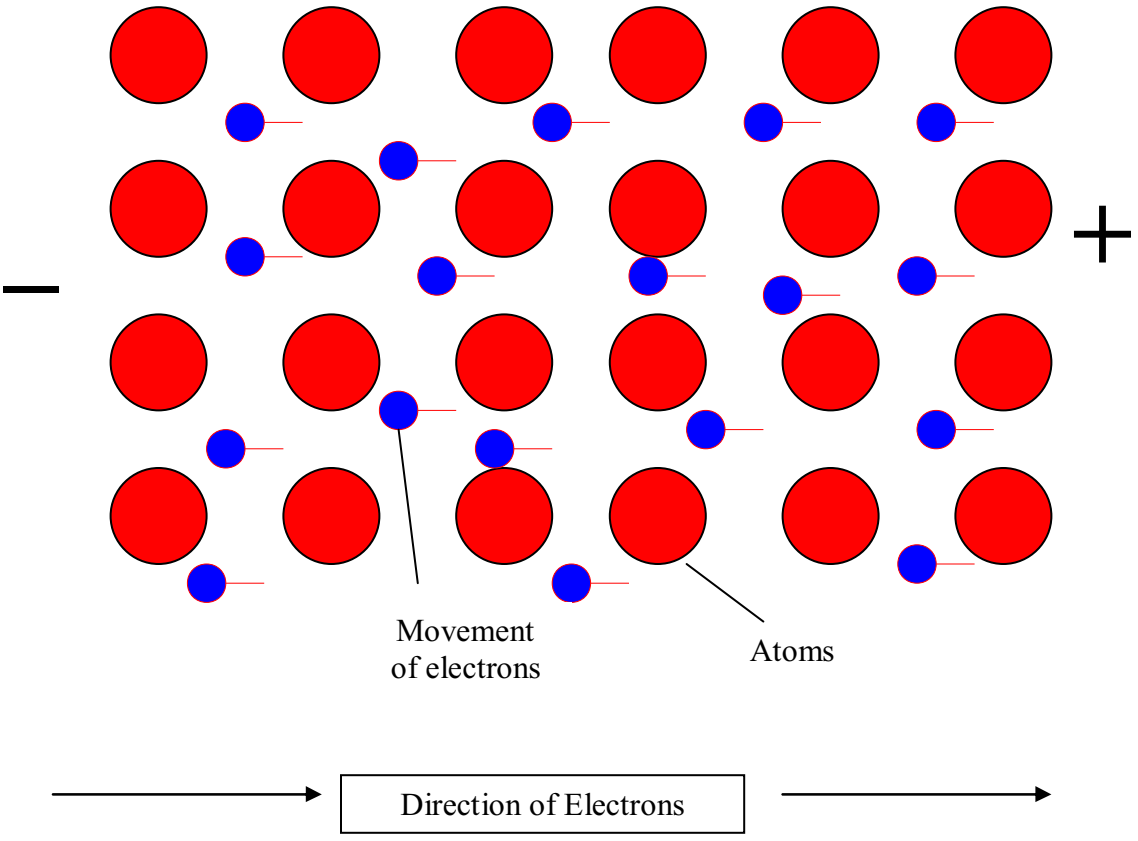
Philip Jacobs 11R

Resistance of A Wire

Theory and Background Write Up

Wires have resistance because they have thousands of atoms inside them. When voltage flows through a wire the electrons hit these thousands of atoms. This slows down the electrons. This slowing down process is what we call resistance. The electrons always travel from negative to positive on diagrams, although in conventional current it actually flows in the other direction.

Figure 1 – Inside of a Wire



The resistance of a wire can be altered depending on the following: -

- The material of a wire – This can be because some wires have more atoms inside them than others do.
- The temperature of the wire – If there is a high temperature in the wire then the atoms will vibrate more. This means that electrons are more likely to "hit" the atoms.
- The cross-sectional area of the wire – When the cross-sectional area of a wire increases the resistance of a wire goes down. This is because the area that is occupied by atoms is reduced.

