Aim –

The aim of this investigation is to find how the length of constantan wire affects the resistance in an electrical circuit

Introduction –

Resistance is a measurment of current in which a object has difficulty going thorugh, the unit it is measured in is ohms. The job of the resistance is to make it hard for the electros to move. The resistance of an object is comfirmed by the potential diffrence across the object. In metals atoms are found in the outer shell of the electrons the electrons are known as delocalised electrons. These electrons are free to manouver creating the metal to be a conductor, but when a potential difference (voltage) is applied it ables the electrons move. The larger the cross section of the object the more the electrons, thus the increase rate of current, so there will be a low amount of resistance. The longer the conductor the harder it is for the electrons to move due to more distance to cover, so the higher the resistance. But different materials have different affects to resistance, so therefore the material has a big affect.

The length of wire can affect resistance because if the wire is long the electrons in the conductor have to travel more distance and more frequent collisions will happen. Therefore the resistance is directly proportional to the length. So if you increase the length the resistance to will increase. If the wire is short there is less distance for the electrons to travel thus there will be a low resistance.

Width of wire can have dramatic affect towards resistance, which is because the width is inversely proportional to resistance; therefore if you increase the width the resistance will decrease. Because there will be more space for the electrons to move around this should therefore decrease the amount of collisions. But if the wire is thin the opposite reaction will happen, less space the increase rate of resistance.

Temperature has a big impact upon resistance whether the wire is hot or cold; if the wire is cold the atoms in the wire move around slowly, it also means the wire will have a low resistance. However if the wire gradually get hot this increases the movement inside the wire, causing more collision and it is likely the conductor will have a high resistance.

Lastly different materials can also have numerous affects to the resistance, some wires are good conductors some are bad conductors. Different materials have different amount of electrons in the outer shells this will affect the wire because it the electrons are free to move around the resistance will be low. But if the electrons are jam packed the resistance will be high.

I have analysed that there are four factors which can affect resistance length, width, temperature and material of the conductor have difftent affects towards resistance. In the experiment I will be test out the relation between the length of constantan wire and how it affects resistance.

Ohms law is relevant to resistance as it states that a current going thorugh a conductor (wire) at a constant temperature is proportional to the the potential diffrence (voltage).

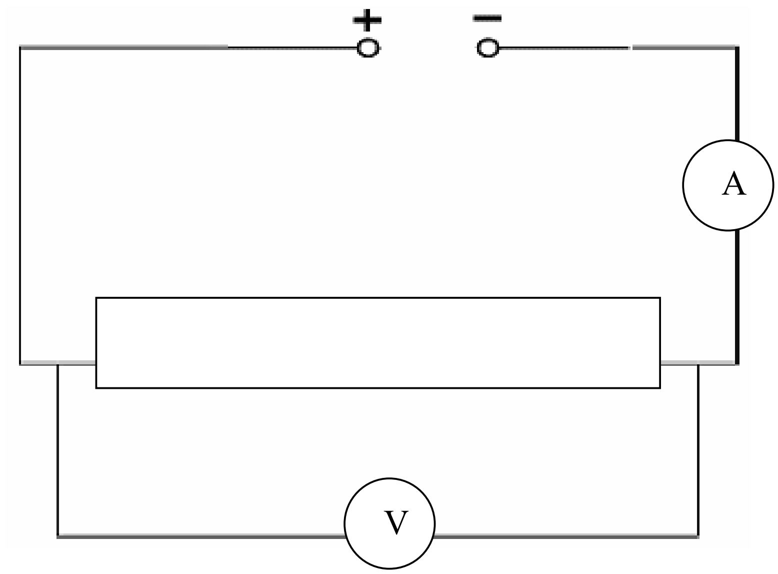
Therfore if you take that into account it means that the resistance of a conductor is constant if the the temperature reamains also constant. If the resistance of a conductor such as a wire increases the temperature also increases. This is due to high temperature making the particles of the conductor move around more quickly increasig the chance of a collison. This is known as the collision theory, particles spread through out the conductor when the particles and the reactant meet they connect causing a collison this happens more frequently if the rate of reaction increases.

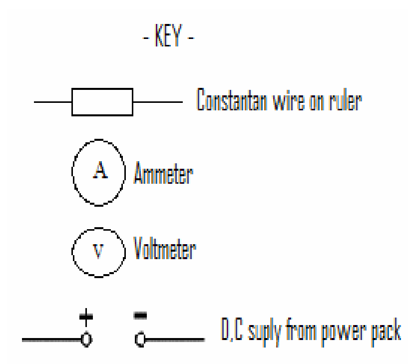
I am going to calculate the resistance of constantan wire in which I will Resistance is can be calculated by using R= V/I where R is resistance, V is voltage and I is current.

<u>Apparatus –</u>

In this experiment the following equipment was used:

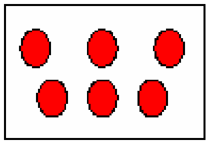
- Ammeter (A)
- Voltmeter (Volts)
- Power Pack
- Constantan wire
- 100 cm ruler
- Wires (to connect circuit)
- Crocodile clips





Hypothesis –

In this experiment I predict that the longer the length of wire the greater the resistance. This happens because the positive ions in the constantan wire have no space to move around and the wire is long so it takes time for the electron to manoeuvre. But if the wire is shorter it will have less resistance and space hence allowing the electrons to travel around easily in less time.

