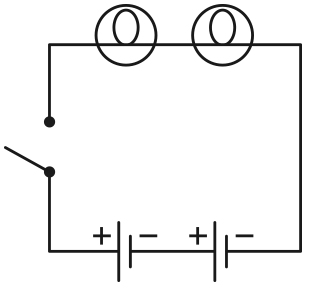
# **Investigation 17D: Series and parallel resistances**

**Essential question: What are the advantages and disadvantages of series versus   
parallel circuits?**

Have you ever had a string of holiday lights where one bulb is burned out, preventing all the other bulbs from lighting? Was it easy to find the burned out bulb? This investigation explores series and parallel circuits by connecting bulbs and observing their brightness. By comparing the two circuit types, you will learn why the wiring of *some* strings of lights allows one bad bulb to disconnect all the other bulbs.

Part 1: Connecting bulbs in series

1. Create a circuit using two batteries, one bulb, a switch, and any necessary wire modules.
2. Close the switch and observe the brightness of the bulb.
3. Create a circuit with two bulbs *in series*, as shown in the circuit diagram. Compare the brightness of the two bulbs to the previous circuit with one bulb.

Questions

1. What property makes this a series circuit?

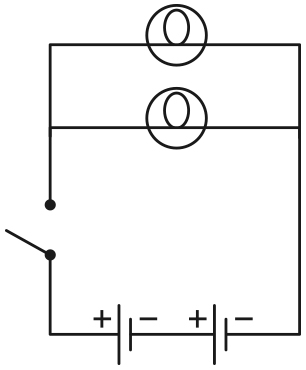
answer: The bulbs are connected one after another so that all the current that flows through the first bulb must flow through the second bulb.

1. How bright are the two bulbs in series compared to a single bulb circuit? Why?

answer: The bulbs in series are dimmer than the single bulb. This circuit has a larger total resistance, so less current flows through it to light the bulbs. Another way to explain this is that the single bulb is connected across the full 3 V of the power source, but the voltage across each bulb in series is only about 1.5 V.

1. Unscrew one bulb from the series circuit. What happens to the other bulb? Why?

answer: The other bulb goes out because the circuit is no longer complete. Removing one bulb creates an open circuit.

Part 2: Connecting bulbs in parallel

1. Create a circuit with two bulbs *in parallel*, as shown in the circuit diagram.
2. Compare the brightness of the bulbs in this circuit to the prior circuit with two bulbs in series.

Questions

1. What property makes this a parallel circuit?

answer: The current splits into two paths through the two different bulbs, and then comes back together again. The voltage across the two paths is identical.

1. How bright are the parallel bulbs compared to the series bulbs? Compared to the single bulb? Why?

answer: The parallel bulbs are brighter than the series bulbs. They have the SAME brightness as the single bulb. The total resistance of this circuit is less than the series circuit, so more current flows through each bulb. Also, each of these bulbs is connected to the full 3 V of the power supply, so they will get the same current flow as the single bulb.

