Name: Group Members:

CIRCUITS GALORE!

Problem 1

Using the circuit simulator, construct a circuit that will make a lightbulb glow. If the blue dots represent electrons, which side of the battery is the + side (higher potential)? Explain. Use the voltage meter to check your answer (the meter shows the potential of the red probe minus the potential of the black probe).

The grey end has the low potential. Electrons want to move through the circuit from low potential to high potential.

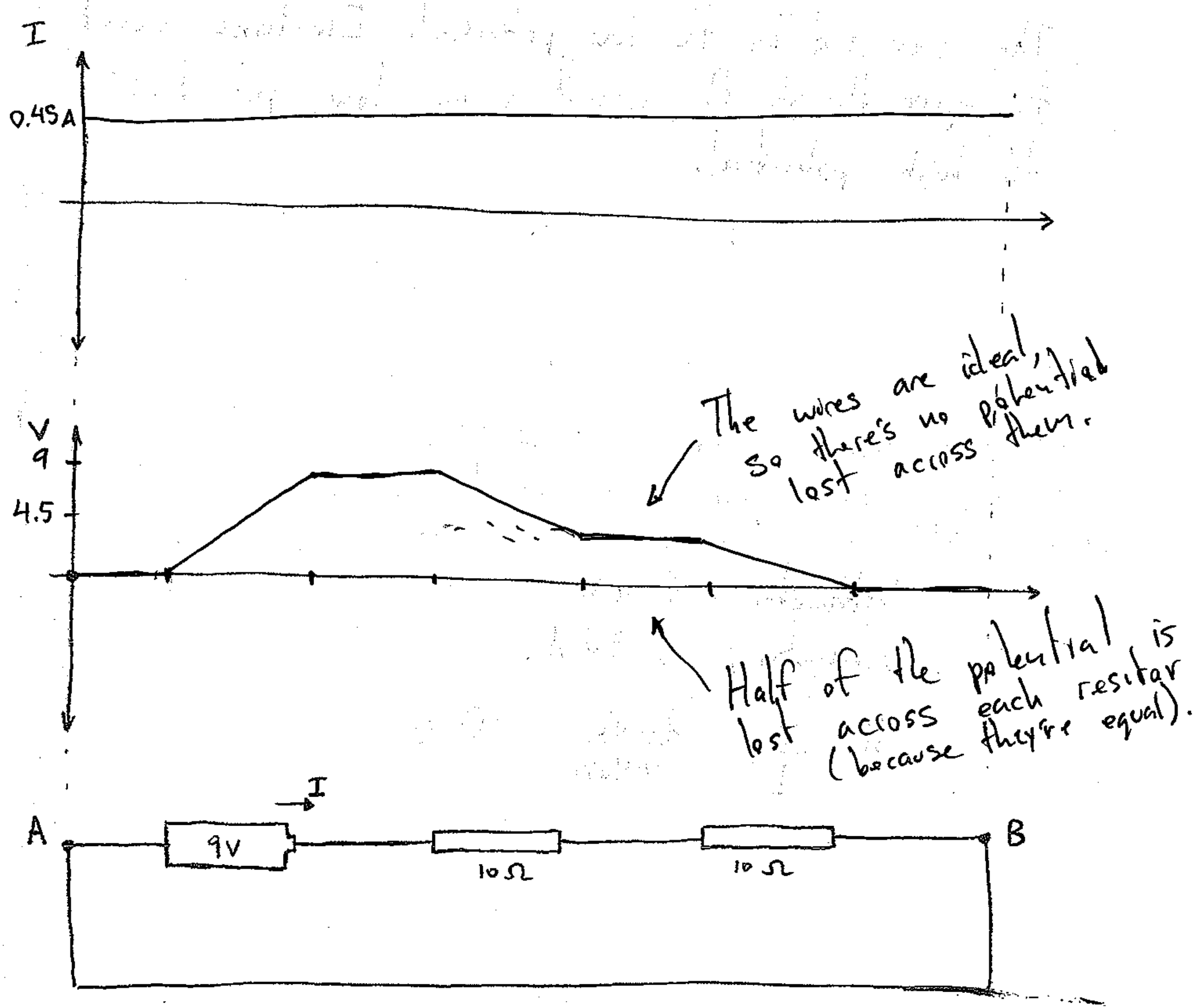
Using the voltmeter and an ammeter (or a non-contact ammeter), determine the resistance of the lightbulb (no cheating!). Explain your method.

