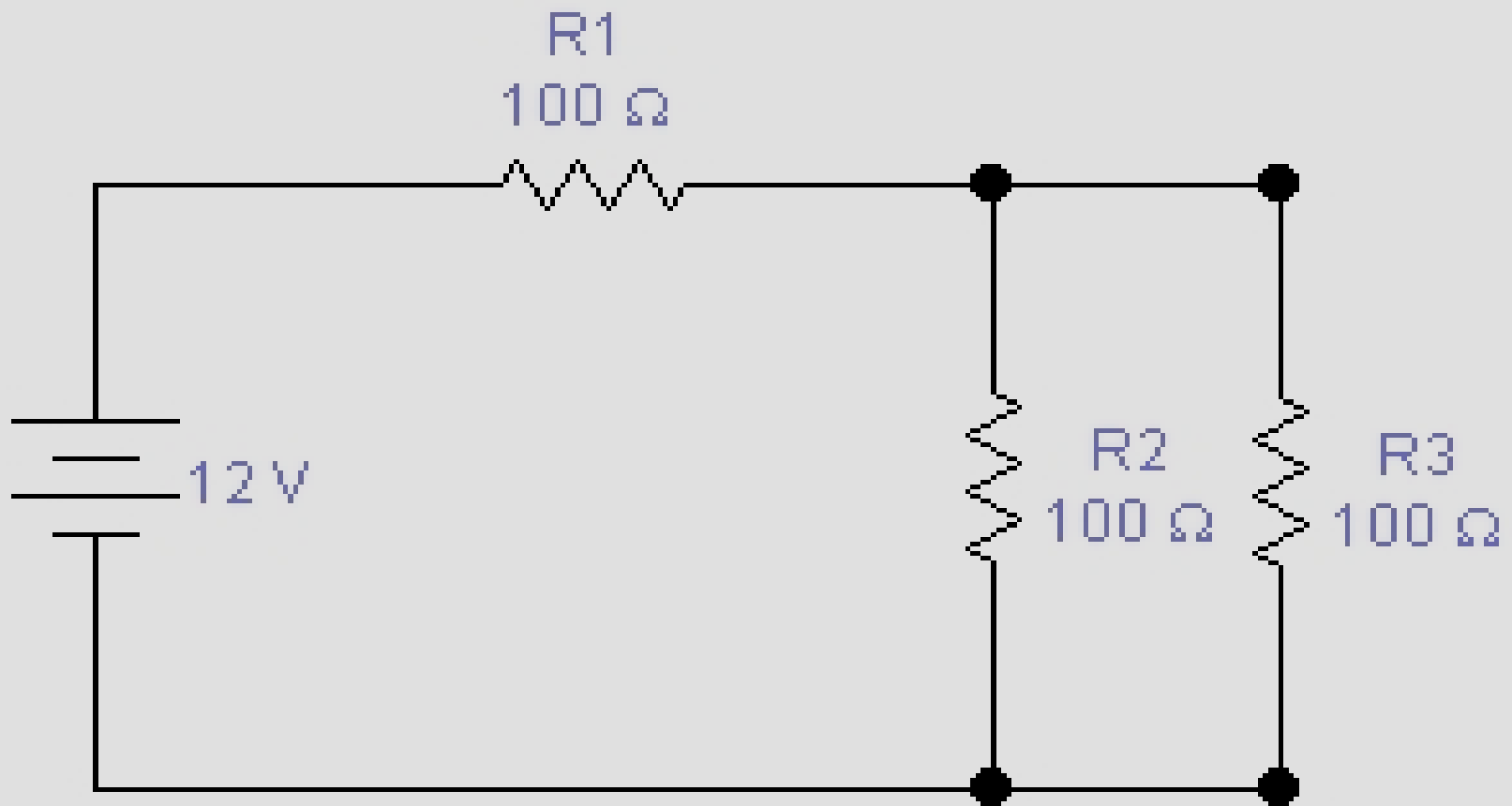


Unit 8

SERIES-PARALLEL CIRCUITS

In the last two units we discussed loads connected in series and in parallel.

