PHYSICS cOuRsEwOrK

"Investigating the effect of 'length' on the resistance of a wire"

NAME :

Physics coursework

Investigating the effect of length on the 7

~PLAN~

For this investigation, I first decided to list all the factors which I think may affect the resistance of a wire and the reason for their importance. These factors are:

- **Material of the wire –** If the wire is a conductor, more electric current will flow therefore the resistance would decrease, copper is an example of a good conductor. Insulators do not allow the flow of electric current which means the resistance will be at its peak.
- **The length of the wire –** The longer the conductor, the further the electrons have to travel, the more likely they are to have collisions with metal ions and so the greater the resistance.
- **The temperature of the wire & surroundings –** As the temperature increases the metal ions vibrate more (kinetic theory) leading to more frequent collisions with the electrons and therefore provide greater resistance to the flow of electrons.

From the factors above, I chose the length of the wire to investigate.
I obtained most of my information from:

- "KEY SCIENCE *for GCSE* Physics" by Jim Breithaupt.
- "Collins Total Revision GCSE Science" by Chris Sunley & Mike Smith.
- "CGP GCSE Double Science Higher Physics" by Richard Parsons.
- "*Letts* AS Physics" by Graham Booth.
- Class work that I have done throughout my GCSE course.
- The internet (educational websites, e.g. www.gcsephysics.com & www.physlink.com). I also used "www.goodfellow.com".

I used the sources above to choose the suitable equipment needed for my investigation including the type (material) of wire and its appropriate diameter. I also used them to write about the background information or *scientific knowledge*.

Aim:

My aim is to investigate 'how the length of a wire will affect its resistance'.
I chose this because it is the most practical to carry out within the laboratory. Not a lot of equipment is needed and it can be controlled without complications as I would have to use one wire and just keep changing the length by connecting one end of the circuit to the wire at the length required. It will also produce reliable results where trends can be observed easily. Had I chosen any other variable, for example the diameter (or cross-sectional area) I would have had to use wires of different diameter, this can be very expensive and impractical. If I were investigating the affect of material then I would have had to keep changing the type of wire. The same applies to the temperature where I would have to change the temperature of the room which would be extremely difficult.

Useful Scientific Knowledge:

The electric current is the amount of charge flowing every second, that is the number of coulombs per second. Electric charge is measured in coulombs (**C**). Electric current is measured in amperes (**A**):

I = current (A)

$I = Q \div t$ Q = charge (C)

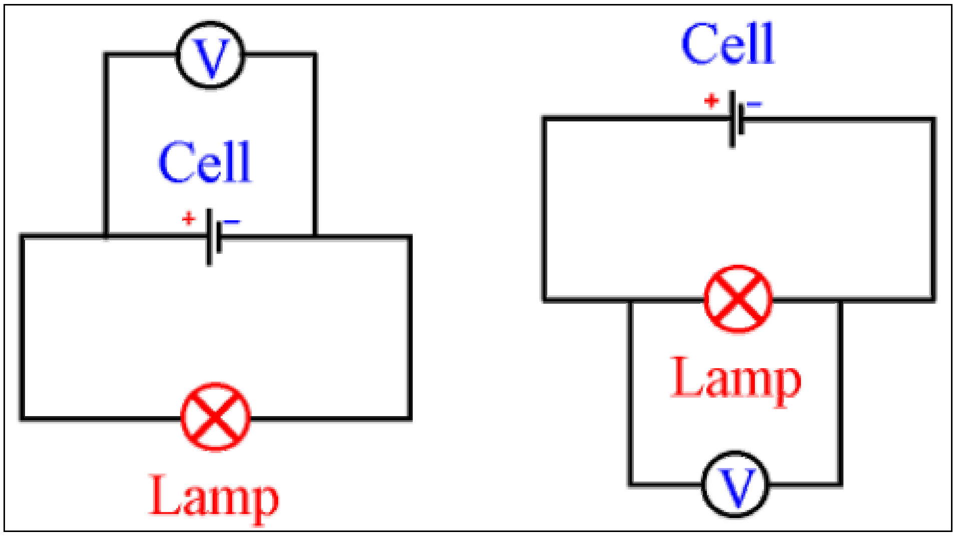
t = time (s)

The charge flowing round a circuit has some potential energy. For example, when the charge flows through a lamp it transfers some of its energy to the lamp. Voltage is a measure of the energy delivered by the electrons. The unit of voltage is the volt (**V**). Voltage is also defined as the amount of energy delivered by each coulomb of charge passing through it; this is sometimes called potential difference (or p.d). One volt of p.d is equal to one joule of energy per coulomb of charge. The term 'potential difference' is used for the voltage between two points in a circuit. If you increase the voltage then more current will flow.