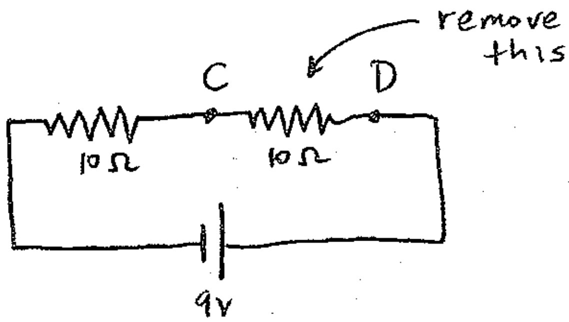
Voltmeter: 9.00V
Ammeter: 0.90 A

$$R = \frac{V}{I} = \frac{9.00V}{0.90A} = 10\ \Omega$$

Problem 2

In the circuit shown below, the battery is 9V and each resistor is 10 Ohms. On the graphs below, plot the current and the potential as a function of position between the points A and B, assuming the potential at A is zero volts. Use the circuit simulator to check your results (your graphs should include the regions inside the resistors, though the voltmeter can't measure the potential there).



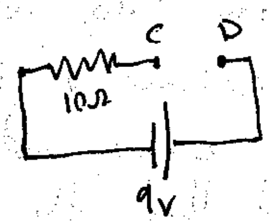


Problem 3

In the same circuit from problem 2 (shown schematically above) what is the potential difference between points C and D? Predict what the potential difference will be after you remove the indicated resistor. Use the simulator to check your result. Explain this result.

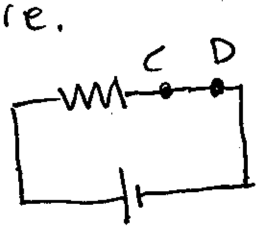
Before removal: $V_D - V_c = 9v - 4.5v = 4.5v$

After removal: After the resistor is removed there is a break in the circuit.



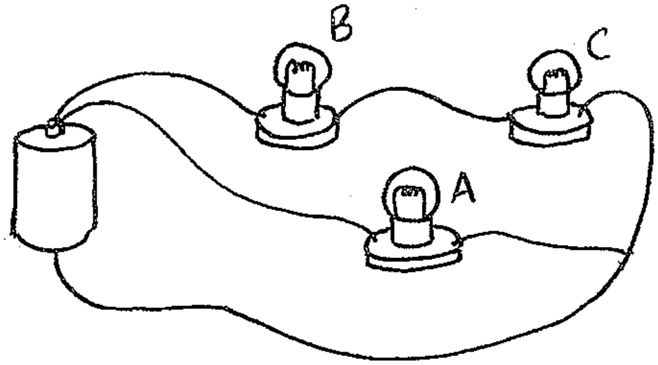
No current flows, so there is no potential drop across the 10 Ω resistor ($V = IR = 0$).
So $V_D - V_c = 9V$.

note: Alternatively, you could interpret the question as removing the resistor, but replacing it with a wire.



$V_D - V_c = 0$

because there is no potential lost in an ideal wire.



Problem 4

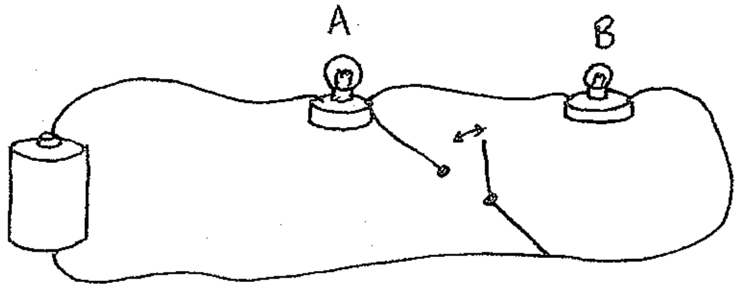
In the diagram shown, predict what will happen to the brightness of bulbs A and B when bulb C is removed. Test your prediction with the simulator. Explain the results.