- The length of a wire – When the length of a wire is increased so is the resistance of that wire. This is because there are more atoms inside a longer wire.

The factor that I have chosen to investigate is how the length of a wire effects the resistance of the wire. I have chosen to investigate this factor because I have only one type of wire available to use in the experiment. That wire is called constanton. If I were to increase the temperature of the wire I would have no piece of apparatus available to accurately measure the temperature. Finally I have no piece of apparatus to accurately measure the cross sectional-area of a wire and I am limited to the cross-sectional areas of wire that I have available to me. When doing my main experiment I am going to keep the voltage in the circuit the same. I am also going to keep the temperature as constant as I can. In all the experiments that I do I am going to keep the type of wire and the thickness of the wire the same.

Ohm's law states that current is directionally proportional to the voltage applied to a conductor and inversely proportional to the conductors resistance.
Source – http://www.encarta.com

This will help me in my investigation because it will help me in working out the resistance of the wire using the following formula: -

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}} \qquad \text{Or} \qquad R = \frac{V}{I}$$

Preliminary Investigation

When I conducted my preliminary investigation I did it so that I could test and check that the currents and voltages that I would use in my main investigation.

Preliminary Investigation Write Up

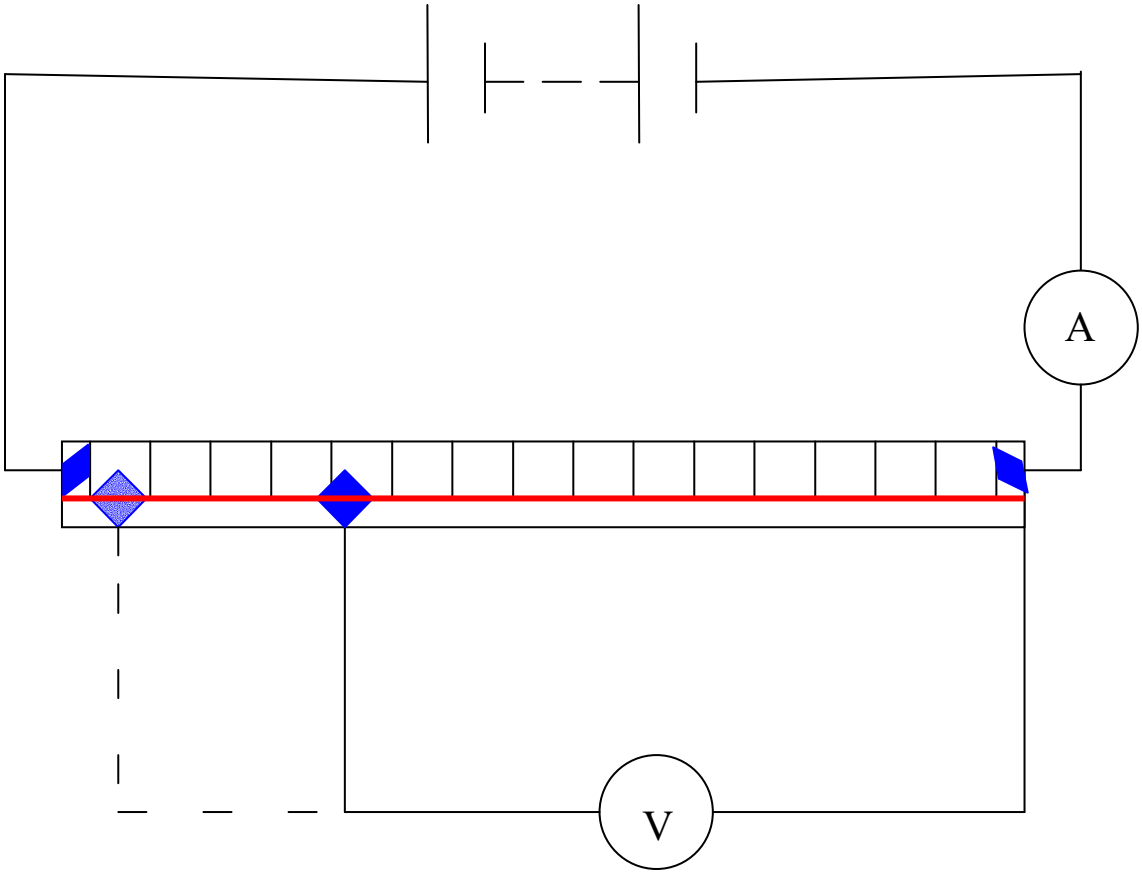
Apparatus

In my preliminary investigation I used 70cm of constanton wire, 3 crocodile clips, 6 coated wires, 1 power pack, 1 ammeter, 1 voltmeter, 1 meter ruler, 8 pieces of cellotape (3cm each) and 1 pair of scissors.

Method

1. I plugged in a power pack to a plug socket and connected a wire to it. I put this wire in to my ammeter.
2. Out of this ammeter came another wire on the end of this wire was a crocodile clip which I attached to the constanton wire which had been attached to the meter ruler.
3. Connected to this crocodile clip was another crocodile clip which via another wire led to a voltmeter which was in parallel to the meter ruler.
4. Coming out of the other side of the voltmeter was another wire. Again I added a crocodile clip, this was the crocodile clip that I used at the different intervals.
5. To the other end of the length of constanton wire was another length of coated wire which led to the power pack.
6. Once the circuit was set up I was able to record my results at the 7 different intervals.