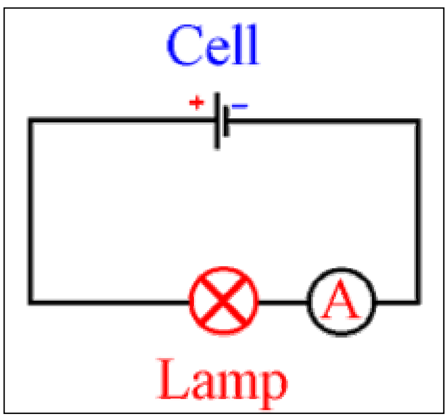
Voltage = joules per coulomb.

Current can only flow in a complete circuit. Two different kinds of circuit can be made. These circuits are called series and parallel circuits. The current is the same anywhere in series circuits as current has no choice of route. Current isn't used up but it does give up some of its energy to the components of a circuit (e.g. bulbs or motors). In series circuits the current is either ON or OFF, the switch open or any other break in the circuit will stop the current flowing everywhere. In parallel circuits the current has a choice. If say for example, a circuit has three routes then the current will have a "choice" and so it splits down routes 1, 2 and 3. On its way back to the battery the split up current joins up again. As opposed to series circuits, part of the parallel circuits can be ON while other bits are OFF.

Current is measured using an ammeter. An ammeter must always be connected in series to the circuit. Potential difference (or voltage) is measured using a voltmeter. Voltmeters are always connected in parallel to the circuit. Those two measuring meters are the substantial equipment needed for my investigation as I will need to know the voltage and the current when calculating the resistance of the wire. Two diagrams showing how voltmeters and ammeters are connected are on the next page.



⇧ DIAGRAM Nº.2 OF A VOLTMETER CONNECTED IN PARALLEL TO A CIRCUIT IN TWO DIFFERENT POSITIONS.



⇧ DIAGRAM Nº.3 OF AN AMMETER CONNECTED IN SERIES TO A CIRCUIT.

Resistance is a measure of the opposition to current. The greater the resistance of a wire, the smaller the current that passes for a given voltage. Resistance is defined and calculated using the formula:

Resistance = voltage ÷ current *or* $R = V \div I$

Ohm's law states that: *"The current through a metallic conductor is directly proportional to its voltage provided that temperature is kept constant".*
The unit of resistance is the ohm (Ω) and its symbol is 'R'. 1Ω means that 1V would be needed across the wire to drive 1A of current.

Substances which allow an electric current to flow through them are called conductors. Those which do not are called insulators. Metals behave as conductors because of their structure. In a metal structure the metal atoms release their outermost electrons to form an 'electron cloud' throughout the whole structure. In other words, the atoms in a metal exist as ions surrounded by an electron cloud. Some conductors are better than others.
For example, copper is a better conductor than iron. When the electrons are moving through the metal structure they bump or 'collide' into the metal ions and this causes resistance to the electron flow or current. In different conductors the ease of flow of the electrons is different and so the conductors have different resistance.

The amount of current flowing through a circuit can be controlled by changing the resistance of the circuit. This can be done with a resistor which is a component designed to have a specific resistance. Accurate resistors can be made from metal wires. A variable resistor is used in a circuit to change the current. For example, a variable resistor in series with a motor could be used to control the speed of the motor. A variable resistor consists of a conducting track of resistance material with a fixed contact at one end and a sliding contact on the track. Moving the contact along the track changes the length of material and also the resistance between the contacts.

The resistance of a uniform conductor depends on the length, the cross-sectional area and the type of material.

- The longer the length of a conductor, the greater its resistance.
- The narrower a conductor is, the greater its resistance.
- Metals conduct much better than non-metals. Copper is the best conductor.

So the resistance of a uniform conductor is
1. proportional to its length,
2. Inversely proportional to its area of cross-section.

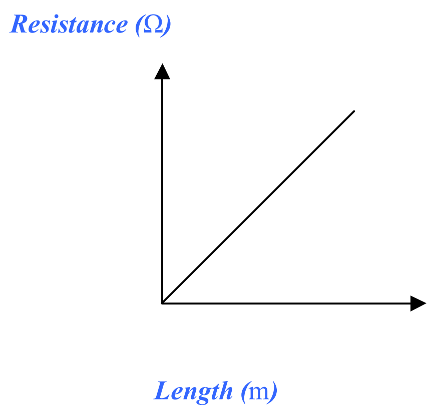
In other words, its **resistance** = $\dfrac{\textbf{constant (resistivity)} \times \textbf{length}}{\textbf{Area of cross-section}}$

The constant depends on the type of material and is referred to as the resistivity of the material. The unit of resistivity is the ohm metre (Ωm). The symbol for resistivity is the Greek letter ρ, pronounced 'rho'. If the resistivity of a material is known, the resistance of a given length of material of known area of cross-section can be calculated.

