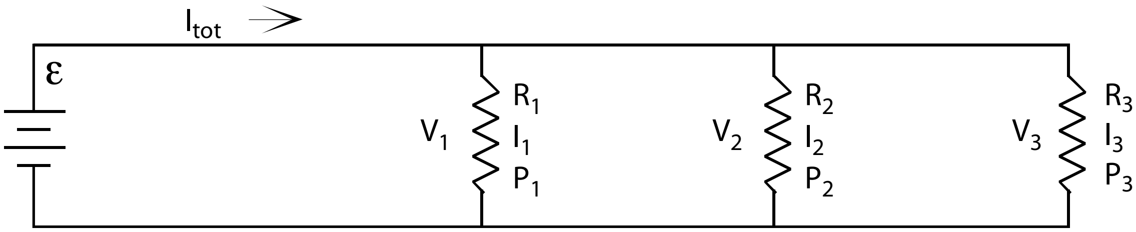
PhyzExamples: Parallel Circuits



In ALL circuits...

$$I_{tot} = \frac{\varepsilon}{R_{eq}}$$

OHM'S LAW
The total current in the circuit is equal to the emf of the voltage source (battery) divided by the equivalent resistance of the circuit.

$$P_{tot} = I_{tot}\varepsilon$$

JOULE'S LAW
The total power developed in the circuit is equal to the product of the total current and the emf of the voltage source.

$$P_{tot} = P_1 + P_2 + P_3 + \cdots$$

POWER SUM
The total power in the circuit is equal to sum of the power values of each of the resistors.

In PARALLEL circuits...

$$I_{tot} = I_1 + I_2 + I_3 + \cdots$$

PARALLEL CURRENT
The current in a parallel circuit is divided among parallel resistors. The total current in the circuit is equal to the sum of the currents across each resistor.

$$\varepsilon = V_1 = V_2 = V_3 = \cdots$$

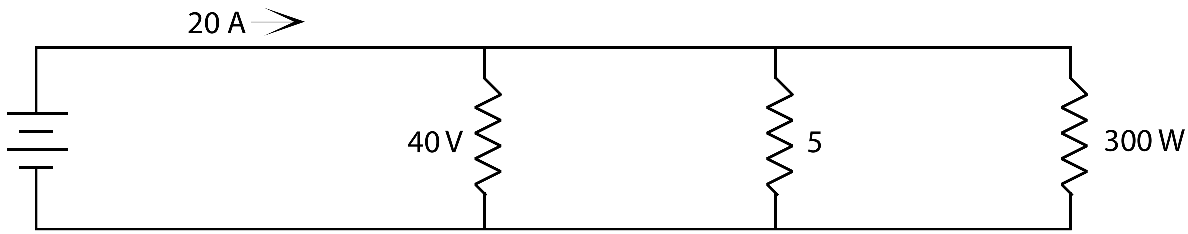
PARALLEL VOLTAGE
The potential in a parallel circuit is the same across all elements of the circuit. (Equal to the emf of the battery.)

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$$

PARALLEL EQUIVALENT RESISTANCE
The inverse of the equivalent resistance of a parallel circuit is equal to the sum of the inverse values of the resistances of each resistor. (Easier to write as an equation!)

In ANY resistor R_n...

$V_n = I_nR_n$ $\quad P_n = I_nV_n$ $\quad P_n = V_n^2/R_n$ $\quad P_n = I_n^2R_n$



Given this information, what can be determined about the circuit? EVERYTHING!!!

1. Since the potential in the circuit is 40 V (same across all resistors in parallel) and the total current in the circuit is 20 A, the equivalent resistance in the circuit is

   $R_{eq} = \mathcal{E}/I = 40 \text{ V} / 20 \text{ A} = 2\ \Omega$

2. Since $R_2 = 5\ \Omega$ and $V = 40$ V, the current through R_2 is

   $I_2 = V/R_2 = 40 \text{ V} / 5\ \Omega = 8 \text{ A}$

3. The power dissipated in R_2 is

   $P_2 = V^2/R_2 = (40 \text{ V})^2 / 5\ \Omega = 320 \text{ W}$

4. Since the power dissipated in R_3 is 300 W, the current through R_3 is

   $I_3 = P_3/V = 300 \text{ W} / 40 \text{ V} = 7.5 \text{ A}$

5. And the resistance of R_3 is

   $R_3 = V^2/P = (40 \text{ V})^2 / 300 \text{ W} = 5.3\ \Omega$

6. Since the equivalent resistance of the circuit is 2 Ω, R_2 is 5 Ω, and R_3 is 5.3 Ω, R_1 can be found:

   $1/R_1 = 1/R_{eq} - 1/R_2 - 1/R_3 = 1 / 2\ \Omega - 1 / 5\ \Omega - 1 / 5.3\ \Omega$ thus $R_1 = 8.9\ \Omega$

7. The current through R_1 is

   $I_1 = I_{tot} - I_2 - I_3 = 20 \text{ A} - 8 \text{ A} - 7.5 \text{ A} = 4.5 \text{ A}$ or $I_1 = V/R_1 = 40 \text{ V} / 8.9\ \Omega = 4.5 \text{ A}$

8. And so the power dissipated in R_1 is

   $P_1 = V^2 / R_1 = (40 \text{ V})^2 / 8.9\ \Omega = 180 \text{ W}$

9. So the total power dissipated in the circuit is

   $P_{tot} = P_1 + P_2 + P_3 = 180 \text{ W} + 320 \text{ W} + 300 \text{ W} = 800 \text{ W}$

   or $P_{tot} = I\mathcal{E} = 20 \text{ A} \cdot 40 \text{ V} = 800 \text{ W}$