In this unit we will learn how to deal with series and parallel loads in the same circuit.

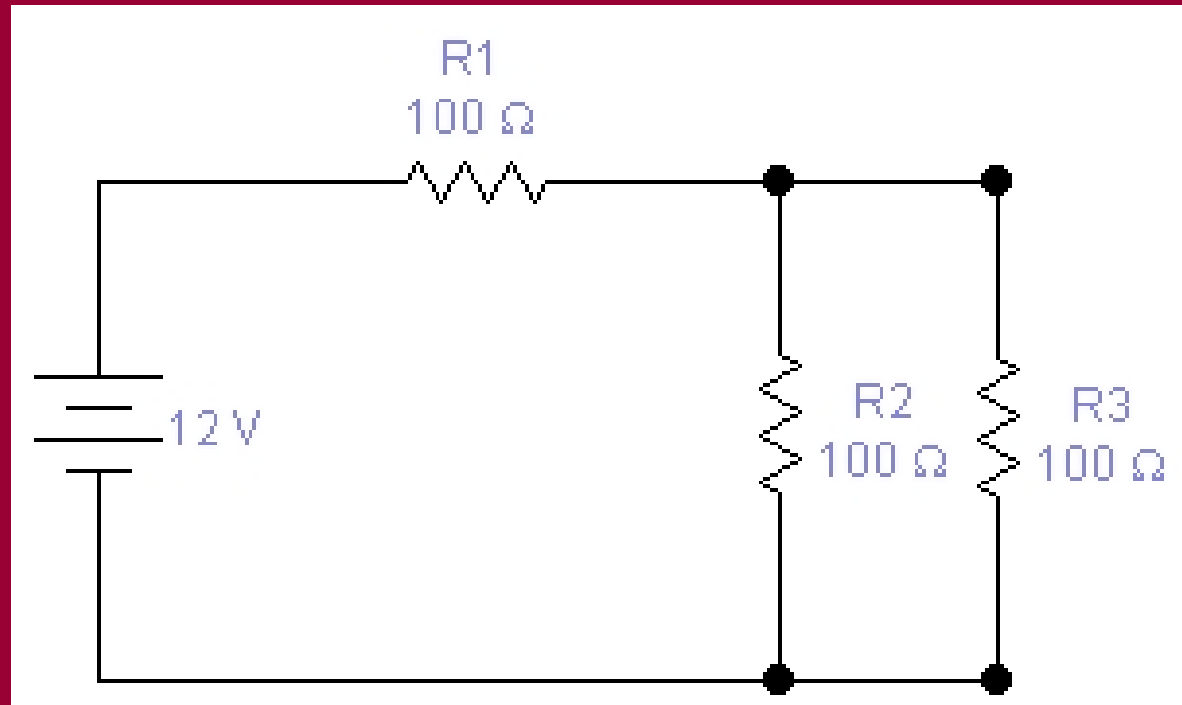


R1 is in series
R2 and R3 are in parallel

Voltage in a combination circuit.

