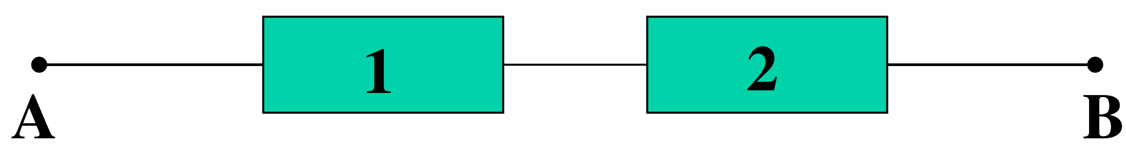
Series and Parallel Circuits

When devices are connected in an electric circuits, they can be connected in "series" or in "parallel" with other devices.

Series Connection

When devices are series, any current that goes through one device must also go through the other devices. For example:



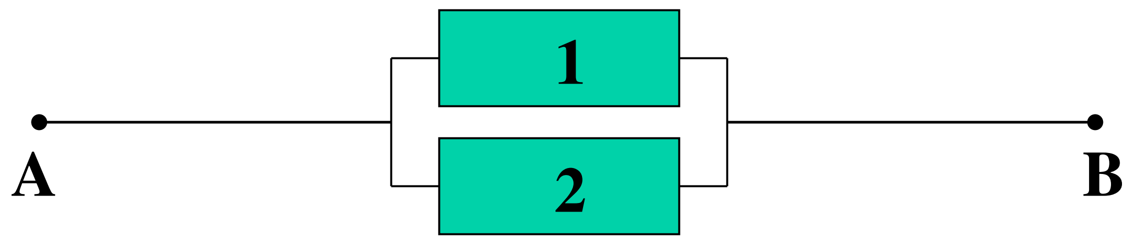
The devices, numbered "**1**" and "**2**" in the diagram above, are connected in series. If an electron (or even conventional positive current) needs to move from point **A** to point **B**, it must go through both device **1** and device **2**. Everything that goes through one must also go through the other.

Series and Parallel Circuits

When devices are connected in an electric circuits, they can be connected in "series" or in "parallel" with other devices.

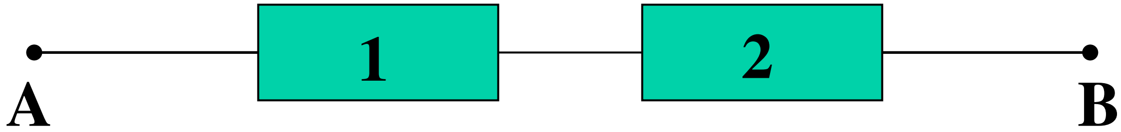
Parallel Connection

When devices are parallel, the current splits and each "piece" of charge goes through only one resistor. For example:



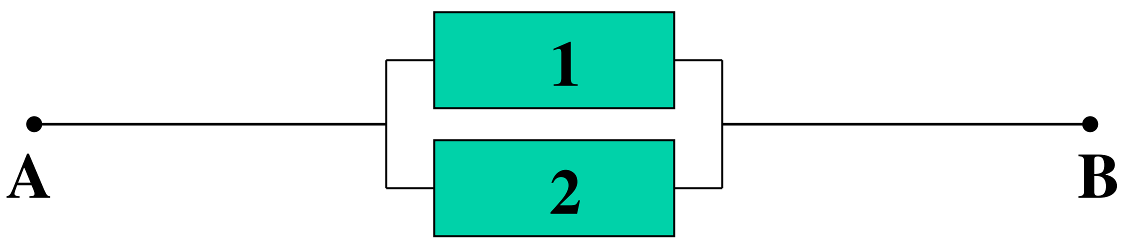
The devices, numbered "**1**" and "**2**" in the diagram above, are connected in parallel. If an electron (or even conventional positive current) needs to move from point **A** to point **B**, it must go through only one device, not both. Some current goes through one, some through the other.

Resistors in Series



If devices 1 and 2 are resistors, think of the series connection as a longer resistor. Longer resistors have greater resistance. The total resistance of a combination of resistors in series is greater than any of the individual resistances.

