Ohms Law (these theory notes support the ppt)

In this section you will learn about Ohm's Law as applied to a single resistor circuit.

Phillips Textbook pp. 43-59 including some maths on notation.

At the end of this section the student will be able to:
- Define the term conductance.
- State the equation for Ohm's Law and use it to calculate values of voltage, current and resistance for single resistor circuits.
- Identify the direction of current flow and polarity of components in single resistor circuits.
- State and verify by calculation the effects of increasing/decreasing the resistance of a circuit.
- State and verify by calculation the effects of increasing/decreasing the voltage applied to a simple circuit.
- State and verify by calculation the conditions required to increase/decrease the current in a single resistor circuit.
- Illustrate, using a circuit diagram, the cormeetions for an ammeter and voltmeter in a single resistor circuit.

What is Ohms Law?

It has been already pointed out that a potential difference, or electric pressure is required to force a current of electricity through a circuit just as water pressure is needed to cause a stream of water to flow through a water circuit. It was also shown that resistance is the opposition to the electric flow just as friction in pipes is the opposition to the water flow. Thus, in a simple electric circuit three quantifies must be considered:
- potential difference (V) expressed in volts;
- the resistance (R) expressed in ohms;
- the current (I) expressed in amperes.

Dr Ohm was first to formulate the relationship which exists between these three quantities and his statement, now known as Ohm's law, can be considered as the basic law of the electric circuit. Ohm's law is stated -
'Provided that the temperature of a given conductor remains unchanged, the ratio of the potential d~ference between its ends, and the steady current in it is a constant quantity"

Ohm's law can be expressed algebraically as **V/I= Resistance**, which is a constant quantity providing the Voltage and Current remain the same.

Connecting the statement into an equation -

- V= potential difference between ends of the circuit in volts
- I = current in eireuit in amperes
- R = resistance of circuit in ohms

Can covert the equation to terms of Current

Can convert the equation in terms of Resistance

In relation to current

From the second Ohm's Law equation, where I = V/R it is observed the current in a circuit is -

__________________________ to the voltage applied to a circuit

and

__________________________ to the resistance of the circuit.

This means the current in a circuit is -

____________________________ by raising the voltage, and

____________________________ by increasing the resistance.

example: 1.
A coil with a resistance of 6 ohms has an applied potential difference of 120 volts. What is the coil current?

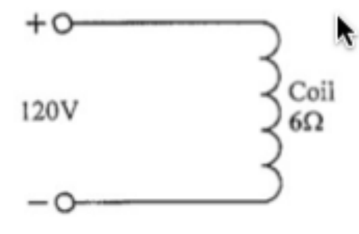


Figure 1

Example: 2
An incandescent lamp has a resistance of 960 ohms. What is the lamp current when it is connected to a 240-volt supply?

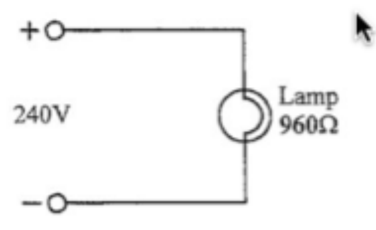


Figure 2

Example: 3
Two coils, A and B have resistances of 10 and 20 ohms respectively. Determine the current in each coil when connected separately across -
a) a 120 volt supply, and
b) a 240 volt supply.

Coil A on 120V

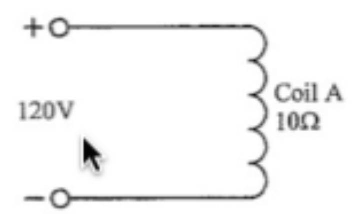


Figure 3

Coil B on 120V

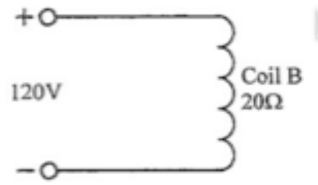


Figure 4

Coil A on 240V

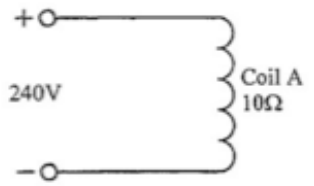


Figure 5

Coil B on 240V

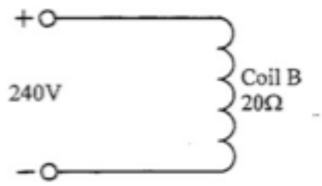


Figure 6

Example 3 shows the effect of changing the supply voltage and changing the resistance.