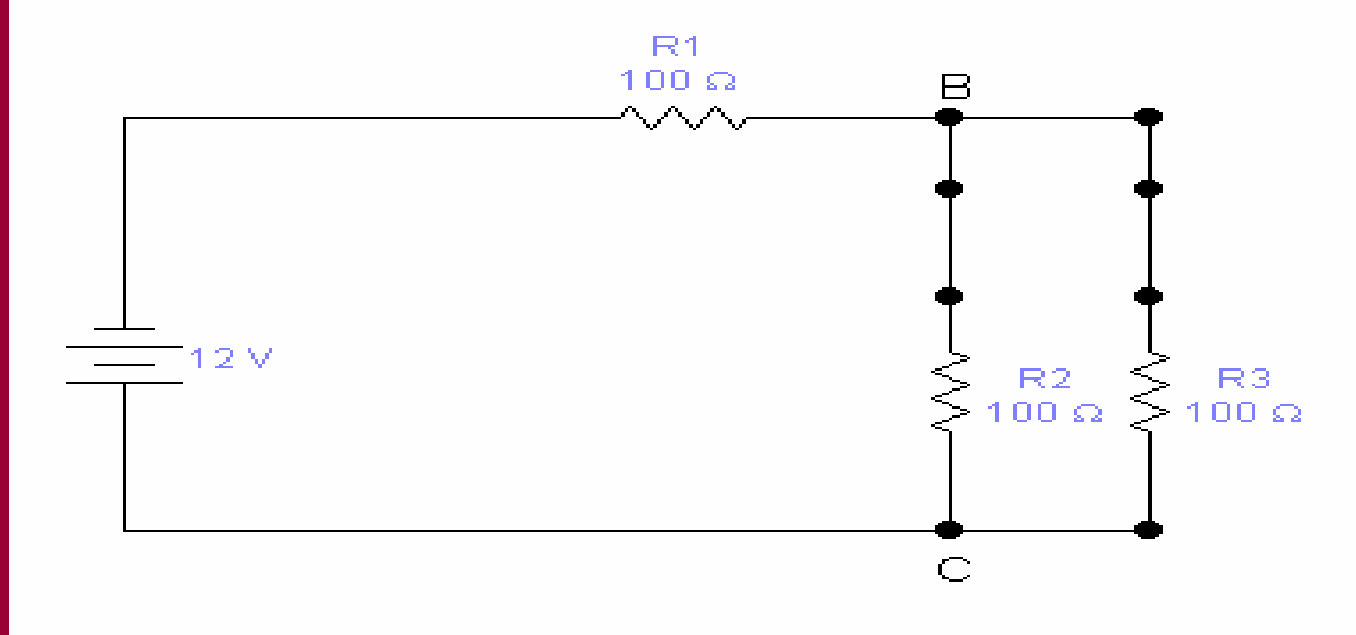
- Kirchhoff's law of voltage is still true.
- However the *voltage across any **parallel branch** must be considered as only one voltage drop.*
- $E_t = E_1 + E_2 + E_3 \dots$

In this example how many voltage drops are there?