Diagram



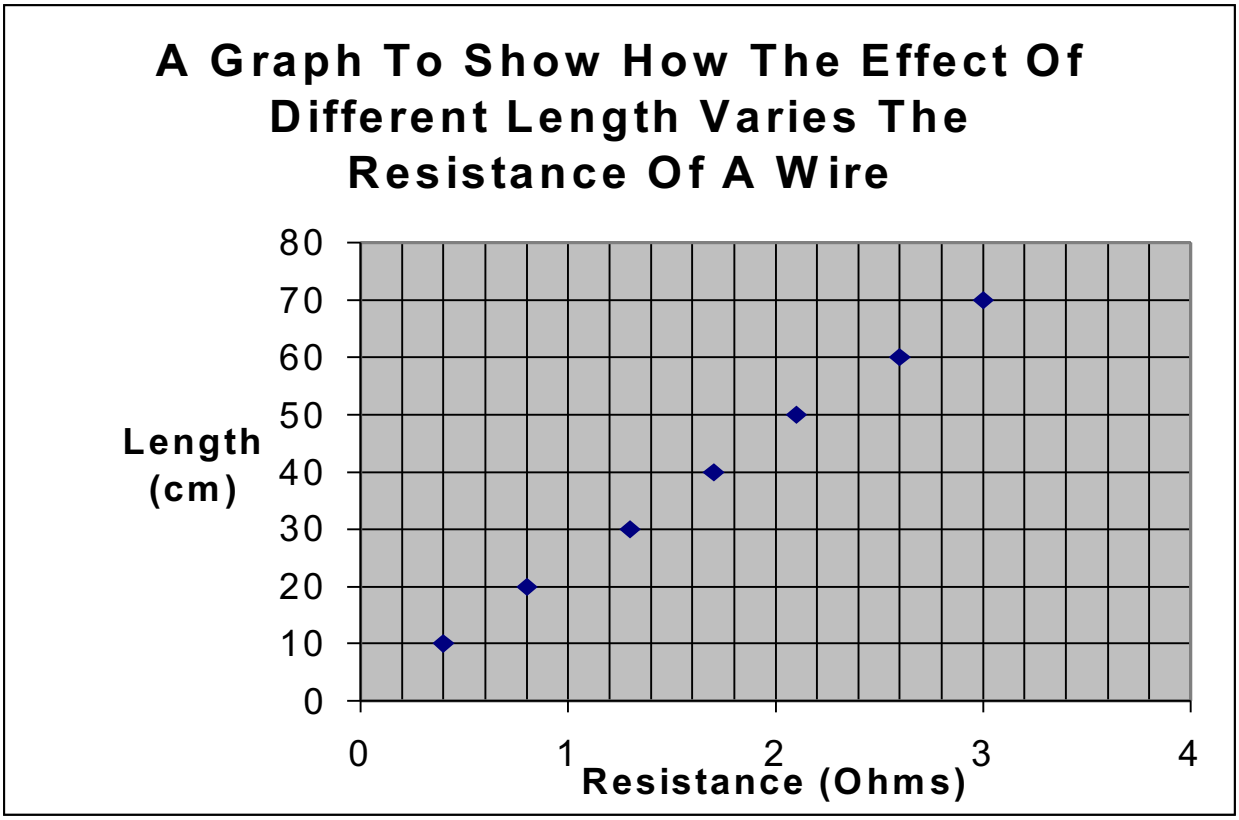
Key

- Length of constanton wire
- 1 meter ruler
- Crocodile clip
- Extension of wire (To be moved)
- Crocodile clip to be moved for wire readings

Results

Length of Wire (cm)	Voltage (V)	Current (A)	Resistance (Ω)
10	0.25	0.59	0.40
20	0.48	0.59	0.80
30	0.77	0.59	1.30
40	1.02	0.59	1.70
50	1.26	0.59	2.10
60	1.52	0.59	2.60
70	1.77	0.59	3.00

Results Graph



The results show me that when the length of wire is increased the resistance also increases. The length of the wire and the amount of resistance are directly proportional to each other. The results show this because of the amount of atoms in the wire. As the length of the wire increases the number of atoms also increases. This means that there is more chance the electrons will collide with the atoms, this therefore increases the

resistance. When looking at my main experiment I expect to see results almost identical to these results. The results that I obtain in my main experiment will perhaps be more accurate because I am going to change some of the equipment that I have used in my preliminary investigation.

