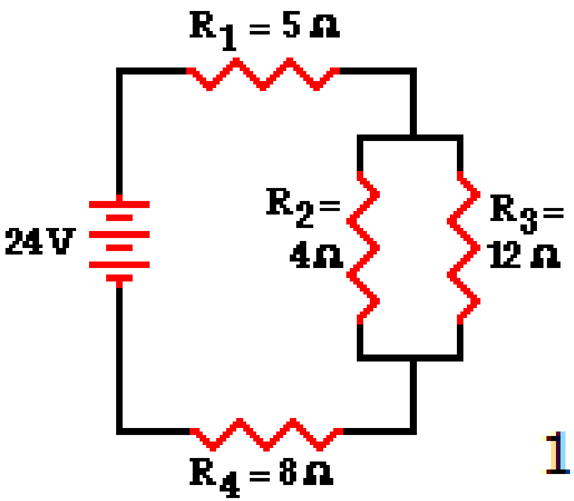
Physics Year 11 Term 4

Circuit Analysis

Circuit with different resistor values



- Simplify circuit
- Replace 2 parallel resistors

$$1 / R_{eq} = 1 / R_1 + 1 / R_2 + 1 / R_3 \ldots$$

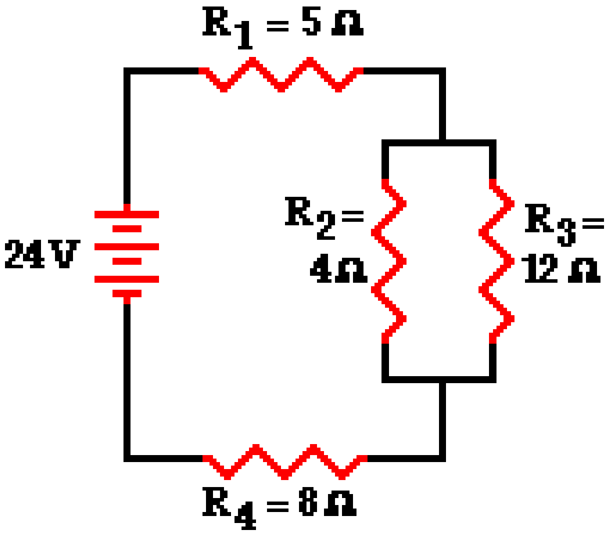
$$1 / R_{eq} = 1 / (4\ \Omega) + 1 / (12\ \Omega)$$

$$1 / R_{eq} = 0.333\ \Omega^{-1}$$

$$R_{eq} = 1 / (0.333\ \Omega^{-1})$$

$$R_{eq} = 3.00\ \Omega$$

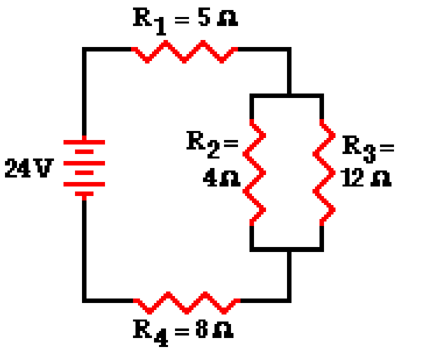
Total Resistance



$$R_{tot} = R_1 + 3\ \Omega + R_4 = 5\ \Omega + 3\ \Omega + 8\ \Omega$$

$$R_{tot} = 16\ \Omega$$

Ohm's Law for I



- Ohm's law equation (V = I • R)
- To determine the total I in the circuit.
- In doing so, the total resistance and the total voltage will have to be used.

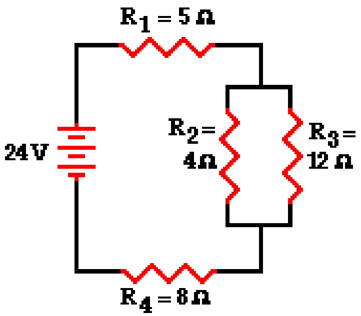
$$I_{tot} = \Delta V_{tot} / R_{tot} = (24\ V) / (16\ \Omega)$$

$$I_{tot} = 1.5\ Amp$$

- The 1.5 Amp current calculation represents the current at the battery location.
- Yet, resistors R_1 and R_4 are in series and the current in series-connected resistors is everywhere the same. Thus,

$$I_{tot} = I_1 = I_4 = 1.5\ Amp$$

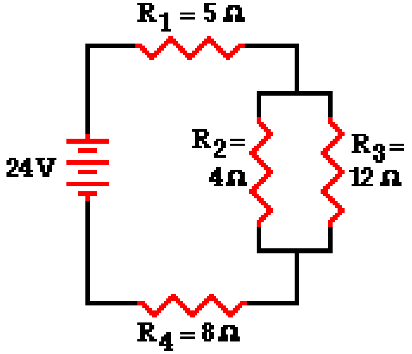
A Complication.....