If the supply voltage is doubled the current is ___________________________

Doubling the resistance of a circuit ________________ the current to _______________ .

OHM'S LAW IN RELATION TO NECESSARY VOLTAGE

Where it is required to know the voltage necessary to pass a current through a circuit of known resistance the equation V = IR can be used as shown by the following example.

Example: 4.

What potential difference is required to maintain a current of 0.4 ampere in an incandescent lamp with a resistance of 600 ohms?

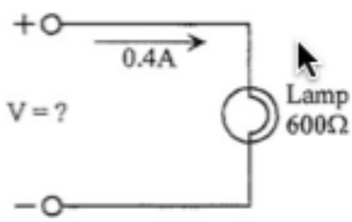


Figure 7

Example: 5.
Determine the lamp current in example 4 when the potential difference across the lamp terminals is -
a) 234 volts, and
b) 300 volts.

Lamp on 234V

Lamp on 300V

It will be shown later that the resistance of an appliance remains fixed, except for changes due to variations of temperature.
Ira lamp current is normally 0.4A on a 240V supply, then a reduction of the voltage to 234V, as in example 5 (a), reduces the current to 0.39 ampere. This current reduction of 0.01A will not greatly affect the correct functioning of the lamp.
If the available voltage is too low, the current will decrease to such an extent that the lamp will not be incandescent. If the voltage applied to the lamp is too high, excessive current will pass through the lamp filament with the danger that the filament will become excessively hot and 'bum out'.

OHM'S LAW IN RELATION TO RESISTANCE

The last paragraph of the previous section is an explanation of why it is essential to limit the current in a lamp, or an appliance, to a particular value. If the applied voltage is known, it is then necessary to determine the resistance which will permit the desired current in the circuit.

v
The resistance of a circuit may be obtained from the equation, R=V/I as shown in the following example.

Example: 6

Determine the resistance of a heater element required to carry a current of 3 amperes when connected to a 240-volt supply.

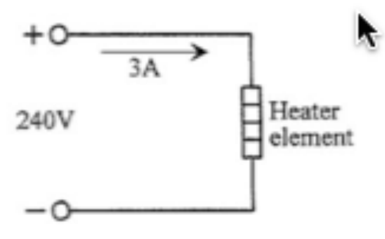


Figure 7

CONDUCTANCE

It has been shown previously, that the ohm is the unit of electric resistance. Resistance, of course, is a measure of the opposition to the flow of current in a conductor.
Frequently, however, it is convenient to operate with the concept of conductance, the opposite concept to that of resistance. The definition for conductance is as foUows **-**

'Electric *conductance is a measure* ***of the capability of a conductor to conduct an*** *electric current:*

Since conductance is the opposite of resistance, it is logical that the unit of conductance was named the mho, which is simply ohm spelt backwards.

However, in the SI system, the recommended unit of conductance is the siemens (S).

Conductivity is expressed mathematically as the inverse of resistance and the following relationship exists between these two quantities:

where:
G = conductance in siemens (S)
R = resistance in ohms

Example: 7
What is the conductance of a 2000-ohm resistor?

Example: ***8***
What is the resistance of a resistor that has a conductance of 5S?

DETERMINATION OF RESISTANCE

The resistance of a circuit may be determined using a voltmeter, an ammeter and the application of Ohm's Law.
For example, to determine the resistance of a lamp an ammeter is used to measure the current taken by the lamp and a voltmeter to measure the voltage applied to the lamp. The two meter readings are then used in conjunction with Ohm's Law to calculate the resistance of the lamp.

Example: 9
Using measured values of voltage and current, determine the resistance of the lamp shown in figure 8.