1. Unscrew one bulb from the parallel circuit. What happens to the brightness of the other bulb? Why?

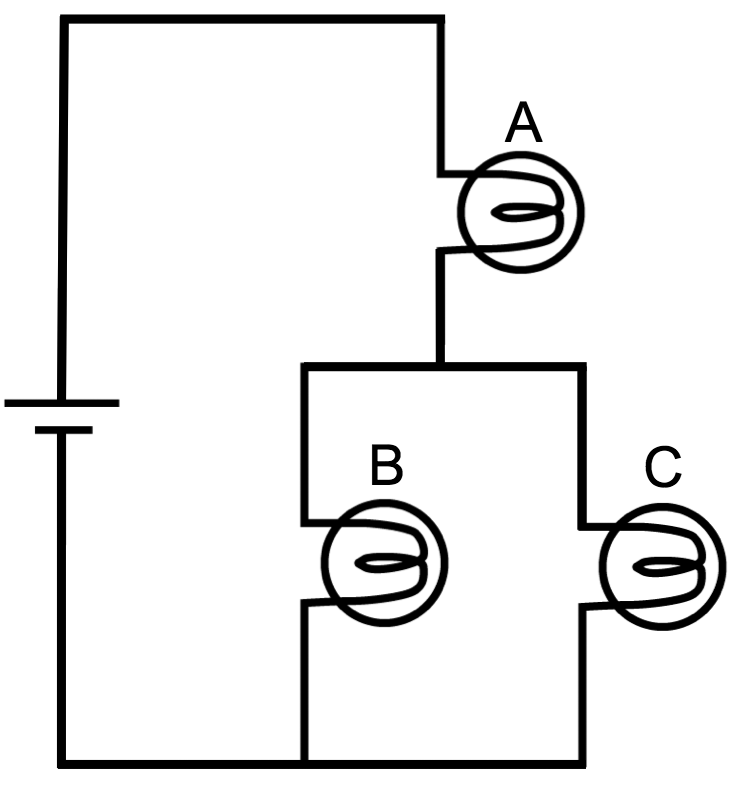
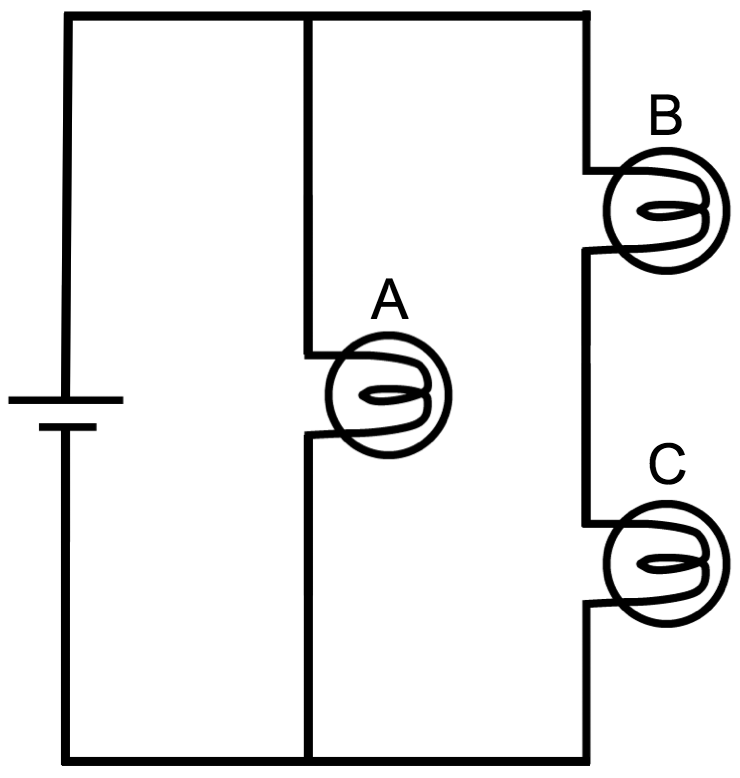
answer: The brightness of the other bulb does not change. It stills forms a complete circuit, and is still connected to the full 3 V of the power supply.

1. Is a series or parallel circuit better for connecting a string of lights? Why?

answer: A parallel arrangement is better. If one light in a series arrangement goes out, the whole circuit stops working. If one light in a parallel arrangement goes out, the rest of the bulbs continue to function normally.

1. Design a circuit of three bulbs that combines series and parallel arrangements, and sketch the circuit diagram. Predict the relative bulb brightness based on the previous experiments. Build the circuit and test your predictions. Were you correct?

answer: Two possible arrangements are shown. In both cases, A> B=C



Applying new knowledge

1. When resistors are connected in series:
   1. Is their equivalent resistance smaller or larger than the individual resistances? larger
   2. Is the current through them when connected together larger or smaller than their current if alone in the circuit? smaller
2. When resistors are connected in parallel:
   1. Is the combined resistance smaller or larger than the individual resistances? smaller
   2. Is the total current through the circuit larger or smaller than the total current if there were one resistor alone in the circuit? larger
   3. Is the current through each individual resistor larger or smaller than the current if it was alone in the circuit? Current is the same in both cases.
3. Two strings of tree lights, each with a resistance of 200 Ω, are connected together. What is their equivalent resistance if they are:
   1. connected in series? 400 Ω
   2. connected in parallel? 100 Ω
4. For two resistors with resistances of 10 Ω and 23.7 Ω, what is the equivalent resistance if they are:
   1. connected in series? 33.7 Ω
   2. connected in parallel? 7.0 Ω
5. What would be the equivalent resistance if a third resistor of 12.8 Ω were:
   1. added in series with them? 46.5 Ω
   2. added in parallel with them? 4.5 Ω