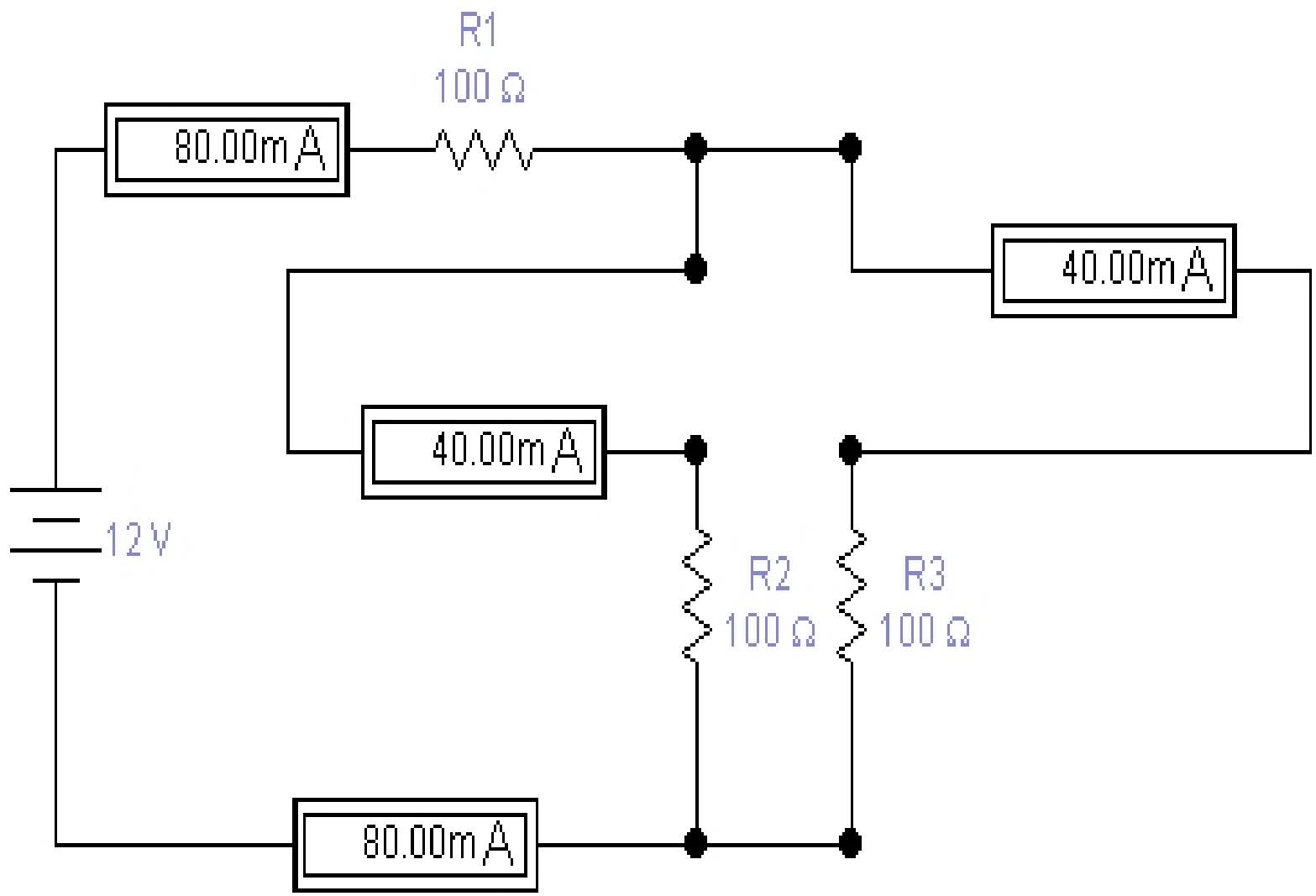


Current in a combination circuit.

- Kirchoff's law of current is still true.
- All the current that goes into a node comes out.



- Total current will flow into R1 and then at point B the current splits some will go through branch 1 and the rest will go through branch 2.
- The two branch currents will come back together at a point C.



Before solving for any individual voltage drops or current *we must know the total resistance, total voltage and the total current.*

We will use two formulas to help us find total resistance

$$R_t = R_1 + R_2 + R_3$$

$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Steps to analyze a complex combination circuit

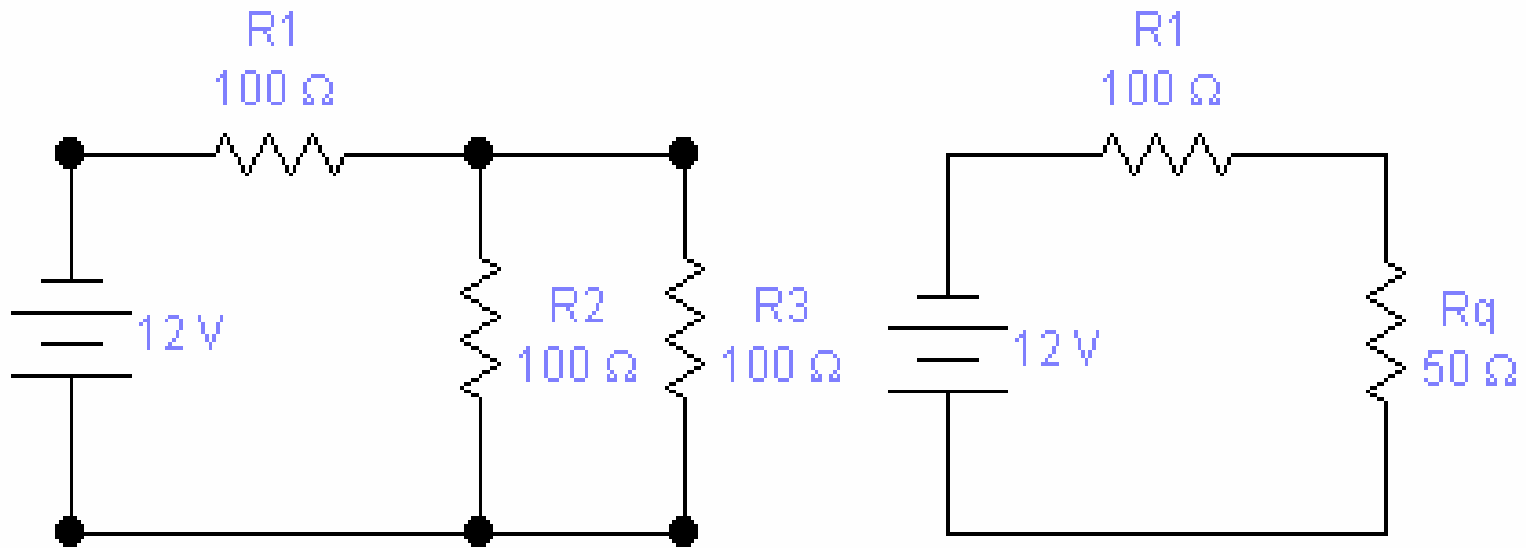
Determine which resistances are in series and which are in parallel