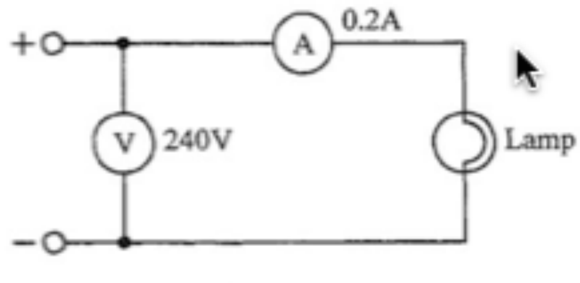


Figure 8

Example: 10
Calculate the resistance of the heating element shown in figure 9.

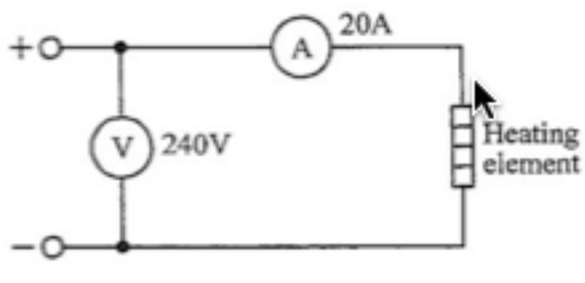


Figure 9

Practical for Ohm's Law

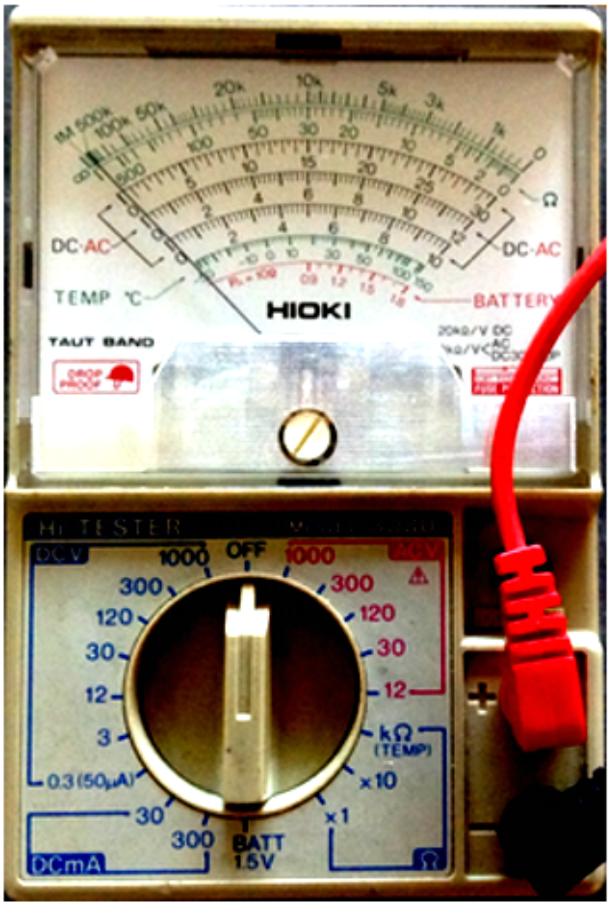
For this Practical you will be using an analogue multimeter as shown.
The meter has Positive side and Negative side on it's connections.
YOU MUST BE VERY CAREFUL WITH THE METER AS IT CAN BE EASILY DAMAGED.

LET YOUR TEACHER CHECK YOUR WIRING BEFORE APPLYING ANY POWER TO YOUR CIRCUIT.

At the end of this practical assignment the student will be able to:

- Connect electrical circuits using circuit diagrams as a guide.
- Adjust applied circuit voltage, measure and record values of circuit current. Draw the V-I characteristics for fixed resistors.
- Apply Ohm's Law to a practical circuit.
- Extract and interpret information from graphs.
- Observe correct circuit isolation procedures when working with electrical equipment.

Study the meter face and know what scale and range to use! Very important!



This is a multi-meter. It can do many different measurement functions. Volts, Amps, Ohms. Really versatile and not an old out-dated appliance, so please do not call it that. Every test item has it's place in electronics work.
Taut band suspension models such as this are quite expensive. Delicate and fragile, be careful with it.

At the very top of the meter is the Ohms range. It's non-linear and you do not need to worry about it for this Lab.

The next scales moving down the meter face are for DC and AC (volts and amps).

One scale goes from 0 to 30.

