

UWTSD

Wales Institute of Science and Art



Prifysgol Cymru

Y Drindod Dewi Sant

University of Wales

Trinity Saint David

Tensile Test Lab Report

Engineering Science ACHA4002 & ACHA4028

Rhodri Jones

2305734

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Introduction

(65 words)

This laboratory report will discuss the experimental procedure of a tensile stress and yield stress test on different materials.

The report will also discuss the raw data, and will use graphs and tables to explain trends, an analysis of the data, a conclusion to discuss and compare researched results, and an evaluation and further work section which will discuss how the experiment could be improved.

Experimental procedure

(392 words)

Four materials were tested: The first piece, the black one, is made from PVC plastic, the second is made from aluminium, the third piece is made from duralumin, which is an aluminium (94.4%), copper (4%) and magnesium (0.5%) alloy (A Modak, 19/12/2022), and the last piece is made from steel.

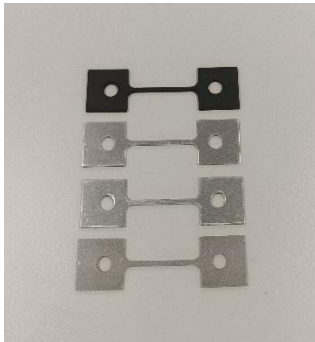


Figure 1 The experiment pieces before the experiment, Gray, 2024

Figure 1 shows the test pieces used for the experiment. They are presented in this shape so that the ends can be securely clamped and the centre section can be stretched by applying forces to the ends.

Figure 2 shows how the experiment was set up.

The test pieces were attached to the experimental apparatus via the two chucks in the middle. The two square pieces of the test sample are screwed into each chuck using the two square screws in the middle; this ensures the piece is securely held in place. The lower chuck is secured in place and does not move.

After a sample piece was secured into the equipment, the load nut at the top is turned. This pulls the top chuck upwards, which subsequently stretches the piece of material.

The load nut has 10 notches that go around the centre piece, each notch representing 0.1 mm of upward movement by the top chuck and a full turn equalling 1mm of upward movement of the top chuck.

The dial on the front shows the distance the top chuck has moved up. The dial works in increments of 0.01mm and where one full turn is 1 mm.

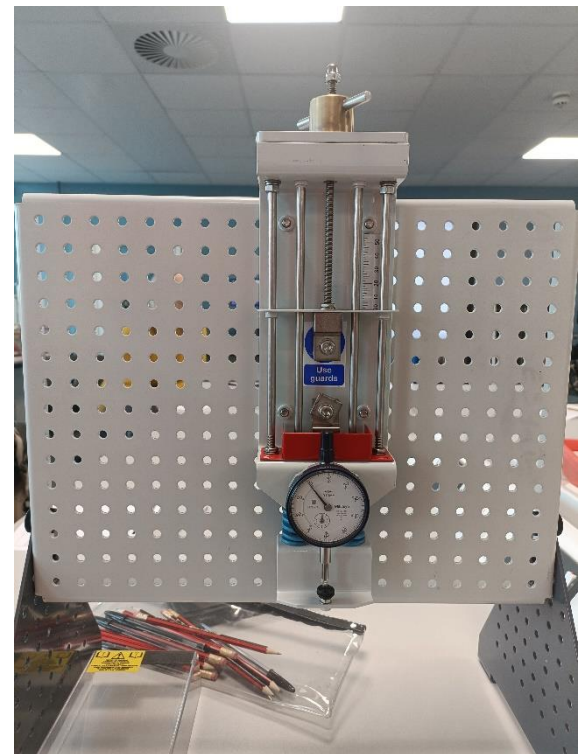


Figure 2 The testing kit setup before the experiment, Gray, 2024

For each material sample, one person turned the load nut by the specified increments in the tables provided, while another person read out the dial readings after each turn. The other members of the experiment recorded the values of each turn increment. This process would be repeated until the test piece snapped.

The length of each test piece was measured before and after the experiment in order to calculate the total stretch extension.

After the test piece snaps, it is removed from the test kit, placed back together to re-assemble its previous form and measured with a Vernier digital calliper to record the new length and calculate the extension. This new length is recorded for use in later calculations.

The elongation is calculated by using:

$$\frac{Final\ Length - Original\ Length}{Original\ Length} \times 100$$

Calculation of the elongation of the four samples, measured in mm:

$$\text{Steel elongation} = \frac{38.3-31}{31} \times 100 = 23.55\%$$

$$\text{Duralumin elongation} = \frac{33-31.1}{31.1} \times 100 = 6.11\%$$

$$\text{Aluminium elongation} = \frac{33.7-31}{31} \times 100 = 8.71\%$$

$$\text{PVC elongation} = \frac{43.9-30.9}{30.9} \times 100 = 42.07\%$$

Results

(37 words)

These are the tables showing the raw data from the experiment that was recorded at the time.

