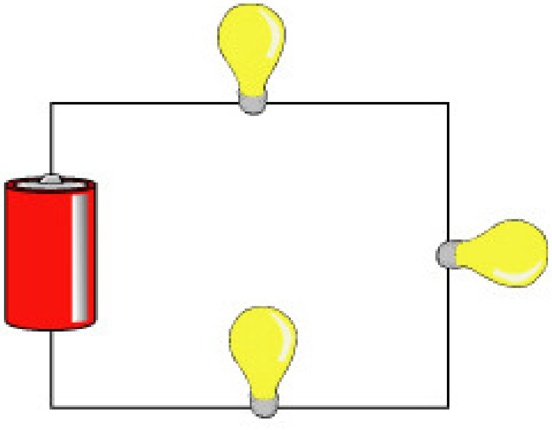
Electric Circuits

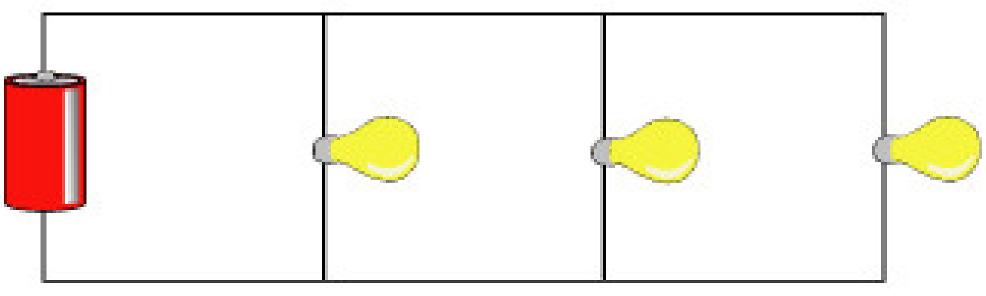
AP Physics 1

Ways to Wire Circuits

There are 2 basic ways to wire a circuit. Keep in mind that a resistor could be ANYTHING (bulb, toaster, ceramic material…etc)

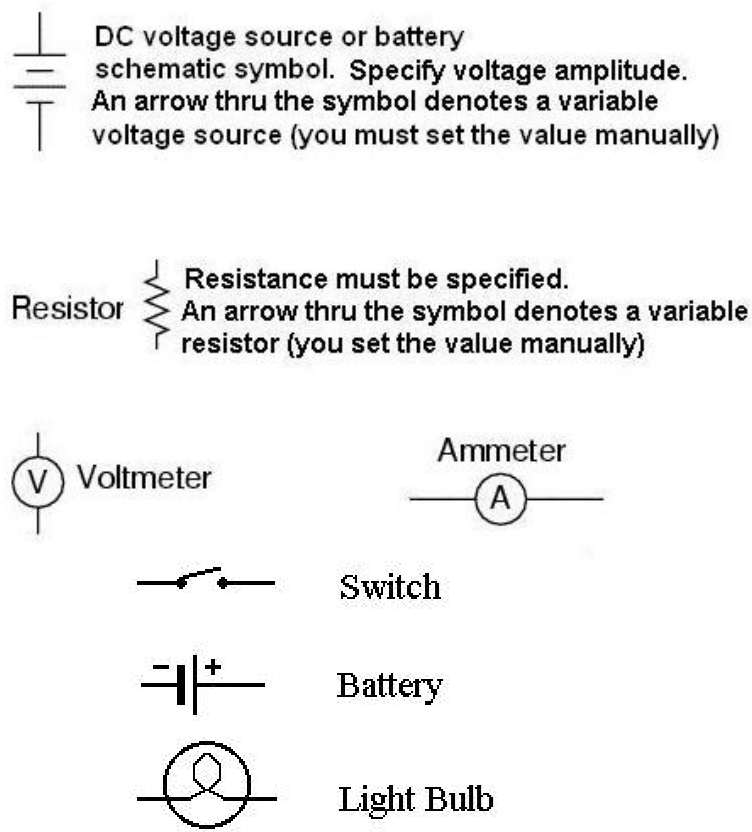
Series – One after another
Parallel – between a set of junctions and parallel to each other





Schematic Symbols

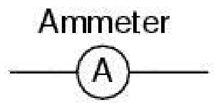
Before you begin to understand circuits you need to be able to draw what they look like using a set of standard symbols understood anywhere in the world



For the battery symbol, the LONG line is considered to be the POSITIVE terminal and the SHORT line , NEGATIVE.

