HIMALAYAN MAKERS GUILD

ACTIVITY 11 – OHM'S LAW AND RESISTOR VALUES

LEARNING OUTCOMES

Students will,

1. Use Ohm's Law to choose the resistor for an LED circuit.
2. Read resistor colour-code values.
3. Test their LED circuit.

This activity can be done in **~1 hour**, however **~1.5 hours** would be a more comfortable duration.

Outline:

1. 5m Rock-slide Analogy of Electricity
2. 5m Using a Smaller Battery in the Night-Light
3. 10m Ohm's Law
4. 10m Find the New Resistor Value
5. 10m How to Read Resistor Values
6. 15m Test the Circuit
7. 5m Reflection

This lesson plan assumes free access to a black-and-white printer, a classroom with a whiteboard, blackboard, or chart-paper. This activity does not require regular access to electricity.

MATERIALS AND COSTS PER STUDENT

Item	Qty.	Cost per Student[1]	Expendable[2]	Supplier
LED Assorted 3mm 5mm	1	0.02	y	AliExpress
Resistors Assorted 2100pcs	4	0.02	y	AliExpress
9V Battery Snap	1	0.16		AliExpress
Jumper cables MM MF FF 10cm	2	0.04	y	AliExpress
Breadboard 400 point	1	1.49		AliExpress
Breadboard Power Supply	1	0.75		AliExpress
9V Ni-Mh 450mAh	1	5.17		AliExpress
Total Cost per Student		**$7.66 CAD**		

1. Currency is CAD, 2017-06-10. Assuming one set of parts per student. ↩
2. Likely to be broken or lost during the activity. ↩

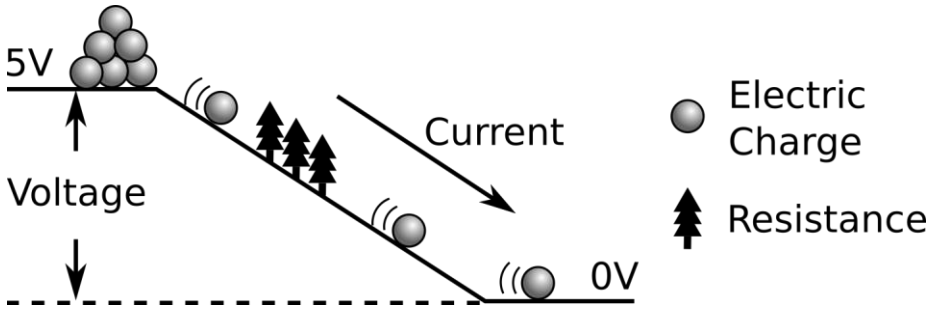
Recommended resistor values to have are 2.2, 10, 220, and 680 ohms. At least one 10 ohm resistor should be available per student. Note that the Breadboard Power Supply Output must be switched to 3.3V for the activity. 3.2V is used in the students' calculations to simplify the outcome to a whole 10 ohms. White 5mm LEDs should be used for the activity (forward voltage of ~3V).

LESSON

Before class: connect each of the power supplies to a breadboard and change output voltage to 3.3V; snap the battery snaps onto the 9V batteries; print student handouts.

Bold text indicates direction or notes for the instructor.

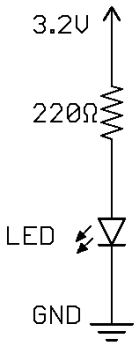
1. ROCK-SLIDE ANALOGY OF ELECTRICITY



- What happens to current when we increase the voltage? **(draw a higher hill)** A: current increases
- What happens to current when we increase the resistance? **(draw in more trees)** A: current decreases

2. USING A SMALLER BATTERY IN THE NIGHT-LIGHT

- So far, we've used a 5V power supply for our night-light. However, we want to be able to use a small coin-cell battery. The battery only gives about 3.2V. What will happen to the brightness of our LED when we change the voltage from 5V to 3.2V? A: more dim, because there will be less current.



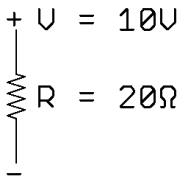
- What can we change about the circuit to get full brightness again? A: instead of using a 220 ohm resistor, we can use a smaller one.
- But, how much smaller should the resistor be? Is 200 ohms small enough? What about 5 ohms? What happens if we make it too small? A: burnout.
- To find the exact value we need, we can use Ohm's Law. It's an equation that relates voltage, current, and resistance.

3. OHM'S LAW

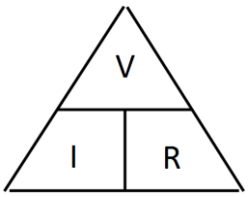
- **Review units and symbols. Amps is a new unit for the students, though Volts and Ohms have been introduced already.**

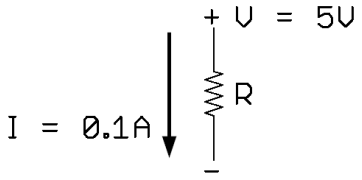
Rock-slide Symbol	Electrical Property	Unit	Symbol
Height of the Hill	Voltage	Volts [V]	V
Trees	Resistance	Ohms [Ω]	R
Moving Rocks	Current	Amps [A]	I

- I = V/R: as we looked at with the rock-slide, I gets bigger as V gets bigger and I gets smaller with R.
- Example 1: Find I. A: I = V/R = 10V/20ohms = 0.5A.