Specimen material: *Steel*
Original cross-sectional area (mm² or m²): *31 mm x 2 mm x 1 mm*
Original Length (mm): *31 mm / 36.3 mm*

Load Nut movement (mm)	Dial Indicator (mm)	Force (N)	Extension (mm)	Stress σ (N/m ²)	Nominal Strain ϵ
0	0	0	0	0	0
0.2	0.17				
0.4	0.33				
0.6	0.49				
0.8	0.65				
1.0	0.81				
1.2	0.97				
1.4	1.13				
1.6	1.29				
1.8	1.45				
2.0	1.61				
2.2	1.77				
2.4	1.93				
2.6	2.09				
2.8	2.25				
3.0	2.41				
3.2	2.57				
3.4	2.73				
3.6	2.89				
3.8	3.05				
4.0	3.21				
4.2	3.37				
4.4	3.53				
4.6	3.69				
4.8	3.85				
5.0	4.01				
5.2	4.17				
5.4	4.33				
5.6	4.49				
5.8	4.65				
6.0	4.81				
6.2	4.97				
6.4	5.13				
6.6	5.29				
6.8	5.45				
7.0	5.61				
7.2	5.77				
7.4	5.93				
7.6	6.09				
7.8	6.25				
8.0	6.41				
8.2	6.57				
8.4	6.73				
8.6	6.89				
8.8	7.05				
9.0	7.21				
9.2	7.37				
9.4	7.53				
9.6	7.69				
9.8	7.85				
10.0	8.01				
10.2	8.17				
10.4	8.33				
10.6	8.49				
10.8	8.65				
11.0	8.81				
11.2	8.97				
11.4	9.13				
11.6	9.29				
11.8	9.45				
12.0	9.61				
12.2	9.77				
12.4	9.93				
12.6	10.09				
12.8	10.25				
13.0	10.41				
13.2	10.57				
13.4	10.73				
13.6	10.89				
13.8	11.05				
14.0	11.21				
14.2	11.37				
14.4	11.53				
14.6	11.69				
14.8	11.85				
15.0	12.01				
15.2	12.17				
15.4	12.33				
15.6	12.49				
15.8	12.65				
16.0	12.81				
16.2	12.97				
16.4	13.13				
16.6	13.29				
16.8	13.45				
17.0	13.61				
17.2	13.77				
17.4	13.93				
17.6	14.09				
17.8	14.25				
18.0	14.41				
18.2	14.57				
18.4	14.73				
18.6	14.89				
18.8	15.05				
19.0	15.21				
19.2	15.37				
19.4	15.53				
19.6	15.69				
19.8	15.85				
20.0	16.01				
20.2	16.17				
20.4	16.33				
20.6	16.49				
20.8	16.65				
21.0	16.81				
21.2	16.97				
21.4	17.13				
21.6	17.29				
21.8	17.45				
22.0	17.61				
22.2	17.77				
22.4	17.93				
22.6	18.09				
22.8	18.25				
23.0	18.41				
23.2	18.57				
23.4	18.73				
23.6	18.89				
23.8	19.05				
24.0	19.21				
24.2	19.37				
24.4	19.53				
24.6	19.69				
24.8	19.85				
25.0	20.01				
25.2	20.17				
25.4	20.33				
25.6	20.49				
25.8	20.65				
26.0	20.81				
26.2	20.97				
26.4	21.13				
26.6	21.29				
26.8	21.45				
27.0	21.61				
27.2	21.77				
27.4	21.93				
27.6	22.09				
27.8	22.25				
28.0	22.41				
28.2	22.57				
28.4	22.73				
28.6	22.89				
28.8	23.05				
29.0	23.21				
29.2	23.37				
29.4	23.53				
29.6	23.69				
29.8	23.85				
30.0	24.01				
30.2	24.17				
30.4	24.33				
30.6	24.49				
30.8	24.65				
31.0	24.81				
31.2	24.97				
31.4	25.13				
31.6	25.29				
31.8	25.45				
32.0	25.61				
32.2	25.77				
32.4	25.93				
32.6	26.09				
32.8	26.25				
33.0	26.41				
33.2	26.57				
33.4	26.73				
33.6	26.89				
33.8	27.05				
34.0	27.21				
34.2	27.37				
34.4	27.53				
34.6	27.69				
34.8	27.85				
35.0	28.01				
35.2	28.17				
35.4	28.33				
35.6	28.49				
35.8	28.65				
36.0	28.81				
36.2	28.97				
36.4	29.13				
36.6	29.29				
36.8	29.45				
37.0	29.61				
37.2	29.77				
37.4	29.93				
37.6	30.09				
37.8	30.25				
38.0	30.41				
38.2	30.57				
38.4	30.73				
38.6	30.89				
38.8	31.05				
39.0	31.21				
39.2	31.37				
39.4	31.53				
39.6	31.69				
39.8	31.85				
40.0	32.01				
40.2	32.17				
40.4	32.33				
40.6	32.49				
40.8	32.65				
41.0	32.81				
41.2	32.97				
41.4	33.13				
41.6	33.29				
41.8	33.45				
42.0	33.61				
42.2	33.77				
42.4	33.93				
42.6	34.09				
42.8	34.25				
43.0	34.41				
43.2	34.57				
43.4	34.73				
43.6	34.89				
43.8	35.05				
44.0	35.21				
44.2	35.37				
44.4	35.53				
44.6	35.69				
44.8	35.85				
45.0	36.01				
45.2	36.17				
45.4	36.33				
45.6	36.49				
45.8	36.65				
46.0	36.81				
46.2	36.97				
46.4	37.13				
46.6	37.29				
46.8	37.45				
47.0	37.61				
47.2	37.77				
47.4	37.93				
47.6	38.09				
47.8	38.25				
48.0	38.41				
48.2	38.57				
48.4	38.73				
48.6	38.89				
48.8	39.05				
49.0	39.21				
49.2	39.37				
49.4	39.53				
49.6	39.69				
49.8	39.85				
50.0	40.01				
50.2	40.17				
50.4	40.33				
50.6	40.49				
50.8	40.65				
51.0	40.81				
51.2	40.97				
51.4	41.13				
51.6	41.29				
51.8	41.45				
52.0	41.61				
52.2	41.77				
52.4	41.93				
52.6	42.09				
52.8	42.25				
53.0	42.41				
53.2	42.57				
53.4	42.73				
53.6	42.89				
53.8	43.05				
54.0	43.21				
54.2	43.37				
54.4	43.53				
54.6	43.69				
54.8	43.85				
55.0	44.01				
55.2	44.17				
55.4	44.33				
55.6	44.49				
55.8	44.65				
56.0	44.81				
56.2	44.97				
56.4	45.13				
56.6	45.29				
56.8	45.45				
57.0	45.61				
57.2	45.77				
57.4	45.93				
57.6	46.09				
57.8	46.25				
58.0	46.41				
58.2	46.57				
58.4	46.73				
58.6	46.89				
58.8	47.05				
59.0	47.21				
59.2	47.37				
59.4	47.53				
59.6	47.69				
59.8	47.85				
60.0	48.01				
60.2	48.17				
60.4	48.33				
60.6	48.49				

