



a place of mind

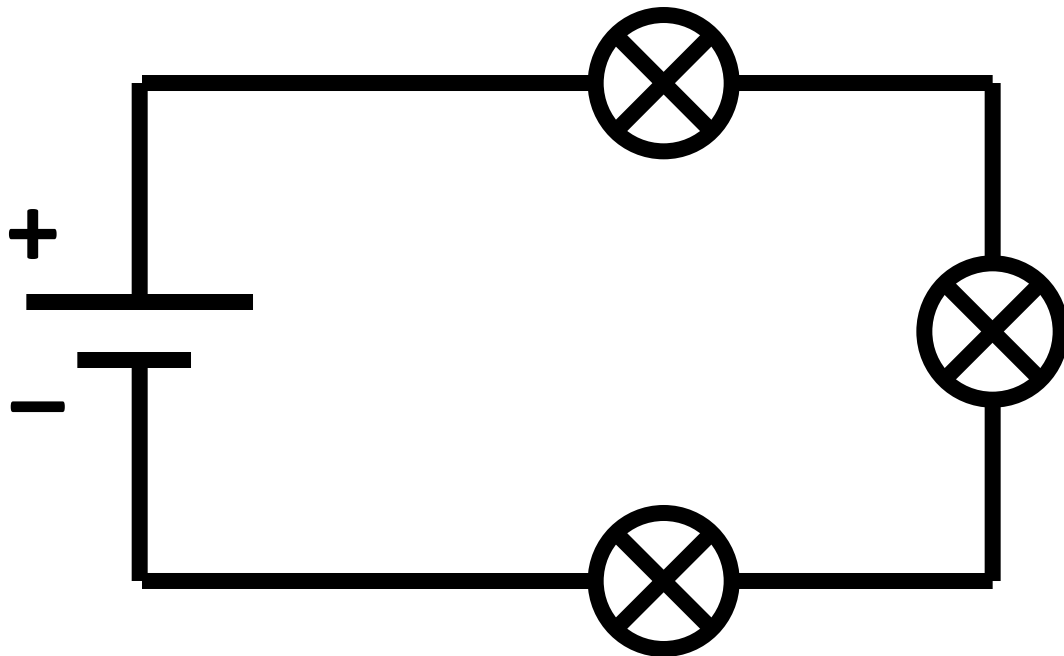
FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

Physics Circuits: Series

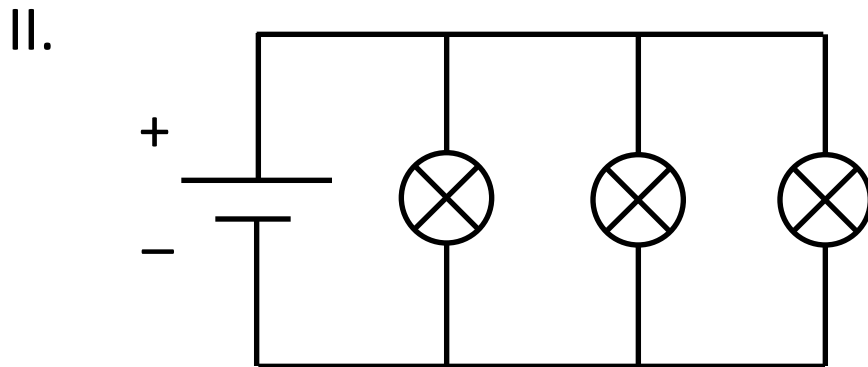
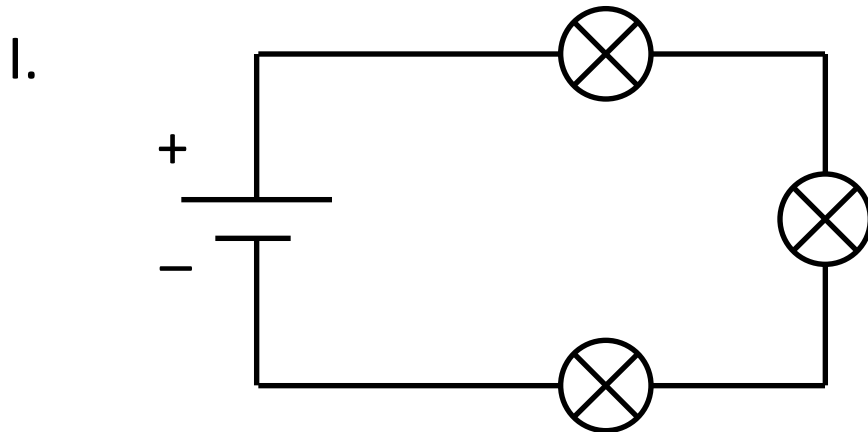
Science and Mathematics
Education Research Group

