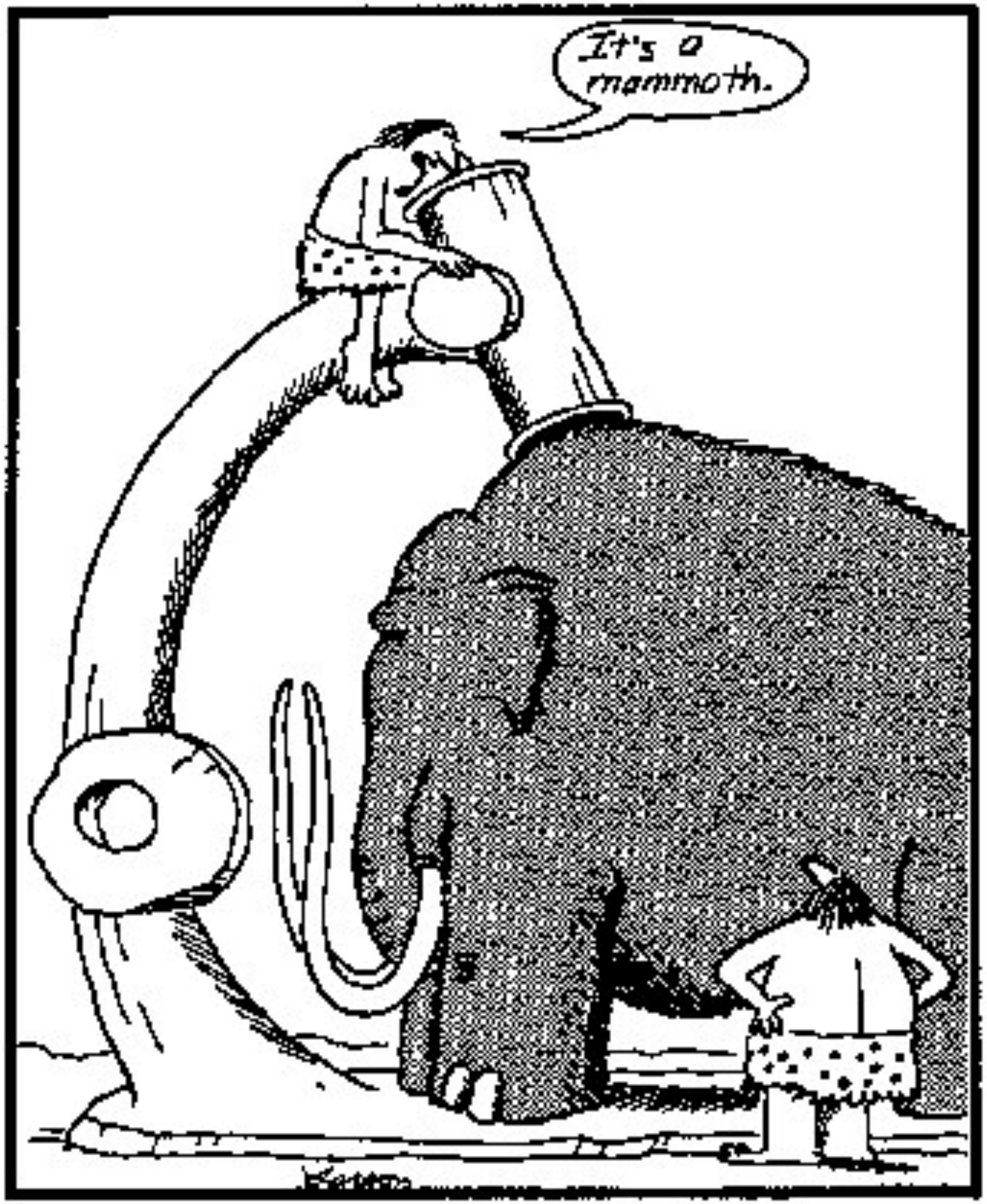
I think I learn more with this set up because you have to understand what you're doing.

Thank You!



Early microscope