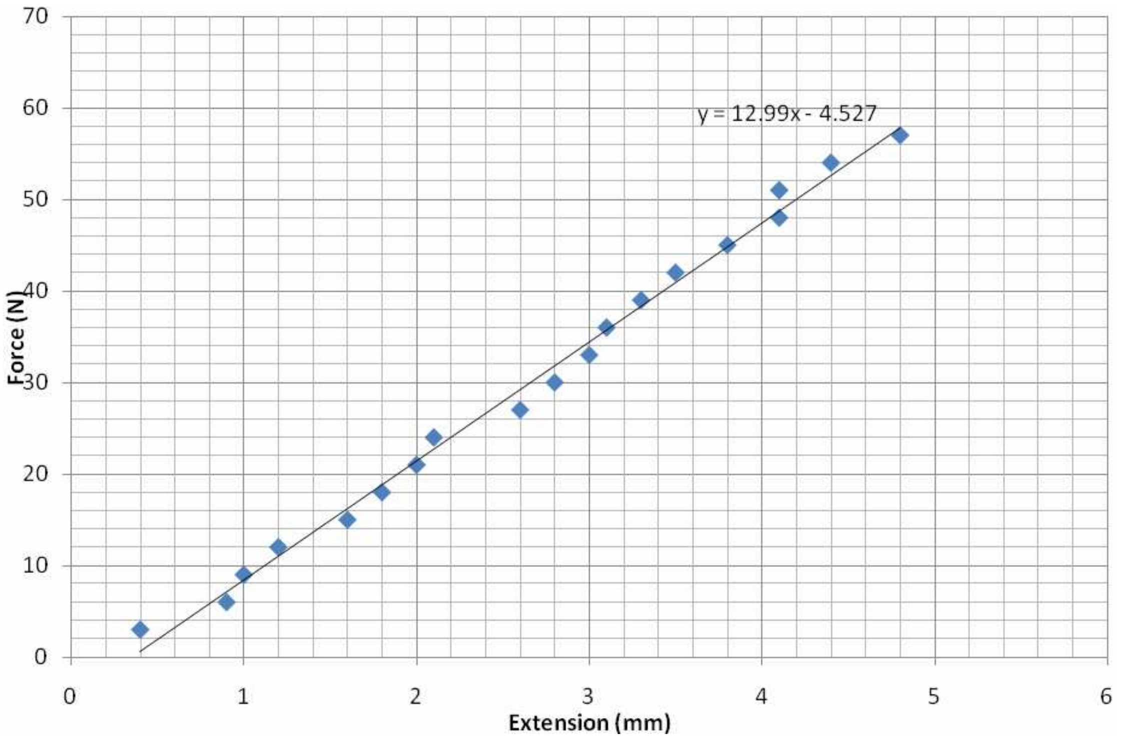
Physics Coursework
Data handling

The results I have been given are from a tensile strength experiment. In this experiment a piece of material; usually a wire would be hung with a varying weights attached to it and the amount by which its length increased w ould be measured.

I am told the extension of the material and the force applied for 19 pairs of results. I am also told that the diameter is 0.45mm and the original length is 2m

The results are as follows:

Force(N)	Extension(mm)
3	0.4
6	0.9
9	1
12	1.2
15	1.6
18	1.8
21	2
24	2.1
27	2.6
30	2.8
33	3
36	3.1
39	3.3
42	3.5
45	3.8
48	4.1
51	4.1
54	4.4
57	4.8



The graph above shows how extension changes with increasing force. It shows what is expected; the extension increases when the force is increased. However this relationship is not directly proportional and the rate at which extension changes varies. However the extension never decreases so I can tell so far that there are no immediately obvious anomalies. Although at one point 48N and 51N the extension does not change but this is plausible because in the experiment the wire is held in with only two wooden blocks and this setup is liable to slippage of the wire in the blocks, so this would explain the anomalies.

I have plotted force against extension, even though the independent variable is force, because of Hooke's law