Series Circuits



Series Circuits I

Which of the two circuits below is a series circuit?



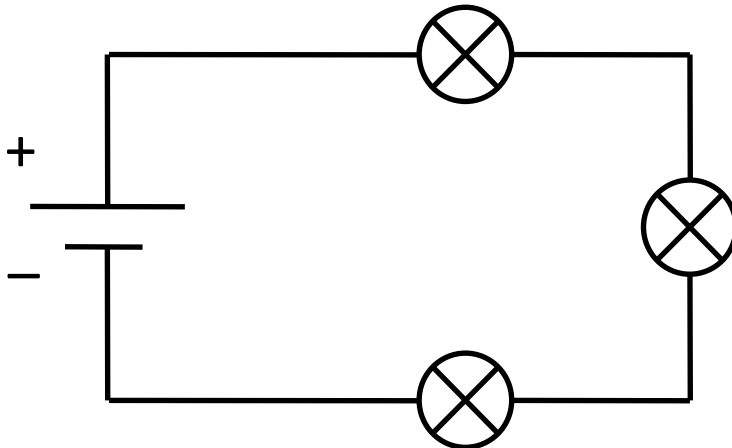
- A. I
- B. II
- C. Both are series circuits
- D. Both are parallel circuits
- E. Depends on the battery

Solution

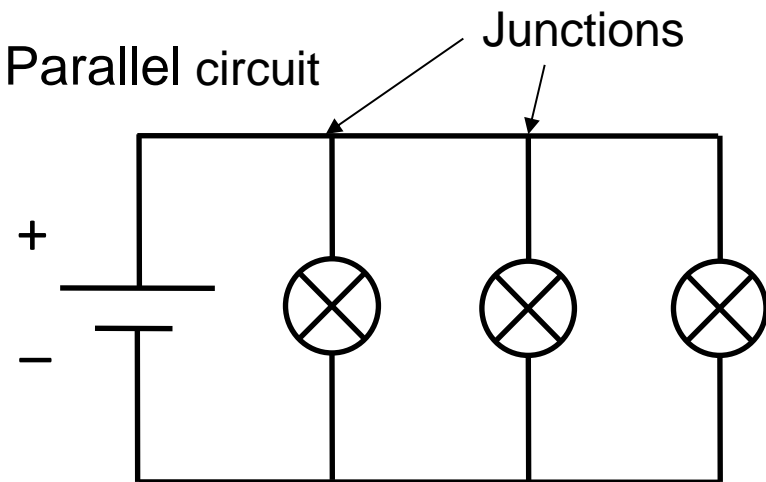
Answer: A

Justification: The series circuit has no junctions (branches) between consecutive circuit elements. Each element follows consecutively after the other, and there is only one path for the current to follow. In a parallel circuit there are two or more branches for the current to follow, and elements of the circuit are connected along these branches.