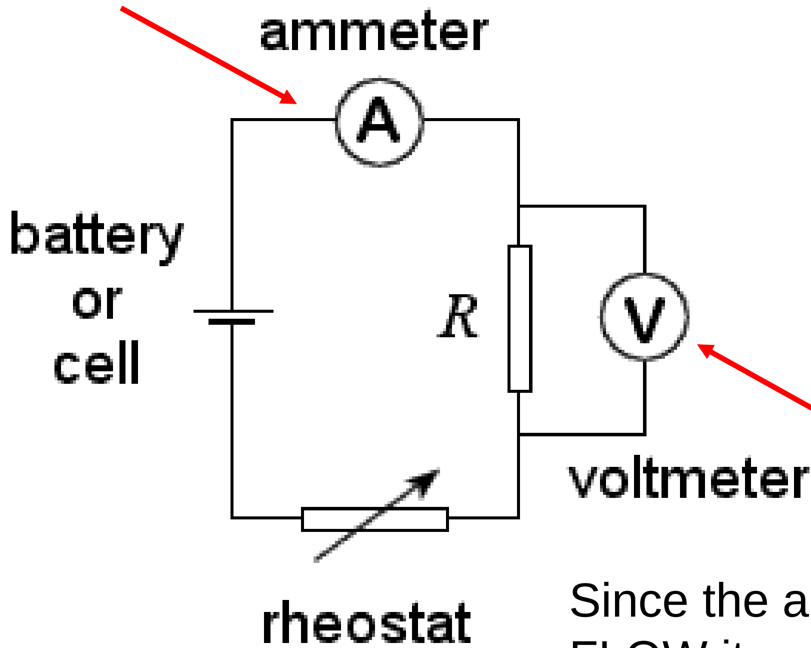
The VOLTMETER and AMMETER are special devices you place IN or AROUND the circuit to measure the VOLTAGE and CURRENT.

The Voltmeter and Ammeter



The voltmeter and ammeter cannot be just placed anywhere in the circuit. They must be used according to their DEFINITION.

Current goes THROUGH the ammeter

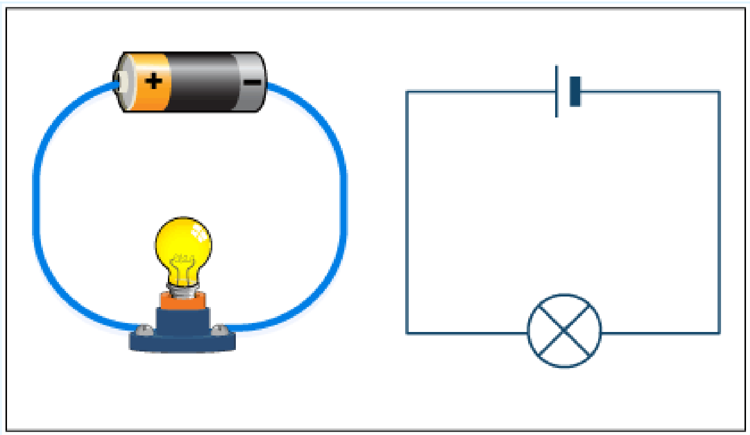


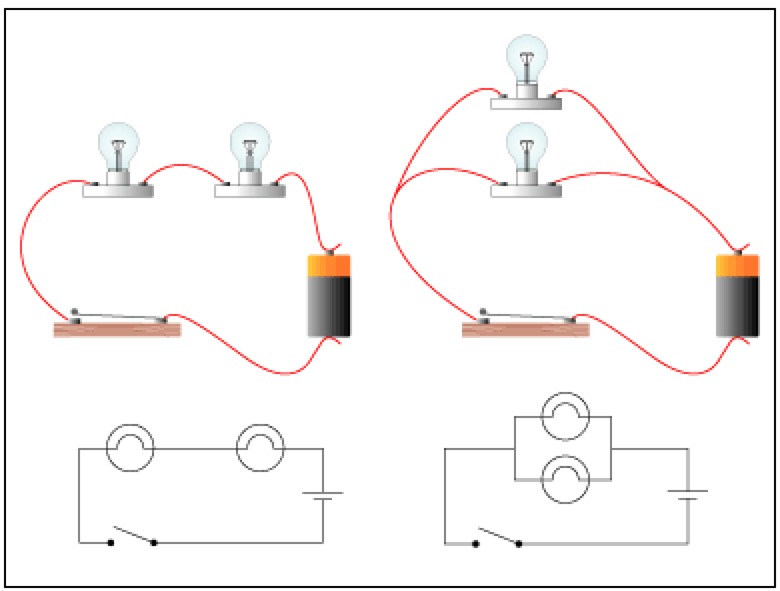
Since a voltmeter measures voltage or POTENTIAL DIFFERENCE it must be placed **ACROSS** the device you want to measure. That way you can measure the CHANGE on either side of the device.