Prediction:

As shown by the behaviour of resistors, when the length of the conducting wire increases, the further the electrons have to travel and so the possibility of them having collisions with the metal ions is higher and so the greater the resistance.

Based on the scientific knowledge I have just mentioned I predict that as the length of the material or wire increases its resistance will also increase, so if the length is doubled then the resistance will also be doubled. Therefore the length of the wire is directly proportional to the resistance. I will be using Resistance-Length graphs to show my results, if a graph is plotted showing resistance against length then it should be like the sketch on the next page:



The formula which I will mainly be using in the investigation is the resistance equation:

$$\frac{\textbf{Voltage (V)}}{\textbf{Current (I)}} = \textbf{Resistance (R)} \text{ or } \textbf{V/I = R}$$

Preliminary Test:

I carried out a preliminary test (or a trial run) to see which type, diameter of wire and the input current is the best for my investigation to give me a suitable range of current values and so that the results are more reliable, so if there was to be problems then they would be solved before the real experiment. I also used this test to find out how to make this test fair and so that any mistakes will not be repeated in the real experiment.

In the preliminary test, I used two types of wire: The first was a copper wire and the second was a constantan. Being one of the best metal conductors, copper's resistance was very low. On the other hand the constantan wire gave a higher resistance. As I was investigating one of the factors affecting resistance I found the second wire, constantan, with a higher resistance more appropriate for my experiment. The results of this test were as follows:

Type of Wire	**Resistance (Ω)**
Thick copper	0.09
Medium copper	0.17
Thin copper	0.27
Thick steel	0.19
Medium steel	0.47
Thin steel	1.02
Thick constantan	1.94
Medium constantan	3.08
Thin constantan	6.29

I also tested different diameters of wires and finally I chose a constantan wire which had a diameter of 0.11mm (I used a micrometer to measure it and its accuracy was up to 2 d.p). The resistance was too high in wires which had a smaller cross-sectional area and so they would sometimes burn. The thicker wires were not giving me suitable readings nor were they giving a suitable range of results (the ammeters to be used do not go that high). I also tested different input voltages and I came to the conclusion that I should use two batteries of 1.5V each (3V total input voltage). More than 4.5V (three batteries) would make the wire too hot and at lengths below 30cm it would burn (which was what happened during the preliminary test).

Fair test (control variables):

- I will make sure that I use the same material of wire for the investigation, with the same cross-sectional area.
- I will ensure that the temperature stays the same throughout the experiment by allowing the wire to cool and not keeping the crocodile clips on the wire for too long. The room temperature will also be kept the same by conducting the experiment in the same room and by making sure the wire is not near any window where it could be in direct contact with the sunlight or wind.
- I will use the same batteries with the same voltage. (2×1.5V).
- I will make sure that the wire is taut and has no kinks at all to ensure that results are more accurate and that no short-circuiting will occur.

All of the variables above must be kept the same as they all will affect the resistance of the wire.

Independent variable

- The length of the wire, I will do this by changing the length of the wire using the crocodile clips.

Dependant variable

- The resistance of the wire. This is calculated by measuring voltage and current. This represents the effect of varying the length of a wire on resistance.

Reliability

Confidence in the truth of the results

I will repeat each reading twice to make sure results are **fair** and **true** and then take the average. Repetition would produce maximum reliability of results. If the second reading is similar to the first then the first confirms the second and vice-versa, if somehow two results are not similar then I will repeat it again until two results are similar, and these two results will be averaged.