I. Series circuit

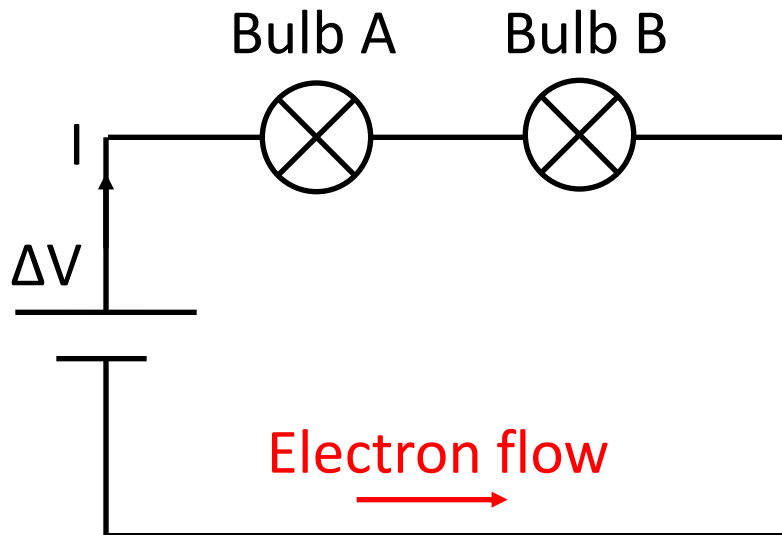


II. Parallel circuit



Series Circuits II

Assume that 100 electrons flow out of the negative terminal of the battery into Bulb B over a period of time. The bulb dissipates energy, creating heat and light in the process. How many electrons flow out of Bulb B?



- A. More than 100 electrons
- B. Exactly 100 electrons
- C. Fewer than 100 electrons
- D. Exactly 0 electrons
- E. Depends on the resistance of the bulbs

Solution

Answer: B

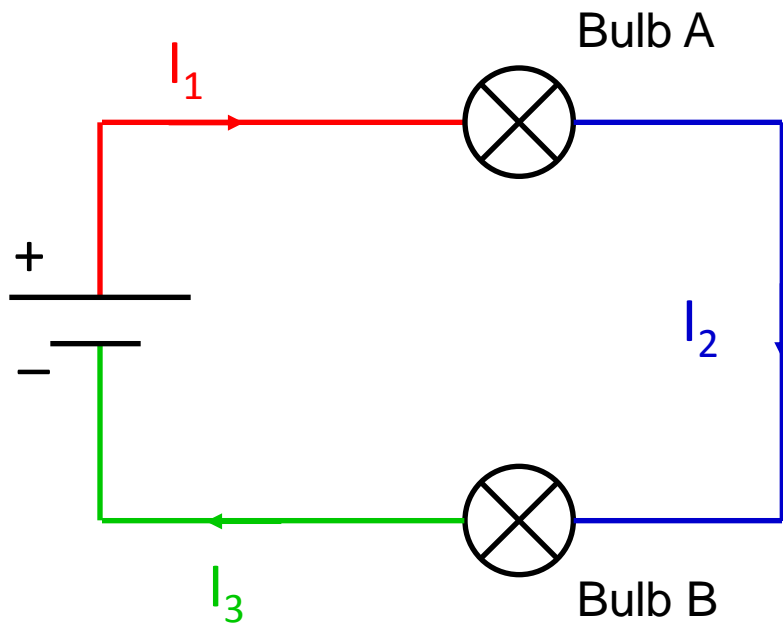
Justification: Electrons are not “used up” in a light bulb, they have nowhere else to go. The light bulb cannot give up any electrons either, so the number of electrons does not change.

The same number of electrons enter and exit the light bulb.

Hint: Imagine a circuit carrying electrons is like a hose carrying water. The rate that water enters a device must be equal to the rate that water leaves a device.

Series Circuits III

A current I_1 flows from the positive terminal of the battery into Bulb A. The current I_2 leaves Bulb A and enters Bulb B. A current I_3 leaves Bulb B and returns to the battery. Which of the following correctly describes the relationship between I_1 , I_2 and I_3 ?



- A. $I_1 > I_2 > I_3$
- B. $I_1 = I_2 = I_3$
- C. $I_1 < I_2 < I_3$
- D. $I_1 = I_2 + I_3$
- E. $I_1 = I_2 - I_3$

Solution

Answer: B

Justification: Current is defined as the amount of charge that passes through a point in a wire per unit of time. The amount of charge is determined by the number of electrons.

