Series and Parallel Circuits

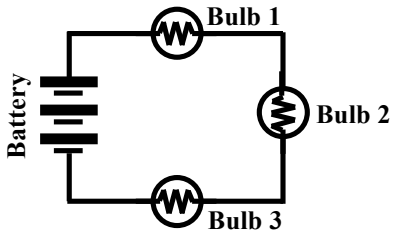
When two or more devices are connected to a battery in a circuit, there are a couple of methods by which they can be connected. One method is called a *series connection* and the other method is called a *parallel connection*. In a **series circuit**, such as that shown in **Figure 1**, all the devices are connected such that charge passes through each device in a consecutive fashion. When devices are connected in **parallel**, such as Bulbs 1, 2 and 3 shown in **Figure 2**, charge comes to a branching location. At the branching location, the charge divides into multiple pathways, passing through only one of the branches. Any charge that passes through Bulb 1, will not pass through Bulb 2 or Bulb 3.

A group of physics students conducted the following experiments in order to compare and contrast the characteristics of series and parallel circuit connections. In their experiments, light bulbs are used to indicate the amount of current (rate of charge flow) at each location. The brightness of the bulbs is proportional to the amount of current.

Experiment 1

Students constructed a series circuit consisting of a battery and three identical light bulbs as shown in **Figure 1**. All the bulbs are lit. They then unscrew Bulb 1 from its socket; they observe that Bulb 2 and Bulb 3 are no longer lit. They then unscrew Bulb 3; they observe that Bulb 1 and Bulb 2 are no longer lit.

Figure 1



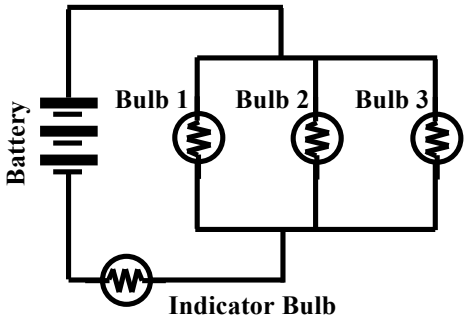
Experiment 2

Using the circuit in **Figure** 1, students observe that the brightness of all three bulbs is identical. The students remove Bulb 3 from the circuit. They then *re-wire* the circuit so that it includes only two bulbs. They observe the brightness of the remaining bulbs are equal, but brighter than when there were three. They then remove a second bulb so that there is only bulb in the circuit. They observe that the bulb is brighter than when present in the 2-bulb and the 3-bulb circuit.

Experiment 3

The students construct the circuit shown in **Figure 2**. Three identical bulbs - 1, 2, and 3 – are wired in parallel. A fourth bulb (a different type than bulbs 1, 2 and 3) is added outside the branches to serve as an indicator of the amount of current in the entire circuit. All the branch bulbs are lit and the students observe that their brightness is the same. The Indicator Bulb is lit as well; it is brighter than the branched bulbs. The students then unscrew bulb 1 from its socket. They observe that Bulb 2 and Bulb 3 remain lit; the Indicator Bulb becomes dimmer than it was when all three bulbs were present.

Figure 2



Then the students unscrew both Bulb 1 and Bulb 2 from their sockets. They observe that Bulb 3 remains lit. They also observe that the Indicator Bulb is dimmer than it was with two and with three branched bulbs.

Questions

1. In which type of circuit does charge flow through every light bulb in the circuit?
   a. Series Circuits
   b. Parallel Circuits
   c. Both Series and Parallel Circuits
   d. Neither Series and Parallel Circuits

2. Which type of circuit is characterized by the presence of branch locations?
   a. Series Circuits
   b. Parallel Circuits
   c. Both Series and Parallel Circuits
   d. Neither Series and Parallel Circuits

3. Which one of the following conclusions is **NOT** consistent with the findings of **Experiment 1** and **Experiment 2**?
   a. Increasing the number of bulbs in a series circuit will decrease the current.
   b. Identical bulbs in a series circuit will be equally bright regardless of their location.
   c. If the last bulb in the series *breaks down*, the bulbs that come before it can still remain lit.
   d. The brightness of bulbs in a series circuit is inversely proportional to the number of bulbs.