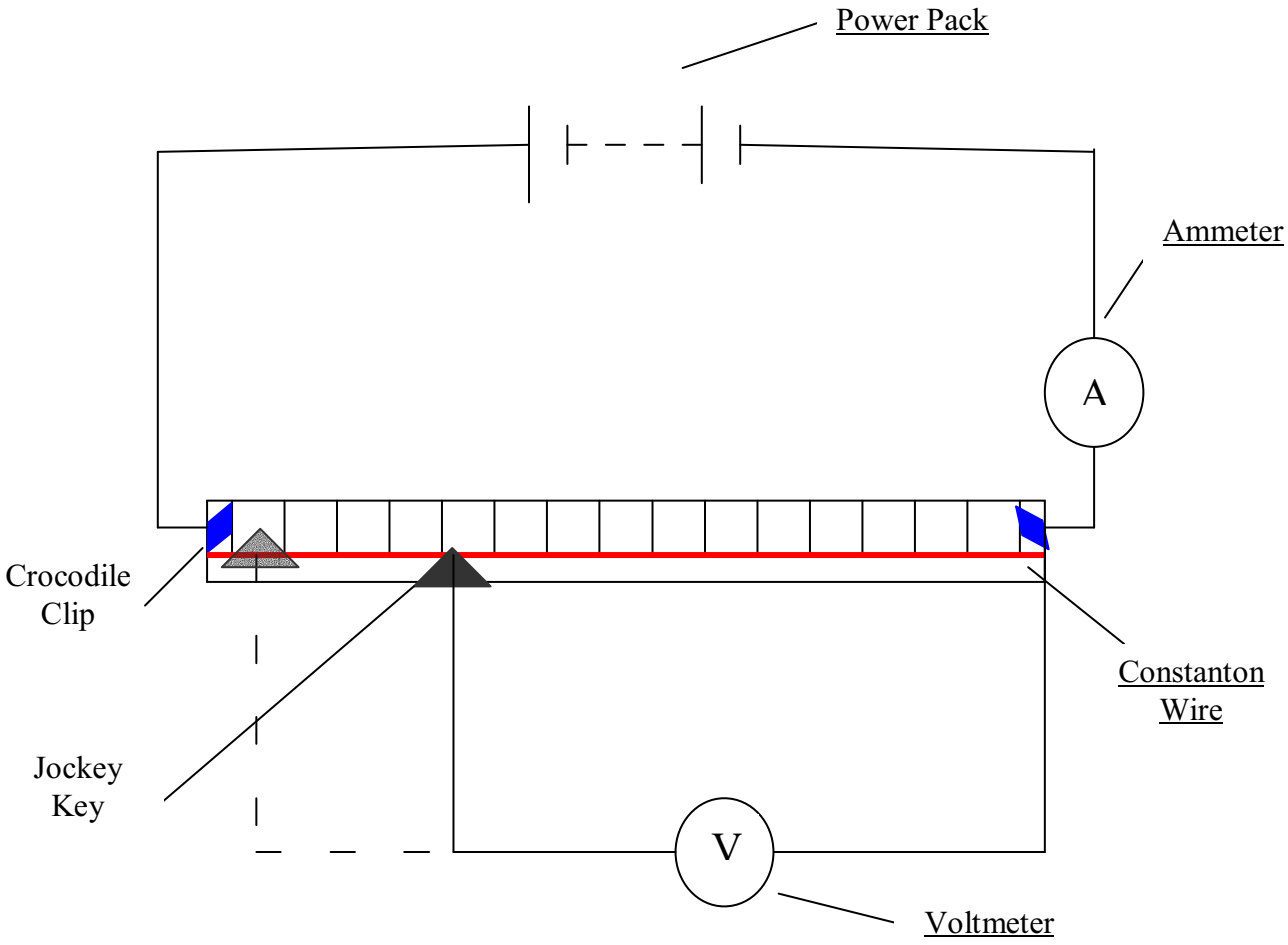
In my main experiment I am going to use 2 volts in the circuit. I am doing this because I believe that this will give me accurate results and will also be safer than other voltages. This is because if a high voltage is used the Constanton wire can become hot which can cause injuries and also damage the wire. To make my main experiment safe I am going to make sure that the wire does not get hot. I am also going to ensure that there is no chance that any other person or I will fall as a result of a bag or a chair near my experiment. To make my main experiment more accurate I am going to use a jockey key instead of a crocodile clip to attach to the Constanton wire and read the readings. This should create a better connection and should lead to better more accurate results. Other that using a jockey key I am going to use the same equipment for my main experiment as I did for my preliminary experiment. The amount of volts that I used in my preliminary investigation was 6volts, I have decided to change this to 2volts so that the wire does not become over heated and cause a safety problem. In my preliminary investigation I used 7 lengths of Constanton wire. The lengths that I used were 10cm, 20cm, 30cm, 40cm, 50cm, 60cm and 70cm. When conducting my preliminary investigation I had to make sure that it was safe. I checked that bags and chairs were away from my investigation and also ensured that my working area was free of other objects. I will also ensure that this will be enforced during my main experiment. When conducting my preliminary experiment I was using crocodile clips on my connections and found that this was inaccurate. For my main experiment I have decided that for a better connection, which in turn will lead to more accurate readings I am going to use a jockey key. When conducting my main experiment I will collect 10 sets of results and do this on three separate occasions to ensure that I have a big set of results. When conducting my preliminary investigation I found that readings on the ammeter and the voltmeter were tending to flicker. To make sure that this doesn't happen in my main investigation I am going to use a jockey key to make sure that the connection between the wire and the circuit are improved.