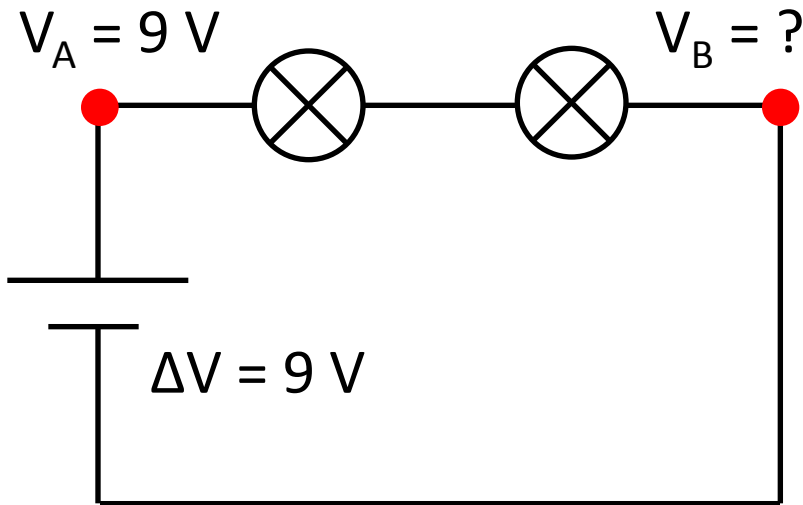
$$I = \frac{\Delta q}{\Delta t}$$

From the previous question, we know that no charge is lost when electrons move in a circuit. Since the amount of current is defined by the number of electrons in the circuit, the current must be the same at all points along the single path in a series circuit.

Since current starts in the battery, it is impossible for there to be more current entering the battery at the end of the circuit than what exits the battery at the beginning.

Series Circuits IV

The battery in the circuit has a voltage of 9 V. If the electric potential at point A is $V_A = 9$ V, what is the electric potential at point B? (The light bulbs do not necessarily have the same resistance.)



- A. Exactly 9 V
- B. Between 9 V and 4.5 V
- C. Exactly 4.5 V
- D. Between 4.5 V and 0 V
- E. Exactly 0 V

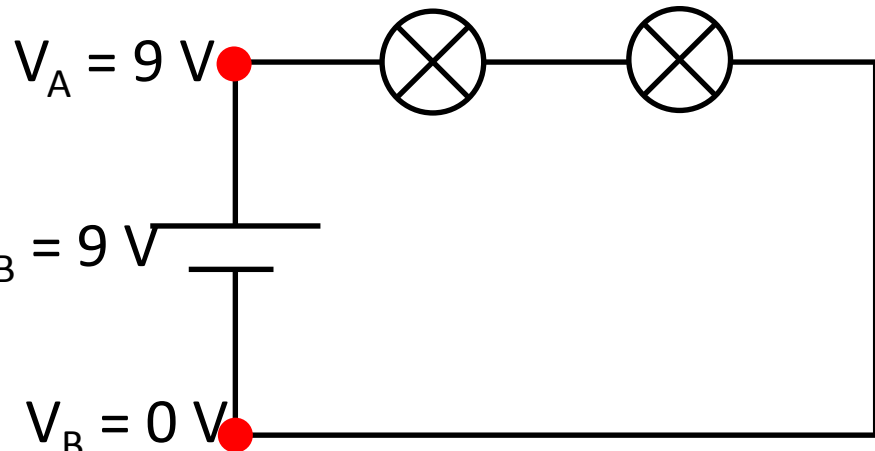
Solution

Answer: E

Justification: The potential at the positive terminal of the battery is equal to the potential at point A because there are no voltage drawing elements between the battery and A. Similarly, the potential at the negative terminal is equal to the potential at point B.

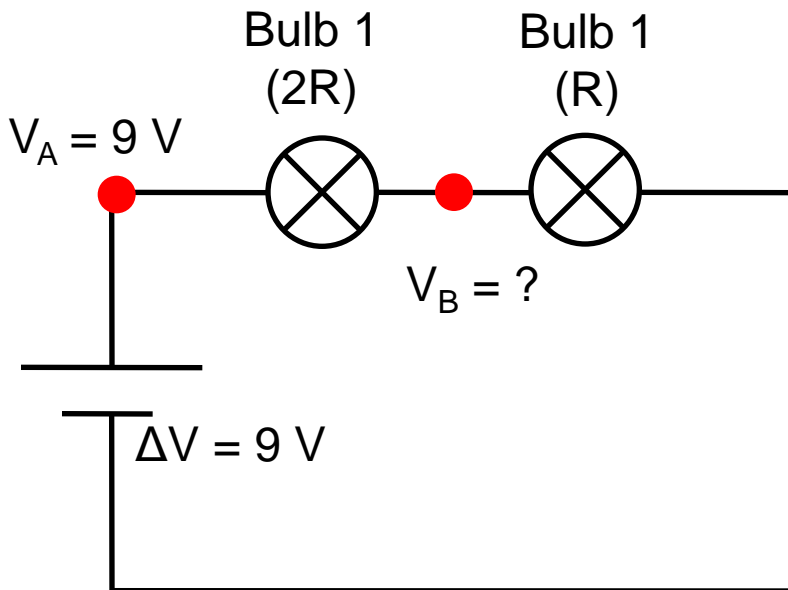
If the potential difference across the terminals of the battery is 9 V, the voltage drop across the entire circuit must be 9V. Since there are no voltage drawing elements between V_B and the negative terminal, the 9V voltage drop must occur over the two light bulbs, meaning the voltage at V_B is 0V.