Start with the parallel circuit the most distant from the power source

- Calculate the *equivalent resistance* ($R_q =$)
- *equivalent resistance is the total resistance of a bank of parallel resistances*

Redraw circuit into a simple series circuit using R_q instead of the bank parallel resistances

Combination circuit redrawn to a series circuit



R_q = total resistance of R_2 and R_3

Now that all resistances are in series use this formula to find the total resistance

- $R_t = R_1 + R_2 + \dots$
- $R_t = 100 + 50$
- $R_t = 150$

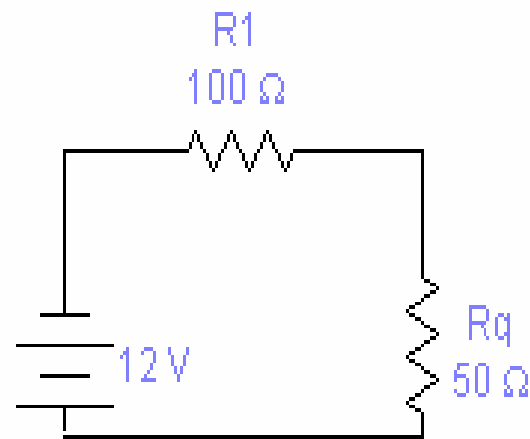
Now that we know R_t and E_t (which is usually a given) we can calculate I_t by using Ohm's law

- $I_t = E_t / R_t$
- $I_t = 12 / 150$
- $I_t = .08 \text{ A}$
- $I_t = 80 \text{ mA}$

When all totals for E, I and R are known we can calculate the individual voltage drops and use the voltage drops to help calculate the current at the individual resistances

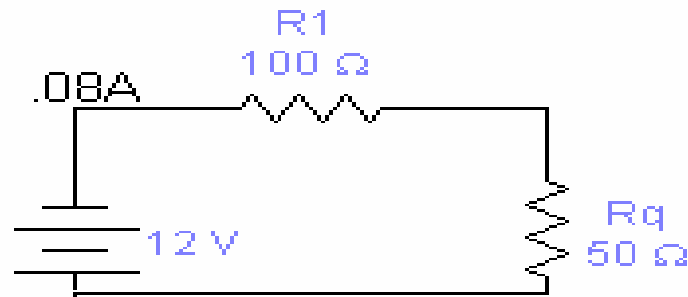
Look back at the redrawn series circuit

- How many voltage drops do we have ?
- Two is correct.



We have two voltage drops the first at $R1$. The second at Rq , each resistance in the bank of parallel resistances labeled Rq will have the same voltage present.

The current flowing through R1 and the resistance of R1 can be used to calculate the voltage at R1