Voltmeter is drawn ACROSS the resistor

Since the ammeter measures the current or FLOW it must be placed in such a way as the charges go **THROUGH** the device.

Simple Circuit

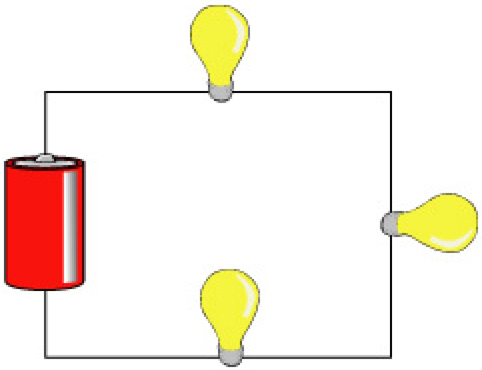




When you are drawing a circuit it may be a wise thing to start by drawing the battery first, then follow along the loop (closed) starting with positive and drawing what you see.

Series Circuit

In in series circuit, the resistors are wired one after another. Since they are all part of the SAME LOOP they each experience the SAME AMOUNT of current. In figure, however, you see that they all exist BETWEEN the terminals of the battery, meaning they SHARE the potential (voltage).



$$I_{(series)Total} = I_1 = I_2 = I_3$$

$$V_{(series)Total} = V_1 + V_2 + V_3$$

Series Circuit

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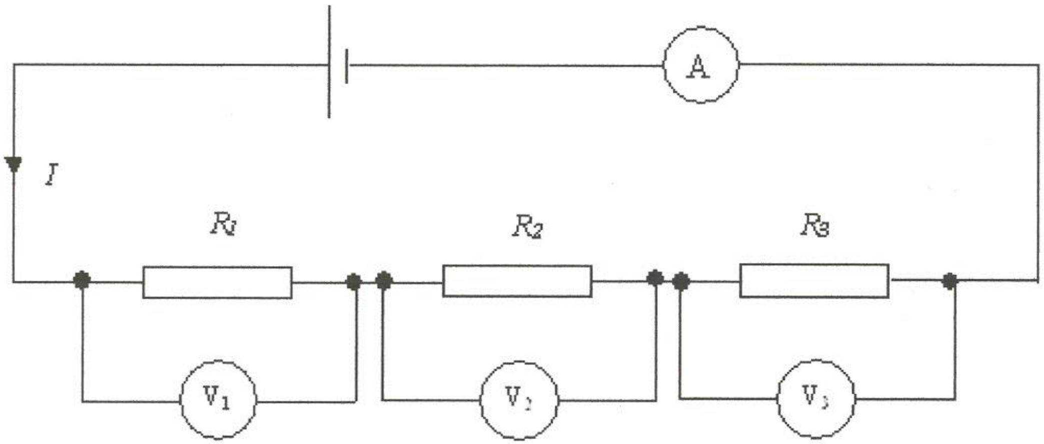


As the current goes through the circuit, the charges must USE ENERGY to get through the resistor. So each individual resistor will get its own individual potential voltage). We call this VOLTAGE DROP.