$$\Delta V_{B \text{ to } A} = V_A - V_B = 9 \text{ V}$$



Series Circuits V

The battery in the circuit has a voltage of 9 V. The resistance of Bulb 1 is $2R$ while the resistance of Bulb 2 is R . If the electric potential at point A is $V_A = 9 \text{ V}$, what is the electric potential at point B?

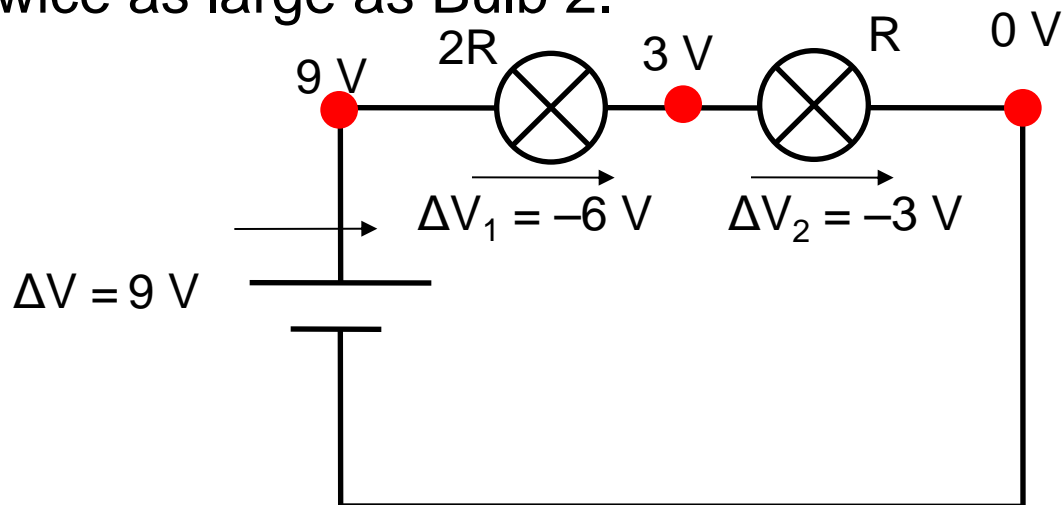


- A. $V_B = 9 \text{ V}$
- B. $V_B = 6 \text{ V}$
- C. $V_B = 4.5 \text{ V}$
- D. $V_B = 3 \text{ V}$
- E. $V_B = 0 \text{ V}$

Solution

Answer: D

Justification: From the previous question, we know that the potential drop across both bulbs must total 9 V (to go from 9 V to 0 V). From Ohm's law, we know that $\Delta V = IR$, and we also know that current is constant in the circuit. The bulbs have different resistances, so the voltage drop across each bulb will not be the same. Because Bulb 1 has twice the resistance of Bulb 2, the potential drop across Bulb 1 must be twice as large as Bulb 2.