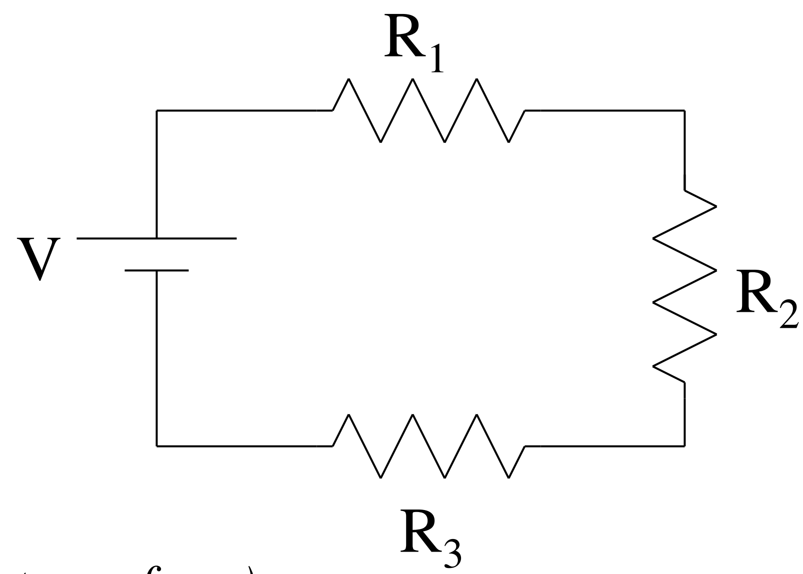
Resistors in Parallel



If devices 1 and 2 are resistors, think of the parallel connection as a wider resistor. Wider resistors have lower resistance. The total resistance of a combination of resistors in paralle is smaller than any of the individual resistances.

<u>Series Circuits</u>

The schematic circuit diagram to the right shows three resistors (R) connected in series with a source of potential difference (V).



Rules for a simple series circuit…. (in sentence form)

1) The total <u>equivalent resistance</u> of resistors in series is equal to the sum of the individual resistances.

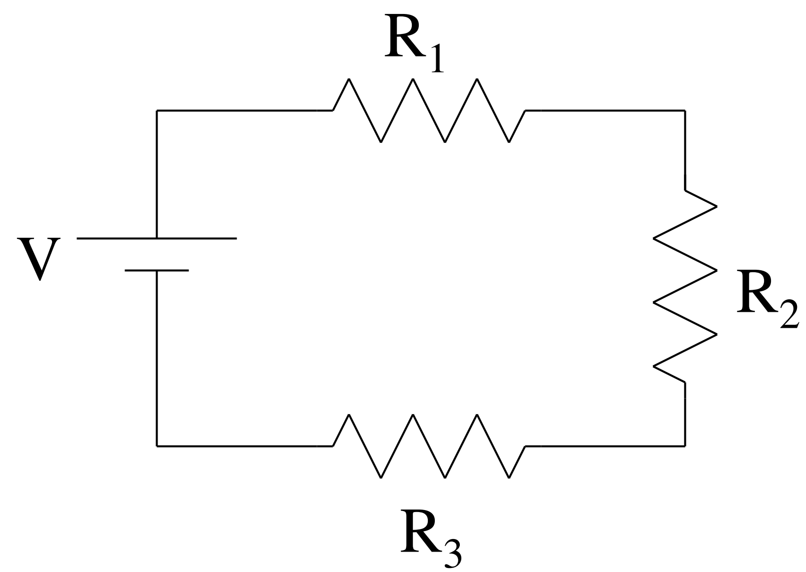
2) The sum of the voltage drops across each of the resistors is equal to the total voltage of the power supply.

3) The same amount of current flows through all the resistors.

4) The total power converted by the three resistors is equal to the sum of the individual powers

Series Circuits

The schematic circuit diagram to the right shows three resistors (R) connected in series with a source of potential difference (V).



Rules for a simple series circuit…. (in equation form)

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

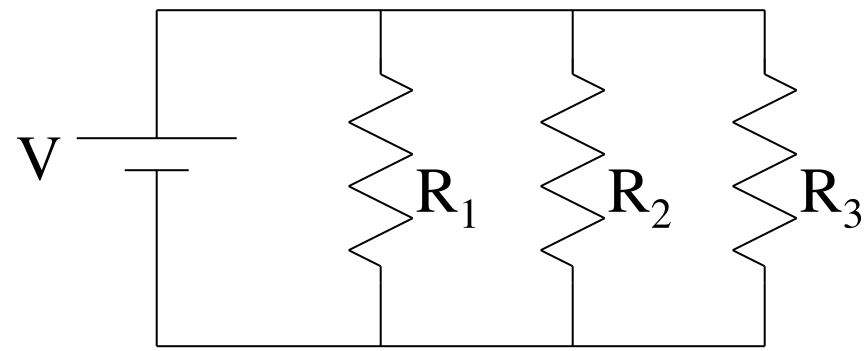
$$V = V_1 + V_2 + V_3 + \ldots$$

$$I = I_1 = I_2 = I_3 = \ldots$$

$$P = P_1 + P_2 + P_3 + \ldots$$

<u>Parallel Circuits</u>

The schematic circuit diagram to the right shows three resistors (R) connected in parallel with a source of potential difference (V).



