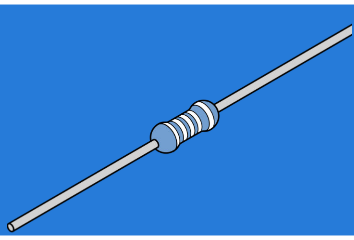
Ohm’s law



$$R = \frac{V}{I}$$

Apparatus

A Voltage and Current sensor 5 V - 0.1 A.
Resistor 22Ω .
2.5 V 0.3 A lamp.
3 V battery pack.
22Ω potentiometer.
Wires / 4 mm patch leads or Locktronics circuit kit.

For extension work.
LDR.
Thermistor e.g. an NTC disk thermistor 300Ω at 250˚C and 24Ω at 1,000˚C.

Data recording setup.

Use default settings.

Select start to record data, when complete select stop.

Ohm’s law describes the link between voltage, current and resistance in a conductor.

If we take a simple resistor and measure the current flowing through it as we change the voltage we find that the current through the resistor depends upon the applied voltage. When the voltage is changed the current also changes.

Describing this as a mathematical function gives us the equation.

$$R = \frac{V}{I}$$

R = resistance, V = voltage and I = current.

In this investigation you will be applying different voltages across one or more resistors and measuring both the voltage and current. The data will then be plotted as current vs. voltage to see what the relationship is between them.

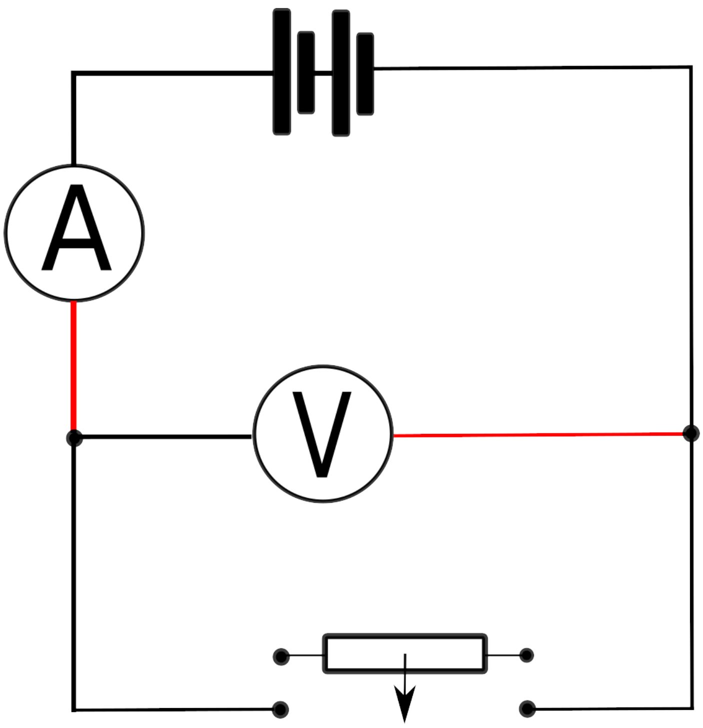
Use a circuit as shown in the diagram.

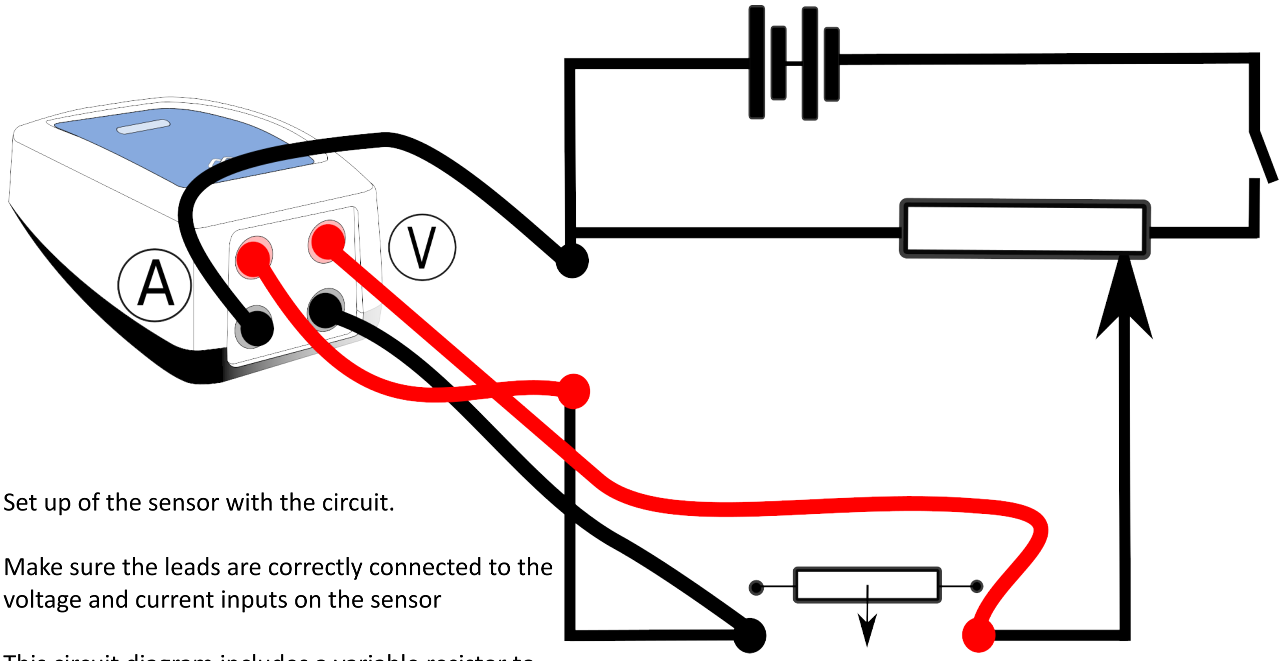
Current is measured in series in the circuit (after the component).

