HIMALAYAN MAKERS GUILD

ACTIVITY 9 – VOLTAGE DIVIDER NIGHT-LIGHT

LEARNING OUTCOMES

Students will,

1. Use a voltage divider circuit to control an LED with a light-sensitive resistor

This activity is intended to lay the foundation for discussing both transistors and Ohm's Law in the next activities. The night-light circuit design is deliberately flawed, creating an opportunity to make good use of a transistor. It also introduces specific resistor values and the unit of resistance (ohms), leading the way to a more formal discussion of Ohm's Law.

This activity should take **~1 hour** to complete:

- 5m review of the rock-slide analogy of electricity and how voltage drops across resistors
- 15m discuss voltage divider, LED, and LSR
- 25m hands-on activity
- 10m 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 220 ohm, 2.2k/22k ohm	2	0.01	y	AliExpress
9V Battery Snap	1	0.16		AliExpress
Jumper cables male/male 10cm	4	0.08	y	AliExpress
Photoresistor Light Sensor (LSR)	1	0.05		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		**$7.74 CAD**		

Note that the LED used here is a white LED (turns on at 2.8V).

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

If running the activity in a room with daylight, I recommend using a 2200 ohm resistor in the voltage divider. If running the activity in a fluorescent lit room, use a 22000 ohm resistor in the voltage divider. This will also depend on your light sensitive resistor (LSR). The one used in this activity behaves as follows:

- In daylight: 2.2k ohms, 20k ohms when covered with a finger
- At dusk: 10k ohms, 40k ohms when covered with a finger
- Fluorescent lighting: 11k ohms, >50k ohms when covered with a finger

LESSON

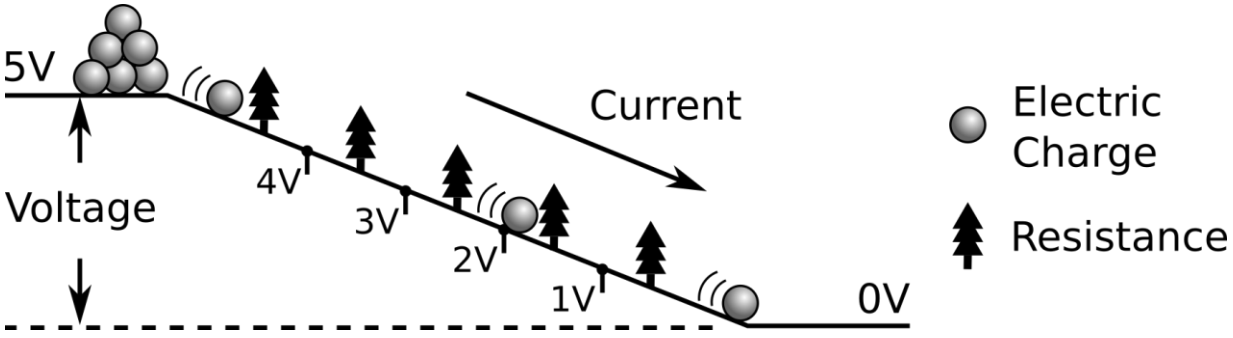
Before class: connect each of the power supplies to a breadboard; snap the battery snaps onto the 9V batteries; gather electronic components; print student handouts.

Outline:

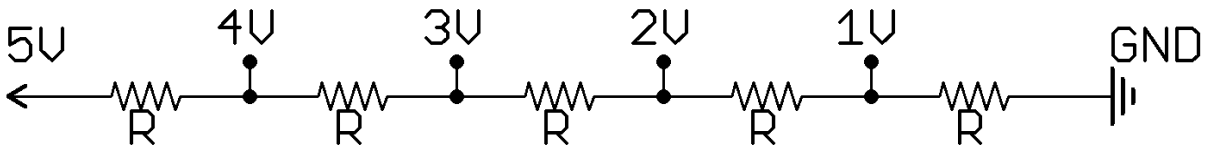
1. Voltage Divider
2. LED Properties
3. Light Sensitive Resistor
4. Build the Circuit
5. Reflection

VOLTAGE DIVIDER

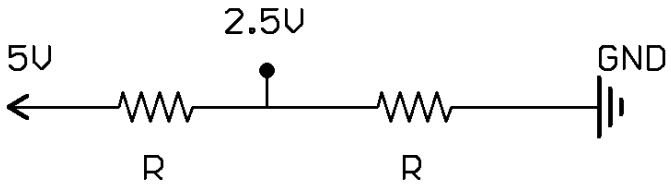
- Today, we are going to use a light sensor to make a night-light: a light that turns on when the room becomes dark.
- Looking at the rock-slide analogy of electricity, as current passes through a resistance, voltage is dropped. The amount of voltage dropped depends on how much of the total resistance the resistor is. So if we have 5 equal resistors, the 5V is dropped equally across them (1V across each).