Analysis

(510 words)

The objective of this experiment was to produce a table of data which can be used to measure the stress and strain for different materials, and then to use that data to calculate Young's modulus for the materials.

After the data had been collected, it was entered into an Excel spreadsheet so that it could be analysed and manipulated. Secondary data was produced for each table, and the primary and secondary graph was produced for each material.

After the extension had been calculated for each increment of the applied force, the stress and strain values were calculated as follows:

$$\text{stress} = \frac{\text{force}}{\text{cross-sectional area of sample}} \quad (\text{measured in N/m}^2)$$

and

$$\text{strain} = \frac{\text{extension}}{\text{original length}} \quad (\text{has no units})$$

For each stress/strain graph, the position of the Yield Point will be assessed. For each graph, the data up to and including the Yield Point will then be drawn in a new secondary graph. According to theory, this should produce a straight line graph which will give a gradient which represents Young's modulus for that material. The gradient will be calculated by Excel, and represents Young's modulus from this equation:

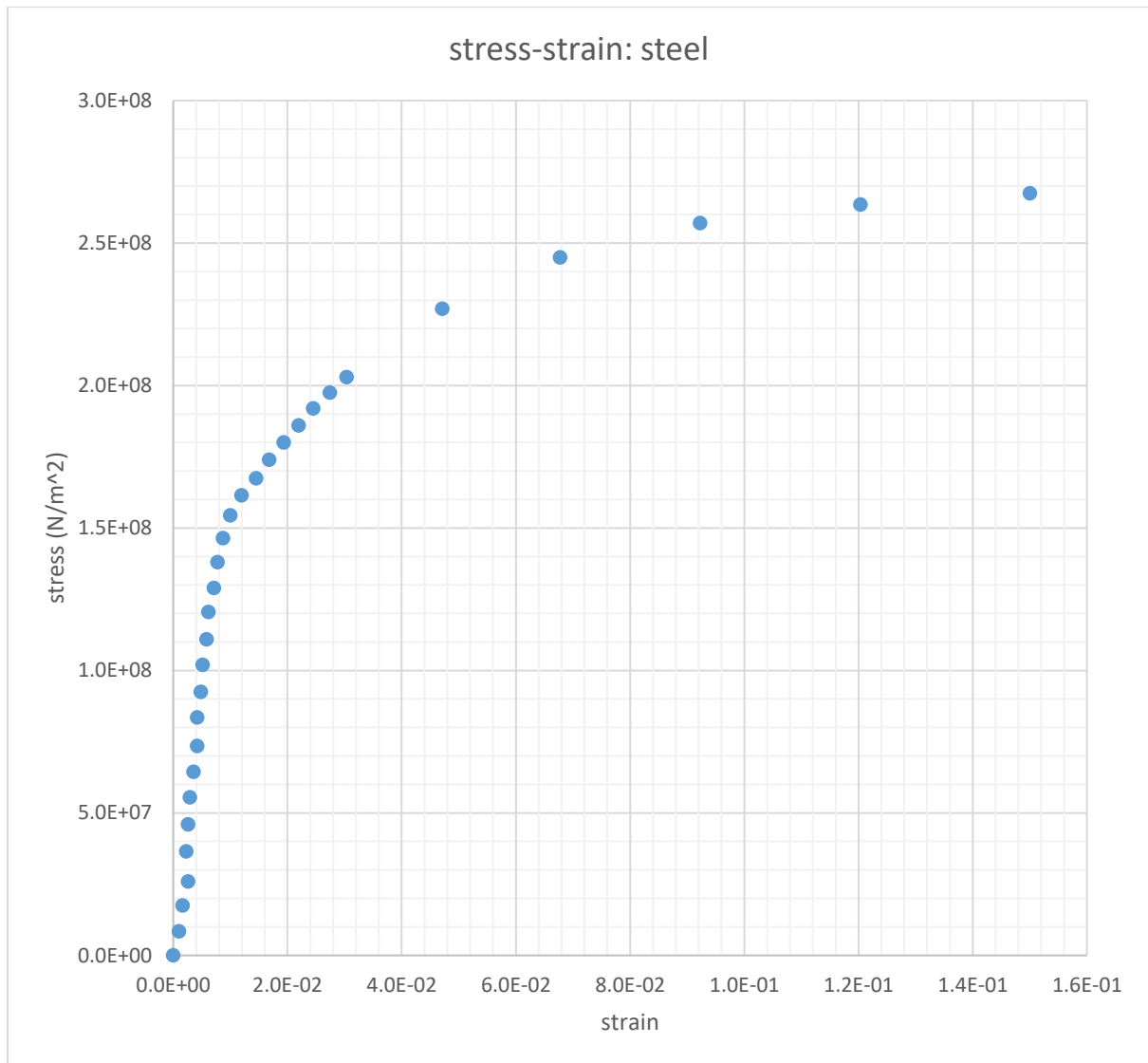
$$\text{Young's Modulus} = \frac{\text{stress}}{\text{strain}} \quad (\text{measured in N/m}^2)$$

In total, four materials were tested: steel, duralumin, aluminium and PVC.

On the following pages, the data table, primary graph and secondary graph for each material will be shown, together with brief comments.

