2022 MCAS Sample Student Work and Scoring Guide

High School Introductory Physics
Question 42: Constructed-Response

Reporting Category: Motion, Forces, and Interactions
Practice Category: Mathematics and Data
Standard: HS.PHY.2.9 - Evaluate simple series and parallel circuits to predict changes to voltage, current, or resistance when simple changes are made to a circuit.
Item Description: Identify a circuit component and describe its function, calculate the total resistance of a circuit, compare the current through two resistors, and calculate the voltage drop across a resistor.

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Scoring Guide

Select a score point in the table below to view the sample student response.

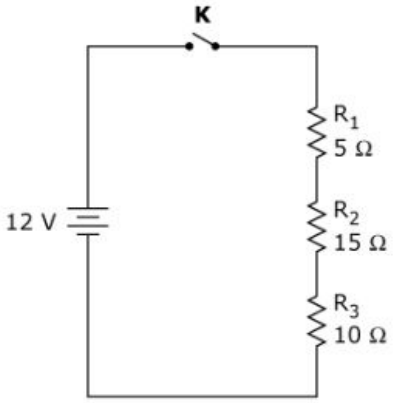
Score*	Description
4A	The response demonstrates a thorough understanding of series circuits and Ohm's law. The response correctly identifies and clearly explains the main function of component K. The response correctly calculates the total resistance of the circuit, clearly explains whether the amount of current through R_1 and R_2 is the same, and also correctly calculates the voltage drop across the R_1.
4B	
3	The response demonstrates a general understanding of series circuits and Ohm's law.
2	The response demonstrates a limited understanding of series circuits and Ohm's law.
1	The response demonstrates a minimal understanding of series circuits and Ohm's law.
0	The response is incorrect or contains some correct work that is irrelevant to the skill or concept being measured.

*Letters are used to distinguish between sample student responses that earned the same score (e.g., 4A and 4B).

Score Point 4A

This question has four parts.

The diagram shows a circuit with a 12 V battery, three resistors, and component K.



Part A

Identify component K **and** explain its main function.

Component K is a switch. Its main function is to controll whether there is current or no current in the circuit. When the switch is open, current doesn't flow, but when the switch is closed, current flows.

Part B

Component K is replaced with a piece of wire.

Calculate the total resistance of the circuit. Show your calculations and include units in your answer.

The total resistance in the circuit is 30Ω

$R_T = R_1 + R_2 + R_3 = 5\Omega + 15\Omega + 10\Omega = \square$ 30Ω

Part C

Is the amount of current flowing through R_1 the same as the amount of current flowing through R_2? Explain your reasoning.

The amount of current flowing through R1 is the same amount of current flowing through R2. These resistors are wired in series, so, they have the same current across them.

Part D

Calculate the voltage drop across R_1. Show your calculations and include units in your answer.

The voltage drop across R_1 is 2V

$$V = I \cdot R_1 \qquad I = \frac{V}{R_T}$$

$$\square = \frac{V}{R_T} \cdot R_1 \qquad R_T = 30\Omega$$

$$\square = \frac{12V}{30\Omega} \cdot 5\Omega$$

$$\square = 2V$$

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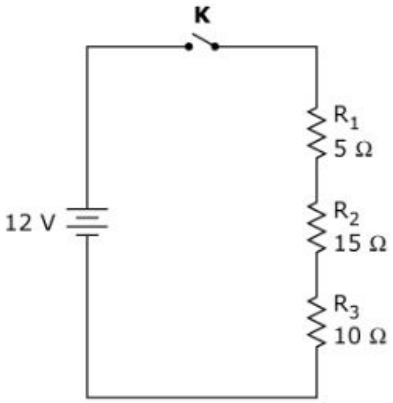
Score Point 4B

This question has four parts.

The diagram shows a circuit with a 12 V battery, three resistors, and component K.



Part A

Identify component K **and** explain its main function.

Component K is a switch. It's main function is to open and close the circuit, in other words turn on and turn off the current. Because the current stops flowing when the circuit is open.

Part B

Component K is replaced with a piece of wire.

Calculate the total resistance of the circuit. Show your calculations and include units in your answer.

$R_{total} = R_1 + R_2 + R_3 = 5\Omega + 15\Omega + 10\Omega = 30\Omega$

Part C

Is the amount of current flowing through R_1 the same as the amount of current flowing through R_2? Explain your reasoning.

Yes it is. Because in a series circuit, the amount of current flowing is the same at any point.

Part D

Calculate the voltage drop across R_1. Show your calculations and include units in your answer.

$$I = \frac{V}{R} = \frac{12V}{30\Omega} = 0.4A$$

$$V = IR = 0.4A \times 5\Omega = 2V$$

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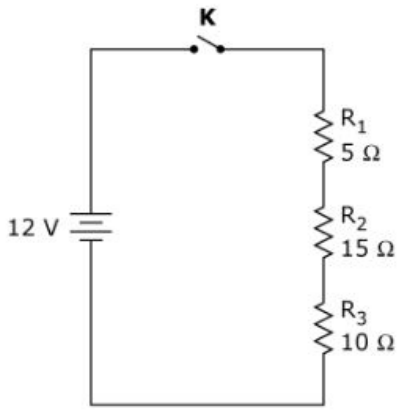
Score Point 3

This question has four parts.

The diagram shows a circuit with a 12 V battery, three resistors, and component K.



Part A

Identify component K **and** explain its main function.

Component K is a switch. A switch can turn a circuit on and off, which means that it can control when there is and isn't current flowing through the circuit.

Part B

Component K is replaced with a piece of wire.