We plan to use the 300mA range on the meter, so all our readings, we need to add a 0 to the scale, or if you like, multiply it by a factor of 10.

If the needle is on the 20, it will be telling us that 200mA is flowing in the circuit.

Be sure to select the 300mA range!
Check with your teacher before switching on any power.

Now, what are we going to do?
We learned that current leaves the voltage source and travels through the individual components before it returns to the voltage source. A loop of current. A current loop in fact.

The voltage source can be a battery or it can be an electronically controlled and regulated variable voltage supply.

There are two channels.

This is a dual power supply.

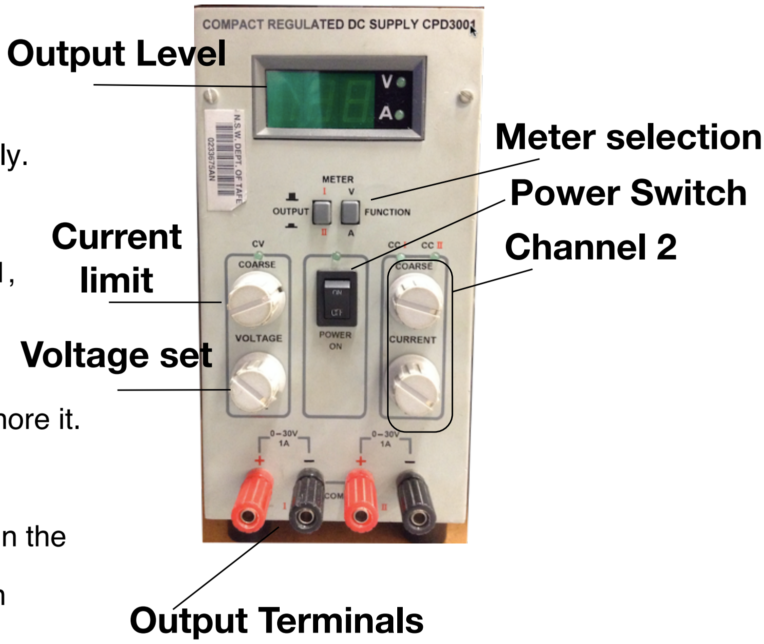
We plan to use the left channel only.

The current limit, set fully CW

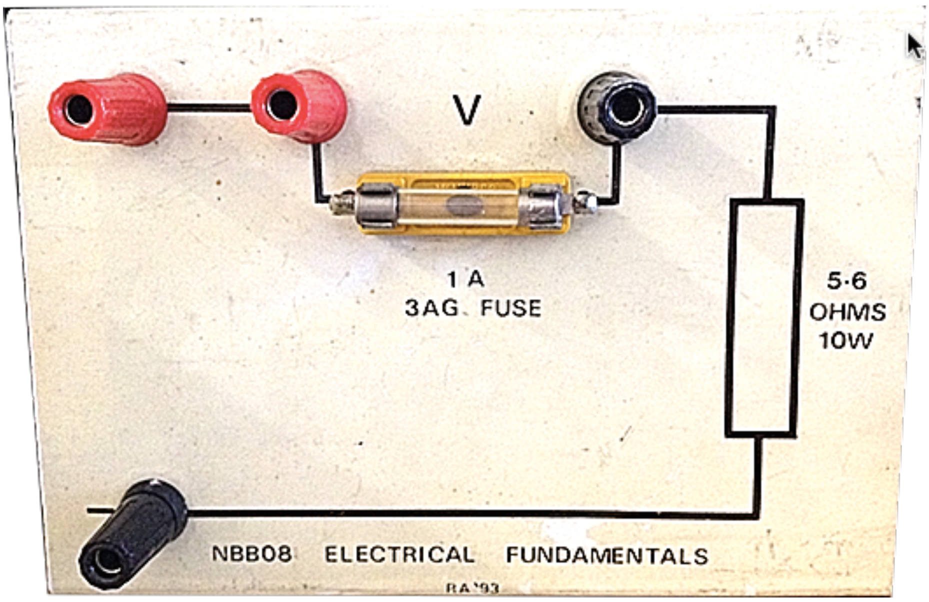
The meter switch, select channel 1, Voltage display.

Set the voltage to 15V

We are not using channel 2, so ignore it.