Rules for a simple parallel circuit…. (in sentence form)

1) The <u>reciprocal</u> of the total <u>equivalent resistance</u> of resistors in parallel is equal to the <u>sum of the reciprocals</u> of the individual resistances.

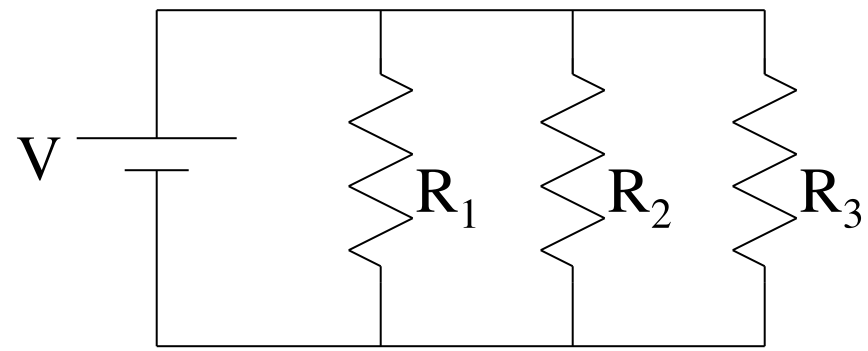
2) All of the resistors have the same voltage drop across them.

3) The sum of the currents through all the parallel resistors is equal to the total current supplied by the voltage source.

4) The total power converted by the three resistors is equal to the sum of the individual powers.

Parallel Circuits

The schematic circuit diagram to the right shows three resistors (R) connected in parallel with a source of potential difference (V).



Rules for a simple parallel circuit…. (in equation form)

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

$$V = V_1 = V_2 = V_3 = \ldots.$$

$$I = I_1 + I_2 + I_3 + \ldots.$$

$$P = P_1 + P_2 + P_3 + \ldots.$$

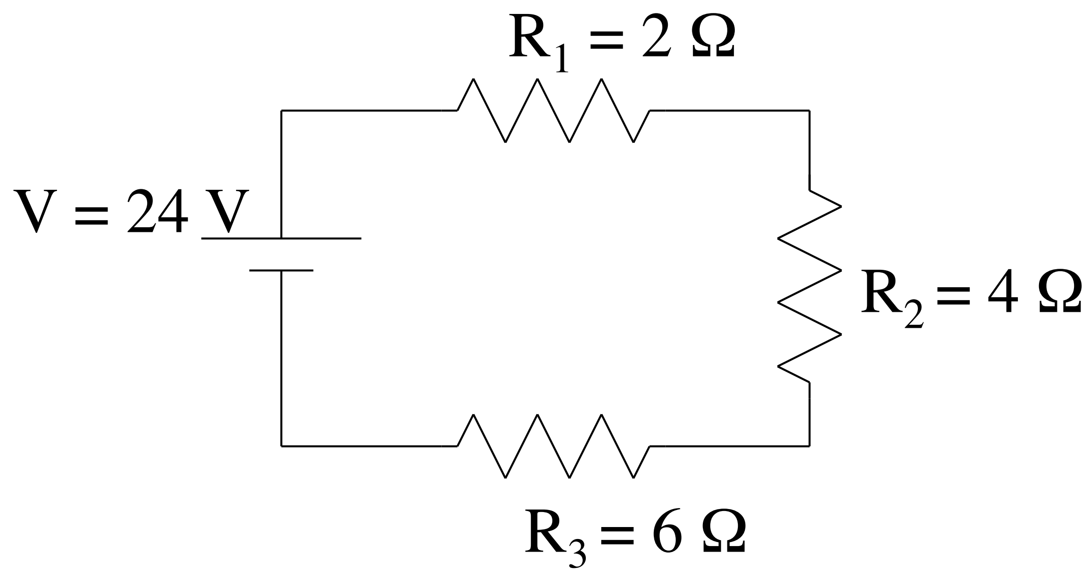
Series Circuits: Example Problem

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

$$V = V_1 + V_2 + V_3 + \ldots$$

$$I = I_1 = I_2 = I_3 = \ldots$$

$$P = P_1 + P_2 + P_3 + \ldots$$



Fill in Given

Use $R_{eq} = R_1 + R_2 + R_3 + \ldots$ to find the total equivalent resistance.