The procedure that I use in my main experiment will be slightly different to that of my preliminary experiment, this will be because I will collect 10 sets of results and will then repeat the experiment for a total of 3 times.

I predict that in my main experiment I will find that the resistance of a wire is directly proportional to the length of a wire. I have predicted this due to the results I gathered in my preliminary experiment and from my background work which was that when the length of a wire increases so does the resistance.

Main Experiment

Diagram



Apparatus

In my main investigation I used 1 meter of constanton wire, 2 crocodile clips, 6 coated wires, 1 power pack, 1 ammeter, 1 jockey key, 1 voltmeter, 1 meter ruler, 8 pieces of cellotape (3cm each) and 1 pair of scissors.

Method

1. I plugged a power pack to a plug socket and connected a wire to it. I put this wire in to my ammeter.
2. Out of this ammeter came another wire on the end of this wire was a crocodile clip which I attached to the constanton wire which had been attached to the meter ruler.
3. Connected to this crocodile clip was another crocodile clip which via another wire led to a voltmeter which was in parallel to the meter ruler.

4. Coming out of the other side of the voltmeter was another wire. Here I added a jockey key this was the jockey key that I used at the different intervals.
5. To the other end of the length of constanton wire was another length of coated wire which led to the power pack.
6. When collecting the data I was in a group with 2 others. Each person in the group had a different job. My job was to move the jockey key to each of the different intervals. Another person would read the ammeter and the voltmeter. Finally the third person would record the results.

Once the circuit was set up I was able to record my results at 10 different intervals. Once I had collected the 10 different results I did the experiment a further 2 times. In total I conducted the experiment 3 times.

Obtaining Evidence

Length (cm)	Voltage (V)	Current (A)	Resistance (Ω)	Average Resistance (Ω)
10.0	1 – 0.04	1 – 0.16	1 – 0.25	0.29
	2 – 0.07	2 – 0.16	2 – 0.44	
	3 – 0.03	3 – 0.16	3 – 0.19	
20.0	1 – 0.11	1 – 0.16	1 – 0.69	0.71
	2 – 0.12	2 – 0.16	2 – 0.75	
	3 – 0.11	3 – 0.16	3 – 0.69	
30.0	1 – 0.22	1 – 0.16	1 – 1.38	1.35
	2 – 0.22	2 – 0.16	2 – 1.38	
	3 – 0.21	3 – 0.16	3 – 1.31	
40.0	1 – 0.33	1 – 0.16	1 – 2.06	2.02
	2 – 0.33	2 – 0.16	2 – 2.06	
	3 – 0.31	3 – 0.16	3 – 1.94	
50.0	1 – 0.42	1 – 0.16	1 – 2.63	2.65
	2 – 0.42	2 – 0.16	2 – 2.63	
	3 – 0.43	3 – 0.16	3 – 2.69	
60.0	1 – 0.53	1 – 0.16	1 – 3.31	3.38
	2 – 0.54	2 – 0.16	2 – 3.38	
	3 – 0.55	3 – 0.16	3 – 3.44	
70.0	1 – 0.62	1 – 0.16	1 – 3.88	4.06
	2 – 0.68	2 – 0.16	2 – 4.25	
	3 – 0.65	3 – 0.16	3 – 4.06	
80.0	1 – 0.73	1 – 0.16	1 – 4.56	4.73
	2 – 0.77	2 – 0.16	2 – 4.81	
	3 – 0.77	3 – 0.16	3 – 4.81	
90.0	1 – 0.85	1 – 0.16	1 – 5.31	5.35
	2 – 0.86	2 – 0.16	2 – 5.38	
	3 – 0.86	3 – 0.16	3 – 5.38	
100.0	1 – 0.95	1 – 0.16	1 – 5.94	6.04
	2 – 0.96	2 – 0.16	2 – 6.00	
	3 – 0.99	3 – 0.16	3 – 6.19	

I have rounded the Voltage, Current, Resistance and Average Resistance to two decimal places.

