Department of ELECTRICAL & COMPUTER ENGINEERING
THE UNIVERSITY OF UTAH

Representing Circuit Components with Functions

Teacher Notes

Designed for 8th or 9th Grade

Standard 8.F.5 Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear).
Standard A.REI.10 Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).
Standard F.LE.1 Distinguish between situations that can be modeled with linear functions and with exponential functions.

Supplies needed:

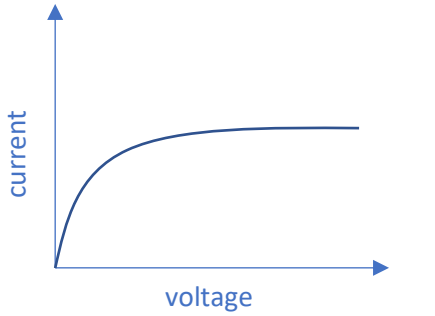
3 AA batteries	Battery holders	Resistor	Alligator clip wires
Voltage meter	Current meter	LED	

Overview:

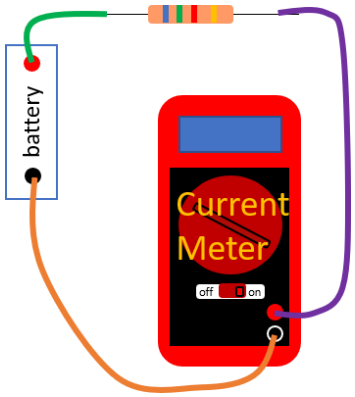
Electrical devices work through the flow of electrons, which are charged particles. For an electrical circuit to work, it must have something that provides power (like a battery), something that consumes power (like a resistor or LED), and wires must connect everything in a circle, so the electrons can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

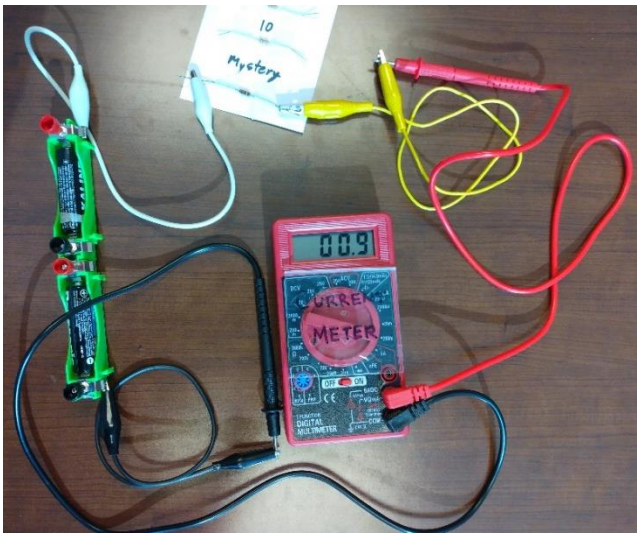
Some electrical components obey linear laws and others have more complicated relationships between voltage and current. Electrical engineers often represent the behavior of different circuit components by plotting their i-V curves, which is a graph relating current and voltage for that particular electrical component. Today we are going to create i-V curves for two basic circuit components—resistors and LEDs (Light Emitting Diodes)—to determine which is a linear circuit component and which is a nonlinear circuit component.

Example i-V curve: (for a transistor)



1) **RESISTOR.**
   a) Build the following circuit, which includes a battery, a resistor, and the current meter in a loop. The current meter will measure the current. Use any resistor from the card, but make sure you use the same one for reach measurement. We will collect 3 different data points by changing the voltage. We will start with 1 battery, then add a second battery in a row and then a 3rd battery to get 3 different points. Make sure the red side of the batteries all face the same direction.





Using the resistor labeled 5, I got the following readings. (Since each battery is not exactly 1.5 volts, students' answers may vary by several tenths.)

1 battery:	2 batteries:	3 batteries:
Voltage = 1.5 Volts	Voltage = 3 Volts	Voltage = 4.5 Volts
Current = 0.3	Current = 0.6	Current = 0.9

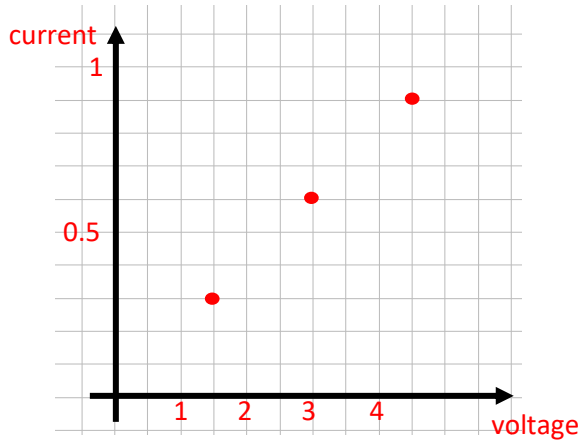
Each time they add a battery, the current should double.

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

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
- For #2: LED backwards (+ side of LED must connect to + side of batteries)

b) Plot the data. Make sure to label your axes.