 [2]

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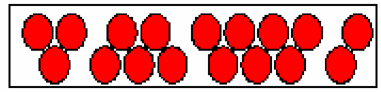


Resistance is when it makes it more difficult for electrons to get round a circuit, but the greater the resistance the more voltage needed to push the current through the wire, resistance happens when:

- Metals are made up of positively charged ions, and free electrons Voltmeter
- when a current flows, the electrons starts to move
- Sometimes they get slowed down when they bump into big positive ions.
- This is called Resistance.

Resistance can be calculated by the following formula:

Resistance, R= <u>p.d across the wire (V)</u>

Current through the wire (I)

The ohms law is relationships among voltage, current, and resistance as follows:

The current in a circuit is directly proportional t o the applied voltage and inversely proportional to the resistance of the circuit.

[2]Short thick wires have less resistance and more space so it is easier for electrons and positive ions to move around.

[1]Longer thin have higher resistance and less space so it is harder for electrons and positive ions to move around.

<u>Plan-</u>

What do I keep the same?

To insure a fair test in the practical I kept the voltage on the power pack the same which was five volts. I did this because I do not want to see the relation between voltage and resistance but I want the relation between the length of wire and resistance. Taking that into account I used the same wire through out the experiment to show that if the temperature increases as to will the resistance.

What did I change?

In the experiment I had to show the resistance increases once you increase the size of length in the wire. I had to change the distance in the length of the wire every 10cm to keep the experiment fair until I got my 100cm reading. If the distance increases not only does the resistance increase but so does voltage, however the current decreases during the practical.

Safety precautions –

- Switch off the circuit when changing the wire
- Remove any unnecessary equipment from the table e.g. bags, books etc
- Do not touch the wire whilst the power pack is on
- Once you off the power pack wait for the wire to cool down before changing the length
- Make sure the plug is plugged in properly and there is no loose wires around

- Do not carry out the experiment whilst next to water as you can get electrocuted
- Make sure you do the experiment in a wide space so you are not clogged up
- Most importantly do not increase the voltage of the power pack excessively as the wire will and your safety is in harm

How did I ensure a fair test?

To ensure the experiment was fair I decided to have the same length of wire 100cm. I also kept the same amount of voltage entering the circuit which was five volts in the power pack. When moving the crocodile clip every 10cm after getting the ammeter and voltage reading I switched off the power pack so the wire does not get burnt. This gives us sufficient amount of time change the distance.

<u>Method –</u>

1. Collect apparatus: a voltmeter, an ammeter, connection wires, crocodile clips, 100cm ruler, a piece of constantan and a power pack
2. Set apparatus up experiment
3. Set the power pack on 5 volts so the current does not burn the wire.
4. Place the 100 cm of constantan wire on top of the ruler and in between the two crocodile clips.
5. Turn on the power pack and record what the ammeter and voltmeter reads
6. Move the crocodile clip every 10cm on the constantan wire using the ruler as guidance until you have your 100^{th} cm reading
7. Repeat the experiment seven times

8. Work out the resistance for all the results using $R = \frac{V}{I}$ formula
9. Calculate average resistance
10. Record your results on a graph.

Controlled variables –

- Voltage (power pack)
- Temperature (room temperature)
- Wire material

Dependent variable –

- Resistance
- Ammeter reading
- Voltmeter reading

Independent variable –

- Length of wire

Observations and measurements –

Overall the results went rather well most of the graphs have a strong correlation it shows that my prediction was correct, the longer the wire the greater the resistance. However if longer wires do no not have a high resistance the plots on the graph would have been everywhere and it would have been a negative correlation. I have taken notice in most the graphs that when results of the voltmeter increases the current in the ammeter decreases. This is because the increased resistance reduces the amount of current flowing in the circuit. The greater the resistance the greater the electrical push needed. I decided to do the experiment seven times this is because I wanted a good average result. If I repeated the experiment 1- 3 times there is a chance of the experiment being a fluke so by me doing the experiment seven times I reduce the possibility of any fluky results. I calculated my averages by adding all my voltmeter readings and ammeter readings and dividing the answer by how many times I done the experiments for each length, which so happened to be seven. For e.g. 1.95+ 1.96+1.99+2.03+2.10+2.14+2.72=answer/7 is for 10cm voltmeter reading. Once I done this I was able to do my ammeter reading before I calculated the average resistance for 10cm constantan wire. I also took notice that every time I repeated the experiment for all my voltmeter lengths the readings increased this shows that the temperature must have increased in the wire.