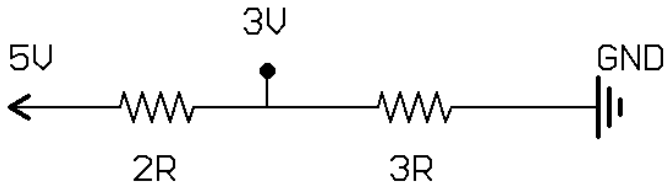
- We can also draw this as a circuit diagram:
- Would the voltage drop change if we doubled each of the 5 resistors? A: no. What would change? A: the current would become smaller.



- If we have two equal resistors, the voltage is dropped equally between them (5V/2 = 2.5V)



- If we consider the five equal resistances combined into a group of 2R and 3R, then 2V is dropped across the 2R and 3V is dropped across the 3V



- We can use this concept with a light-sensitive resistor to turn an LED on and off automatically if the room becomes dark or light.

LIGHT EMITTING DIODE (LED) PROPERTIES

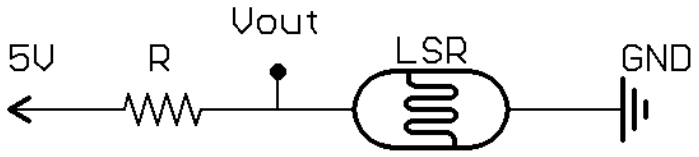
- When the voltage across the LED is less than 3V, current cannot flow through it (it's like an open switch)
- When the voltage across the LED is greater than 3V, current flows through the LED very easily (almost no resistance, like a closed switch)
- To help prevent high current from passing through the LED and burning it out, we use a resistor. For a 5V supply, we usually use a resistor that is 220 ohms. An ohm is a unit of resistance, similar to meters for distance or degrees Celsius for temperature.
- Where would we connect the LED and resistor to the voltage divider so that it turns on? A: above the 3rd (3V), 4th (4V), 5th (5V) resistors, but R must be much bigger than 220 ohms, so that current prefers to flow through then LED rather than the resistors in the divider.

LIGHT SENSITIVE RESISTOR (LSR)

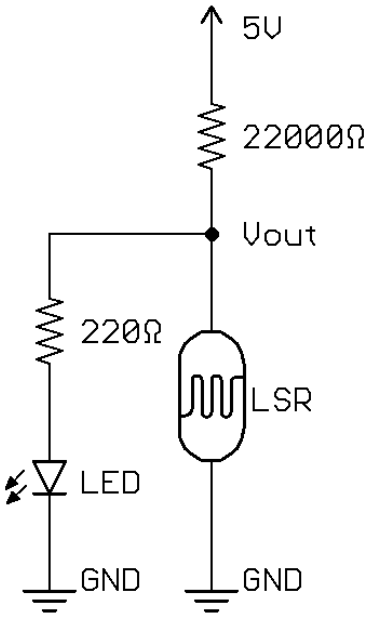
- When in a dark room, an LSR has a large resistance
- When light shines on the LSR, its resistance becomes smaller
- If we connect the LSR in series with the LED and 220 ohm resistor, what happens in when it's light and dark? A: In the light, the LSR resistance is small, so lots of current will flow through the LED, making it shine brightly. In the dark, the resistance of the LSR becomes

large, and very little current flows through the LED, so it gives off little or no light. That's not a very helpful circuit; we'd like the LED light to turn on when the room becomes dark.

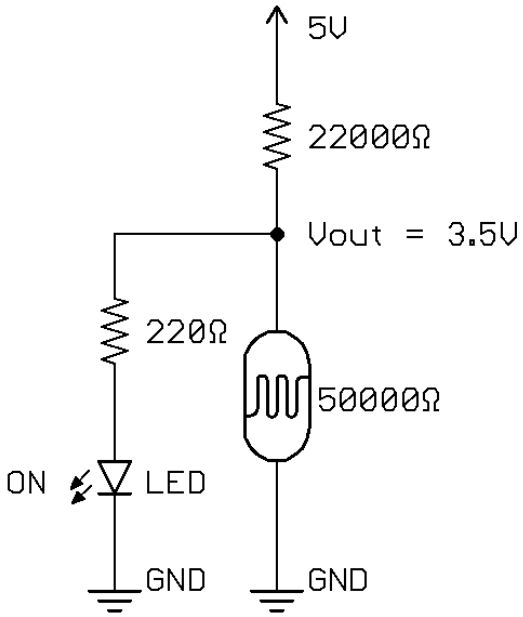
- How can we do this using the LSR in a voltage divider? Can someone try drawing the circuit? A:



- Let's attach the LED and 220 ohm resistor to this voltage divider:
  - Note: in this case, the 220 ohm resistor is not needed to protect the LED from excessive current because the current must flow through the top resister in the voltage divider. I have kept it in the circuit so the students can compare it to the value of the resistor in the divider (which is much bigger) and understand why the LED is so much dimmer than it usually is.