$$V_{(series)Total} = V_1 + V_2 + V_3; \quad \Delta V = IR$$

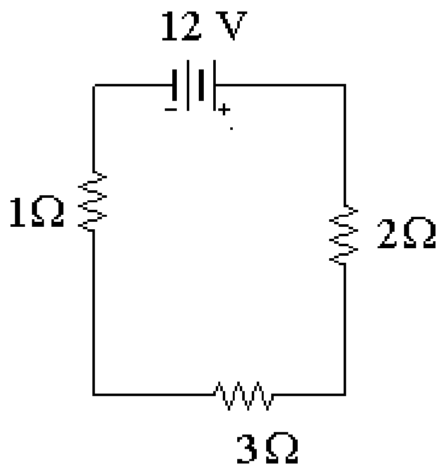
$$(I_T R_T)_{series} = I_1 R_1 + I_2 R_2 + I_3 R_3$$

$$R_{series} = R_1 + R_2 + R_3$$

$$R_s = \sum R_i$$

Note: They may use the terms “effective” or “equivalent” to mean TOTAL!

Example



A series circuit is shown to the left.

a) What is the total resistance?

R(series) = 1 + 2 + 3 = 6Ω

b) What is the total current?

ΔV=IR 12=I(6) I = 2A

c) What is the current across EACH resistor?

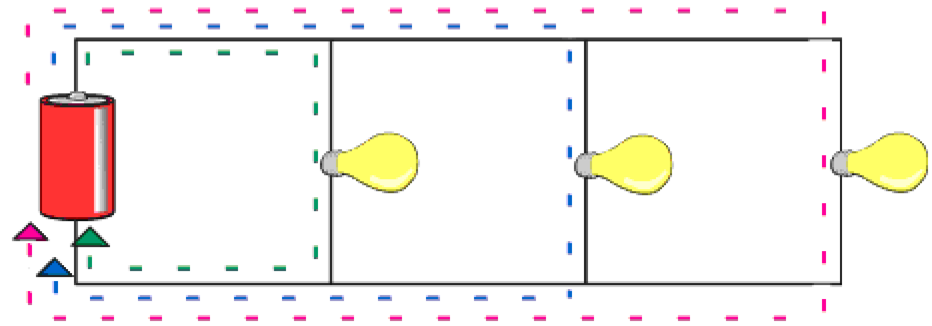
They EACH get 2 amps!

d) What is the voltage drop across each resistor?(Apply Ohm's law to each resistor separately)

$V_{1\Omega}$=(2)(1)= **2 V** $V_{3\Omega}$=(2)(3)= **6V** $V_{2\Omega}$=(2)(2)= **4V**

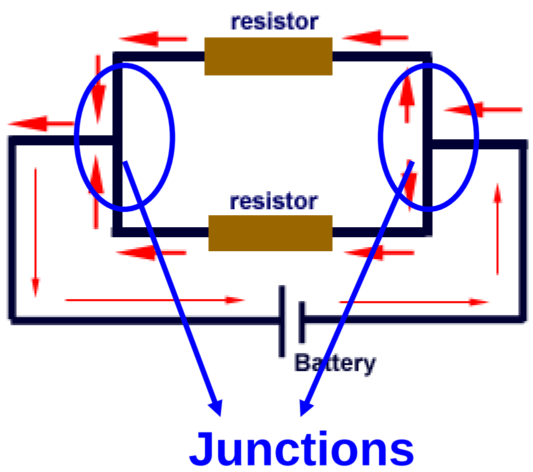
Notice that the individual VOLTAGE DROPS add up to the TOTAL!!

Parallel Circuit



In a parallel circuit, we have multiple loops. So the current splits up among the loops with the individual loop currents **adding** to the total current

It is important to understand that parallel circuits will all have some position where the current splits and comes back together. We call these **JUNCTIONS**.



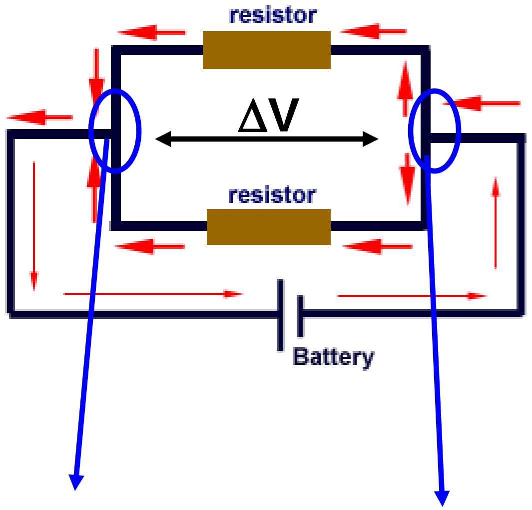
The current going IN to a junction will always equal the current going OUT of a junction.