Voltage is measured across the component.

The circuit is designed to let you easily swap the resistor to be investigated.

To vary the voltage you will be supplied with a variable resistor or a variable voltage power supply.



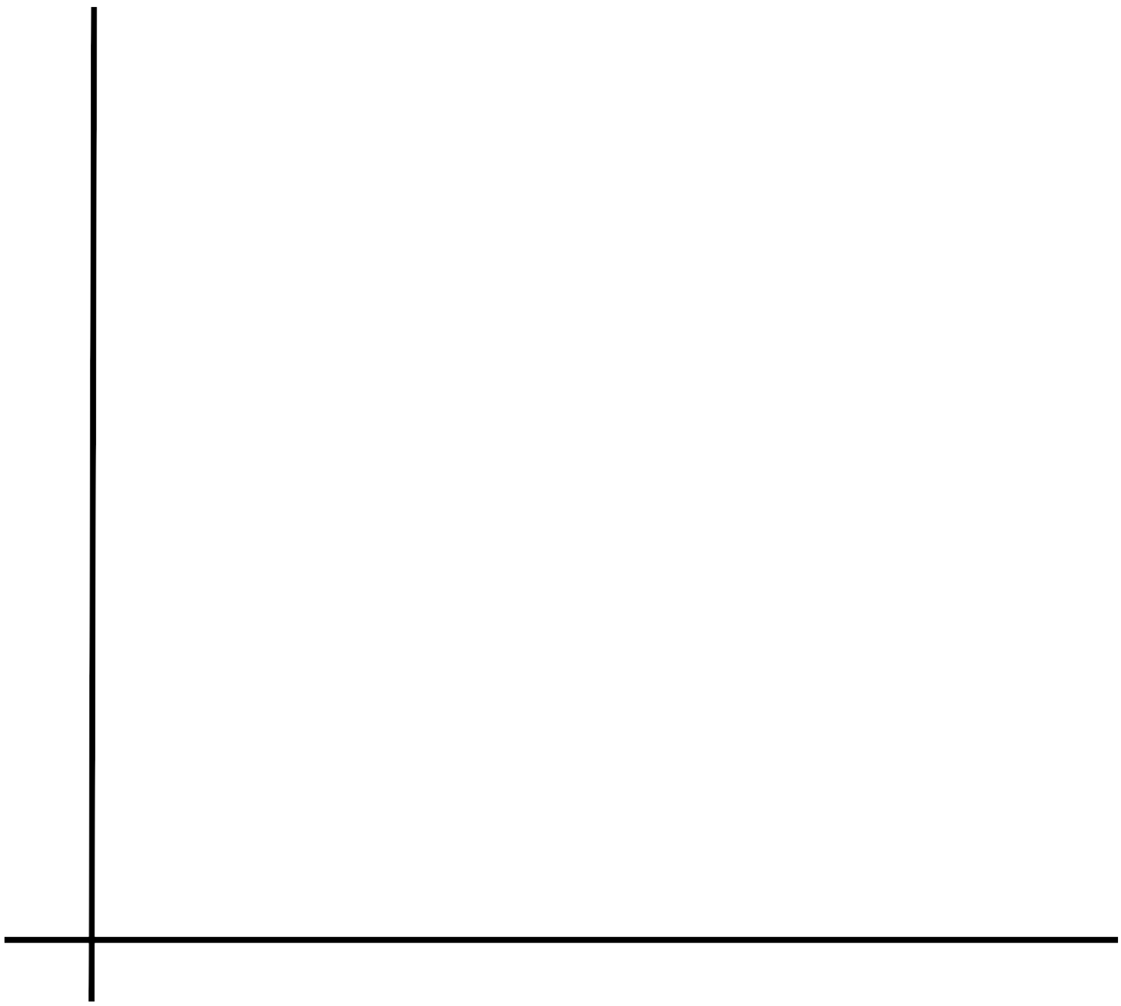


Set up of the sensor with the circuit.

Make sure the leads are correctly connected to the voltage and current inputs on the sensor

This circuit diagram includes a variable resistor to control the voltage

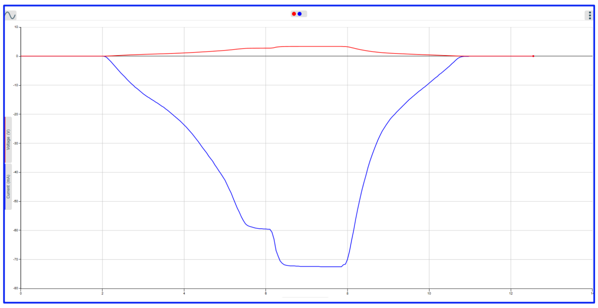
Place the component to be investigated in the gap in the circuit.



Use the axis above to sketch a graph to show how you expect current to change as the voltage increases

Method

1. Assemble the apparatus and make up the circuit as shown. Check that the leads are connected to the correct Voltage and current sensor sockets.
   - The voltage is measured across the resistor.
   - The current is measured in series after the resistor.
2. Open the software and connect the Voltage and Current sensor.
