Chapter 27 Review: Current and Resistance

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Background / Summary:

A fundamental part of daily life is technology that utilizes electricity. Breaking down these technologies to their simplest origins takes us to simple electrical circuits, voltmeters, batteries, resistors, and more.

Key Ideas and Points for the Subject:

- Current is the number of charges going through a specific area during a given span of time.
- Electromotive force ($\mathcal{E}$) is what creates the electric field that motivates the movement of charges through the circuit.
- Resistors limit the current and can convert electrical energy into other types of energy.

*Current is measured in amps, $\mathcal{E}$ is measured in volts, resistance in ohms (□) and power is measured in Watts.

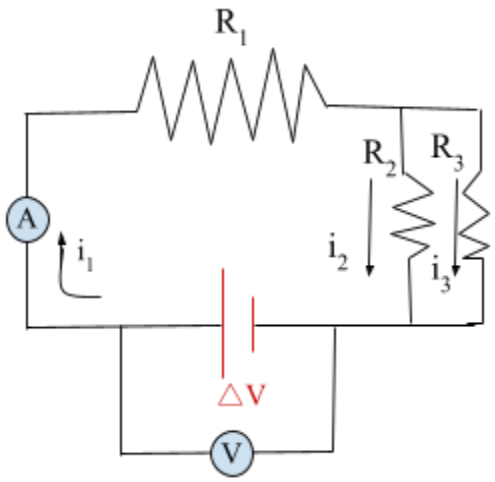


Diagram Explanation:

When a battery or other apparatus creates a difference in voltage within a circuit, it produces an electrical current. In this specific circuit, there is a battery, a resistor, which reduces current flow, an ammeter, and a voltmeter. Ammeters and voltmeters measure amps and voltage respectively. R_1 is in series with R_2 and R_3, while R_2 and R_3 are parallel to each other.

Key Equations and Relationships:

$I = \triangle V / R$

$I = dQ / dt$

$R_{series} = \Sigma R_i$

$R_{parallel} = (\Sigma (R_i)^{-1})^{-1}$

$P = I^2 * R$

$P = I * \triangle V$

$V_{terminal} = \mathcal{E} - (I * r)$

Kirchhoff's Law:

$\Sigma i_{input} = \Sigma i_{output}$

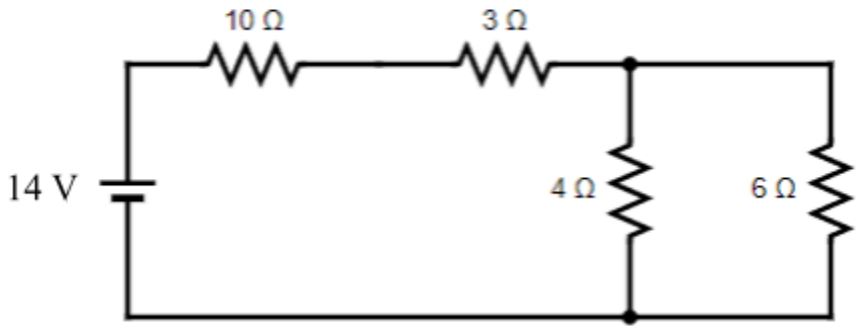
$*\triangle V_R = V_R$

*The voltage over a resistor is the same as the voltage of said resistor

Problem Set:

1. [Easy] Suppose that the charge in a wire varies with time according to the equation:
   $q = 6t^2 + 9t + 4$. Create an expression for the current through the wire as a function of time, and then come up with the current at 3.00 seconds.

2. [Medium] An LED light bulb is rated at 145 volts and 90 Watts. Assuming we use a 145-volt power supply to power the bulb, what would the current in the bulb be? What is the resistance of the bulb?



3. [Hard] As displayed in the diagram above, four resistors are connected to a 14-volt battery. $R_1 = 10$ □, $R_2 = 3$ □, $R_3 = 4$ □, and $R_4 = 6$ □. What is the $R_{equivalent}$ of all four resistors? When connected to the battery, how much current and power is drawn?

Solutions:

1. Known values:

   $q = 6t^2 + 9t + 4$

   To solve this problem, we must use the relationship $I = dQ / dt$

   $I(t) = dQ / dt = d(6t^2 + 9t + 4) / dt$

   Take the derivative with respect to t.

   $I(t) = 12t + 9$

   To find the current at 3.00 seconds, just plug in 3.00 to t.

   $I(3) = 36 + 9$

   $\rightarrow$ = 45 amps (A)

2. Known values:

   V = 145 volts

   P = 90 watts

   To solve for the current in the bulb, we just have to use one of the power relationships that we know.

   $P = IV$

   $\rightarrow I = P / V$

   $\rightarrow$ = 90 / 145

   $\rightarrow$ = 0.621 amps (A)

   To solve for the resistance of the bulb, we must use another power relationship.

   $P = I^2R$

   $\rightarrow R = P / I^2$

   $\rightarrow$ = 90 / $(0.621)^2$

   $\rightarrow$ = 233.38 ohms (□)

3. Known values:

   $R_1 = 10$ □, $R_2 = 3$ □, $R_3 = 4$ □, and $R_4 = 6$ □

   $V = 14$ volts

   First, we need to condense R_3 and R_4, which are parallel to each other.

   $R_{parallel} = (\Sigma\ (R_i)^{-1})^{-1} = ((¼) + (⅙))^{-1}$

   → = 2.4 ohms (□)

   Then, we can condense R_1, R_2, and $R_{parallel}$ as they are all in series with each other.

   $R_{series} = \Sigma\ R_i$

   → =10 + 3 + 2.4

   → = 15.4 ohms (□)

   So, our $R_{equivalent} = 15.4$ □

   To find the current, drawn from the battery, we just have to use $I = \triangle V / R$

   $I = 14 / 15.4$

   → = 0.91 amps (A)

   To get the power drawn from the battery, we can use $P = I\triangle V$

   $P = 0.91 * 14$

   → = 12.74 Watts