Use $V = IR$ to find the total current

$I = I_1 = I_2 = I_3 = \ldots$

Use $V = IR$ to find the individual voltages

Use $P = VI$ to find all the powers

	V	I	R	P
1			2	
2			4	
3			6	
T	24			

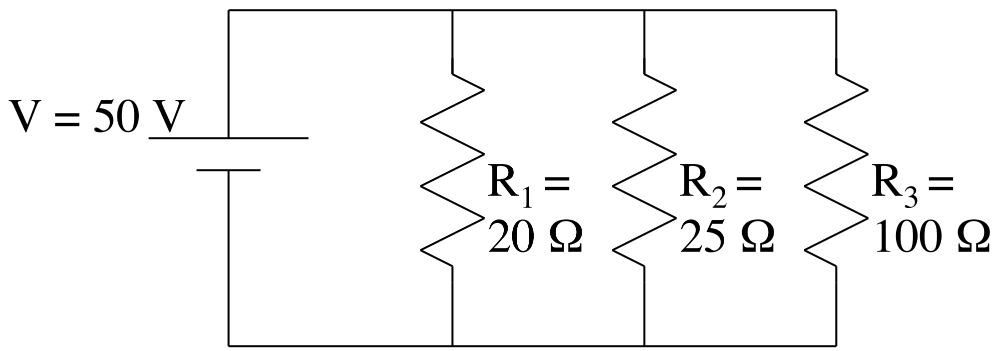
Parallel Circuits: Example Problem

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

$$V = V_1 = V_2 = V_3 = \ldots$$

$$I = I_1 + I_2 + I_3 + \ldots$$

$$P = P_1 + P_2 + P_3 = \ldots$$



Fill in Given

$V = V_1 = V_2 = V_3 = \ldots$

Use $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots.$ to find the total equivalent resistance.