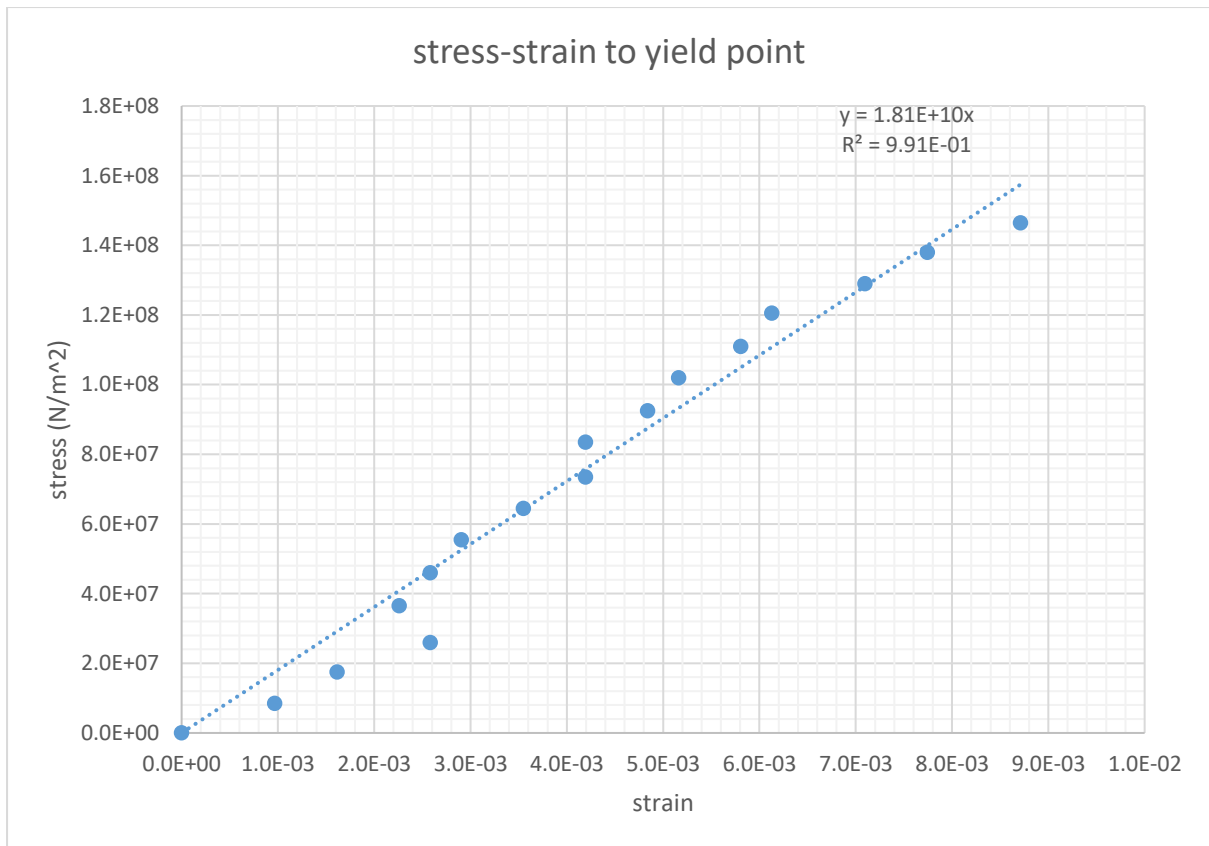
Steel

Load nut movement (mm)	Load nut movement (m)	Dial indicator (mm)	Dial indicator (m)	Original length (mm)	extension (mm)	extension (m)	Force (N)	Sample cross-sectional area (m ²)	Stress (N/m ²)	Strain	Young's Modulus (N/m ²)
0.0	0.0	0.00	0.00	31.0	0.00	0.0	0	2.E-06	0.0	0.0	"-"
0.2	2.0E-04	0.17	1.70E-04	31.0	0.03	3.0E-05	17	2.E-06	8.5E+06	9.7E-04	8.8E+09
0.4	4.0E-04	0.35	3.50E-04	31.0	0.05	5.0E-05	35	2.E-06	1.8E+07	1.6E-03	1.1E+10
0.6	6.0E-04	0.52	5.20E-04	31.0	0.08	8.0E-05	52	2.E-06	2.6E+07	2.6E-03	1.0E+10
0.8	8.0E-04	0.73	7.30E-04	31.0	0.07	7.0E-05	73	2.E-06	3.7E+07	2.3E-03	1.6E+10
1.0	1.0E-03	0.92	9.20E-04	31.0	0.08	8.0E-05	92	2.E-06	4.6E+07	2.6E-03	1.8E+10
1.2	1.2E-03	1.11	1.11E-03	31.0	0.09	9.0E-05	111	2.E-06	5.6E+07	2.9E-03	1.9E+10
1.4	1.4E-03	1.29	1.29E-03	31.0	0.11	1.1E-04	129	2.E-06	6.5E+07	3.5E-03	1.8E+10
1.6	1.6E-03	1.47	1.47E-03	31.0	0.13	1.3E-04	147	2.E-06	7.4E+07	4.2E-03	1.8E+10
1.8	1.8E-03	1.67	1.67E-03	31.0	0.13	1.3E-04	167	2.E-06	8.4E+07	4.2E-03	2.0E+10
2.0	2.0E-03	1.85	1.85E-03	31.0	0.15	1.5E-04	185	2.E-06	9.3E+07	4.8E-03	1.9E+10
2.2	2.2E-03	2.04	2.04E-03	31.0	0.16	1.6E-04	204	2.E-06	1.0E+08	5.2E-03	2.0E+10
2.4	2.4E-03	2.22	2.22E-03	31.0	0.18	1.8E-04	222	2.E-06	1.1E+08	5.8E-03	1.9E+10
2.6	2.6E-03	2.41	2.41E-03	31.0	0.19	1.9E-04	241	2.E-06	1.2E+08	6.1E-03	2.0E+10
