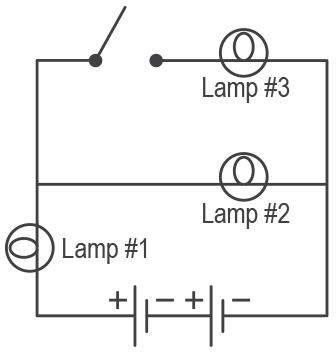
# **Investigation 17F: Compound circuits**

**Essential question: How can voltage, current, and power be used to predict the behavior of electric circuits?**

In the first part of this investigation, you will predict the brightness of lamps in a circuit. Lamp brightness is a measure of the dissipation of power. In the second part, you will explore the properties of a commonly used kind of circuit called a voltage divider.

Part 1: Power dissipated by elements in a compound circuit

1. Open the experiment file **17F\_CompoundCircuits**, and then power-on the Current and Voltage sensors and connect them to your software.
2. For the circuit at right, predict the relative brightness of the lamps when the switch is closed and when it is open.

Prediction of relative brightness when switch is closed:

Prediction of relative brightness when switch is open:

Prediction: Will lamp #1 get brighter, dimmer, or stay the same when the switch is closed?

Prediction: Will lamp #2 get brighter, dimmer, or stay the same when the switch is closed?

1. Construct the circuit.
2. Note the brightness of the lamps when the switch is open.
3. Close the switch and note how each bulb’s brightness changes.

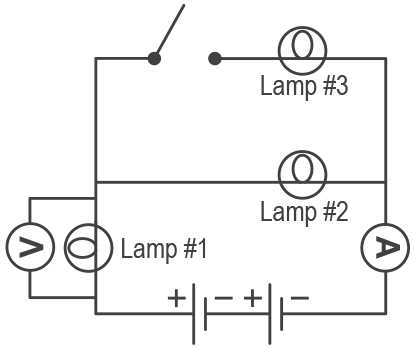
Questions

1. Using Kirchhoff’s laws and/or an equation for power, justify your prediction for the relative brightness of the lamps when the switch is closed.

Answer: Lamp #1 will be the brightest because it has the most current. Identical bulbs have equal resistance. Since *P = I2R*, the lamp with the greatest current is brightest. Lamps #2 and #3 will be of equal brightness because they have the same resistance and the same voltage drop (since they are in parallel), and *P = V2/R.*

1. Did the brightness of lamp #1 change when the switch was closed? Provide an explanation.

Answer: Lamp #1 gets brighter. Closing the switch causes the *Req* to decrease, so total current increases. Since *P = I2R*, lamp #1 will get brighter when the current increases.

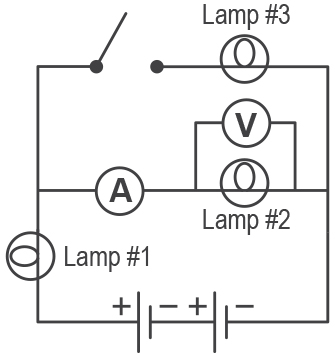
1. Add a voltage and current sensor to your circuit. Measure the voltage across and current through lamp #1 with the switch open and closed then calculate the power. How do the measurements justify your explanation?

|  |  |  |  |
| --- | --- | --- | --- |
| Switch | V (V) | I (A) | P (W) |
| open | 1.474 | 0.053 | 0.078 |
| closed | 2.361 | 0.067 | 0.158 |

Answer: The power output from Lamp #1 is much higher when the switch is closed than when the switch is open. The brightness is directly related to the power output.

1. Did the brightness of lamp #2 change when the switch was closed? Provide an explanation.

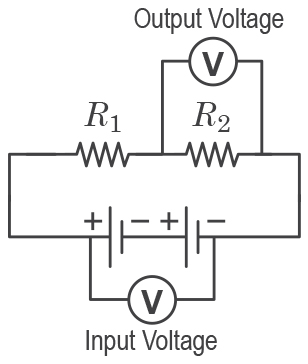
Lamp #2 gets dimmer. Since the total current decreases, the voltage drop (*V = IR*) across lamp #1 also decreases. If the voltage across lamp #1 increases, the voltage across lamp #2 must decrease (by Kirchhoff’s voltage rule). Since *P = V2/R,* lamp #2 will get dimmer.



1. Add a voltage and current sensor to your circuit. Measure the voltage across and current through lamp #2. Calculate the power. How do the measurements justify your explanation?

|  |  |  |  |
| --- | --- | --- | --- |
| Switch | V (V) | I (A) | P (W) |
| open | 1.511 | 0.052 | 0.078 |
| closed | 0.623 | 0.033 | 0.021 |

Answer: The power from Lamp #2 is less when the switch is closed than when the switch is open. Again, the brightness is related to the power output.

Part 2: Voltage divider

1. Construct the circuit shown using the resistor values in Table 1.
2. Measure the input voltage and the output voltage for each resistor combination in the table.
3. Record your measurements in Table 1.

**Table 1: Voltage divider measurements**

|  |  |  |  |
| --- | --- | --- | --- |
| resistor *R*1 | resistor *R*2 | input voltage (V) | output voltage (V) |
| 100 Ω | 10 Ω | 3.005 | 0.275 |
| 33 Ω | 10 Ω | 2.983 | 0.691 |
| 10 Ω | 10 Ω | 2.930 | 1.461 |
| 10 Ω | 33 Ω | 2.981 | 2.280 |
| 10 Ω | 100 Ω | 3.005 | 2.730 |

Questions

1. How does the output voltage vary with *R*1?

Answer: As *R*1 increases, the output voltage decreases.

1. How does it vary with *R*2?

Answer: As *R*2 increases, the output voltage increases

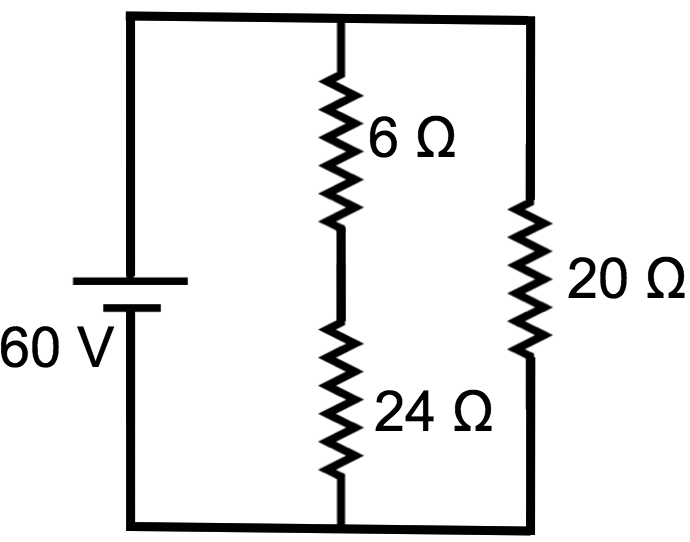
1. Create a mathematical model to predict the output voltage using the values of the input voltage and the two resistances.



1. Why is this circuit called a voltage divider?

Answer: The total input voltage is divided between the two resistors. Changing either resistor changes the ratios of their voltages. The voltage across each resistor is proportional to its relative contribution to the *Req.*

Applying new knowledge



This circuit contains three bulbs, each with a different resistance.

1. Calculate the equivalent resistance of the circuit.



answer: *Req* = 12 Ω

1. Calculate the total current through the circuit.



answer: *I* = 5 amps

1. Calculate the current through each lamp.



1. Calculate the power of each bulb and list them in order of brightness.

answer: The 20 Ω bulb will be brightest, and the 6 Ω bulb will be dimmest