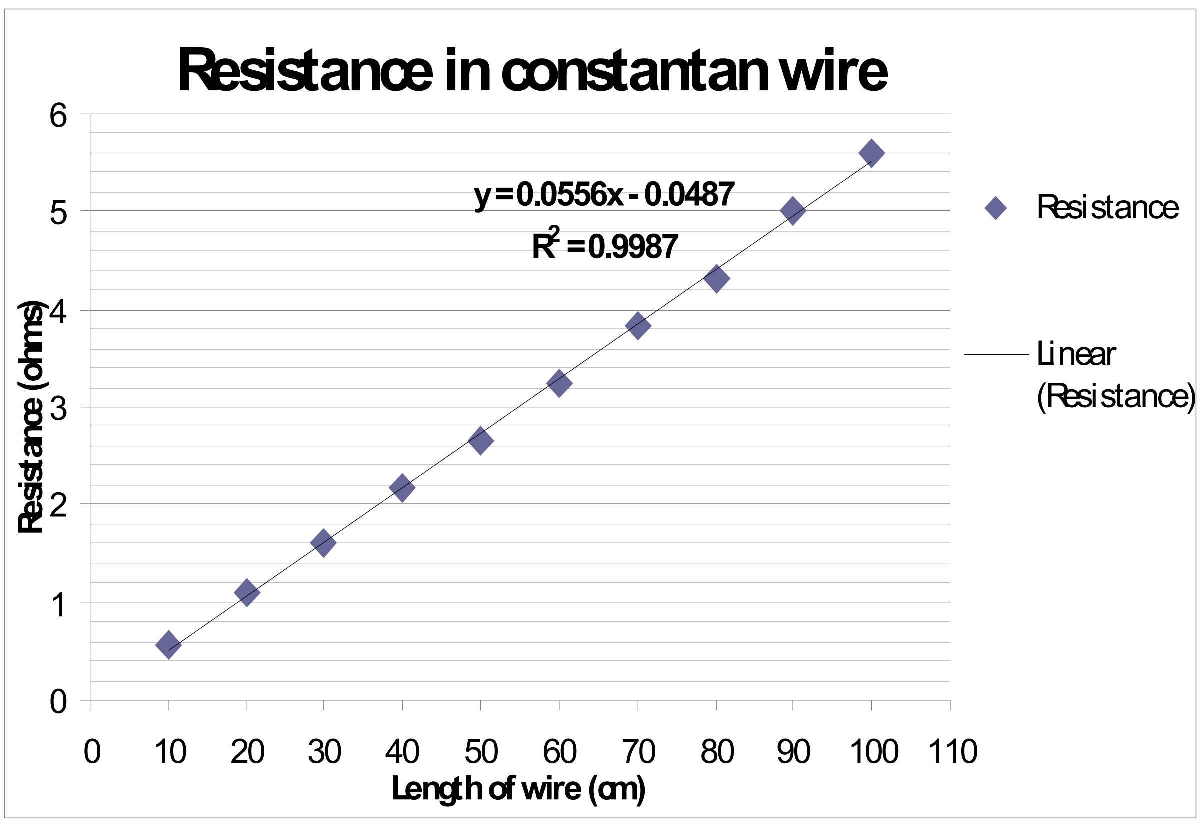
Graphs –

Results at 5 volts

Test 1-

Length (cm)	Voltmeter (v) volts	Current (I) amps	Resistance Ω Ohms
10	1.95	3.45	0.56
20	2.55	2.29	1.11
30	2.80	1.74	1.6
40	2.97	1.36	2.18
50	2.83	1.06	2.66
60	2.80	0.86	3.25
70	3.25	0.85	3.82
80	3.32	0.77	4.31
90	3.42	0.68	5.02
100	3.59	0.64	5.6

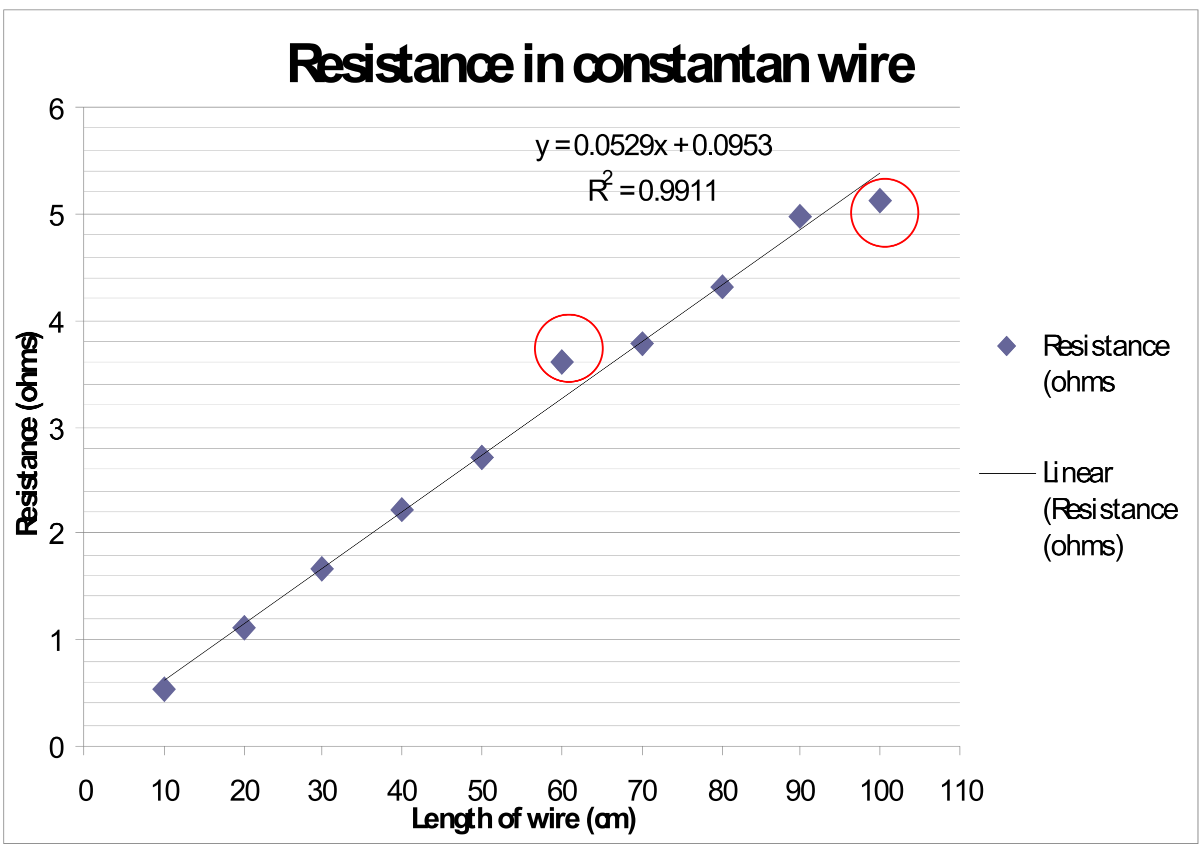
This graph shows strong positive correlation. The graph shows exactly what is expected to happen as stated in my hypothesis. This graph shows that the Ohm's Law works as the resistance increases when the length increases. Resistance being proportional to length confirms the success of the graph.