2.8	2.8E-03	2.58	2.58E-03	31.0	0.22	2.2E-04	258	2.E-06	1.3E+08	7.1E-03	1.8E+10
3.0	3.0E-03	2.76	2.76E-03	31.0	0.24	2.4E-04	276	2.E-06	1.4E+08	7.7E-03	1.8E+10
3.2	3.2E-03	2.93	2.93E-03	31.0	0.27	2.7E-04	293	2.E-06	1.5E+08	8.7E-03	1.7E+10
3.4	3.4E-03	3.09	3.09E-03	31.0	0.31	3.1E-04	309	2.E-06	1.5E+08	1.0E-02	1.5E+10
3.6	3.6E-03	3.23	3.23E-03	31.0	0.37	3.7E-04	323	2.E-06	1.6E+08	1.2E-02	1.4E+10
3.8	3.8E-03	3.35	3.35E-03	31.0	0.45	4.5E-04	335	2.E-06	1.7E+08	1.5E-02	1.2E+10
4.0	4.0E-03	3.48	3.48E-03	31.0	0.52	5.2E-04	348	2.E-06	1.7E+08	1.7E-02	1.0E+10
4.2	4.2E-03	3.60	3.60E-03	31.0	0.60	6.0E-04	360	2.E-06	1.8E+08	1.9E-02	9.3E+09
4.4	4.4E-03	3.72	3.72E-03	31.0	0.68	6.8E-04	372	2.E-06	1.9E+08	2.2E-02	8.5E+09
4.6	4.6E-03	3.84	3.84E-03	31.0	0.76	7.6E-04	384	2.E-06	1.9E+08	2.5E-02	7.8E+09
4.8	4.8E-03	3.95	3.95E-03	31.0	0.85	8.5E-04	395	2.E-06	2.0E+08	2.7E-02	7.2E+09
5.0	5.0E-03	4.06	4.06E-03	31.0	0.94	9.4E-04	406	2.E-06	2.0E+08	3.0E-02	6.7E+09
6.0	6.0E-03	4.54	4.54E-03	31.0	1.46	1.5E-03	454	2.E-06	2.3E+08	4.7E-02	4.8E+09
7.0	7.0E-03	4.90	4.90E-03	31.0	2.10	2.1E-03	490	2.E-06	2.5E+08	6.8E-02	3.6E+09
8.0	8.0E-03	5.14	5.14E-03	31.0	2.86	2.9E-03	514	2.E-06	2.6E+08	9.2E-02	2.8E+09
9.0	9.0E-03	5.27	5.27E-03	31.0	3.73	3.7E-03	527	2.E-06	2.6E+08	1.2E-01	2.2E+09
10.0	1.0E-02	5.35	5.35E-03	31.0	4.65	4.7E-03	535	2.E-06	2.7E+08	1.5E-01	1.8E+09