$$I_{(parallel)Total} = I_1 + I_2 + I_3$$

Regarding Junctions:

$$I_{IN} = I_{OUT}$$

Parallel Circuit



This junction touches the **POSITIVE** terminal

This junction touches the **NEGATIVE** terminal

Notice that the JUNCTIONS both touch the POSTIVE and NEGATIVE terminals of the battery. That means you have the SAME potential difference down EACH individual branch of the parallel circuit. This means that the individual voltages drops are equal.

$$V_{(parallel)Total} = V_1 = V_2 = V_3$$

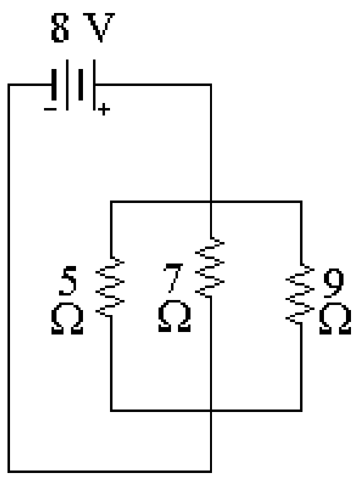
$$I_{(parallel)Total} = I_1 + I_2 + I_3; \ \Delta V = IR$$

$$\left(\frac{V_T}{R_T}\right)_{Parallel} = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}$$

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

$$\frac{1}{R_P} = \sum \frac{1}{R_i}$$

Example



To the left is an example of a parallel circuit.
a) What is the total resistance?

$$\frac{1}{R_P} = \frac{1}{5} + \frac{1}{7} + \frac{1}{9}$$

$$\frac{1}{R_p} = 0.454 \rightarrow R_P = \frac{1}{0.454} =$$ **2.20 Ω**

b) What is the total current? $\Delta V = IR$

$$8 = I(R) =$$ **3.64 A**

c) What is the voltage across EACH resistor?

8 V each!

d) What is the current drop across each resistor?
(Apply Ohm's law to each resistor separately)