4. Which of the following conclusions is **NOT** supported by the findings of **Experiment 2**?
   a. When there are more bulbs in a series circuit, the current is less.
   b. Adding more bulbs to a series circuit causes each bulb to become dimmer.
   c. The current in a series circuit is affected by the number of bulbs in the circuit.
   d. Bulbs that are closer to the battery are brighter than bulbs that are further from the battery.

5. Which statement most accurately describes the purpose of **Experiment 2**?
   a. To determine how many different bulbs the battery could push charge through.
   b. To determine if all branched bulbs must be lit in order for any of them to be lit.
   c. To determine how decreasing the number of light bulbs effects the amount of current.
   d. To determine if unscrewing any bulb would interrupt the change flow and cause the other bulbs to not light.

6. The rate at which charge flows through a series circuit is inversely proportional to the amount of overall *resistance* in the circuit. Based on the results in **Experiment 2**, which one of the following series circuits has the greatest resistance?
   a. A 1-bulb series circuit.
   b. A 2-bulb series circuit.
   c. A 3-bulb series circuit.
   d. The resistance would be independent of the number of light bulbs.

7. The rate at which charge flows through a series circuit is inversely proportional to the amount of overall *resistance* in the circuit. Based on the results in **Experiment 2**, which one of the following rules accurately describes the effect of the number of bulbs upon overall current and overall resistance?
   a. Increasing the number of bulbs will cause both the current and the resistance to increase.
   b. Increasing the number of bulbs will cause both the current and the resistance to decrease.
   c. Increasing the number of bulbs will cause the current to increase and the resistance to decrease.
   d. Increasing the number of bulbs will cause the current to decrease and the resistance to increase.

8. What was the role of the Indicator Bulb in **Experiment 3**?
   a. It indicated whether the circuit was a series or a parallel circuit.
   b. It was included so that there would be at least one bulb in seires.
   c. It brightness indicated the rate of charge flow within the circuit as a whole.
   d. Its presence allowed the students to control the amount of current in the branches.

9. The overall rate at which charge flows through a parallel circuit is inversely proportional to the amount of overall *resistance* in the circuit. Based on the results in **Experiment 3**, which one of the following parallel circuits has the greatest resistance?
   a. A 1-bulb parallel circuit.
   b. A 2-bulb parallel circuit.
   c. A 3-bulb parallel circuit.
   d. The resistance would be independent of the number of light bulbs.

10. Which one of the following statements does **NOT** describe a difference between the findings of **Experiments 1** and **2** and the findings of **Experiment 3**?
   a. In series, adding more light bulbs decreases the current; it is just the opposite for parallel.
   b. In series, when one bulb *burns out*, the other bulbs do not work; it is just the opposite for parallel.
   c. In series, a decrease in the number of bulbs increases the current; it is just the opposite for parallel.
   d. In series, the bulb closest to the battery lights the brightest; they have equal brightness when in parallel.

11. Bulbs 1, 2 and 3 in **Figure 1** were observed to be the same brightness. Bulbs 1, 2, and 3 in **Figure 2** were also observed to be equally bright. Which one of the following experimental conditions were essential for such an observation?
   a. The circuit in **Figure 2** must also include an Indicator Bulb.
   b. The bulb brightness was proportional to the current in each bulb.
   c. The **Figure 1** bulbs were in series and the **Figure 2** bulbs were in parallel.
   d. All the bulbs in **Figure 1** were identical to each other; the same was true for **Figure 2**.

12. Rooms in homes and businesses are wired such that one device in a circuit can be OFF or even *broken*, but the other devices will still work. How are such devices wired - in series or in parallel - and how do you know?

	Series or Parallel?	Explanation
a.	Series	There is more than one pathway for charge to follow in a series circuit; *breaking* one path will not close the other paths.
b.	Series	There is only one pathway through which charge flows in a series circuit; *breaking* that one path will cause all devices in the path to not work.
c.	Parallel	There is more than one pathway for charge to follow in a parallel circuit; *breaking* one path will not close the other paths.
d.	Parallel	There is only one pathway through which charge flows in a parallel circuit; *breaking* that one path will cause all devices in the path to not work.