



Flipping Physics Lecture Notes:

2016 #4 Free Response Question - AP Physics 1 - Exam Solution

<http://www.flippingphysics.com/ap1-2016-frq4.html>

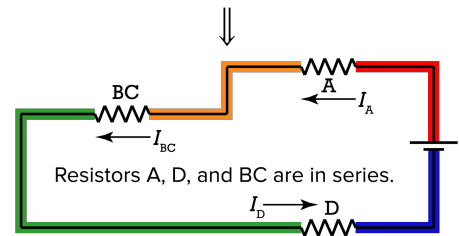
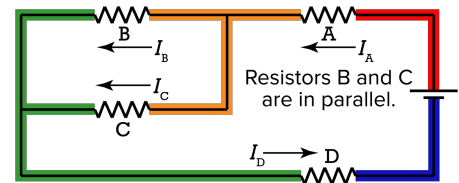
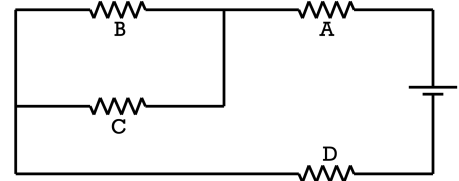
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A circuit contains a battery and four identical resistors arranged as shown in the diagram.

(a) Rank the magnitude of the potential difference across each resistor from greatest to least. If any resistors have potential differences with the same magnitude, state that explicitly. Briefly explain your reasoning.

Ranking: $\Delta V_A = \Delta V_D > \Delta V_B = \Delta V_C$

Brief explanation: Because they are all in series, the currents through resistor A, resistor D, and equivalent resistor BC are all the same. Because electric potential difference equals current times resistance and the resistances of A and D are equal and the currents through A and D are equal, the electric potential differences across A and D are equal. Resistors B and C are in parallel, so they have equal electric potential differences and the current is split between those two resistors, therefore the currents through B and C are less than the current through A and D, therefore the electric potential differences across B and C are less than the electric potential differences across A and D.

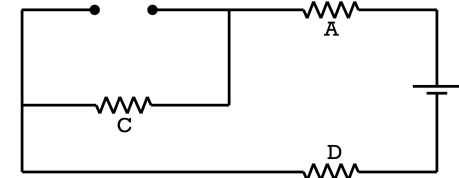


Resistor B is now removed from the circuit, and there is no connection between the wires that were attached to it. The new circuit diagram is shown.

(b) When resistor B is removed, does the current through resistor A increase, decrease, or remain the same?

Increase Decrease Remain the same

Briefly explain your reasoning.



Because the equivalent resistance BC of the two resistors in parallel is less than the resistance of just resistor C, removing resistor B from the circuit increases the equivalent resistance of the circuit. Increasing the resistance of the circuit decreases the current delivered by the battery. The current delivered by the battery is the same as the current through resistor A, therefore the current through resistor A decreases.

(c) When resistor B is removed, does the current through resistor C increase, decrease, or remain the same?

Increase Decrease Remain the same Briefly explain your reasoning.

Because resistor B was removed, resistor C now receives all the current delivered by the battery, however, we have already shown in part (b) that the current delivered by the battery decreases. Use Kirchhoff's Loop Rule. Loop 1 is before B is removed from the circuit and with equivalent resistor BC.

$$\Delta V_{\text{Loop 1}} = 0 = \Delta V_t - \Delta V_{A1} - \Delta V_{BC} - \Delta V_{D1} \Rightarrow \Delta V_{BC} = \Delta V_t - \Delta V_{A1} - \Delta V_{D1} = \Delta V_{C1}$$

Loop 2 is after resistor B is removed from the circuit.

$$\Delta V_{\text{Loop 2}} = 0 = \Delta V_t - \Delta V_{A2} - \Delta V_{C2} - \Delta V_{D2} \Rightarrow \Delta V_{C2} = \Delta V_t - \Delta V_{A2} - \Delta V_{D2}$$

From part (b) we know the current through A and D has decreased, therefore the electric potential differences across A and D have also decreased, therefore, we can see from our two Kirchhoff's Loop Rule equations that the electric potential difference across C has increased. Because electric potential difference equals current times resistance and the resistance of C has not changed, the current through C must have increased.

Grading Note: Part (a) is worth 3 points. Parts (b) and (c) are each worth 2 points and each have this sentence in the scoring guidelines: "If the wrong answer is selected, up to one point can still be earned." In other words, you can put a mark next to the incorrect answer and still get points if your explanation has correct reasoning in it.