Bulb A prediction: Actual result: Stays the same.

Explanation: Removing C means that more current runs through B and, thus, less should go through A. <u>But</u>, the overall resistance of the circuit has decreased, so the current coming out of the battery is higher. It turns out that this cancels the negative effect, and the current through A stays constant.

Bulb B prediction: Actual result: Brightness increases.

Explanation: Removing C means that the current through B increases. The lower resistance means that the current out of the battery increases. These are both positive effects, meaning the bulb B is brighter.



Problem 5

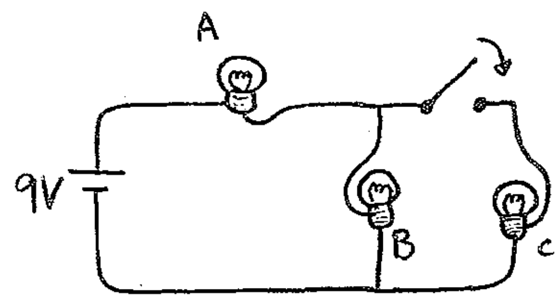
In the diagram shown, predict what will happen to the brightness of bulbs A and B when the switch is closed. Test your prediction with the simulator. Explain the results.

Bulb A prediction: Actual result: Brighter

Explanation: Closing the switch means that B is short circuited (no current runs through B because the wire has zero resistance). With B short circuited, the resistance decreases. Not only does more current now flow through A, but the voltage across it increases.

Bulb B prediction: Actual result: It goes out.

Explanation: If B is short circuited, no current flows through it, so it doesn't shine.



each bulb is 10Ω

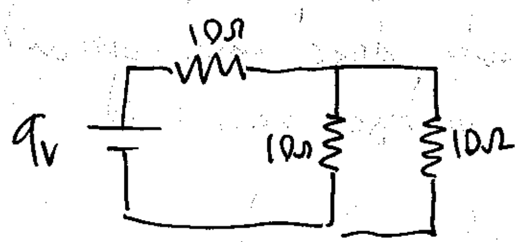
Problem 6

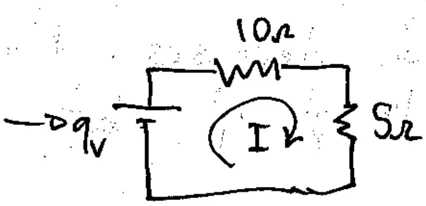
In the circuit shown, predict what will happen to the brightness of bulb A when the switch is closed. Test your prediction with the simulator. Explain the results.

Prediction: Actual result: Brighter.

Explanation: Closing the switch decreases the overall resistance of the circuit. It also increases the relative voltage drop across A. Both of these mean that A gets brighter.

Without using the simulation, predict the magnitude of the current through each bulb after the switch is closed. (explain your work)

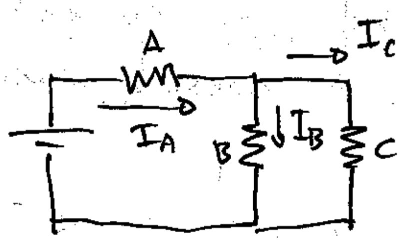




$$\left(\frac{1}{10\Omega}+\frac{1}{10\Omega}\right)^{-1} = 5\Omega$$

$$I = \frac{9V}{15\Omega} = \frac{3}{5}A$$

back to circuit:

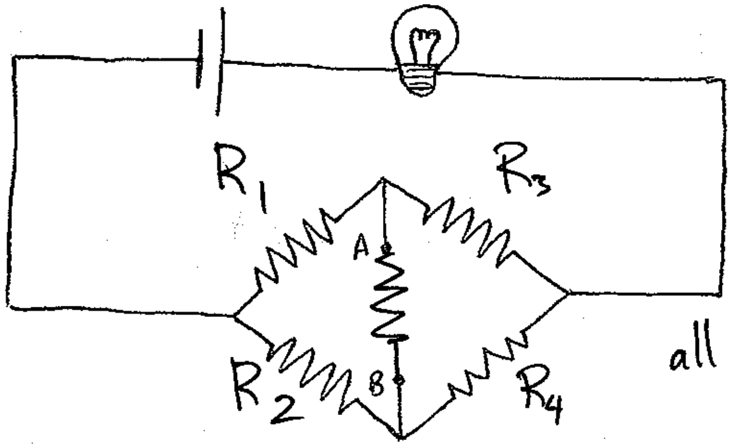


$I_A = I$ ↙ resistance is equal, half the current goes each way.

$I_A = I_B + I_C = 2I_B$

$I_B = I_C = \frac{I_A}{2} = \frac{I}{2}$

$I_A = \frac{3}{5}A$ $I_B = \frac{3}{10}A$ $I_C = \frac{3}{10}A$



Problem 7

In the circuit shown above, a new resistor is added between points A and B. Does the light bulb get brighter, dimmer, or stay the same? Check your prediction. Explain the result.

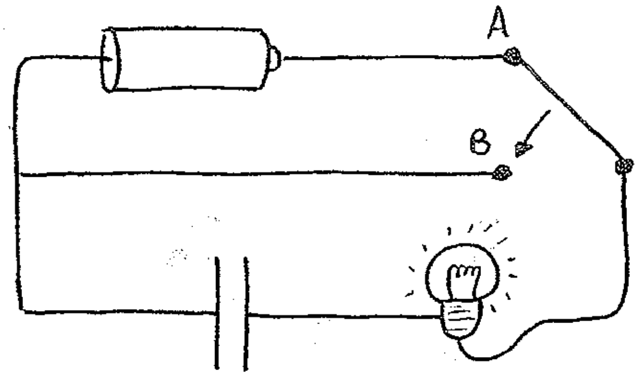
The bulb stays the same brightness.

<u>Voltage arguement:</u>

Because the resistors are all equal, the voltage difference across R_3 must be equal to that across R_4. This means the potential at A must equal that at B. If the potentials are equal, then the resistor is shorted, and the circuit hasn't changed.

<u>Current argument:</u>

The same current must go through both R_3 and R_4. Because R_1 and R_2 are the same, the current through them must be equal. This means that there is a current running from A to B that is equal to the current running up from B to A. The currents cancel, meaning no current runs through the resistor, thus it is shorted.



Problem 8

The circuit shown above includes a light bulb, a battery, and a capacitor. Predict what will happen when the switch is moved from A to B. Check your prediction using the real circuit components. Explain why the process you observe is not instantaneous, and explain how you could estimate the amount of time it takes based on the capacitance (how much charge there is on the capacitor for a given voltage) and the resistance of the bulb.

~~The light bulb will gradually get dimmer~~

With the switch at A, there is no current flowing through the circuit and the capacitor is charged to the voltage of the battery.

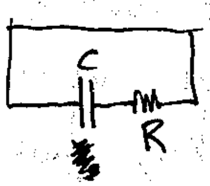
After the switch goes to B, the capacitor discharges through the battery. The istant the switch is flipped the bulb is the brightest. As the charge disipated from the capacitor, the bulb slowly gets dimmer.

math:

$$V_c - V_R = 0 \qquad -\frac{dQ}{dt} = I$$

← the relative negative sign appears because the current is positive as the charge leaves the capacitor.

$$\frac{Q}{C} - IR = 0$$



$$\Rightarrow \frac{dQ}{dt} = -\frac{1}{RC} Q$$

$$\Rightarrow Q = Q_0 e^{-\frac{t}{RC}} \Rightarrow V_c = V_{c0} e^{-\frac{t}{RC}}$$