

Oh no! Just minutes before your end-of-semester presentation begins, the camera you planned to record your talk with ran out of batteries! Quick testing reveals the culprit: one dead AA battery (1.5V). Without any replacement in sight, you set to work building your own battery so the talk can be recorded.

### Part I: Building a Battery

#### Materials:

- vinegar ( $\frac{1}{4}$  cup)
- salt (1 Tbsp)
- small bowl or glass
- multimeter
- pennies
- nickels
- aluminum foil (small strip)
- dish soap
- scissors
- paper towels

#### Procedure:

a. In the small bowl, mix together the vinegar and salt. Stir well.

1. Why do you think we add salt to the vinegar?

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b. Wash the nickels and pennies with the dish soap and dry.

c. With the scissors, cut a 2cm x 8cm strip of aluminum foil. Fold the strip lengthwise in three - it will still be 8cm tall, but now have a folded width of  $\frac{2}{3}$  cm.

d. Use the scissors to cut a paper towel in small squares, each about 2cm x 2cm.

e. For the battery assembly area, place a paper towel on a flat surface and the folder foil on the paper.

f. Put a penny on the end of the folded foil, on top of the last 2 cm.

g. Dip a paper towel square in the vinegar solution - the square should be wet but not dripping.

h. Place the square on top of the penny.

i. Put a nickel on top of the square, then another soaked square on top of the nickel.

j. Repeat until you have a battery of 2 pennies and 2 nickels, with soaked paper towel squares in between.

**Important: Do not let the paper towel squares touch each other! Also make sure the paper towels are not dripping wet.**

2. Why do you think we insist on these precautions?

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k. Congratulations, you've built a battery! Using the voltage setting on your multimeter, measure the battery output by touching one multimeter lead to the top nickel, and the other to the aluminum foil underneath the stack. Record your measurement in the table below:

# of Pennies	2	3	4	5
Measured Voltage				

l. Add a paper towel square, penny, paper towel, and nickel to the stack, and measure the voltage again. Do this for up to 5 penny/nickel pairs in the stack.

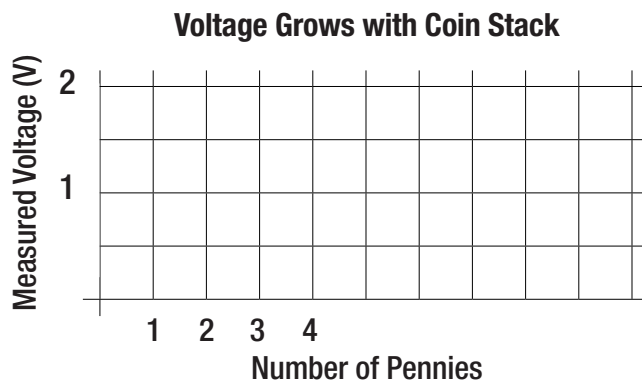
3. Why is it important to always alternate a penny with a nickel in the battery stack?

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m. Plot the values you have measured on this graph.



4. Draw a line through the points. How many pennies would we need in the stack in order to replace the 1.5 V AA battery?

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Now that we've created a working circuit, let's see how current, voltage, and resistance work together. Insert a voltmeter that measures across the light bulb (one lead on one side, the other lead on the other side).

Next, add an ammeter to the circuit to measure current. You'll need to add the ammeter into the same current loop as the bulb - it will require removing a wire and rewiring the ammeter into the loop.

Run the circuit so you can see charge traveling around the loop. When you change the bulb's resistance, what happens to the current and voltage readings? Fill in this table to see:

Resistance ( $\Omega$ )	Voltage (V)	Current (A)
100		
75		
50		
25		
0		

2. Ignoring the results when  $R = 0 \Omega$ , since the circuit became short circuited under this condition, when resistance went up, how did current and voltage change?

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3. Consider the change from  $100 \Omega$  to  $50 \Omega$  - when the resistance was cut in half. Did current change by the same factor, or a different one?

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4. Write a letter of response to a friend who has made two claims:

- Batteries are too complicated to understand or make - you can only buy them from a store.
- There is no relationship between current, resistance, and voltage in a simple circuit - they change randomly. In your response, be sure to include what you believe is the connection between these three.

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