The YIELD POINT is assessed at being at the data point $(1.5 \times 10^8, 8.7 \times 10^{-3})$.

So a new graph will be plotted showing only data up to and including the YIELD POINT.

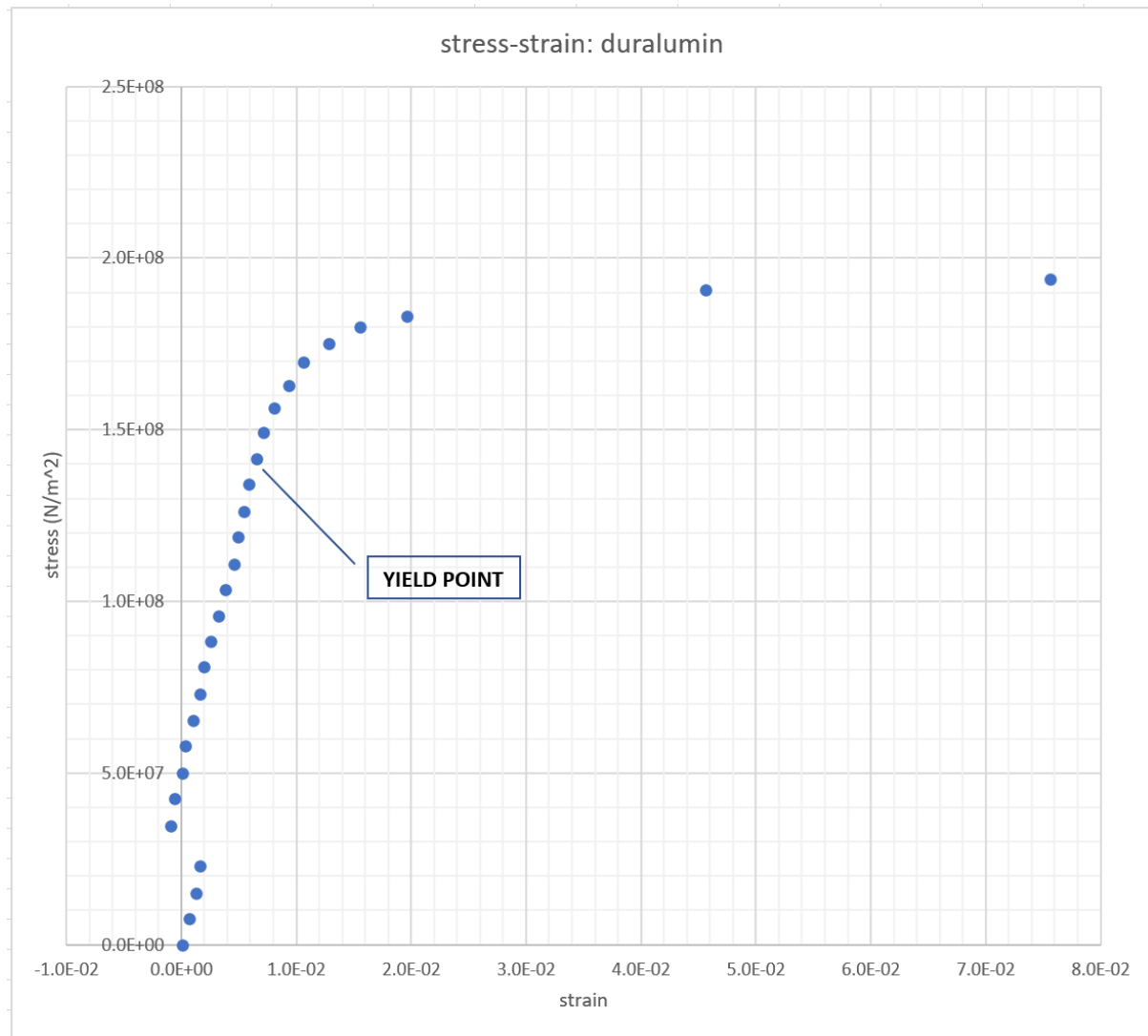


This graph analysis suggests that the gradient is $1.81 \times 10^{10} \text{ N/m}^2$.

Since the gradient is calculated as being stress/strain, this also is the experimental value for Young's Modulus for this material.