Use $V = IR$ to find the individual currents

Use $P = VI$ to find all the powers

	V	I	R	P
1			20	
2			25	
3			100	
T	50			

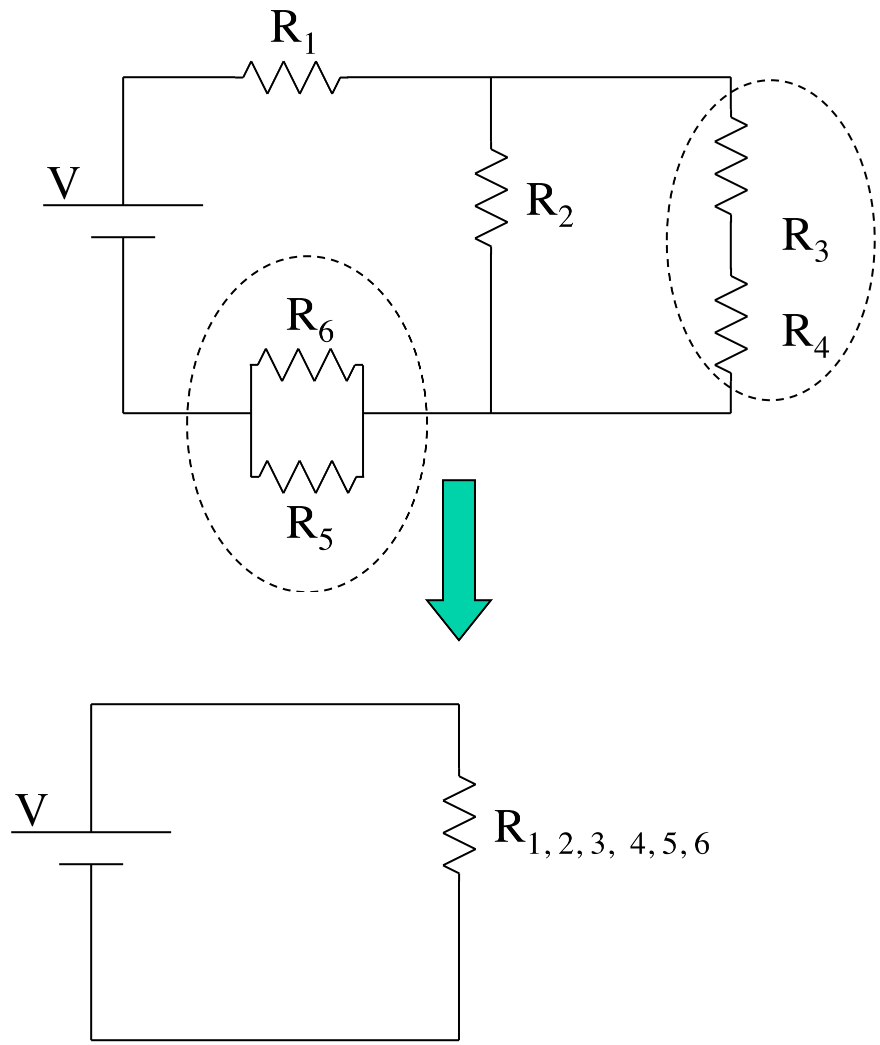
Combination Circuits

The circuit to the right is a complicated combination circuit. The resistors aren't all in series or all in parallel.

To analyze a combination circuit, first look for pairs (or more) of resistors which are in series or parallel. In this example R_3 and R_4 are in series, while R_5 and R_6 are in parallel. Use the series and parallel rules to replace the pairs with "equivalent" resistors.

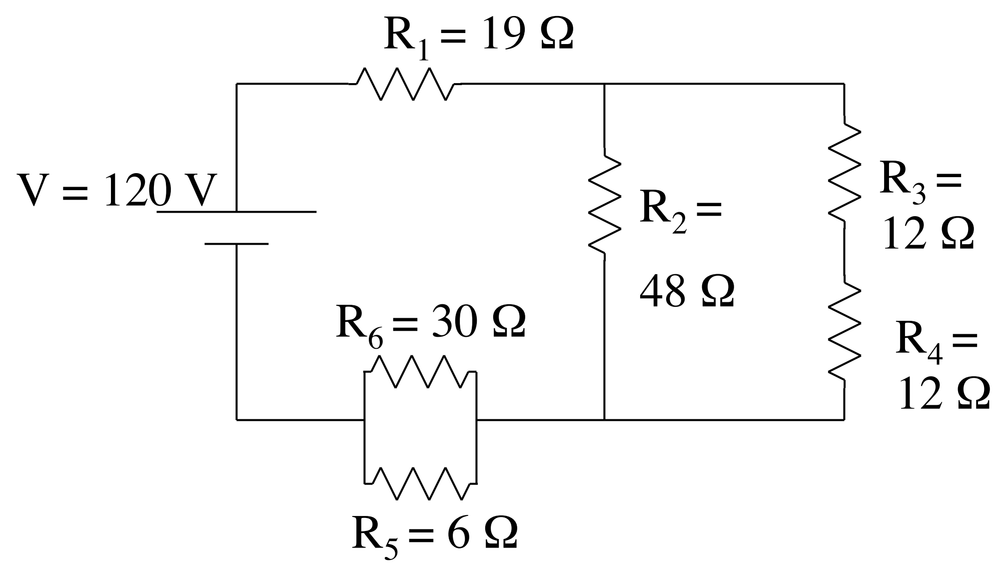
Now R_2 is in parallel with $R_{4,3}$.

Now $R_{2,3,4}$ is in series with R_1 and $R_{5,6}$.



Combination Circuits

Example: Find the equivalent resistance of the six resistors in the circuit at right.



Combination Circuits: Hints

When the current reaches point A, it must split to the right or the left. If R_1 has a bigger resistance than R_2, most of the current will go through R_2.

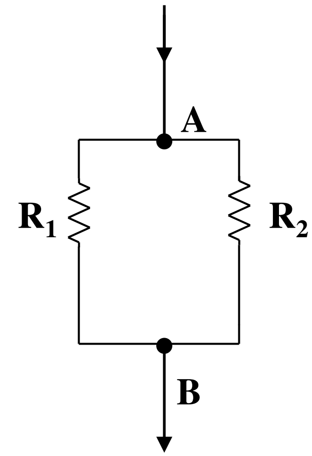
If R1 = 2 x R2, then twice as much current will go through R2 as compared to R1.

$I_1 + I_2 = I$

$2 \times I_1 = I_2$

$I_1 = (1/3)I$

$I_2 = (2/3)I$



Example Problem:

How much of the 30 A of current goes through each resistor in the diagram at right?