We learned about the safety fuse in the circuit.
The fuse we will be using is shown below.



Most all circuits involving higher current levels use a fuse such as this or some other form of current limiting.

Fuses prevent overheating of conductors and therefore prevent fires.

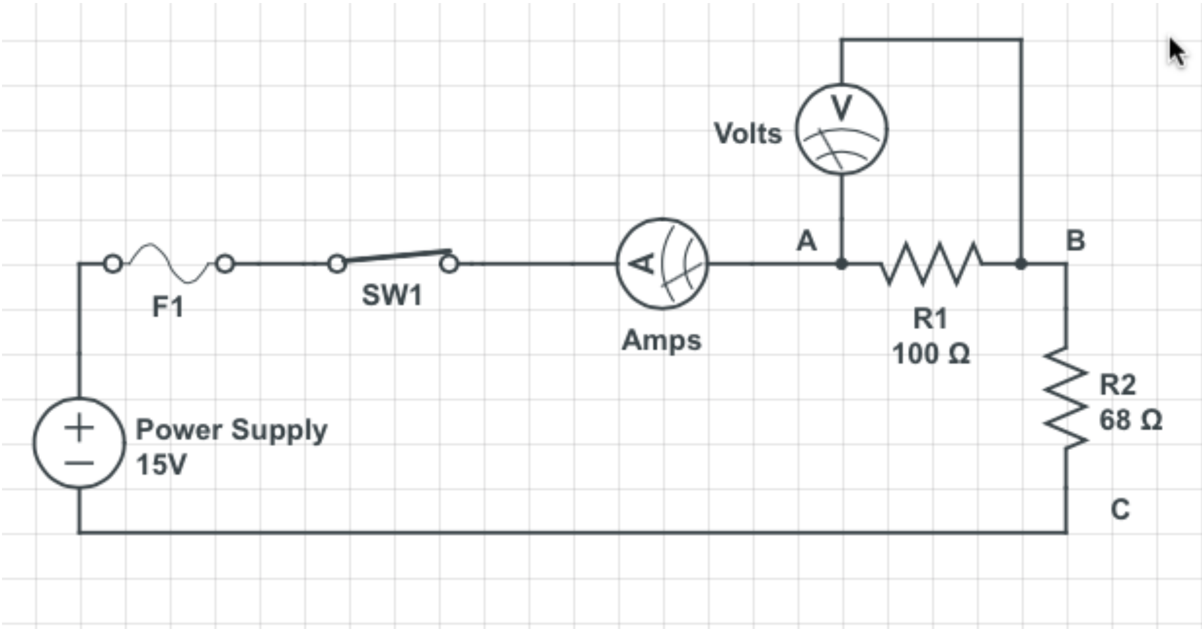
Fuses can prevent major failure of other components in the equipment also.

The fuse, you learned, always goes adjacent to the Voltage source.
By putting the fuse right at the voltage source we guarantee that if we accidentally drop a metal screwdriver etc into the circuit, the fuse will open and the current will stop flowing.
Use the top two terminals adjacent to the fuse.

OK, we now know about the Voltage source, the Fuse, the Multimeter. What comes next?

We need a schematic diagram, a wiring diagram, some resistors and some connecting wires.

Then we can do surgery !



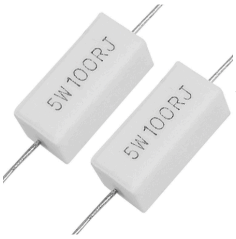
Here is our schematic diagram.

How about a wiring diagram?
Let's first look at the components in more detail.

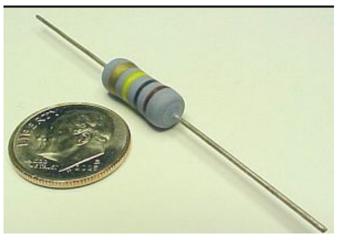
You recall we learned about the effects of electric current.

- Heat
- Light
- Physiological
- Chemical
- Magnetic

We must take care not to 'cook' our electrical components. We must choose resistors which are large enough to handle the heat!