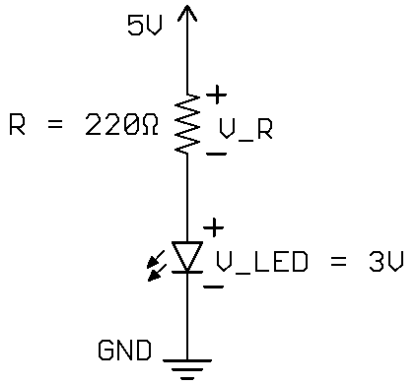


- Example 2: Find R. A: R = V/I = 5V/0.1A = 50 ohms
- To help us rearrange the equation, we can imagine the equation as a triangle. We cover the variable we're looking for, and the equation using the remaining two variables is left. If they are stacked on top of each other, we divide; if they are side-by-side we multiply.





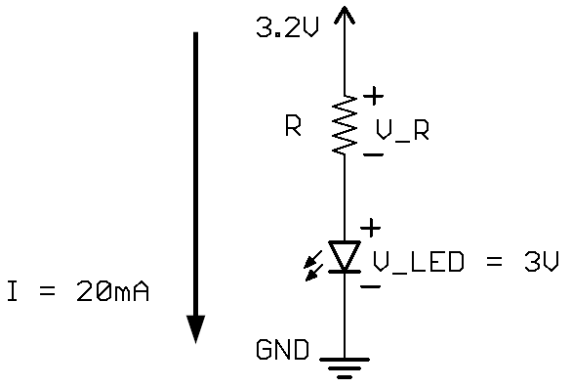
- Example 3: Find I in the 5V LED circuit.
- To solve this, there is one other thing we need to know: in a circuit, the voltage must always balance out to zero. **Note: this is known as Kirchoff's Voltage Law.**
- We a 5V battery, so the voltage dropped across the resistor and the LED must add up to 5V.
- We can write this out as Vbatt = V_R + V_LED
- When the LED is on (current is flowing through the circuit), what voltage drops across the LED? A: 3V



- So, how much voltage is left to be dropped across the resistor? A: 2V.
- When we calculate current through the resistor, we must use this 2V that is across the resistor!
- A: R = V_R/I = 2V/220ohms ~= 0.01A or 10mA **(explain that there are 1000 mA in one A, just like mm in one m)**

4. FIND THE NEW RESISTOR VALUE

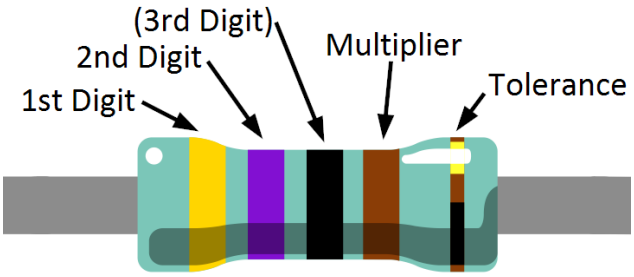
- Challenge: Find the resistor we should use with with the 3.2V battery to get a current of 20mA through the LED



- Once you find the value, we'll build the LED circuit with it and test it!
- **Have the students work in groups of 2-3, and keep their answers to themselves**

5. HOW TO READ RESISTOR VALUES

- The coloured bands on a resistor tell us how much resistance it has.



- The first three bands give us the three digits of the value
- The fourth line is the multiplier, or how many zeros to add to the three digits
- The fifth line is the tolerance, or how close to the desired value the resistor will be
- Sometimes, there are only 4 lines in total, so there are 2 digits instead of 3
- How do we know which side to read from? The tolerance is usually thinner, and the digits are usually closer together at one end. The tolerance is also often silver or gold, while the digits are colours.

Color	Digit value	Multiplier	Multiplier Result	Tolerance
Silver		10-2	0.01	±10%
Gold		10-1	0.1	±5%
Black	0	100	1	±2%
Brown	1	101	10	±1%
Red	2	102	100	
Orange	3	103	1 000	
Yellow	4	104	10 000	
Green	5	105	100 000	
Blue	6	106	1 000 000	
Purple	7	107	10 000 000	
Gray	8	108	100 000 000	
White	9	109	1 000 000 000	

6. TEST THE CIRCUITS

- **Give the students the handouts so they can refer to the colour table.**
- **Have each group write down the colour bands for the resistor value they calculated. Check their answers and give them the nearest resistor value available. Ask them to build the LED circuit with the resistor to see how it works.**
- **Compare the circuits side by side. Hopefully the groups have some different answers, and get different results (dim LEDS, or burnt out LEDs).**
- **Explain how to arrive at the correct value of 10 ohms:**
- This time, the voltage drop across the resistor is 3.2V - 3V = 0.2V
- The current we want is I = 20mA = 0.02A.
- So, R = V_R/I = 0.2V/0.02A = 10 ohms
- **common error #1: 3.2V used instead of 0.2V –> 160 ohms**
- **common error #2: answer is 1000x smaller than it should be because the student divides by 20 instead of 0.02, not accounting for the milliamps unit**

7. REFLECTION

- What happens if the R is much bigger than 10 ohms? A: dim. And if it's smaller than 10 ohms? A: burnout.
- Now that we have calculated 10 ohms, we can use that value to get the most brightness from our LED when using a 3.2V battery like the small coin-cell battery we will use in our night-light circuit.
- What is one reason we might want to use a bigger resistor? A: to make our battery last longer, while making the trade-off of having a dimmer LED.

Further reading: https://learn.sparkfun.com/tutorials/voltage-current-resistance-and-ohms-law