Safety precautions:

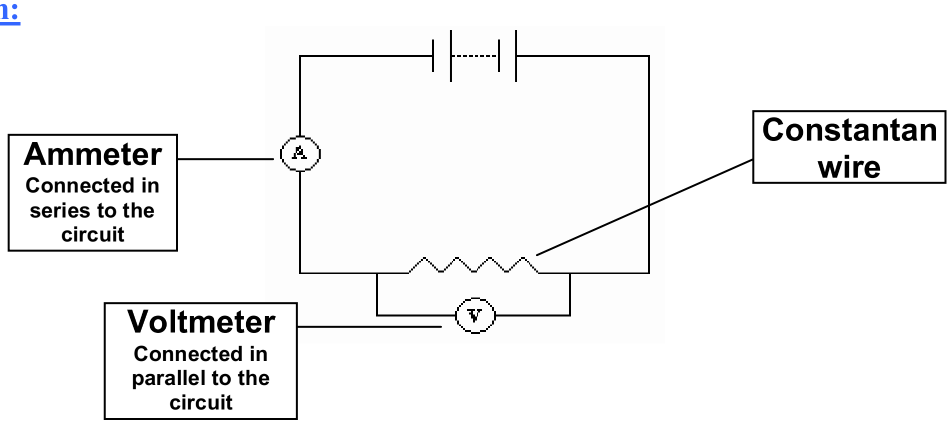
- I will **not** use more than two batteries of 1.5V each as the wire will heat up and could burn.
- I will **not** touch wire during the experiment because it might be hot and the electric charge will be flowing through it.

- I will disconnect the wire between each two readings so it does not overheat.
- I will have a minimum length of 10cm for the wire. Anything below this length would be likely to cause quick overheating of the wire.
- I will keep equipment away from edge of the table as it may fall on me or somebody else causing an injury.

Apparatus:

- Two (2) Batteries (each 1.5 V).
- Crocodile clips.
- Connecting Wires.
- A voltmeter.
- An ammeter.
- A wooden plank slightly longer than 1 metre.
- One metre ruler.
- A constantan wire which has a length of at least 1.15m and a diameter of 0.11mm.
- Two screws.
- Two nails.
- A micrometer.
- A calculator to calculate the resistance and the mean average for each length.

Diagram:



Planned Method:

The ruler will be put in the centre of the wooden plank and it would be nailed into it by two nails. After the ruler has been anchored on the plank of wood, two screws will be screwed into the wooden plank at either ends of the ruler, the screws will also be touching the ruler. The wire chosen for the experiment will be tied around the screws more than once, to ensure that the wire is taut and has no kinks to give better accuracy in the results. The voltmeter will obviously be connected around the wire in parallel to the circuit and the ammeter will be connected in series to the circuit. I will allow the wire to cool for 30 seconds between each two readings. I will use a micrometer to measure the diameter of the wire. I will be taking results every 10cm between the 10cm and 90cm, this range and the intervals were chosen as I found it most appropriate from my preliminary test.

1. I will set-up the equipment as shown in the diagram above.
2. I will start off by putting the crocodile clips on 10cm of the wire.
3. I will read and record (in a table) the readings of the ammeter for that particular length.
4. I will read and record (in the same table but a different column) the readings of the voltmeter for that particular length.
5. I will repeat the same again, but will move the crocodile clips 10cm (0.1m) up the wire.
6. I will keep adding 10 cm to the length and then reading and recording the results until the length is 90cm.
7. I will repeat all of this twice to obtain average results.
8. At the end I will calculate resistance by dividing the voltage by the current (**R=V/I**) and putting the answer in a third column for the resistance of that particular length.
9. I will finally average the resistance for each length. I will do this by adding the 1^{st} and 2^{nd} resistance calculations and then dividing total by two. So for the length of 50cm I will have two resistance calculations and a third which is an average of the two.

~Obtaining Evidence~

I set up the experiment using the equipment I mentioned in the planning section except that I also included a thermometer in the apparatus:

- Two (2) Batteries (each 1.5 V).
- Crocodile clips.
- Connecting Wires.
- An analogue voltmeter.
- An analogue ammeter.
- A wooden plank slightly longer than 1 metre.
- One metre ruler.
- A constantan wire which has a length of at least 1.15m and a diameter of 0.11mm.
- Two screws.
- Two nails.
- A micrometer (0-25mm).
- A calculator to calculate the resistance and the mean average for each length.
- Thermometer (accuracy of up to 1 d.p).

The teacher supervising provided me with the required wooden plank with the ruler nailed onto it and with screws either side touching the ruler. I used a micrometer, which has an accuracy of up to 2 d.p, to measure the diameter of the wire which was 0.11mm. The batteries I used were slightly weak as I decided measured their voltage by connecting the batteries to the voltmeter in a circuit and the reading gave me 2.90V. I found out before starting the experiment, using a thermometer, that the room temperature at the time was '23.3^{o}C'. I then carried out my planned method.