Test 2 –

Length (cm)	Voltmeter (v) volts	Current (I) amps	Resistance Ω Ohms
10	1.96	3.57	0.54
20	2.69	2.43	1.10
30	3.05	1.83	1.66
40	3.24	1.45	2.23
50	3.31	1.22	2.71
60	3.43	0.95	3.61
70	3.53	0.93	3.79
80	3.5	0.81	4.32
90	3.64	0.73	4.98
100	3.69	0.66	5.13

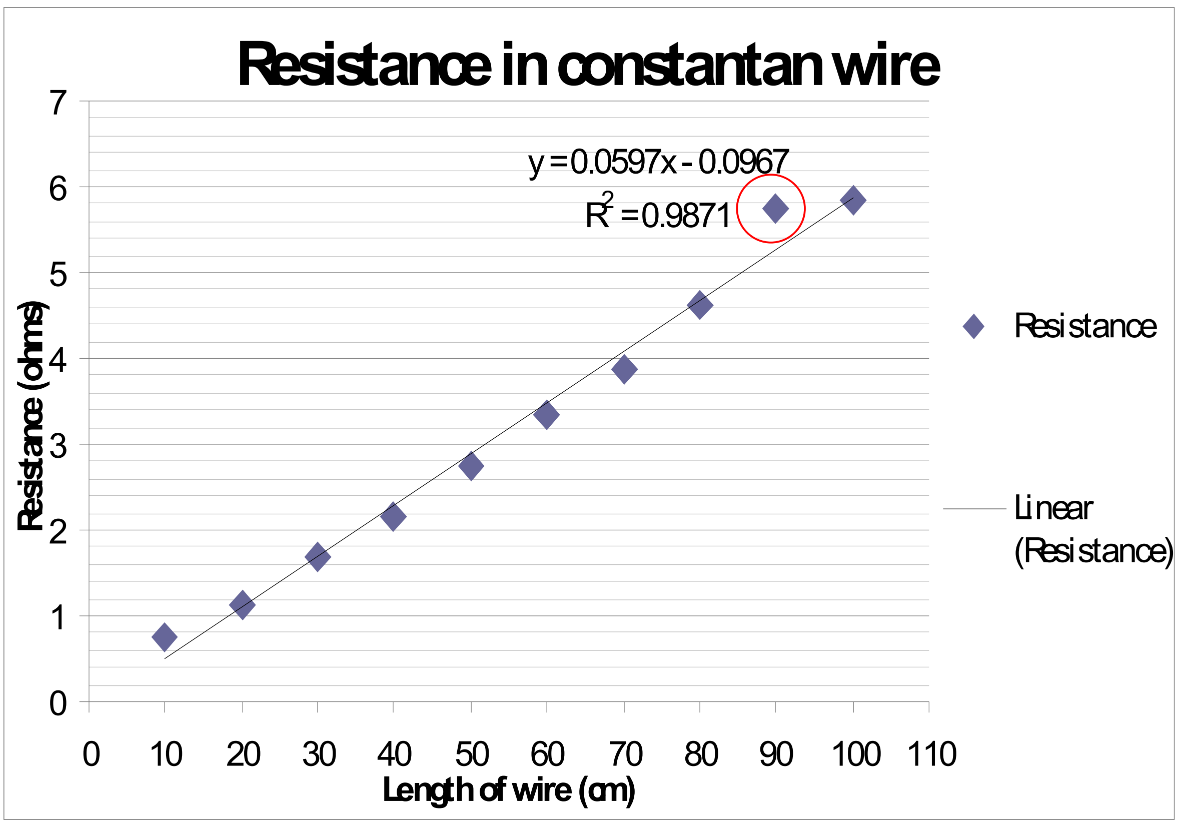
The graph has a strong correlation but some of the results come away from the line of best fit. This may be because the wire over heated or I individually misinterpreted to the voltmeter and ammeter readings. The voltmeter reading increases whilst the current decrease shows the resistance is correct. I believe so far the experiment has gone rather well. Event though the line of best fit should be rather more straight.



Test 3 –

Length (cm)	Voltmeter (v) volts	Current (I) amps	Resistance Ω Ohms
10	1.99	2.65	0.75
20	2.83	2.53	1.11
30	3.17	1.87	1.69
40	3.35	1.54	2.17
50	3.55	1.29	2.75
60	3.51	1.05	3.34
70	3.64	0.94	3.87
80	3.74	0.81	4.61
90	3.79	0.66	5.74
100	3.8	0.65	5.84