The number in the Voltage, Current and Resistance column represents the time that I repeated it. For example first time, second time or third time.

E.G

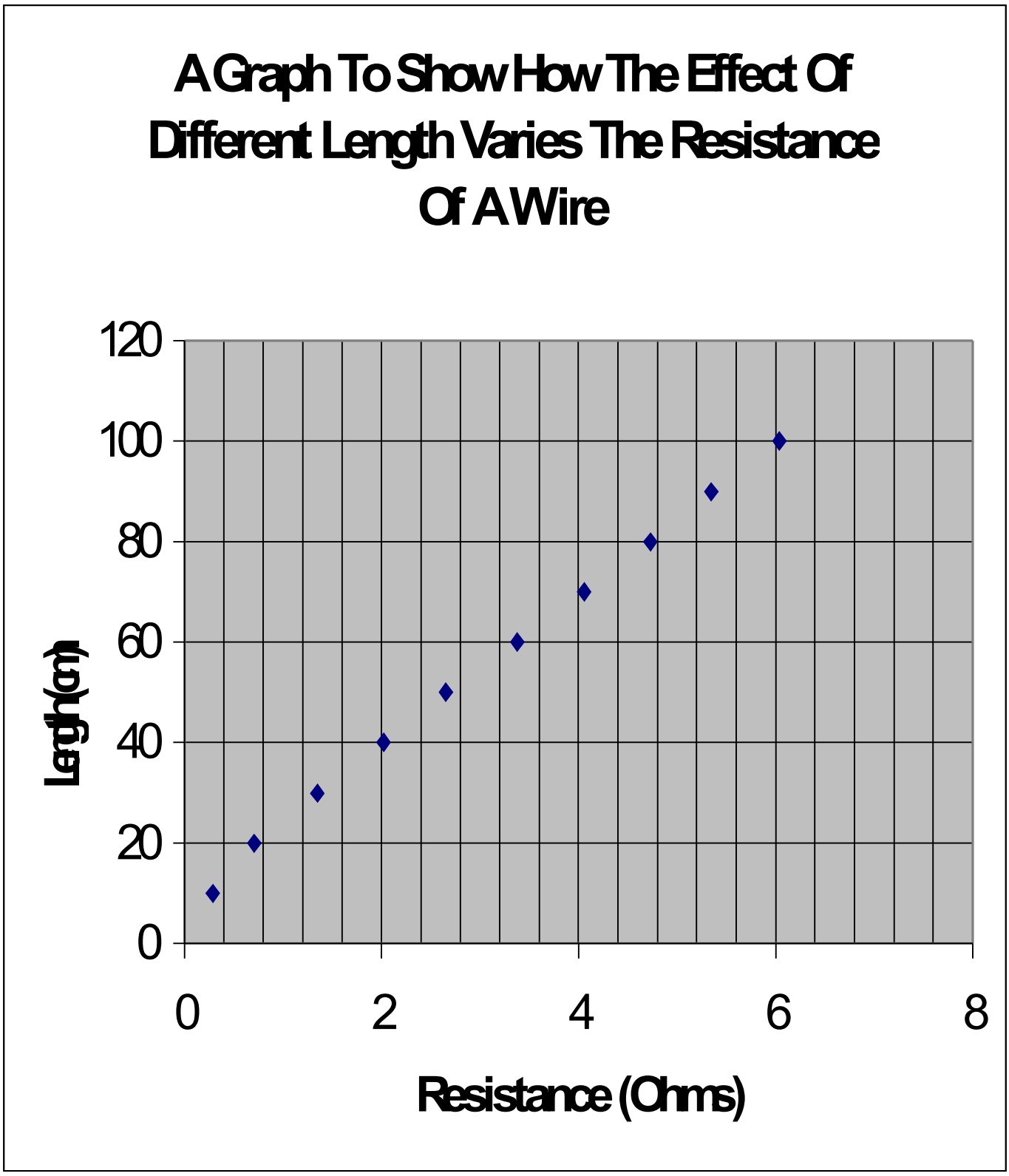
1 – 0.95
2 – 0.96
3 – 0.99

Analyzing Evidence

Length (cm)	Average Resistance (Ω)
10.0	0.29
20.0	0.71
30.0	1.35
40.0	2.02
50.0	2.65
60.0	3.38
70.0	4.06
80.0	4.73
90.0	5.35
100.0	6.04

I have rounded the average resistance to two decimal places.
E.G 6.041666667 ⟶ 6.04

Graph of my main results



The approximate equation of my graph is: - $y=20.8\chi$
So using that equation I should be able to work out what the length of a piece of wire is if I have the resistance of that wire.
E.G A piece of wire with a resistance of 10 Ohm's should have a length of approximately: -
20.8 X 10 Ohm's, which equals 208cm

My results show me that when the length of a wire is increased the resistance also increases. For example when the length of the wire is 10.0cm the resistance is 0.29 Ohms and when the length of the wire is 100.0cm the resistance is 6.04 Ohm's. This clearly shows that the resistance of a wire is directionally proportional to the length of that wire.

I believe that my results show me this because of my theorem at the start of my investigation. That theorem is that if the length of wire is increased the number of atoms inside that wire must also increase. With more atoms inside the wire this means that electrons are more likely to collide with the atoms, which will slow down the time it takes them to travel, therefore increasing the resistance of the wire.

My prediction was: -

I predict that in my main experiment I will find that the resistance of a wire is directly proportional to the length of a wire.

In my main experiment I believe that I have proved this correctly. I have showed in my preliminary work what happens when the length of a wire is increased and have proved this in my main investigation. Looking at my results and graph I have clearly proved my prediction correct.

Evaluation

I felt that my experiment went very well, my results clearly prove that my prediction was correct. The only problem that I had was that on my graph I had two pieces of data that were outlying. The experiment itself was fairly simple to perform, but perhaps different equipment would have made my results more accurate and given me an even better set of results.