For each length, I connected one of the crocodile clips to the length required and gave the voltmeter and ammeter some time to level out and then recorded the readings in a table similar to the one below for the current and voltmeter, I then let the wire cool down by disconnecting the crocodile clip for about half a minute during the time I calculated the resistance for the required length by dividing the voltage by the current.

I also made sure that I carried out the experiment in a safe way and abiding by the safety precautions mentioned in the planning phase.

The Results are on the next page…

The Results:

The first set of results is shown in the table below:

Constantan wire (diameter of 0.11mm)

Temperature of room: 23.3°C

TABLE Nº1

Length of Wire (cm)	Voltage (V)	Current (A)	Resistance (Ω) – rounded up to 2 d.p R=V/I
10.0	1.60	0.35	**4.57**
20.0	2.00	0.22	**9.09**
30.0	2.20	015	**14.67**
40.0	2.30	0.13	**17.69**
50.0	2.40	0.10	**24.00**
60.0	2.50	0.09	**27.78**
70.0	2.55	0.08	**31.88**
80.0	2.59	0.06	**43.17**
90.0	2.60	0.06	**43.33**

The second set of results is shown in the table below:

TABLE Nº2

Length of Wire (cm)	Voltage (V)	Current (A)	Resistance (Ω) – rounded up to 2 d.p R=V/I
10.0	1.70	0.35	**4.86**
20.0	2.00	0.22	**9.09**
30.0	2.25	0.17	**13.24**
40.0	2.30	0.14	**16.43**
50.0	2.45	0.10	**24.50**
60.0	2.50	0.08	**31.25**
70.0	2.55	0.08	**31.88**
80.0	2.60	0.07	**37.14**
90.0	2.75	0.06	**45.84**

Mean Average Resistance Calculations:

For 10cm length: 4.57 + 4.86 = 9.43 ÷2= 4.715 rounded up to 2 d.p→ **4.72 Ω**
For 20cm length: 9.09 + 9.09 = 18.18÷2= 9.09 rounded up to 2 d.p→ **9.09 Ω**
For 30cm length: 14.67+13.24= 27.91÷2= 13.955 rounded up to 2 d.p→ **13.96Ω**
For 40cm length: 17.69+16.43= 34.12÷2= 17.06 rounded up to 2 d.p→ **17.06Ω**
For 50cm length: 24.00+24.50= 48.50÷2= 24.25 rounded up to 2 d.p→ **24.25Ω**
For 60cm length: 27.78+31.25= 59.03÷2= 29.515 rounded up to 2 d.p→ **29.52Ω**
For 70cm length: 31.88+31.88= 63.76÷2= 31.88 rounded up to 2 d.p→ **31.88Ω**
For 80cm length: 43.17+37.14= 80.31÷2= 40.155 rounded up to 2 d.p→ **40.16Ω**
For 90cm length: 43.33+45.84= 89.17÷2= 44.585 rounded up to 2 d.p→ **44.59Ω**

The third set is the average of the two sets of resistance calculations above. The results are shown below:

TABLE N°3

Length of Wire (cm)	**Average Resistance (Ω)**
10.0	*4.72*
20.0	*9.09*
30.0	*13.96*
40.0	*17.20*
50.0	*24.30*
60.0	*29.52*
70.0	*31.88*
80.0	*40.16*
90.0	*44.59*

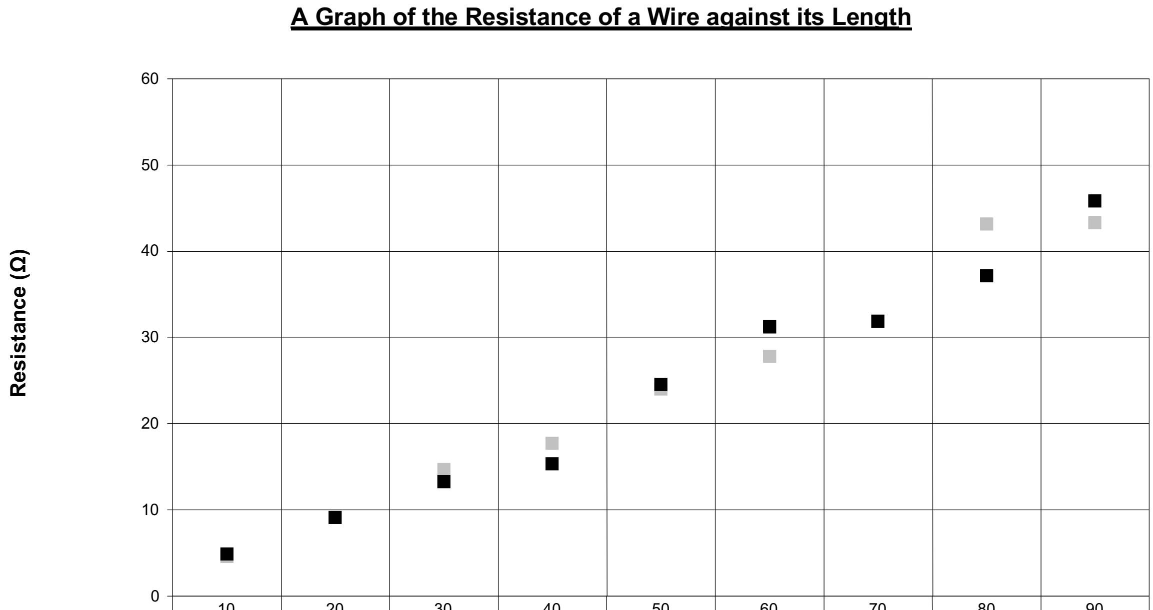
I calculated the cross-sectional area of the constantan wire which I used by firstly measuring its diameter using the micrometer mentioned before and then by using the formula below:

Cross-sectional area of wire = $\pi d^2/4$
So:
Cross-sectional area of wire = $\pi \times (0.11 \times 10^{-3})^2/4$
$= 9.5\times10^{-9} m^2$

As explained in my plan, if the resistivity of a material is known, the resistance of a given length and cross-sectional area can be calculated.

$$\text{Resistance} = \frac{\text{constant (resistivity)} \times \text{length}}{\text{Area of cross-section}}$$

~Analysing Evidence and Drawing Conclusions~

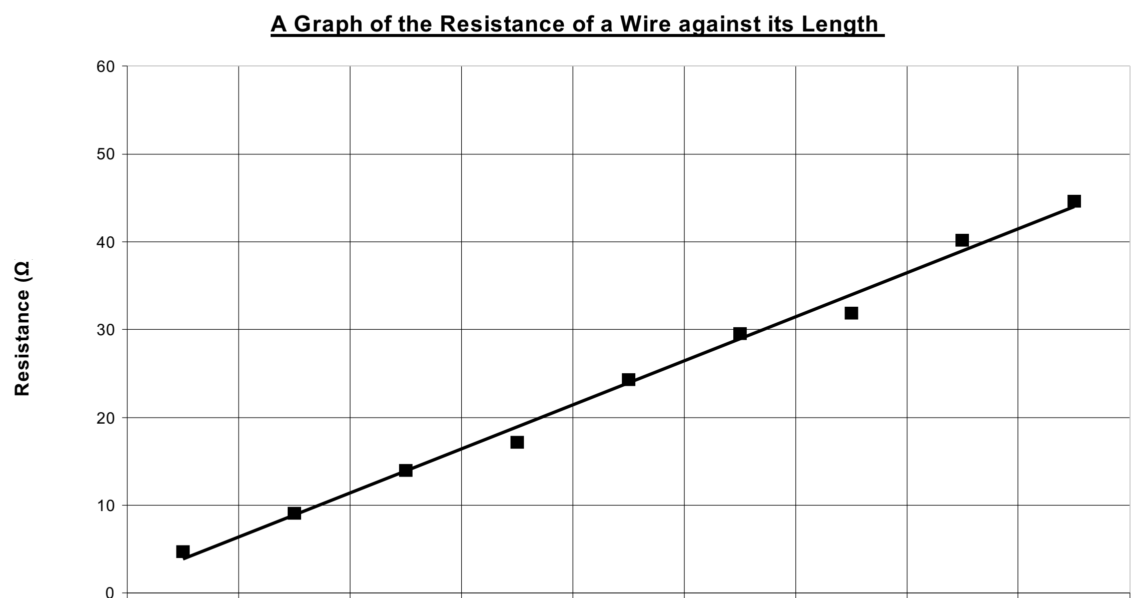


	10	20	30	40	50	60	70	80	90
1st readings	4.57	9.09	14.67	17.69	24.00	27.78	31.88	43.17	43.33
2nd readings	4.86	9.09	13.24	15.34	24.50	31.25	31.88	37.14	45.84

Length (cm)

1st readings ■ 2nd readings

⇧GRAPH №1: Graph of first and second readings…



	10	20	30	40	50	60	70	80	90
Resistance (Ω)	4.72	9.09	13.96	17.20	24.30	29.52	31.88	40.16	44.59

Length (cm)

⇧GRAPH №2: Graph of average results…

From the graph above, I can conclude that increasing the length of a wire increases its resistance. This is clearly shown where the line is straight and has a fixed gradient.