Some resistors need to be large, some resistors can be smaller, even for the same value of Ohms in that resistor.
The fact is.. some dissipate heat better if they are bigger. The resistors to the left are 5 Watt rated. The resistors to the right are 2 Watt rated. We will learn how to calculate power in another lesson.



This is a component holder for our Lab. You will place a 100 Ohm resistor in one, and the 68 Ohm resistor in the other.

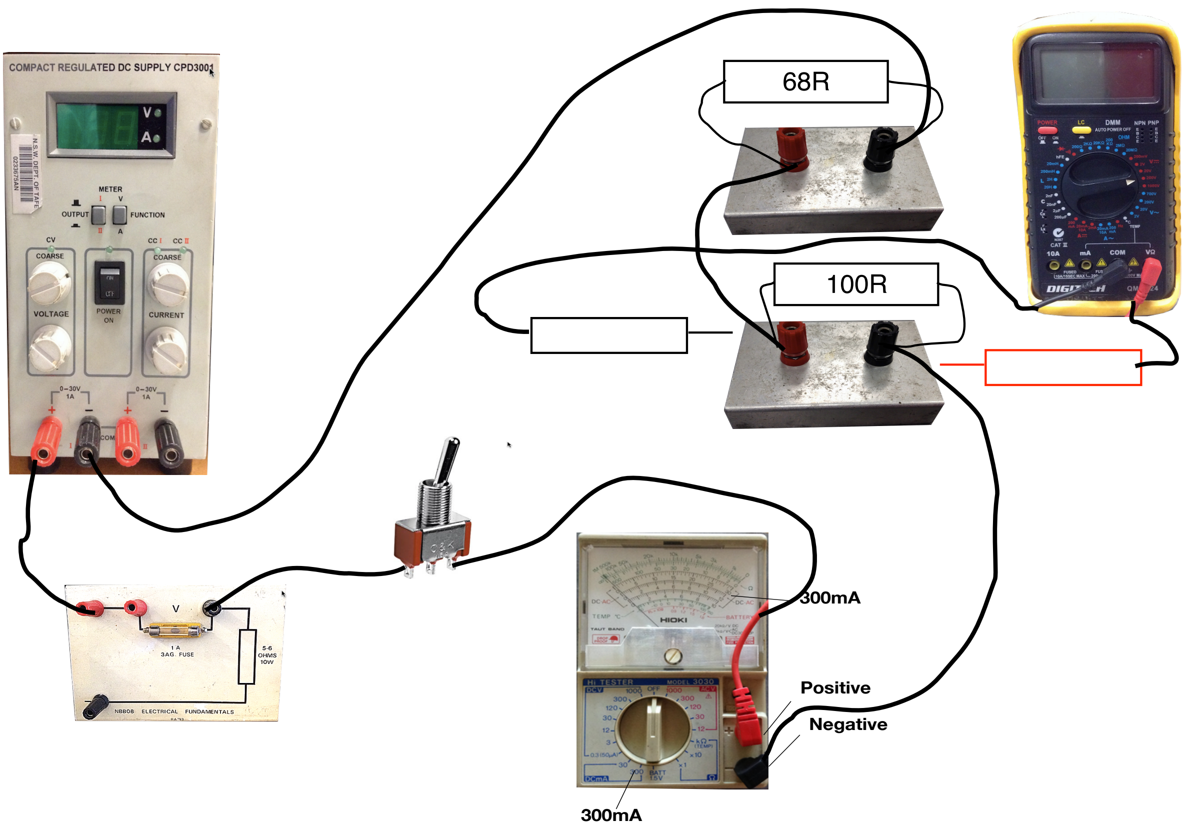
Here is our digital multimeter. We will use this for measuring voltage. Set the switch to point to DC 20 Volts (red scale next to switch)

We will hand hold the leads to measure the voltage across the resistors.