On the graph I have noted that there were two major outlying pieces of data. These pieces of data are that at 20.0 cm I have calculated that the resistance was 0.71 Ohm's and at 100.0cm the average resistance was 6.04 Ohm's. This could be because of a number of factors. Firstly on one or more of the times that I did the experiment there could have been a poor connection in the circuit. Secondly, on one or more of the three experiments that I did the ammeter and/or the voltmeter were flickering making it hard to get an accurate reading. Finally, when the jockey key was being used it may not have been fully connected to the rest of the circuit. This could have meant that my readings were not totally accurate.

When I did my main experiment there were only two changes in apparatus and procedure. The change in apparatus was to use a jockey key to connect to my piece of Constanton wire with the rest of the circuit to give me my readings. Before using a jockey key I used a crocodile clip, this didn't give me a reading as accurate as the jockey key. This is because it is very hard to keep the crocodile clip steady to give an accurate reading without the ammeter and voltmeter flickering. The only change to my procedure was to collect ten pieces of data instead of seven in my preliminary investigation. Also once I had collected the results I repeated the experiment a further two times. Perhaps if I were to do the experiment again I would measure fifteen different lengths and repeat it four times. This would give me an even better set of results and would then give me an even more accurate results graph.

To learn more about the resistance of wire I could have done more experiments. The experiments that I could have done are: -

- To have changed the material of the wire
- To change the temperature of the wire using a optical pyrometer. An optical pyrometer allows you to measure the temperature of a wire without touching it.
- To have changed the cross-sectional area of the wire using a micrometer. A micrometer used with a microscope accurately measures small distances, like that of a wire.