As I plotted resistance against length in my graph N^{o}2, and we know that gradient can be obtained by calculating the change in the *y*-axis divided by the change in *x*-axis. Resistance is on the *y*-axis and the length is on the *x*-axis therefore the gradient of the line of best fit is:

$$\frac{\Delta \text{Resistance}}{\Delta \text{Length}} \text{ or } \Delta R/\Delta L$$

So **Gradient** $= \dfrac{(44.59 - 4.72)}{(0.9-0.1)}$

Gradient = 54.84 Ω/m

If we re-arrange the resistivity formula we will see that:

$$\frac{\text{Resistance}}{\text{Length}} = \frac{\text{Resistivity}}{\text{Cross-sectional area}}$$

Anomalous Results From The Graph Of Average Results:

From my results, I can prove the uncertainty by making use of the resistance formula.

$$\text{Resistance} = \frac{\text{constant (resistivity)} \times \text{length}}{\text{Area of cross-section}}$$

If we re-arrange the formula above then we can also calculate the resistivity if we know the resistance:

$$\text{Resistivity} = \frac{\text{resistance} \times \text{area of cross-section}}{\text{Length}}$$

$$\text{Resistivity} = \text{gradient} \times \text{area of cross-section}$$

$$\text{Resistivity} = 54.84 \times 9.5\times10^{-9}$$
$$= 5.21 \times 10^{-7}\ \Omega\text{m}$$

Resistivity and the area of cross-section are both constant for the wire used which is why the line has a fixed gradient. The length and the resistance increased in a steady fashion, we can therefore say that the resistance of the wire is directly proportional to its length. So if we double the length of the wire then the resistance will also be doubled. We can prove this by looking at graph N^{o}2 where the resistance of the length of 20cm is double that of 10cm, meaning that $R_2 = 2R_1$.

The following calculations also prove what I have just said:

The resistance at 10cm was 4.72Ω. If I then double the length, a resistance of $4.72 \times 2 = 9.44\Omega$ should be given. When I carried out the investigation 20cm gave me 9.09Ω, a small difference of 0.35Ω between the two.

If I multiplied the length of 10cm by 5 then the resistance should be $4.72 \times 5 = 23.60\Omega$, the average result from my experiment for 50cm was 24.30Ω, the difference between the two was 0.70Ω.

Despite the fact that there was a small error margin, the calculations above prove that: *"The resistance of a wire is directly proportional to its length, and if the length is multiplied by a certain number then the resistance will also be multiplied by that same number".* When we double the length, the number of atoms is also doubled resulting in doubling the number of collisions of electrons with metal atoms as well. This proves that my results support the prediction that I have made in the planning section.

In graph N^{o}2 most of the points lie on the line of best fit which means that my results were considerably accurate. From the tables 1 & 2 in the obtaining evidence section we can clearly see that on both of my readings the results for the voltage and the current were very similar and sometimes identical, this is another proof of the reliability of my results.

As the length increased, the voltage increased but the current decreased meaning that the readings of voltage were not proportional to the readings of current. Therefore Ohm's law does not apply for this wire (*see plan section*-ohm's law). An increase in resistance causes a decrease in current which is why the current decreased as the length increased. The voltage is the energy change (or potential difference) between the beginning and the end of wire, so the voltage increased with a decrease in current because as the length of the wire increases, more volts will be lost.

~Evaluating Evidence~

I came to the conclusion after carrying out the experiment, recording the results in table and then drawing graphs, that resistance I directly proportional to the length of the wire meaning that an increase in length would consequently lead to an increase in resistance. As most of the points in graph N^{o}2 lie on the line of best fit, my experiment was accurate enough to prove the prediction I had made earlier in the planning section. Despite this level of accuracy, my experiment could have been more accurate, this is evident as not all the points lie on the line of best fit.

Anomalous Results:

I found out using my secondary sources that the standard resistivity of a constantan wire of a diameter of 0.11mm is $\mathbf{5.2\times10^{-7}\Omega m}$. A very small difference between this figure and the result from my calculations in the analysis section ($\mathbf{5.21\times10^{-7}\Omega m}$). However, the results do follow a general trend which means that they are all affected by the same factors and the uncertainty is constant through out.

After drawing graph N^{o}2, I found that I had a few anomalous results. In graph N^{o}1 the points were in a tight boundary, nevertheless they were still scattered. The certain degree of accuracy of my results is proved by this strong correlation. In the second graph a few of the points were slightly off the line of best fit. Also from the table below, it is evident that the experiment was not conducted in a complete degree of accuracy.