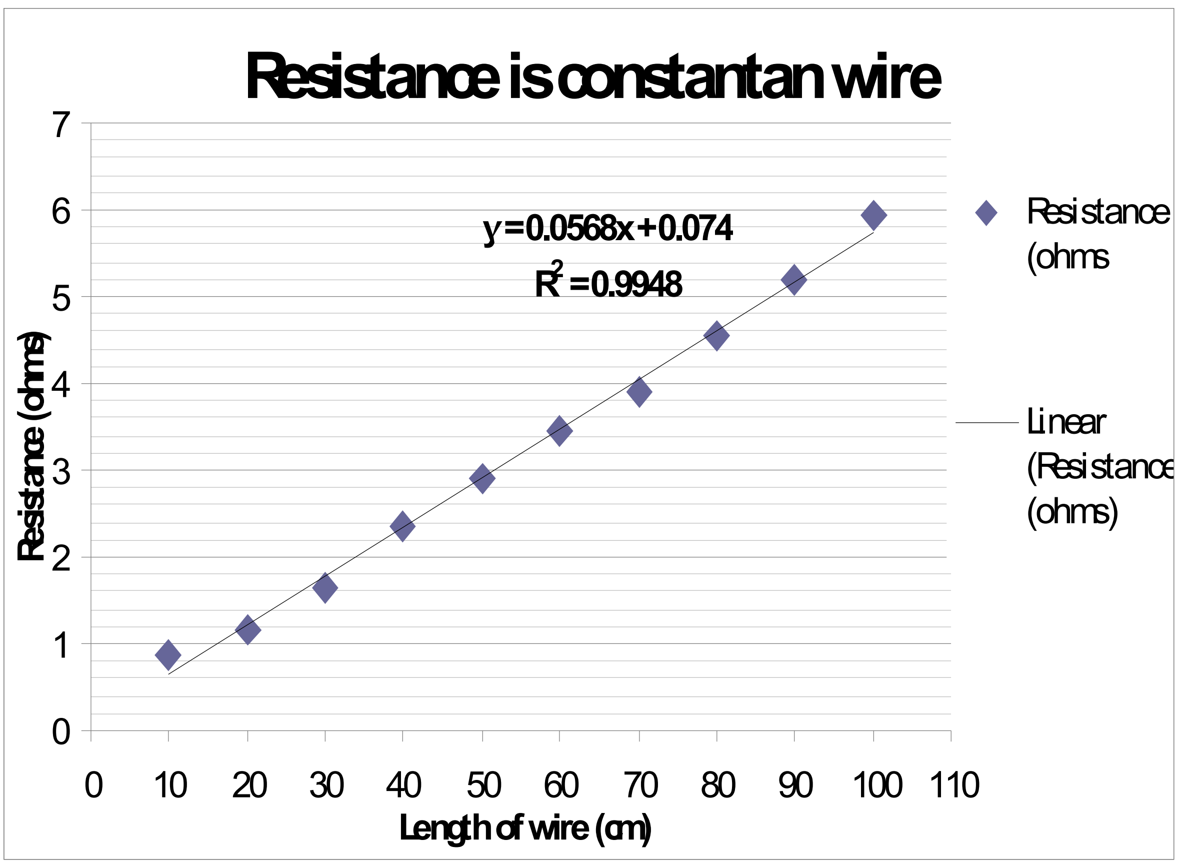
This graph was not too bad I did expect the resistance to be much higher as I though the wires heat of the wires would have increased. But there were some doubts 90cm length of wire was away from the line of best fit, it did not cause too many problems. The graph still has a strong correlation



Test 4 –

Length (cm)	Voltmeter (v) volts	Current (I) amps	Resistance Ω Ohms
10	2.03	2.33	0.87
20	2.82	2.41	1.17
30	3.2	1.96	1.63
40	3.42	1.46	2.34
50	3.58	1.23	2.91
60	3.69	1.07	3.45
70	3.64	0.93	3.91
80	3.65	0.8	4.56
90	3.73	0.72	5.18
100	3.81	0.64	5.95

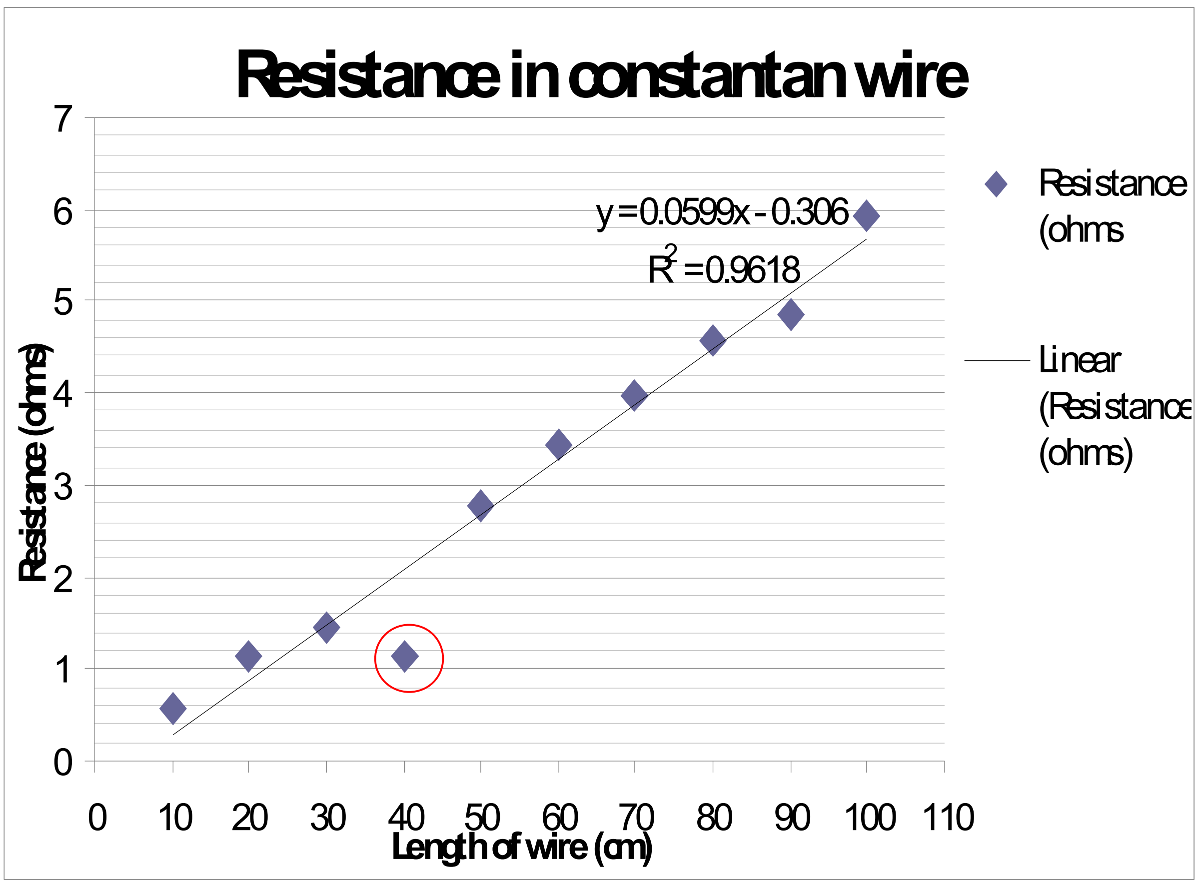
This graph has a strong positive correlation you get to see that the wire is staring to heat up as the resistance is gradually increasing. The resistance is close to the line of best fit so theoretically the ohms law is kind corrects as supports my predictions.