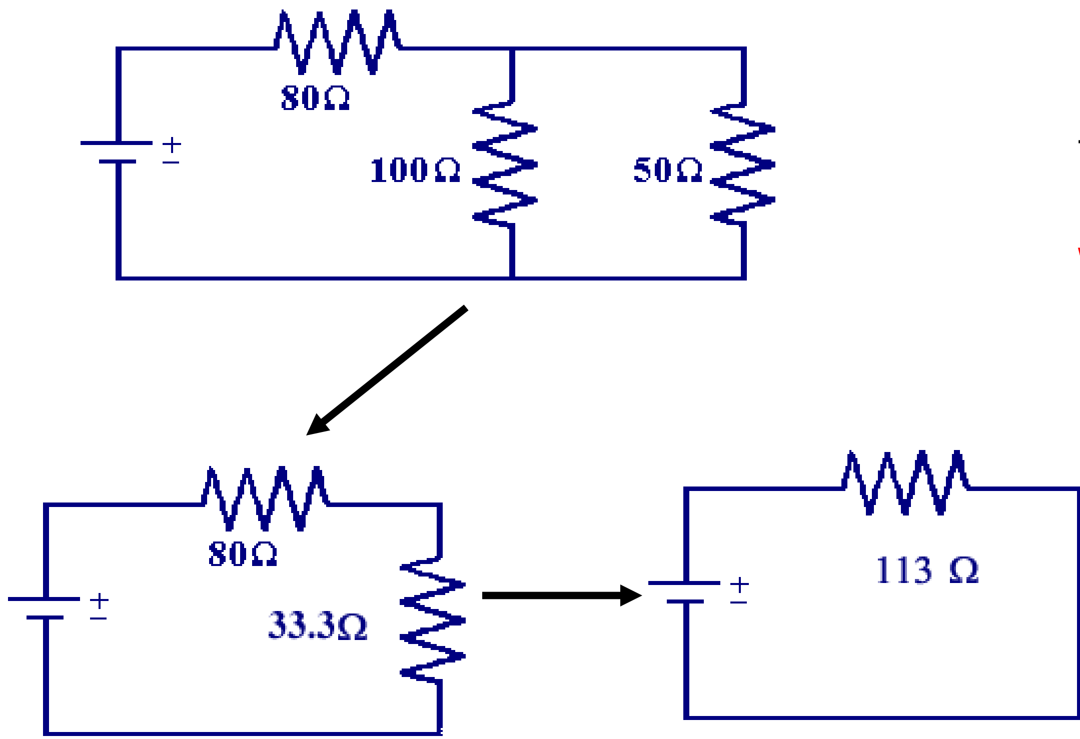
$$\Delta V = IR$$

$I_{5\Omega} = \frac{8}{5} =$ **1.6 A** $I_{7\Omega} = \frac{8}{7} =$ **1.14 A** $I_{9\Omega} = \frac{8}{9} =$ **0.90 A**

Notice that the individual currents ADD to the total.

Compound (Complex) Circuits

Many times you will have series and parallel in the SAME circuit.



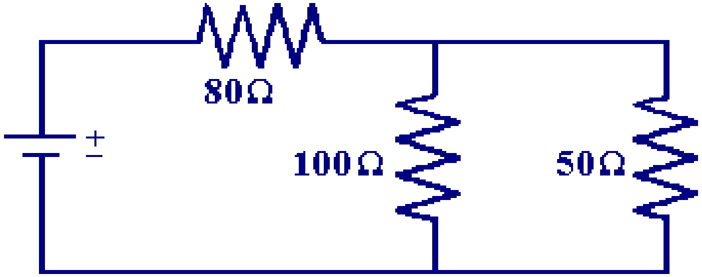
Solve this type of circuit from the inside out.

WHAT IS THE TOTAL RESISTANCE?

$$\frac{1}{R_P} = \frac{1}{100} + \frac{1}{50}; \quad R_P = 33.3\Omega$$

$$R_s = 80 + 33.3 = 113.3\Omega$$

Compound (Complex) Circuits



$$\frac{1}{R_P} = \frac{1}{100} + \frac{1}{50}; \quad R_P = 33.3\Omega$$

$$R_s = 80 + 33.3 = 113.3\Omega$$

Suppose the potential difference (voltage) is equal to **120V**. What is the total current?

$$\Delta V_T = I_T R_T$$

$$120 = I_T (113.3)$$

$I_T =$ **1.06 A**

What is the VOLTAGE DROP across the 80Ω resistor?

$$\Delta V_{80\Omega} = I_{80\Omega} R_{80\Omega}$$

$$V_{80\Omega} = (1.06)(80)$$

$V_{80\Omega} =$ **84.8 V**

Compound (Complex) Circuits

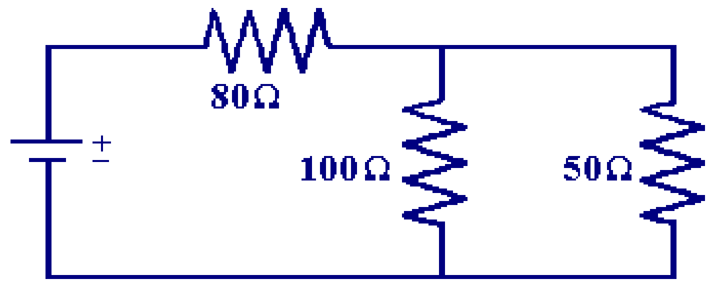
$R_T = 113.3\Omega$

$V_T = 120V$

$I_T = 1.06A$

$V_{80\Omega} = 84.8V$

$I_{80\Omega} = 1.06A$



What is the VOLTAGE DROP across the 100Ω and 50Ω resistor?

$V_{T(parallel)} = V_2 = V_3$

$V_{T(series)} = V_1 + V_{2\&3}$

$120 = 84.8 + V_{2\&3}$

$V_{2\&3} =$ **35.2 V Each!**

What is the current across the 100Ω and 50Ω resistor?

$I_{T(parallel)} = I_2 + I_3$

$I_{T(series)} = I_1 = I_{2\&3}$

$I_{100\Omega} = \frac{35.2}{100} =$ **0.352 A**

$I_{50\Omega} = \frac{35.2}{50} =$ **0.704 A**

Add to 1.06A