I discovered after drawing graph N^{o}2 that a few of the points were slightly off the line of best fit. This can be explained as follows:

- By measuring the voltage of both of the batteries used, I found out that their total voltage was 2.90V, this could be due to the internal resistance of the cell, or because the batteries were either used before I used them. This value decreased as I carried out my experiment, as I mentioned earlier, the problem can be overcome by using a power supply.
- The crocodile clips may not have been placed on the exact point for the length required. The length could have been greater or less than the required length, giving a higher or lower resistance.
- Analogue voltmeters and ammeters do not give a high degree of accuracy due to manmade reading errors. I could have used more accurate or better equipment to record my results, in this case a digital voltmeter and ammeter, they will give readings accurate up to 2d.p.
- The ammeter and the voltmeter were probably not placed exactly at the zero mark prior to the experiment.
- The resistance would have been caused to be greater due to small kinks in the wire which I did not notice.

During the experiment, temperature of the surroundings could not be kept constant, this factor affects the results greatly, as the temperature increases the metal ions vibrate more leading to more frequent collisions with the electrons and therefore provide greater resistance to the flow of electrons. Also, if time was available, I should have allowed the wire more time to cool down between readings and to return to its original temperature (I gave the wire approximately only 30 seconds to cool between each reading).

Improvements:

Although the experiment I conducted was efficient to a certain degree, the calculations above suggest that my method needs some improvement so if I were to repeat it; I would make the following changes:

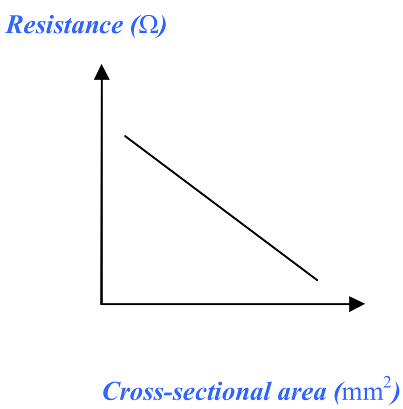
- To improve the accuracy I would use pointers rather than crocodile clips. This is because they are pointed at the ends to a particular spot, meaning that a reading for a particular length would be more accurate.
- Each battery, although it might be labelled as 1.5V, it may be much less or a little more than that. Therefore, a power supply would be able to provide the exact voltage, minimising error.
- I would use a digital voltmeter and ammeter as these would be more accurate than the analogue one, and the possibility of me reading the wrong value would also be lower.
- Again, to improve the accuracy I would repeat the readings three times.
- To see if the graph would still produce a straight line, I would use a longer length of wire (i.e. a wider range) such as 0-200cm.
- I would also take readings at every 5cm.
- To make sure that the wire has returned to its original temperature, I would leave a five minute gap between each two readings.
- In order to control the temperature of the surroundings and keep it at a constant level and if I was able to I would conduct the experiment in a thermostatically controlled room.

My results would have been much more accurate if I had taken these factors into consideration, they would also be better if I make the appropriate improvements.

Further investigation:

To extend the work that I have done, I would like to investigate the effect of varying the cross-sectional area of a wire on resistance. I can do this by using wires of different diameters but of the same material. My original method (with the improvements above) would remain the same but without changing the length.

The greater the cross-sectional area of the conductor, the more electrons available to carry the charge along the conductor's length and due to more free space the collisions will be reduced and so the resistance is lower. I predict that the cross-sectional area would be inversely proportional to the resistance, so if I double the cross-sectional area the resistance would half. I predict that the graph of cross sectional area against resistance would be like the sketch below:



Ten (10) different diameters of the same wire would be appropriate; I would record the three (3) sets of results in 3 different tables similar to the one below:

Cross-sectional area (mm^2)	**Voltage (V)**	**Current (A)**	**Resistance (Ω) R=V/I**
0.1	2	0.1	
0.2	2	0.11	
0.3	2	0.13	
0.4	2	0.17	
0.5	2		
0.6			
0.7			
0.8			
0.9			
1.0			

Finally I would calculate the resistance by adding the three different resistance calculations and the dividing by 3:
$R_1+R_2+R_3/3$=Average Resistance

I would lay out the average resistance results in a table similar to the one below:

Cross-sectional area (mm^2)	**Average Resistance (Ω)**
0.1	
0.2	
0.3	
0.4	
0.5	
0.6	
0.7	
0.8	
0.9	
1.0	