Test 5 –

Length (cm)	Voltmeter (v) volts	Current (I) amps	Resistance Ω Ohms
10	2.1	3.61	0.58
20	2.77	2.4	1.15
30	2.64	1.8	1.46
40	2.77	2.4	1.15
50	2.9	1.05	2.76
60	3.47	1.01	3.43
70	3.51	0.88	3.98
80	3.7	0.81	4.56
90	3.75	0.77	4.87
100	3.79	0.64	5.92

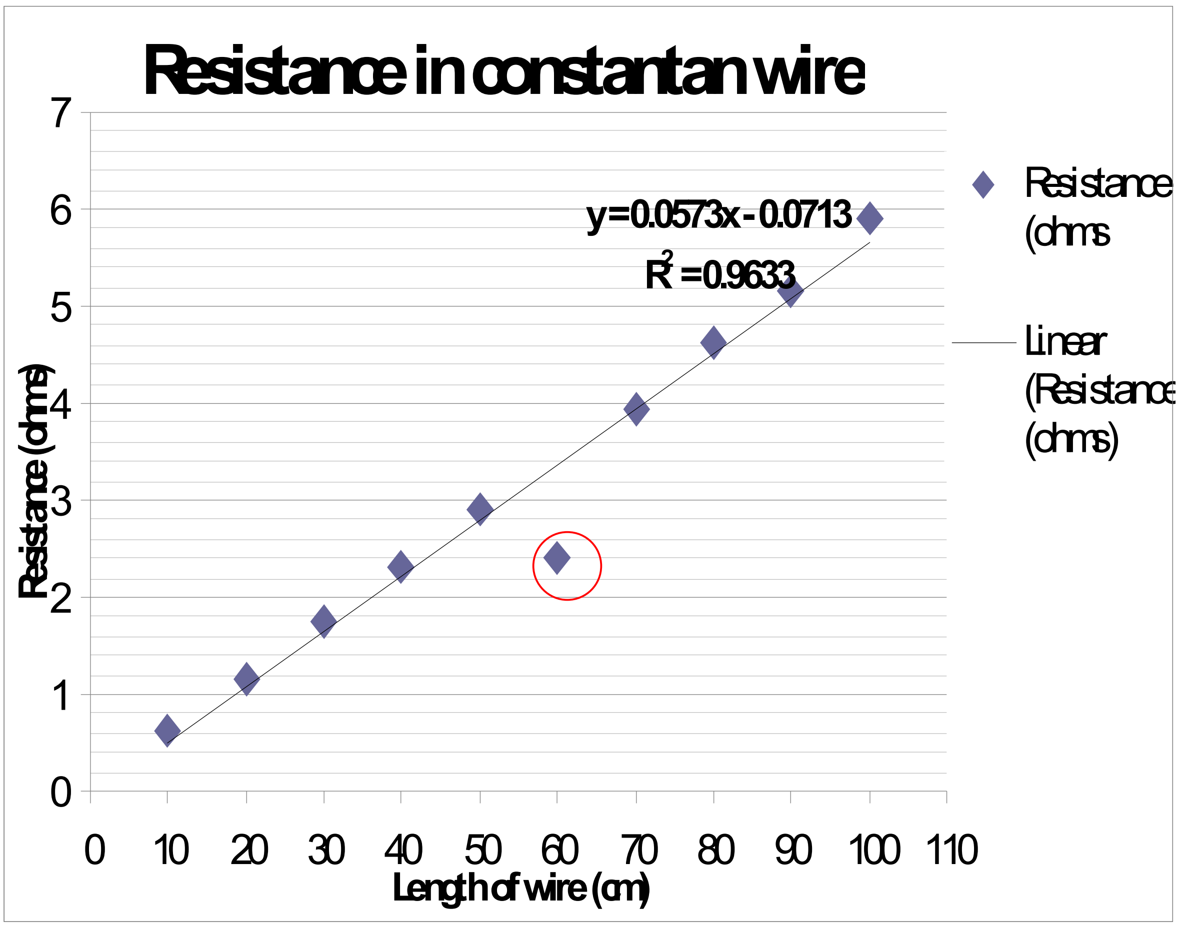
In the fifth graph, it appeared I had a few anomalies, doing more repeats would possibly prevent this from happening. The 40cm length resistant is far away from the line of best fit this could be because either when taking the recording I misinterpreted it resulting in a different result. The change of temperature could have affected it this anomaly.