- For parallel branches, the sum of the current in each individual branch is equal to the current outside the branches.
- Thus, $I_2 + I_3$ must equal 1.5 Amp.
- The unequal current in the two resistors complicates the analysis.
- The branch with the least resistance will have the greatest current.
- Determining the amount of current will demand that we use the Ohm's law equation.
- But to use it, the voltage drop across the branches must first be known.

Determining the Voltage Drop across the Parallel Branches

- Voltage drop across the 2 series-connected resistors (R_1 and R_4) must first be determined.
- The Ohm's law equation ($V = I \bullet R$) can be used to determine the voltage drop across each resistor.



$$\Delta V_1 = I_1 \bullet R_1 = (1.5\ \text{Amp}) \bullet (5\ \Omega)$$

$$\Delta V_1 = 7.5\ \text{V}$$

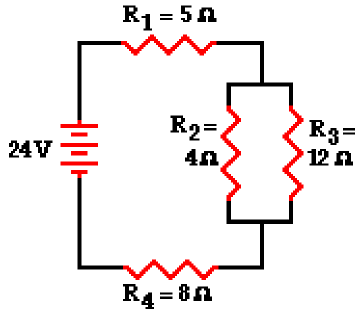
$$\Delta V_4 = I_4 \bullet R_4 = (1.5\ \text{Amp}) \bullet (8\ \Omega)$$

$$\Delta V_4 = 12\ \text{V}$$

Voltage Drop in the Branches

- Circuit 24-volt source.
- Thus, the cumulative voltage drop of a charge traversing a loop about the circuit is 24 volts.
- There will be a 19.5 V drop (7.5 V + 12 V) resulting from passage through the two series-connected resistors (R_1 and R_4).
- The voltage drop across the branches must be 4.5 volts to make up the difference between the 24 volt total and the 19.5-volt drop across R_1 and R_4. Thus, $\Delta V_2 = \Delta V_3 = 4.5\ V$

Nearly there……



- Knowing the voltage drop across the parallel-connected resistors (R_1 and R_4) allows one to use the Ohm's law equation (V = I • R) to determine the current in the 2 branches.

$I_2 = \Delta V_2 / R_2 = (4.5\ V) / (4\ \Omega)$

$I_2 = 1.125\ A$

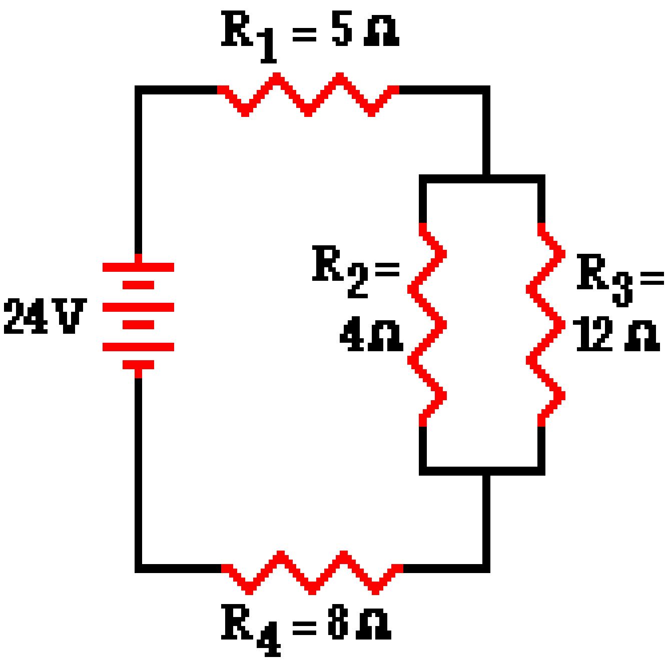
$I_3 = \Delta V_3 / R_3 = (4.5\ V) / (12\ \Omega)$

$I_3 = 0.375\ A$

A Strategy

- If a schematic diagram is not provided, take the time to construct one.
- When approaching a problem involving a combination circuit, take the time to organize yourself, writing down known values and equating them with a symbol such as I_{tot}, I_1, R_3, V_2, etc.
- Know and use the appropriate formulae for the equivalent resistance of series-connected and parallel-connected resistors.
- Transform a combination circuit into a strictly series circuit by replacing the parallel section with a single resistor having a resistance value equal to the equivalent resistance of the parallel section.
- Use the Ohm's law equation ($V = I \bullet R$) often and appropriately.
- Most answers will be determined using this equation.
- When using it, it is important to substitute the appropriate values into the equation. Calculating I_2 substitute the V_2 and the R_2 values into the equation.

The Complete Analysis



R_{tot} =	16 Ω	I_{tot} =	1.5 A
I_1 =	1.5 A	ΔV_1 =	7.5 V
I_2 =	1.125 A	ΔV_2 =	4.5 V
I_3 =	0.375 A	ΔV_3 =	4.5 V
I_4 =	1.5 A	ΔV_4 =	12 V