Calculate the total resistance of the circuit. Show your calculations and include units in your answer.

You calculate total resistance by adding up all 3 resistors: $r_1 + r_2 + r_3$.

$5\Omega + 15\Omega + 10\Omega = 30\Omega$

There is a total of 30Ω of resistance.

Part C

Is the amount of current flowing through R_1 the same as the amount of current flowing through R_2? Explain your reasoning.

The ammount of current flowing through R1 is not the same as the current flowing through R2. All the voltage goes through R1 which is the first resistor, but not all of it comes out because it is being held back by the resistor. What is left, then goes through R2. This is called voltage drop.

Part D

Calculate the voltage drop across R_1. Show your calculations and include units in your answer.

To calculate the voltage drop across R_1, you first have to find what percentage of the total resistance R_1 is. $\frac{R_1}{R_T} = \frac{5\Omega}{30\Omega} = \frac{1}{6}$. You then have to multiply the $\frac{1}{6}$ times the voltage of the battery which is 12V. $12V\left(\frac{1}{6}\right) = voltage$ drop. The voltage drop across R_1 is 2V.

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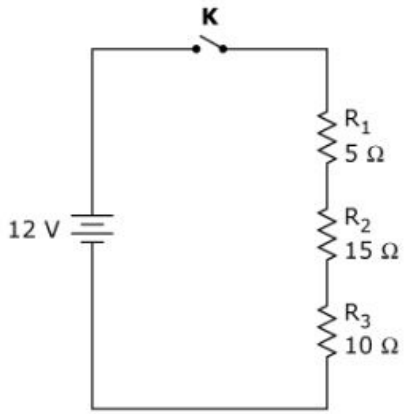
Score Point 2

This question has four parts.

The diagram shows a circuit with a 12 V battery, three resistors, and component K.



Part A

Identify component K **and** explain its main function.

Component K is an open switch. Its main function is to close the circuit or open it.

Part B

Component K is replaced with a piece of wire.

Calculate the total resistance of the circuit. Show your calculations and include units in your answer.

The total resistance is 30Ω. There is 3 different resistances and I added all of them together.

$5\Omega + 15\Omega + 10\Omega = 30\Omega$

Part C

Is the amount of current flowing through R_1 the same as the amount of current flowing through R_2? Explain your reasoning.

The amount of current flowing through R1 is not the same as the amount of current flowing through R2. It is not the same because R2 has a greater resistance than R1. When you divide their voltage by their resistance it will be different.

Part D

Calculate the voltage drop across R_1. Show your calculations and include units in your answer.

The voltage drop is 12V because thats the voltage for each current even if they're added together or not.

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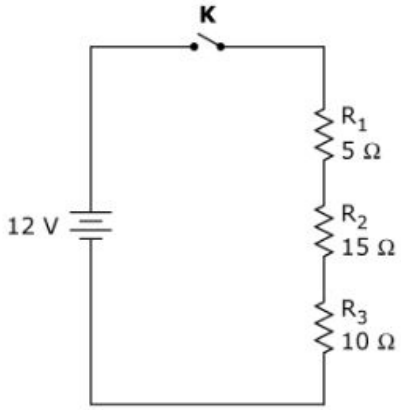
Score Point 1

This question has four parts.

The diagram shows a circuit with a 12 V battery, three resistors, and component K.



Part A

Identify component K **and** explain its main function.

component K is a resistor. The current stops flowing after K.

Part B

Component K is replaced with a piece of wire.

Calculate the total resistance of the circuit. Show your calculations and include units in your answer.

R1 R2 R3

$5 + 15 + 10 = 30\Omega$

Part C

Is the amount of current flowing through R_1 the same as the amount of current flowing through R_2? Explain your reasoning.

No, R2 has more current flowing through it because it has its own current of 15 Ω and R1's current of 5Ω.

Part D

Calculate the voltage drop across R_1. Show your calculations and include units in your answer.

$$V = IR$$
$$V = 30\,(5)$$
$$V = 150\Omega$$

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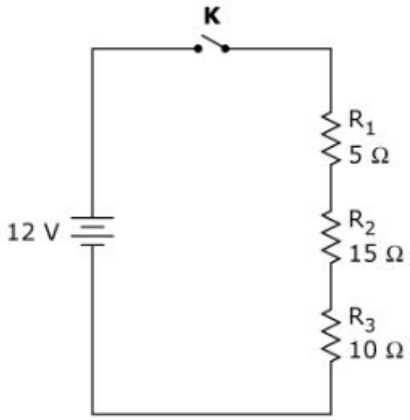
Score Point 0

This question has four parts.

The diagram shows a circuit with a 12 V battery, three resistors, and component K.



Part A

Identify component K **and** explain its main function.

Component K represents a short circuit.

Part B

Component K is replaced with a piece of wire.

Calculate the total resistance of the circuit. Show your calculations and include units in your answer.

$\frac{R_1+R_2+R_3}{3} = R$ Total

$\frac{5+15+10}{3} = 10\Omega$

Part C

Is the amount of current flowing through R_1 the same as the amount of current flowing through R_2? Explain your reasoning.

R1=V=IR 4/5=I5/5 R1=I=0.8 A
R2=V=IR 4/15=I15/15 R2=I=0.26 A
No, the current flowing through R1 is not the same amount of current flowing through R2 because they have different resistances.

Part D

Calculate the voltage drop across R_1. Show your calculations and include units in your answer.

In series, the voltage is split amongst the resistors equally.

3 resistors, total 12 voltage

$12 \div 3 = 4V$

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