Test 6 –

Length (cm)	Voltmeter (v) volts	Current (I) amps	Resistance Ω Ohms
10	2.14	3.47	0.62
20	2.83	2.4	1.17
30	3.19	1.83	1.74
40	3.43	1.5	2.3
50	3.57	1.23	2.9
60	3.67	1.07	2.42
70	3.17	0.94	3.94
80	3.79	0.82	4.62
90	3.88	0.75	5.17
100	3.87	0.66	5.92

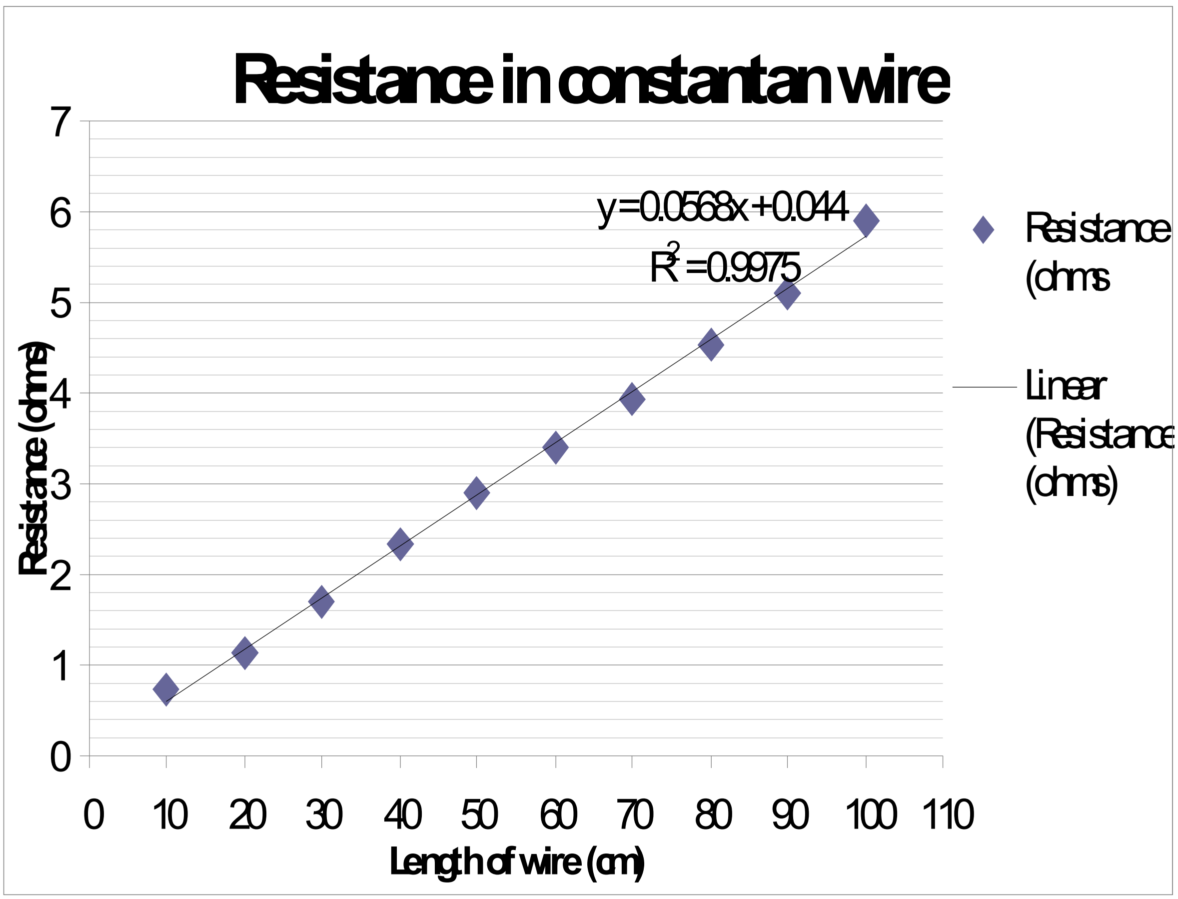
Another anomaly occurred during the experiment this time it was the 60cm resistant reading. This is because I had to do the rest of the experiment the next day and the change of room temperature was part to do with it.



Test 7 –

Length (cm)	Voltmeter (v) volts	Current (I) amps	Resistance Ω Ohms
10	2.72	3.67	0.74
20	2.85	2.53	1.12
30	3.27	1.92	1.7
40	3.51	1.49	2.35
50	3.59	1.24	2.89
60	3.64	1.04	3.4
70	3.67	0.93	3.94
80	5.77	0.83	4.54
90	5.83	0.75	5.1
100	5.89	0.66	5.89