3. Select Start, and slowly increase the current and voltage values using the potentiometer (variable resistor) or voltage control on a variable power supply. Aim to get to the maximum value after about 15 seconds and then slowly reduce so that it is at zero before the end of the 30 seconds.
4. Click stop to end recording.
5. Change the axis to Min Max. Click on the axis labels to locate the setting.
6. Check the graph is showing both voltage and current rising and falling into the positive part of the graph. If any of the data is going negative swap the leads to correct.
7. If the curves are reasonably smooth, name the file and save it. If not repeat.

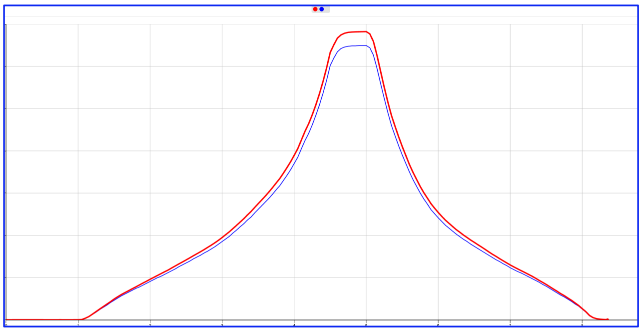


An example of data collected with the voltage leads correctly connected and the current leads wrongly connected

Results and analysis

To see the relationship between the voltage and current you need to create a sensor vs sensor graph.

- You will need the x - axis to be Voltage
- You will need the Y axis to be Current.
- Have both axis to show the data as Max - Min scale.