$$\Delta V + \Delta V_1 + \Delta V_2 = 0$$

$$\Delta V - I(2R) - I(R) = 0$$

$$\Delta V = I(2R + R)$$

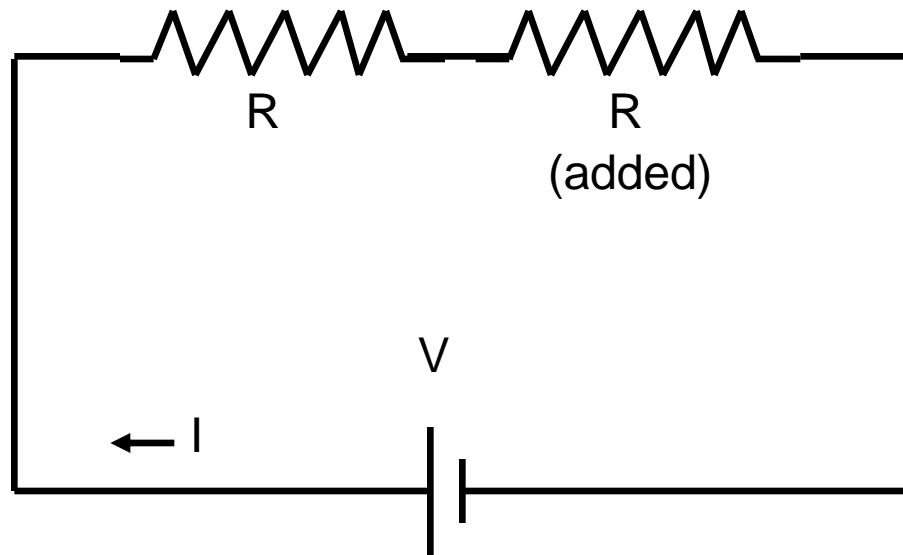
$$9\text{ V} = I(3R)$$

$$\frac{9\text{ V}}{3} = 3\text{ V} = IR$$

Series Circuits VI

Consider a circuit consisting of a battery and a resistor. We add a second identical resistor in series with the first, as shown below. The current in the circuit:

- A. Increases
- B. Decreases
- C. Stays the same



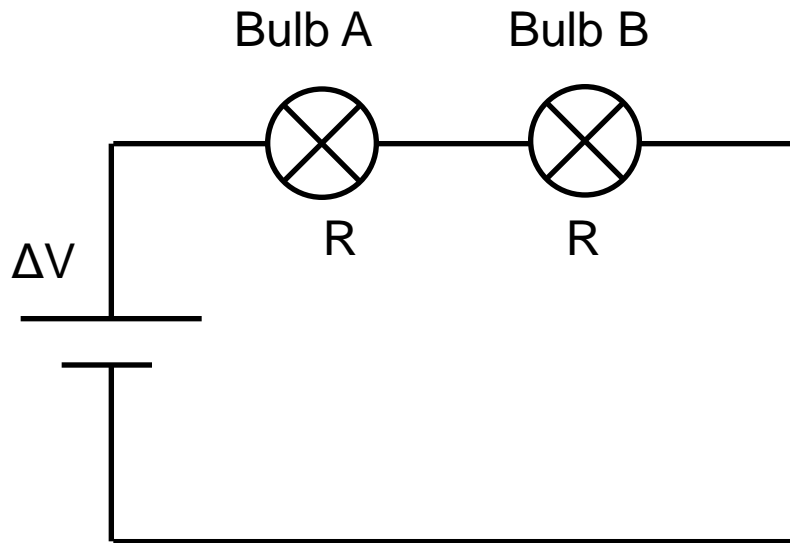
Solution

Answer: B

The voltage provided by the battery does not change, but the resistance doubles. From Ohm's Law, $V=IR$. If the voltage remains the same and the resistance increases, the current must decrease to compensate.

Series Circuits VII

Two *identical* light bulbs are connected in series as shown in the diagram. How will the bulbs' brightness compare with one another?



- A. Bulb A is brighter than Bulb B
- B. Bulb B is brighter than Bulb A
- C. The bulbs are equally bright
- D. Bulb A is lit while Bulb B is not lit
- E. Bulb B is lit while Bulb A is not lit

Solution

Answer: C

Justification: The bulbs are identical so the resistance of each bulb is the same. We know from question 3 that current is not lost over electric elements, and is the same across both light bulbs. This means that both light bulbs will light up.

Ohm's Law, $\Delta V = IR$, tells us that the potential difference across each light bulb is the same if the current and resistance is the same.

Since the voltage, current, and resistance across the two bulbs are the same, the bulbs will act in an identical manner.