- What would happen if the LSR was on the top, toward the 5V source? A: the LED would turn on when it's light out, and off when it's dark.
- How does it behave with the LSR on the bottom? A: when it's light, the LSR resistance is low, and Vout becomes small so the LED is off. When it's dark, the LSR resistance is high and the LED turns on.



- What should we do with the top resistance in the divider if the LED is still on when the room is bright? Should we make it bigger or smaller to lower Vout so the LED is off? A: increase the resistance of the top resistor.

BUILD THE CIRCUIT

- Distribute the parts to the students, and have them try to build the night-light circuit shown on the handout (and above)

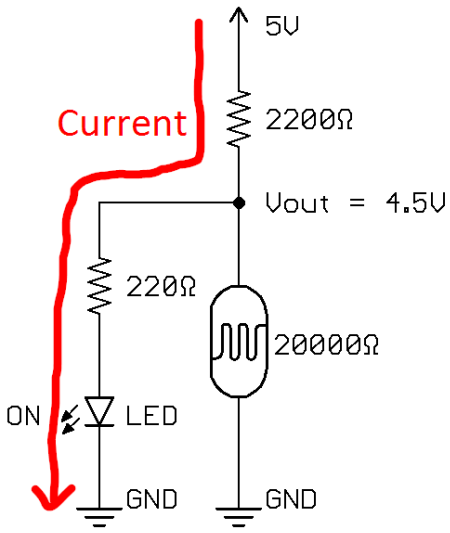
FREQUENTLY ASKED QUESTIONS

- The student thinks the circuit isn't working because the light isn't turning on. A: clarify that in a bright room, we want the light off. To imitate being in a dark room, the student should cover the LSR with their finger, and the LED should turn on.
- The student connects all of the components in series. A: have them try drawing the circuit diagram of the circuit they've built, and compare it to the night-light circuit.
- Circuit looks good, but it's still not working. A: Check LED polarity (long leg should be connected towards the positive voltage, short leg towards ground); check that the power supply isn't on the board backwards (+ from the power supply is connected to + on the breadboard).

REFLECTION

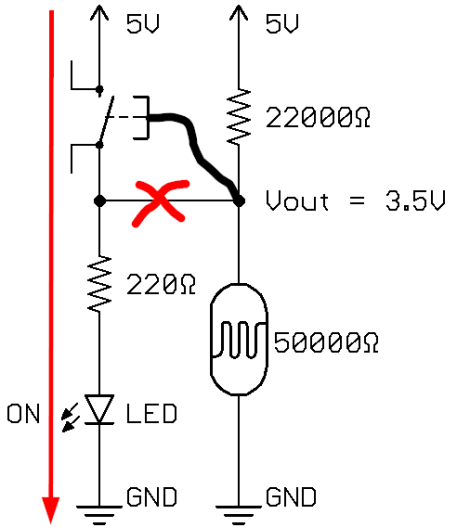
- Are we controlling the LED with an analog or a digital voltage value? A: analog.
- Any observations? Are there things you would change about the circuit? A: 1. the light is very dim (can show the LED and 220 ohm resistor connected directly to 5V for comparison). 2. It would be nice to have a switch so that the light could be turned off even if the room is dark.

- Why is the LED so dim? A: because the current has to flow through the large resistor in the voltage divider before passing through the LED (10-100x the usual 220 ohm resistor used with the LED). Very little current passes through the LSR, since its resistance is much greater than 220 ohms.



- How could we make the LED brighter? A: we could lower the resistance of both the LSR and R in the divider, so they keep the same Vout behavior but have less total resistance.
- What's the problem with lowering the total resistance of the voltage divider? A: there will be more current constantly draining through the divider, which would quickly empty a battery.

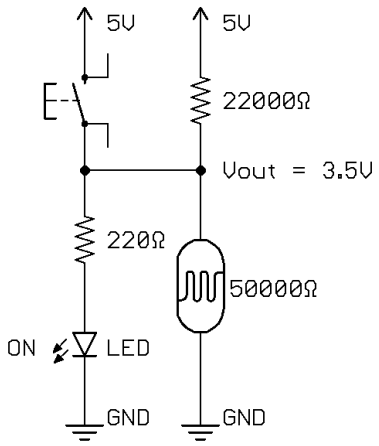
- What if we could connect the LED and 220 ohm resistor to 5V with a switch that is controlled by a voltage, so the current doesn't need to come from the voltage divider?



CHALLENGE AND EXPLORE

Evaluate the students' understanding of the learning objectives by asking them to try the following:

- Add a push button to connect the LED and 220 ohm resister directly 5V. How does the brightness compare to powering it from the voltage divider?
    - Skill: Building breadboard circuits



- Try using the same voltage divider to power a small DC motor. Does it work? A: no, there is too much resistance to power the motor from the voltage divider.
    - Skill: Building breadboard circuits
- How many nodes are there in the circuit?
    - Skill: Reading and drawing circuit diagrams