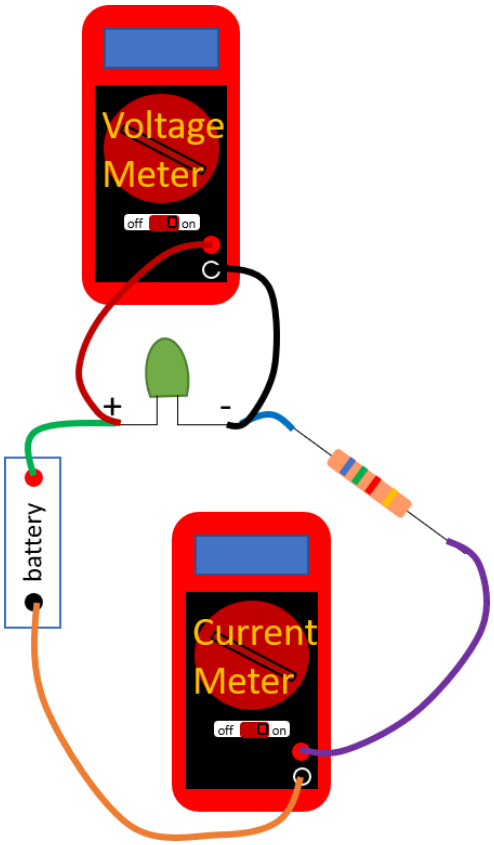


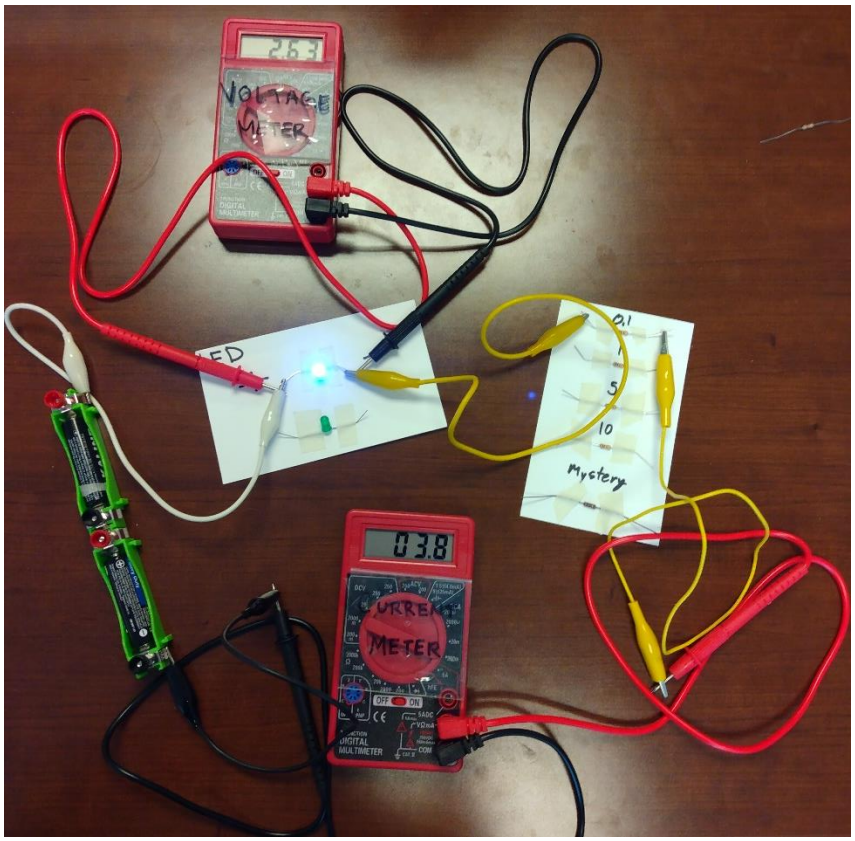
c) Is the relationship between current and voltage (LINEAR) or NONLINEAR ? (circle one)

2) **LED.**

a) Build the following circuit, which includes a battery, resistor, LED, and current meter in a loop. (Whenever we work with LEDs, we must also include a current-limiting resistor.) You should use the 0.1 resistor, but you can choose which color LED you want to use. The + side of the LED must connect to the red side of the battery. Just like before, we will use 1, 2, and 3 batteries to create 3 different data points for our plot.

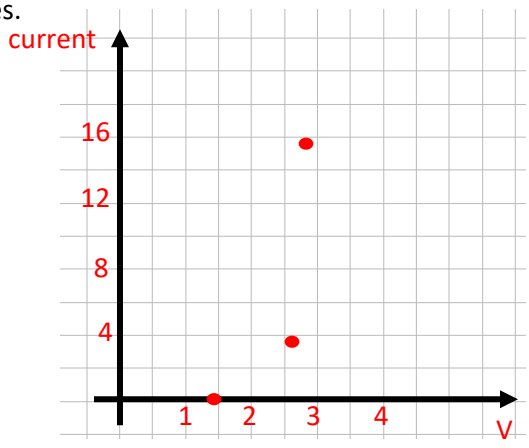
Since there are multiple circuit components in the loop with the battery, they split the voltage from the battery, so this time we must measure BOTH the voltage across the LED and current through the LED (before we could just use the voltage of the battery as our voltage). Connect the red wire from the VOLTAGE READER to the + side of the LED and the black wire from the voltage reader to the "–" side of LED.





1 battery:	2 batteries:	3 batteries:
Voltage = 1.5	Voltage = 2.63	Voltage = 2.85
Current = 0	Current = 3.7	Current = 15.5

b) Plot the data. Make sure to label your axes.



c) Is the relationship between current and voltage LINEAR or NONLINEAR ? (circle one)

3) Which circuit component is represented by each equation?

$y = ax$ LED or RESISTOR

$y = a2.7^{bx} - a$ LED or RESISTOR