Duralumin

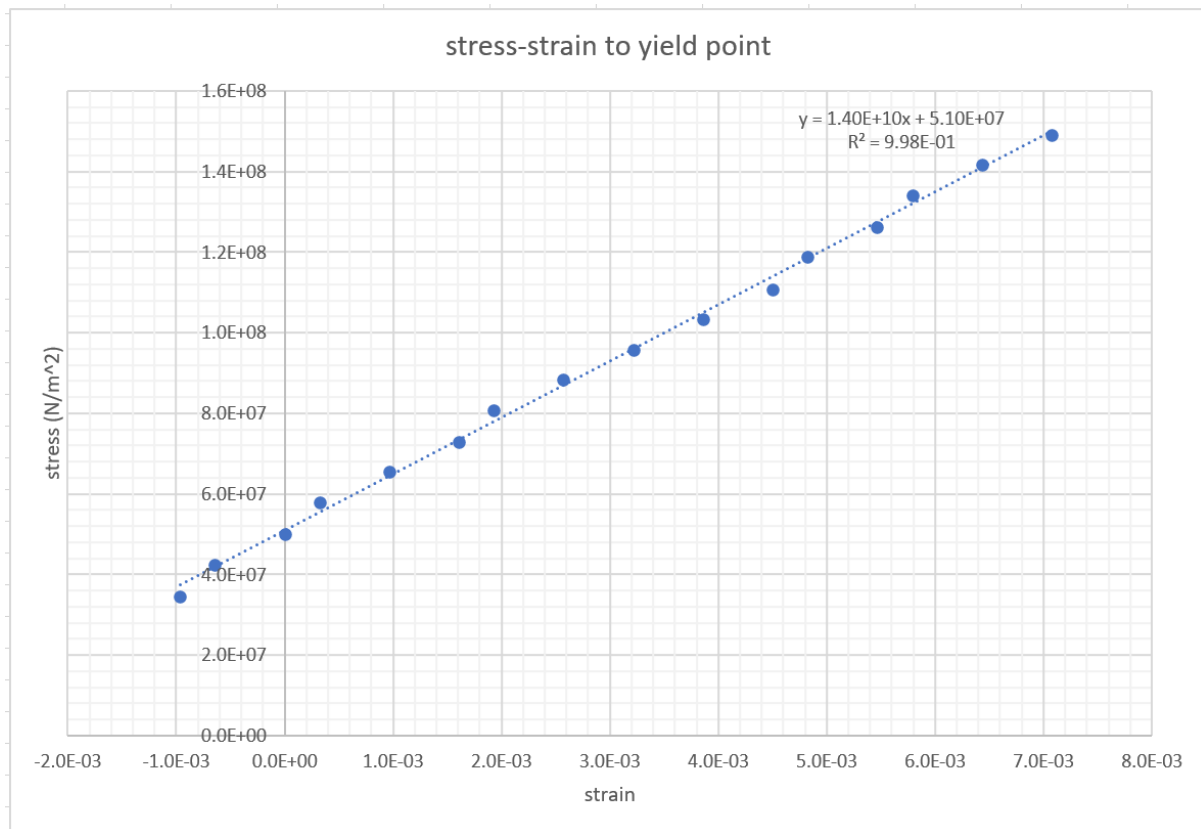
Load nut movement (mm)	Load nut movement (m)	Dial indicator (mm)	Dial indicator (m)	Original length (mm)	extension (mm)	extension (m)	Force (N)	Sample cross-sectional area (m ²)	Stress (N/m ²)	Strain	Young's Modulus (N/m ²)
0.0	0.0	0.00	0.00	31.1	0.00	0.0	0	2.E-06	0.0	0.0	"."
0.2	2.0E-04	0.18	1.80E-04	31.1	0.02	2.0E-05	18	2.E-06	7.5E+06	6.4E-04	1.2E+10
0.4	4.0E-04	0.36	3.60E-04	31.1	0.04	4.0E-05	36	2.E-06	1.5E+07	1.3E-03	1.2E+10
0.6	6.0E-04	0.55	5.50E-04	31.1	0.05	5.0E-05	55	2.E-06	2.3E+07	1.6E-03	1.4E+10
0.8	8.0E-04	0.83	8.30E-04	31.1	-0.03	-3.0E-05	83	2.E-06	3.5E+07	-9.6E-04	-3.6E+10
1.0	1.0E-03	1.02	1.02E-03	31.1	-0.02	-2.0E-05	102	2.E-06	4.3E+07	-6.4E-04	-6.6E+10
1.2	1.2E-03	1.20	1.20E-03	31.1	0.00	0.0E+00	120	2.E-06	5.0E+07	0.0E+00	#DIV/0!
1.4	1.4E-03	1.39	1.39E-03	31.1	0.01	1.0E-05	139	2.E-06	5.8E+07	3.2E-04	1.8E+11
1.6	1.6E-03	1.57	1.57E-03	31.1	0.03	3.0E-05	157	2.E-06	6.5E+07	9.6E-04	6.8E+10
1.8	1.8E-03	1.75	1.75E-03	31.1	0.05	5.0E-05	175	2.E-06	7.3E+07	1.6E-03	4.5E+10
2.0	2.0E-03	1.94	1.94E-03	31.1	0.06	6.0E-05	194	2.E-06	8.1E+07	1.9E-03	4.2E+10
2.2	2.2E-03	2.12	2.12E-03	31.1	0.08	8.0E-05	212	2.E-06	8.8E+07	2.6E-03	3.4E+10
2.4	2.4E-03	2.30	2.30E-03	31.1	0.10	1.0E-04	230	2.E-06	9.6E+07	3.2E-03	3.0E+10
2.6	2.6E-03	2.48	2.48E-03	31.1	0.12	1.2E-04	248	2.E-06	1.0E+08	3.9E-03	2.7E+10
