Solving for Resistance

Teacher Notes

6th grade:

Standard 6.EE.7 Solve real-world and mathematical problems by writing and solving equations of the form $x + a = b$ and $ax = b$ for cases in which a, b and x are all non-negative rational numbers.

Part 6 utilizes knowledge from **Standards 6.SP.3** and **6.SP.5** but may be beyond scope of ability for some students

Mathematics I:

Parts 1,7,8: **Standard A.CED.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's Law* V = IR *to highlight resistance* R.

Part 6: **Standard SI.MP.6** Attend to precision. **Standard N.Q.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Supplies needed:

3 AA batteries	Battery holders	Resistor sheet
Current meter	Voltage meter	Alligator clip wires

Overview:

Electrical devices work through the flow of electrons, which are charged particles. For an electrical circuit to work, it must have something that provides power (like a battery), something that consumes power (like a resistor), and wires must connect everything in a circle, so the electrons can flow. The battery has a given *voltage*, which provides the "umph" needed to get the electrons flowing. We call the flow of electrons *current*.

How much current flows depends on the voltage of the battery and the resistance of the resistor. According to the famous electrical engineering equation Ohm's Law,

Voltage = Current · Resistance

$$\mathbf{V} = \mathbf{I} \cdot \mathbf{R}$$

Today we will apply our math skill of solving equations to solve a real-world electrical engineering problem. Our goal is to calculate the resistance of a mystery resistor. We will make measurements, which we can then use to solve the equation for Ohm's Law.

1. Rearrange the variables to solve for resistance R.

$$\mathbf{R} = \frac{V}{I}$$

2. To figure out the resistance of the mystery resistor, we must know the voltage and the current. The voltage across the resistor is just the voltage of the battery we connect to it. To measure the voltage of 1 AA battery, connect the VOLTAGE METER to each end of the battery (as shown below). Connect RED to RED and BLACK to BLACK (otherwise you will measure a negative number). Make sure you turn the voltage meter on.

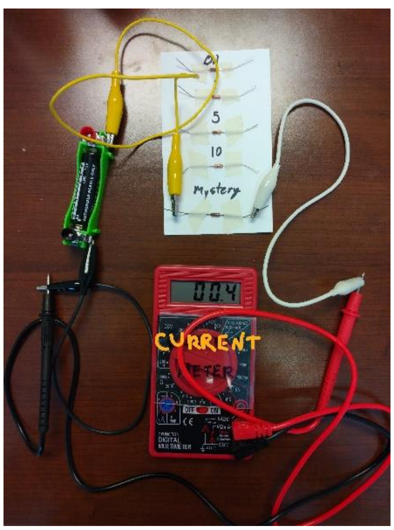
*****WARNING*** If students connect the CURRENT METER instead, they will break it.**

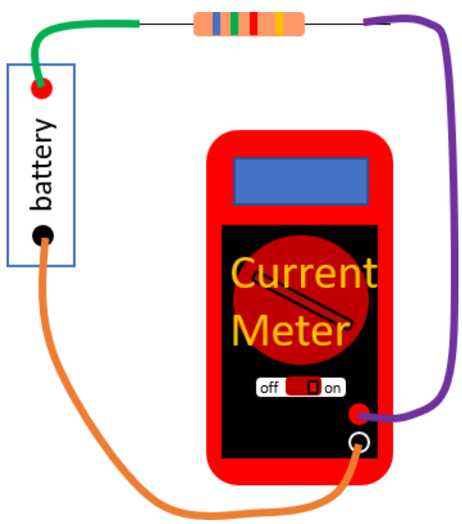
V = should be somewhere around 1.5 but not exact

(if <1.35, get them a new battery)

(if >1.6, check if they are measuring correctly)

3. To measure the current (I) through the resistor, connect the AA battery, the mystery resistor, and the current reader in a circle (shown below). Connect the BLACK end of the battery to the BLACK wire from the current meter (or you will get a negative number). Make sure you turn the current reader on.





I = The mystery resistors range from 0.1 to 30. Therefore, we expect students to get between 0.1 and 15 for I.

Common issues to look for when troubleshooting:

- Mixed up current and voltage meter
- Did not turn on current or voltage meter
- Missing connections (forgot to connect everything in a circle)
- Loose connections (check alligator clips and check red and black cables firmly pushed into holes on meters)
- Batteries not all in same direction
- Batteries dead

4. Using the measurements for V and I, you should now be able to solve for R:
(Hint: Look at your answer to 1 for how to solve)

$$\mathbf{R} = \frac{1.49}{0.04} = 3.7(25) \text{ example}$$

5. Repeat the measurements for voltage (V) and current (I) but with 3 AA batteries connected together as follows this time (this will increase voltage). Make sure all the red knobs are facing the same direction. What did you measure for V, I, and R this time?

V = **4.54 (example)**

I = **1.3 (same resistor as above)**

R = $\frac{4.54}{1.3} = \mathbf{3.5}$ **Using proper significant digits (3.492 exact)**

6. Did you get the same value for resistance each time? Why or why not? If you got different numbers, what do you think the actual resistance is based on your two different measurements?

No. Close but not exact. Those with bigger resistances are likely more off due to rounding errors, since the current meter is only reading to the 10ths digit.

I would guess the actual resistance is in between the two numbers I got (3.5 and 3.7), so 3.6. For classes that have already learned averages, the best guess would be the average of the two measurements.

7. *Predict:* If you used the same resistor and a 9 volt battery instead (voltage = 9), what would be the current?

I = $\frac{V}{R} = \frac{9}{3.6} = \mathbf{2.5}$

If they give more significant digits than the 1st decimal, you can discuss whether the current meter can actually measure that precisely.

8. *Design:* If you are using 3 AA batteries and want a current of 10, what resistance resistor do you need?

R = $\frac{V}{I} = \frac{4.5}{10} = \mathbf{0.45}$ Students likely will use their exact value from part 5 for V

Note about units: For those who are familiar with basic circuits, you may find the resistance values strange, because the resistances being calculated are actually in kilo ohms (kΩ). [1000 Ohms = 1 kΩ] This is because the digital multimeter used to measure current is measuring in milliamperes (mA), not amperes. [1000 mA = 1 Ampere].