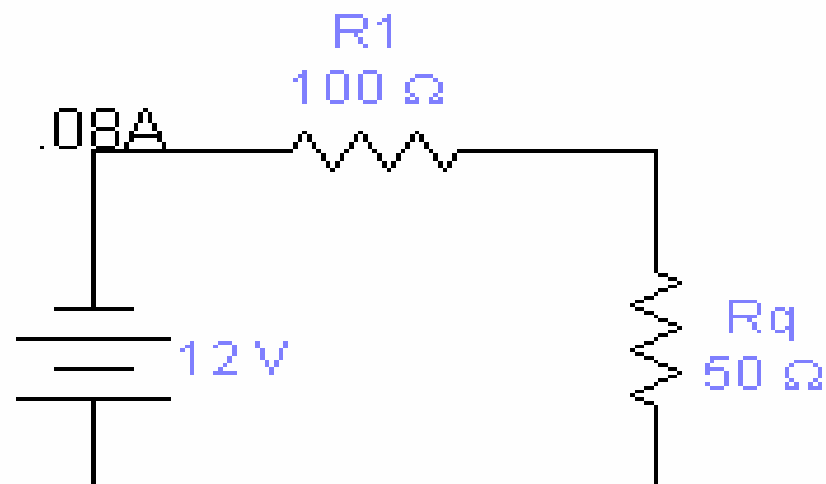


Using Ohm's law to calculate the voltage at R1.

$$E \text{ at R1} = I \text{ at R1} \times R_1$$

$$E \text{ at R1} = .08 \times 100$$

$$E \text{ at R1} = 8 \text{ V}$$



Use Kirchhoff's law of voltage to help find the voltage drop of Rq

$$E_t = E_1 + E_2 \dots$$

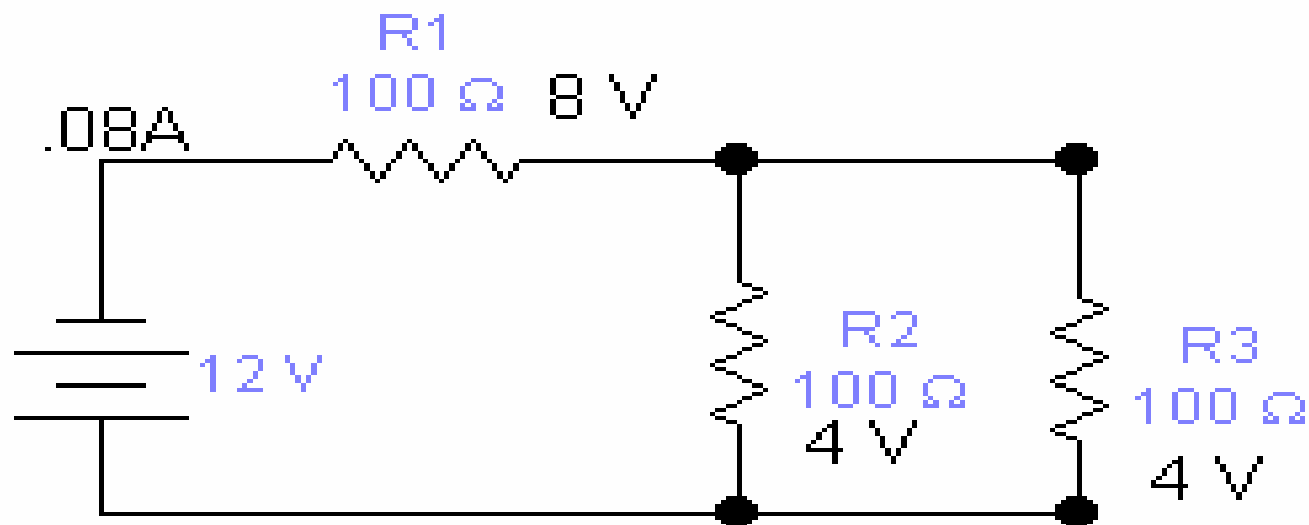
$$12 \text{ V} = E_1 + E_2 \dots$$

$$12 \text{ V} = 8 \text{ V} + ?$$

$$12 \text{ V} - 8 \text{ V} = 4 \text{ V}$$

$$E \text{ at } R_q = 4 \text{ V}$$

Now that the *voltage* and *resistance* are known for each resistance we can use Ohm's Law to calculate the current at the remaining resistances



Ohm's law can be used to help find the current of the two parallel resistances.

$$I \text{ at } R2 = E \text{ at } R2 / R \text{ at } R2$$

$$I = 4 \text{ V} / 100$$

$$I = .04 \text{ A}$$

$$I = 40 \text{ mA}$$

The end