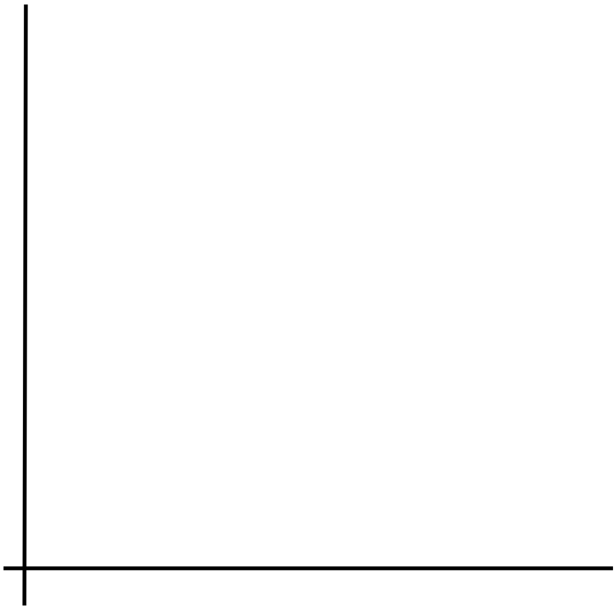


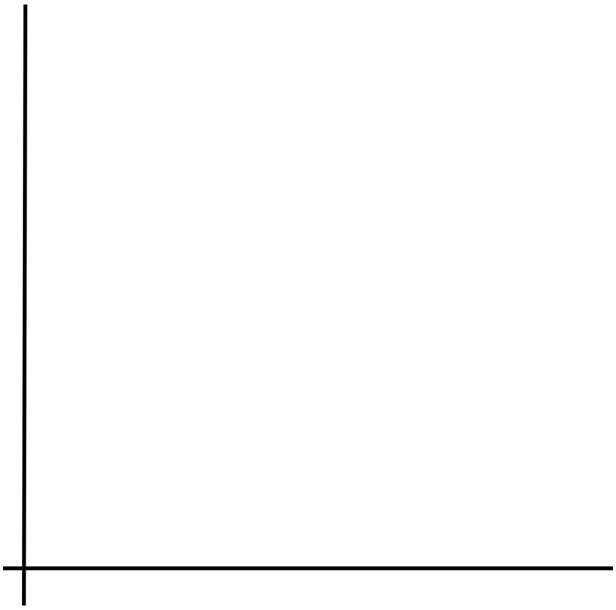
Data as collected. In this example the data was collected over 6 seconds. The resistor was 47 ohm and the supply voltage was from three 1.5 V dry cells. Max and min scaling has been applied.

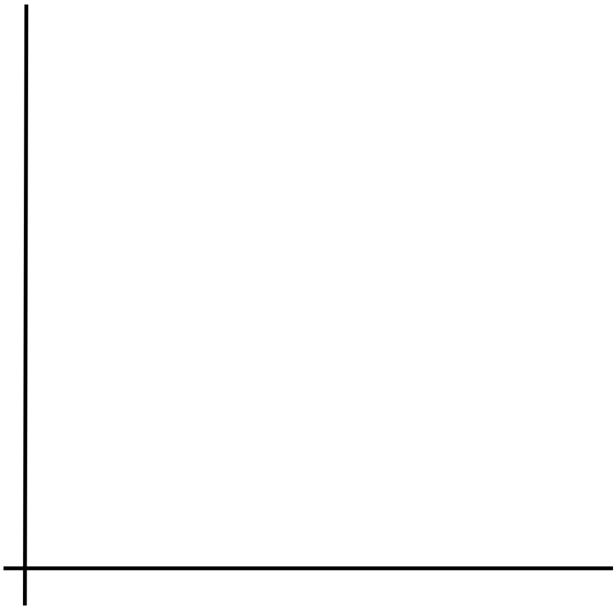
Why do you have Voltage as the x - axis?

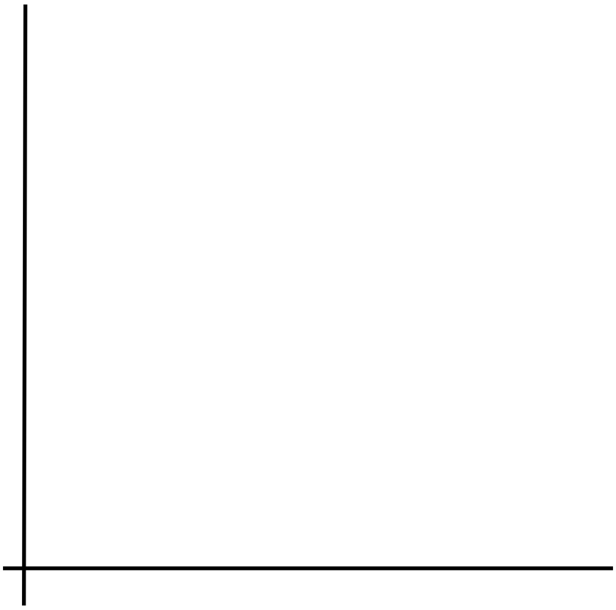
Hint: The x axis is always used for.....?

On the axis provided draw the V -I curves for each of the resistors you tested.









Create a rule that describes how the graph changes as the resistance changes.

Questions

The questions refer to the graph of Current vs. Voltage, which you generated above.

1. Describe in detail how the current changes as the voltage increases.

2. State the relationship between voltage and current for the resistor.

3. Refer to Ohm's law in the Learning Summary. Does your resistor obey Ohm's law?

4. Resistance is the ability of a material to oppose the flow of an electric current. It can be calculated using the equation:

$$R = \frac{V}{I}$$

Where:

R = resistance in ohms (Ω)

V = voltage in volts (V)

I = current in amps (A)

Calculate the resistance of your resistor for a medium value of the current. Show your workings.