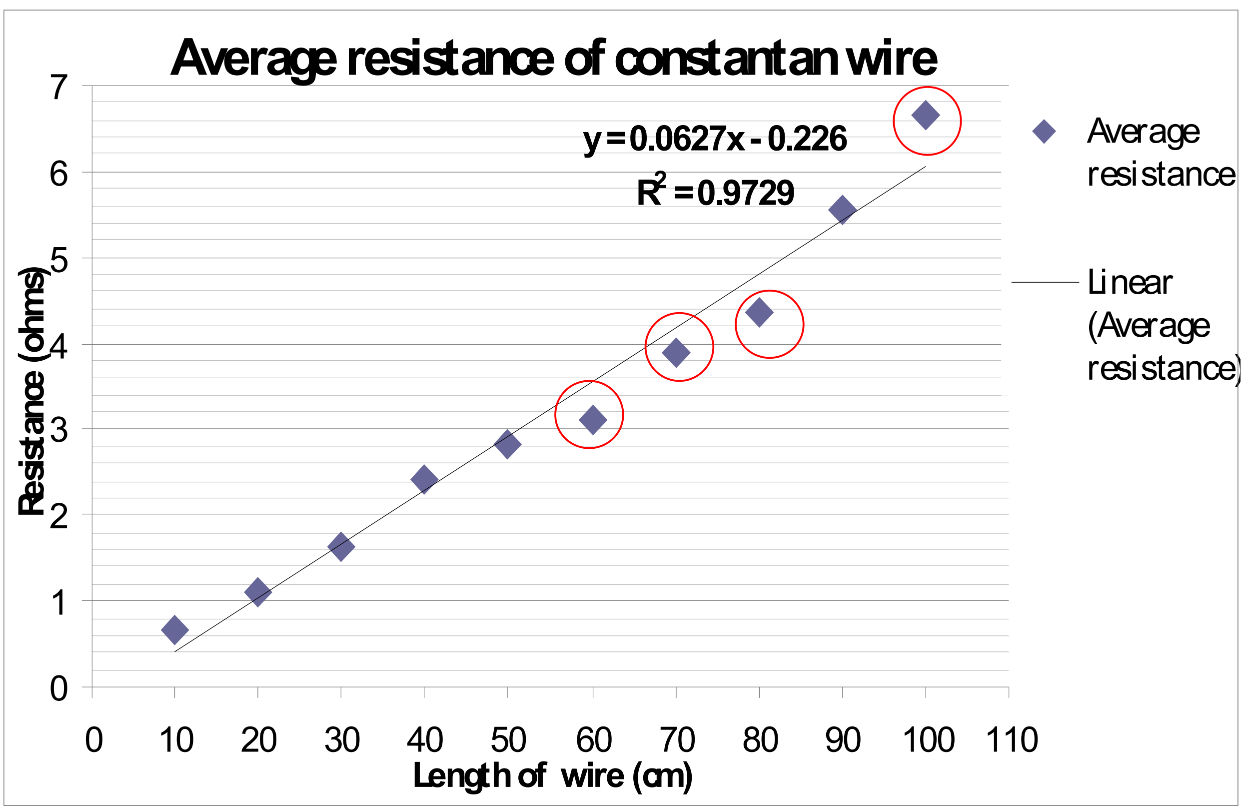
This graph compares the length to the resistance it shows a straight line going though the line of best fit. Not only does it show that the size of the length is directly proportional to the resistance but the heat has not affected the resistant it self.



Average result –

Average Length (cm)	Average Voltmeter (v) volts	Average Current (I) amps	Average Resistance Ω Ohms
10	2.12	3.25	0.65
20	2.76	2.47	1.11
30	3.04	1.85	1.64
40	3.24	1.4	2.42
50	3.33	1.18	2.82
60	3.34	1.07	3.12
70	3.54	0.91	3.89
80	3.5	0.8	4.37
90	4	0.72	5.55
100	4.06	0.61	6.65

There where some anomalies in the experiment, this could have been because the wires did not have the correct length or because I did not read the ammeter or voltmeter correctly. The wires also may have been over heated. Because I added the anomalies in my average resistant this lowered my results and concluded the autonomy of a result. If I did not add in the anomalies then the results would have been closer to the line of best fit like the first graph.



Conclusion-

My prediction was correct. Constantan wire has a high resistance and the longer the wire, the greater the resistance. This happens because the electrons that move in the piece the piece of wire have to slow down because the resistance makes it difficult for electrons to get from one side of the wire to the other. The more the electrons have to bump together then the higher the resistance. The material of the wire makes a difference because some wires cause the electrons to bump together more than others. I have found out that there are four factors which affect resistance

- Length of wire
- Diameter of wire
- Type of wire
- Temperature

The type of wire makes a difference because the electrons have to pass through the material. These electrons may find it easier to pass through some materials than others e.g. Nichrome, Copper and Iron etc. Also the length of the wire will make a difference. This is because when you have a long wire, the electrons have to squeeze together to pass through the wire than they do in perhaps shorter wire. The diameter of wire affects the resistance. This is because if the wire was thin electrons will find it hard to go through, and are most likely to bump into each other. However if the wire was thick the electrons will have more space and are less likely to bump into each. Lastly the temperature of wire affects the rate of reaction because when the wire is cold the protons are not vibrating that much leaving electron to go pass more freely. If the wire however heats up the protons start to vibrate which disturbs the electrons flow of movement. This means the higher the temperature, the higher the resistance.

Evaluation

There were a few awkward results this could have been because the wires were not measured exactly to the right size or the reading on the ammeter and voltmeter was not accurate. Also if I had the chance to repeat the experiment I would reduced the power on the power pack. This is because the wires might have been over-heated as this will affect the resistance. Hot wires have a higher resistance then cold wires.

The method I used was okay, this was because I decided to do the experiment seven times as a precaution. If I done the experiment once there was a chance the results may have been a fluke. I believe by doing the experiment seven times it was beneficial because it gave me an average result for the constantan wire.