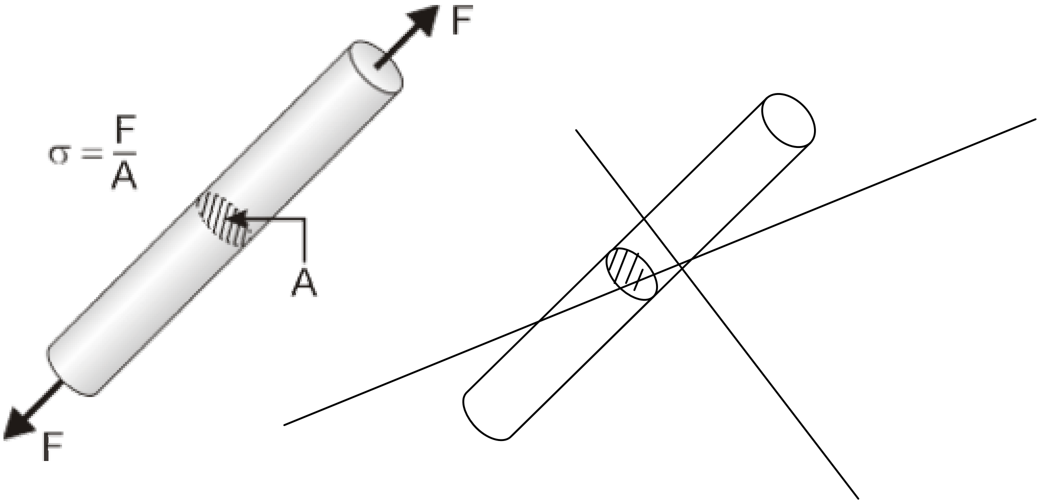
$$F = -kx$$

$$k = \frac{F}{x}$$

I am going to find out the Young's Modulus of the material that has been tested here. To do that I will first need to work out both the tensile stress and tensile strain .

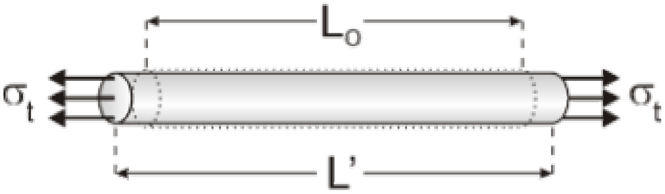
I know that stress is the force applied over the area perpendicular to it

$$\sigma = \frac{F}{A}$$



And that strain is extension of the material over the original length

$$\varepsilon = \frac{x}{L}$$



I already know the force but the area is the cross sectional area of the wire, which has a diameter of 0.45mm. I need to work this out in metres which is 0.00045m .

The area of a circle is = πr^2 where is radius

$= \pi \times 0.000225^2$

$= 1.59043128 \times 10^{-7}\ m^2$

The original length is two metres, and I will need to work out the extensions in metres also. These new values are shown below

Extension (mm)	Extension(m)
0.4	0.0004
0.9	0.0009
1	0.001
1.2	0.0012
1.6	0.0016
1.8	0.0018
2	0.002
2.1	0.0021
2.6	0.0026
2.8	0.0028

3	0.003
3.1	0.0031
3.3	0.0033
3.5	0.0035
3.8	0.0038
4.1	0.0041
4.1	0.0041
4.4	0.0044
4.8	0.0048

I will do the first two stress and strain calculations

Stress:

$$\sigma = \frac{F}{A}$$

$$\sigma = \frac{3}{1.59\ x\ 10^{-7}}$$

$$\sigma = 18867924.5\text{Pa}$$

$$\sigma = 18.9\text{MPa}$$

Strain:

$$\varepsilon = \frac{x}{L}$$

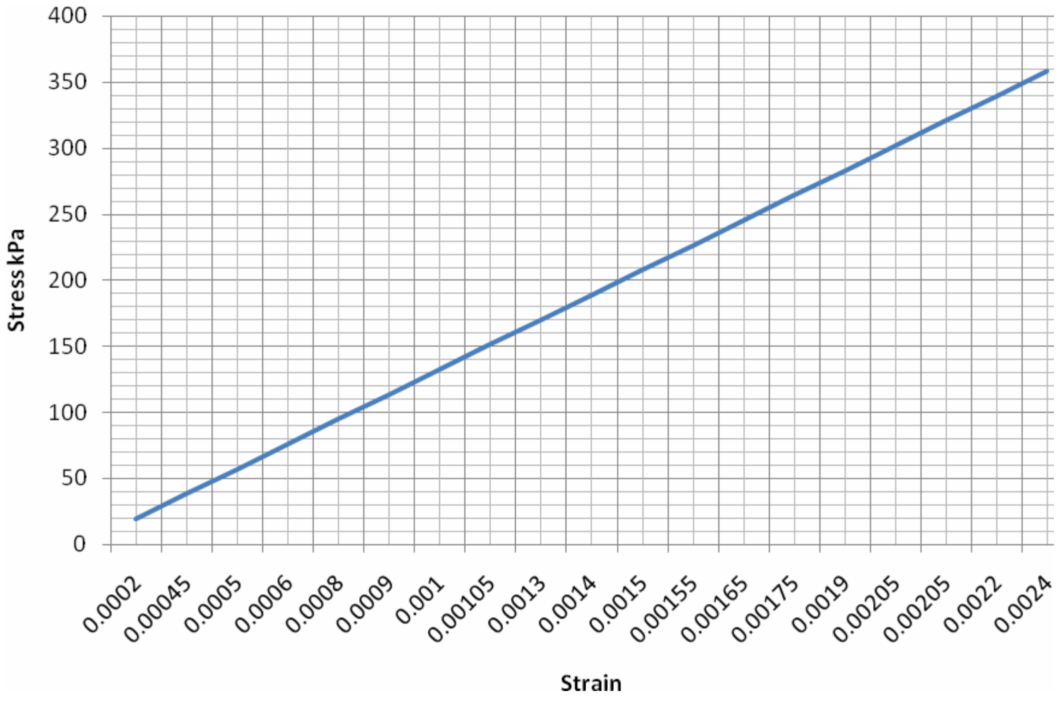
$$\varepsilon = \frac{0.0004}{2}$$

$$\varepsilon = 0.0002 \text{ (no units)}$$

The table below shows the rest of the results

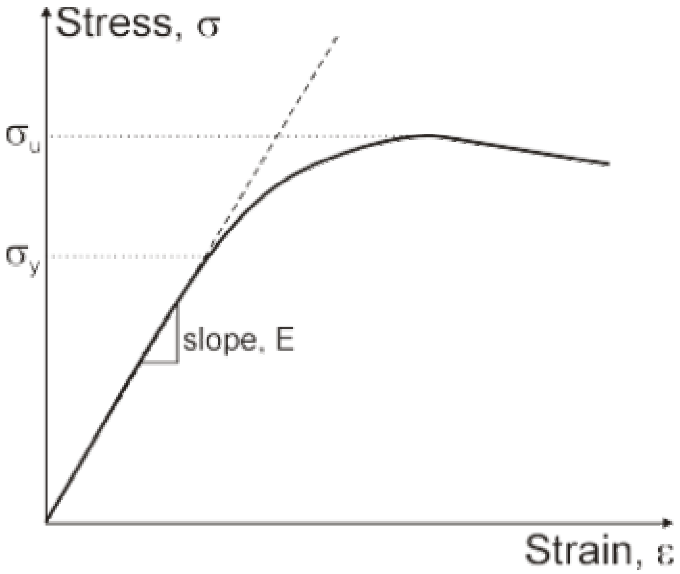
Stress (Pa)	Stress (MPa)	Strain
1.9 x 10^7	18.863	0.0002 (2 x 10^{-4})
3.8 x 10^7	37.726	0.00045(4.5 x 10^{-4})
5.7 x 10^7	56.588	0.0005(5 x 10^{-4})
7.5 x 10^7	75.451	0.0006 (6 x 10^{-4})
9.4 x 10^7	94.314	0.0008 (8 x 10^{-4})
1.1 x 10^8	113.177	0.0009 (9 x 10^{-4})
1.3 x 10^8	132.040	0.001 (1 x 10^{-3})
1.5 x 10^8	150.902	0.00105 (1.1 x 10^{-3})
1.7 x 10^8	169.765	0.0013 (1.3 x 10^{-3})
1.9 x 10^8	188.628	0.0014 (1.4 x 10^{-3})
2.1 x 10^8	207.491	0.0015 (1.5 x 10^{-3})

2.3×10^{8}	226.354	0.00155(1.6×10^{-3})
2.5×10^{8}	245.217	0.00165 (1.7×10^{-3})
2.6×10^{8}	264.079	0.00175 (1.8×10^{-3})
2.8×10^{8}	282.942	0.0019 (1.9×10^{-3})
3×10^{8}	301.805	0.00205 (2.1×10^{-3})
3.2×10^{8}	320.668	0.00205 (2.1×10^{-3})
3.4×10^{8}	339.531	0.0022 (2.2×10^{-3})
3.6×10^{8}	358.393	0.0024 (2.4×10^{-3})



The graph above shows stress plotted against strain. From this graph I can see that stress is directly proportional to strain. The graph however does not show the entire stress strain graph of the material as there is no curve. This suggests that the results were not taken until the material used broke under tension.

The Diagram below shows an ideal stress strain graph. The straight section is the elastic region, in this region the material would return to its original length if the load were removed; the slope here is the Young's Modulus E, after this is the plastic region where any deformations are permanent. The point σ_u is the ultimate strength of the material; the maximum stress a material can withstand before it undergoes buckling. Then at the point the graph stops is the breaking stress.



The Young's Modulus is a measure of stiffness and is calculated using the equation

$$E = \frac{\sigma}{\varepsilon}$$

$$E = \frac{200}{0.00125}$$

$$E = 160\text{MPa}$$

From the results I can conclude that the experiment did work however, the experiment appears to have not been taken through to completion as there is no curve on my stress-strain graph. There may also have been a few inaccuracies, but this could be solved by using less then 3N steps