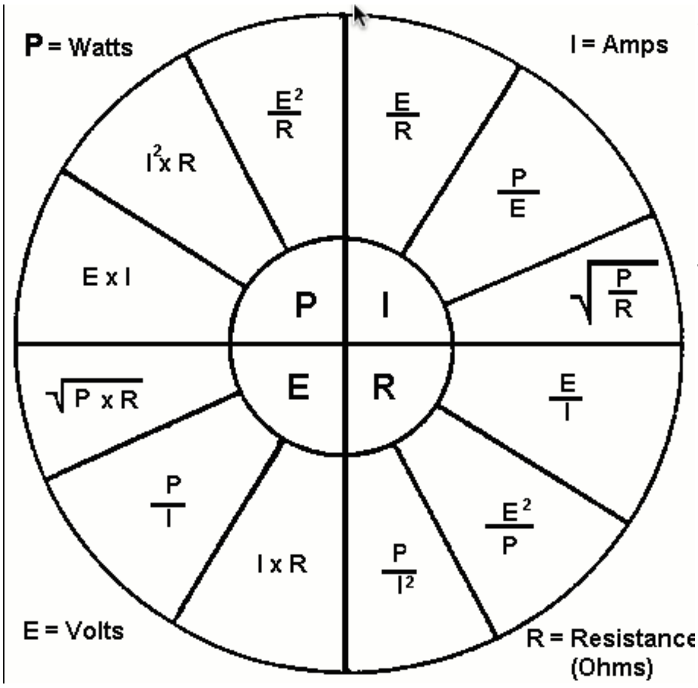
DMM, digital multimeter, is a robust device and easy to use and read, but in some ways it is not so versatile as the Analogue multimeter.
For one thing, it's slow to respond to directional changes in voltage and the user would be unaware what is happening in the circuit being tested.

Above is the switch. Single pole, single throw.
The switch always comes after the fuse.

Finally, here is our wiring diagram.



Here is a little helper for you:



With this Ohm's Law wheel, we can calculate all things we need to about our circuit.

For example.... how much current should be flowing in the circuit?

15 Volts and 168 Ohms.
therefore.. I=V/R (E is read as V here because Volts are the unit of EMF, E)

so.. do the calculation, 89mA.

Soon, we will be using all of the equations on this wheel.

Procedure

With the voltage to the power supply turned off, wire the circuit as it is drawn. Check against the schematic diagram for accuracy and comparison.

Call the teacher to check!

Then you may proceed after it's wired correctly.

Turn on the voltage and adjust to read 15 Volts on the power supply. The current meter should be measuring around 90mAmps.

Use the DMM on the 20 Volt DC range and measure the voltage across the 100 Ohm resistor.

Write the value here.

Use the appropriate Ohm's law from the wheel above and check if the voltage measured corresponds with the maths.

Move the DMM leads and measure the voltage across the 68 Ohm resistor.

Write the value here.

Check the maths... does it work? You know the current, you know the voltage.... what can you calculate?

Add the two voltages together.
100 Ohm Voltage plus the 68 Ohm Voltage....

Does this voltage add to equal the same as the power supply?

Why do you think that is so or not so?

If you reverse the leads on the DMM to each resistor, do you still read the same voltage? What happened?

Now increase the voltage from the DMM to read 20 Volts. The resistors will become warm, it's ok.

Voltage on the 100 Ohm now

Voltage on the 68 Ohm now

Did the voltage increase or decrease? Do the two voltages add to equal the power supply voltage?

We increased the Voltage and the Current and Voltages in the Circuit behaved in what way? Write down here what happened and form a law which you can deduct from this.

The new current at 20 Volts supply voltage was how much?

