PHYS040C – PRE-LAB 05 – DC Electrical Circuits

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Section 109

1. Using the Power Law, $P = IV$, and Omh's Law, $V = IR$, obtain an expression for the maximum current you can safely apply to a ¼ watt 3 Ω resistor.

We can write the power law as $V = \frac{P}{I}$

If we plug this into Ohm's Law, $V = IR \rightarrow \frac{P}{I} = IR$

Now we solve for I:

$$\frac{P}{I} = IR$$

$$P = I^2R$$

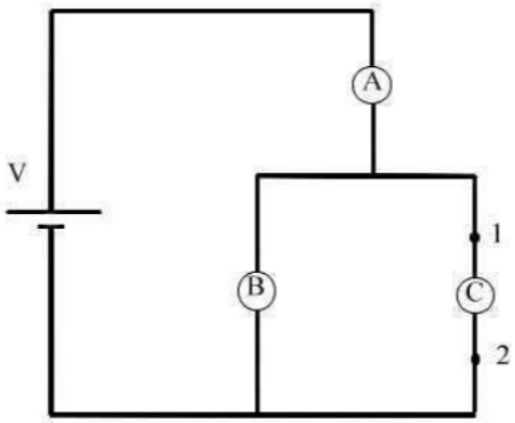
$$I^2 = \frac{P}{R}$$

$$I = \sqrt{\frac{P}{R}}$$

Plugging in the given values into this formula:

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{1/4}{3}} = 0.0833\ A$$

2. Bulbs A, B and C in the circuit diagram below are identical.



a) Rank in order, from most to least, the brightest of the three bulbs. Explain your reasoning.

Voltage across A:

$$V_A = IR_A$$

Voltage across B and C:

$$V_{BC} = I\left(\frac{1}{R_B} + \frac{1}{R_C}\right)^{-1} = I\left(\frac{R_B + R_C}{R_B R_C}\right)^{-1} = I\left(\frac{R_B R_C}{R_B + R_C}\right)$$

$\left(\frac{R_B R_C}{R_B + R_C}\right) > R_A$ because $R_A = R_B = R_C$, so $V_{BC} > V_A$

So $I_B = \frac{V_{BC}}{R_B}$, $I_C = \frac{V_{BC}}{R_C}$, and $I_A = \frac{V_A}{R_C}$. Since $V_{BC} > V_A$, $I_B = I_C > I_A$.

By power law $P = IV = I(IR) = I^2R$,

$P_B = I_B^2 R_B$, $P_C = I_C^2 R_C$, and $P_A = I_A^2 R_A$. Since $I_B = I_C > I_A \; and \; R_A = R_B = R_C$, then

$P_B = P_C > P_A$. The power of a light bulb determines how bright it shines, and therefore in terms of brightness, B = C > A.

b) Suppose an ideal wire (with zero resistance) is connected between points 1 and 2. What happens to each bulb? Does it get brighter, dimmer, or go out completely? Explain your reasoning for each bulb.

It seems that if we pass a wire from point 1 to point 2, we would be undoing the resistance that light C is providing. Therefore:

Bulb A:

- For this lightbulb, since we removed one of the resistors in the parallel component, resistor B is practically in series. Thus the total resistance of the circuit increases and thus since $P = IV = I^2R$, this bulb should become brighter.

Bulb B:

- Bulb B is not as if it was connected in series, so it should become brighter because the current is the same as in A, and not split by the junction.

Bulb C:

- This light should go out because now current passes through the wire instead of the resistor.