5. Does the resistance vary as the current increases?
To answer this question you can use the Gradient function in the tools and sample several points on the V - I graph. The gradient is 1/R.

Then generate a resistance data set to get a graphical presentation of Resistance on your graph.

To produce a data set for Resistance.

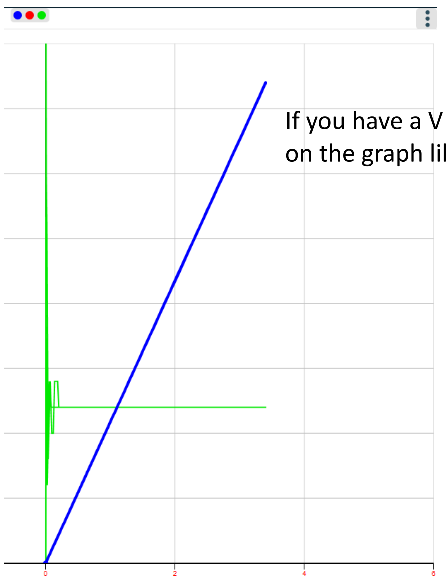
Click on calculate.

- Click on Add a new series.
- Name = resistance
- Number of decimals = 1
- Series unit = Ohms
- Formula = ax/by
- Value for a = 1
- Value for b = 0.001
- Series for x = Voltage
- Series for y = Current

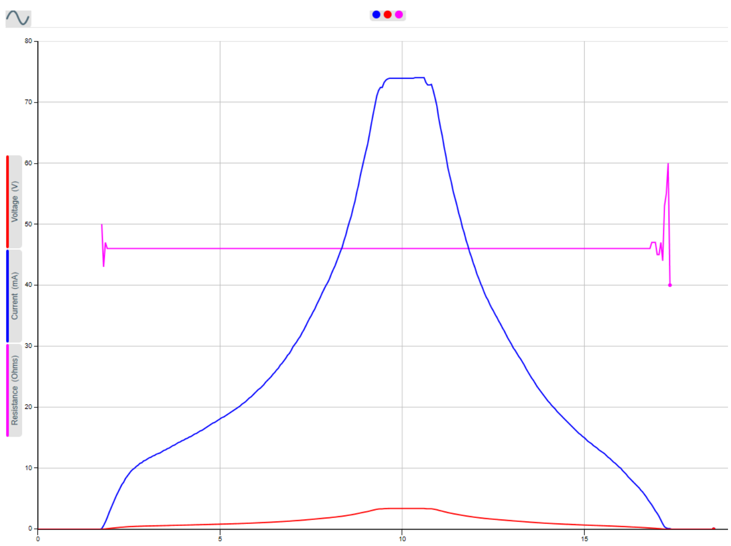
Why do we make the value for a =1?

Why do we make the value for b = 0.001?

Note: The x and y in the formula refer to mathematical variables not the graph axis.



If you have a V vs I graph your resistance will appear on the graph like this.



If you plotted your resistance series on the data as it was collected your graph will look like this.

Use the Values tool to find the resistance. Ignore the “squiggles” at either end, these are values calculated from where either current or voltage is zero

How do the calculations you did, the graph and the value on the resistor agree?

Learning summary

Ohm's law

From your results, you have learned the following.

- The graph of I vs. V was a straight line through the origin.
- Therefore, the voltage was directly proportional to the current.
- The resistance was independent of the voltage and current.

This resistor therefore obeyed Ohm's law which states: The current flowing in a resistor is directly proportional to the voltage across it, provided the temperature remains constant.

Extension activity

1. Repeat the procedure outlined in this experiment with a small lamp. It is advisable to allow time for the temperature of the filament to stabilise at each value of the voltage. Use **SnapShot** and increase the voltage in 0.2 V intervals from 0 V. Analyse the data as above.
    - Is the relationship between I and V, for the lamp filament, the same as for the resistor above?
    - What happens to the resistance as the current increases?
    - What happens to the temperature of the filament as the current increases?
2. Therefore, what happens to the resistance of the metal filament as the temperature increases?
3. Repeat the experiment for other types of resistor e.g. an LDR, a thermistor.

Rearrange $R = \frac{V}{I}$ to make V and I the subject of the equation.

Some research questions.

1. Who was Ohm?

2. When was Ohm's law established?

3. How is a resistor described if it follows Ohms law?

4. How do the colour bands on a resistor describe it's resistance?