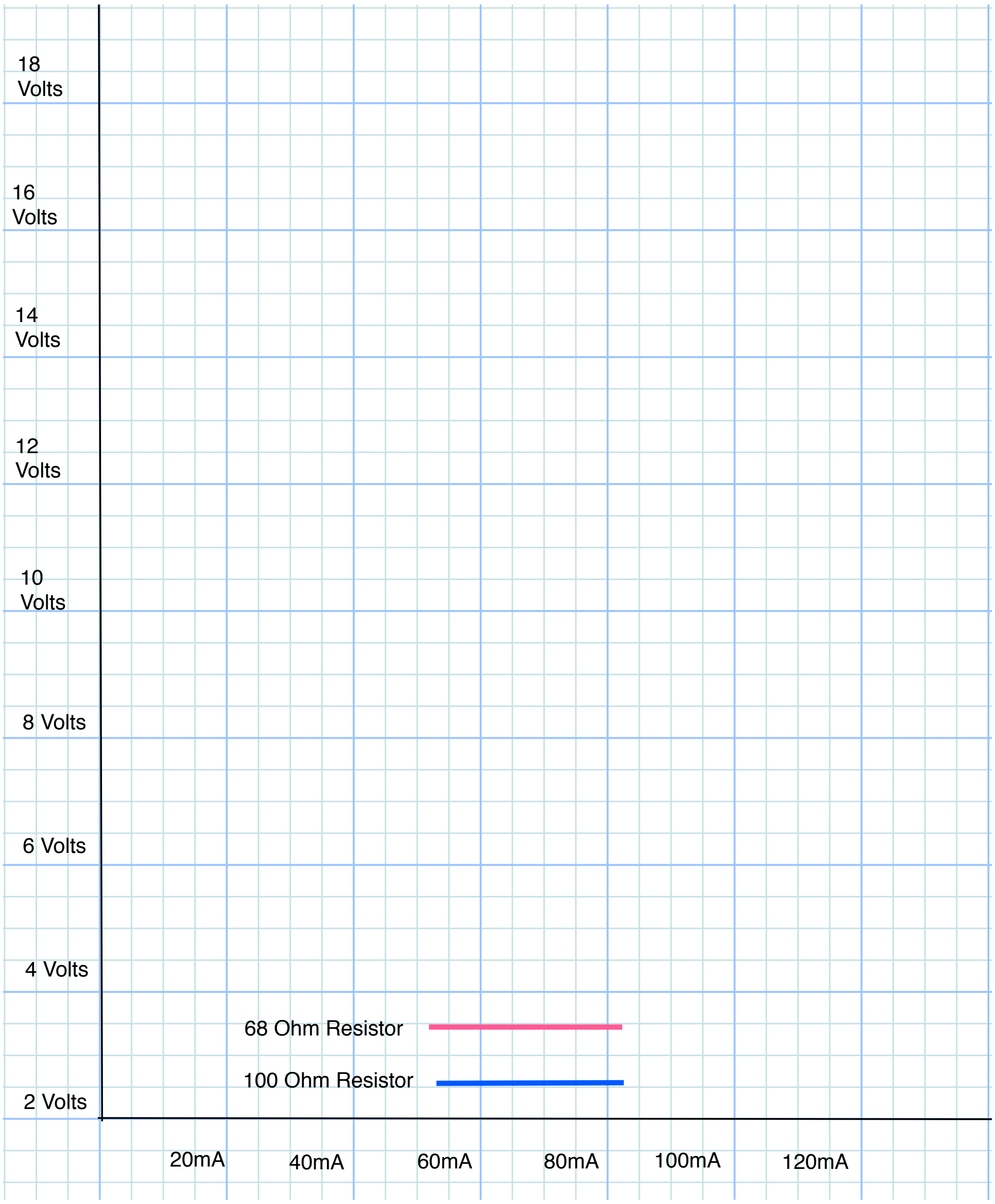
Do the maths from the Ohm's law wheel above. 168 Ohm's total resistance.

In fact there is a pattern going on here with the relationship between voltage, current and resistance. We will go on now to plot this in a graph.
Well, that's the plan anyway.

Do the required voltage changes to fill in the following table.

Change	Power Supply Voltage	Voltage 100 Ohm Resistor	notes	Voltage 68 Ohm Resistor
1	4			
2	6			
3	8			
4	10			
5	12			
6	14			
7	16			
8	18			

Now, you will complete the graph below. Plot for the two resistors, use different colours.



Now that you have completed the graph, are the two lines linear? Why?

Is there a relationship between current and voltage and resistance?

Is a Lamp resistance the same as a basic resistor?

We will replace the 68Ohm resistor with the 24 Volt lamp.

now, power the circuit but measure the voltage across the lamp at each point.

Change	Power Supply Voltage	Lamp Voltage
1	4	
2	6	
3	8	
4	10	
5	12	
6	14	
7	16	

Plot the values on your graph in another colour and label it.

Is the plot of resistor voltage linear?

What do you notice?

We will learn more about resistance in a later lesson. Lamp filaments have what is called a positive temperature coefficient. As the temperature increases, the resistance increases!