2.8	2.8E-03	2.66	2.66E-03	31.1	0.14	1.4E-04	266	2.E-06	1.1E+08	4.5E-03	2.5E+10
3.0	3.0E-03	2.85	2.85E-03	31.1	0.15	1.5E-04	285	2.E-06	1.2E+08	4.8E-03	2.5E+10
3.2	3.2E-03	3.03	3.03E-03	31.1	0.17	1.7E-04	303	2.E-06	1.3E+08	5.5E-03	2.3E+10
3.4	3.4E-03	3.22	3.22E-03	31.1	0.18	1.8E-04	322	2.E-06	1.3E+08	5.8E-03	2.3E+10
3.6	3.6E-03	3.40	3.40E-03	31.1	0.20	2.0E-04	340	2.E-06	1.4E+08	6.4E-03	2.2E+10
3.8	3.8E-03	3.58	3.58E-03	31.1	0.22	2.2E-04	358	2.E-06	1.5E+08	7.1E-03	2.1E+10
4.0	4.0E-03	3.75	3.75E-03	31.1	0.25	2.5E-04	375	2.E-06	1.6E+08	8.0E-03	1.9E+10
4.2	4.2E-03	3.91	3.91E-03	31.1	0.29	2.9E-04	391	2.E-06	1.6E+08	9.3E-03	1.7E+10
4.4	4.4E-03	4.07	4.07E-03	31.1	0.33	3.3E-04	407	2.E-06	1.7E+08	1.1E-02	1.6E+10
4.6	4.6E-03	4.20	4.20E-03	31.1	0.40	4.0E-04	420	2.E-06	1.8E+08	1.3E-02	1.4E+10
4.8	4.8E-03	4.32	4.32E-03	31.1	0.48	4.8E-04	432	2.E-06	1.8E+08	1.5E-02	1.2E+10
5.0	5.0E-03	4.39	4.39E-03	31.1	0.61	6.1E-04	439	2.E-06	1.8E+08	2.0E-02	9.3E+09
6.0	6.0E-03	4.58	4.58E-03	31.1	1.42	1.4E-03	458	2.E-06	1.9E+08	4.6E-02	4.2E+09
7.0	7.0E-03	4.65	4.65E-03	31.1	2.35	2.4E-03	465	2.E-06	1.9E+08	7.6E-02	2.6E+09



The YIELD POINT is assessed at being at the data point (1.5×10^8 , 7.1×10^{-3}).

There is a discrepancy between the first four data points and the rest of the data points. This will be discussed later.

These four points will be discounted, and a new graph will be plotted showing only data up to and including the YIELD POINT.

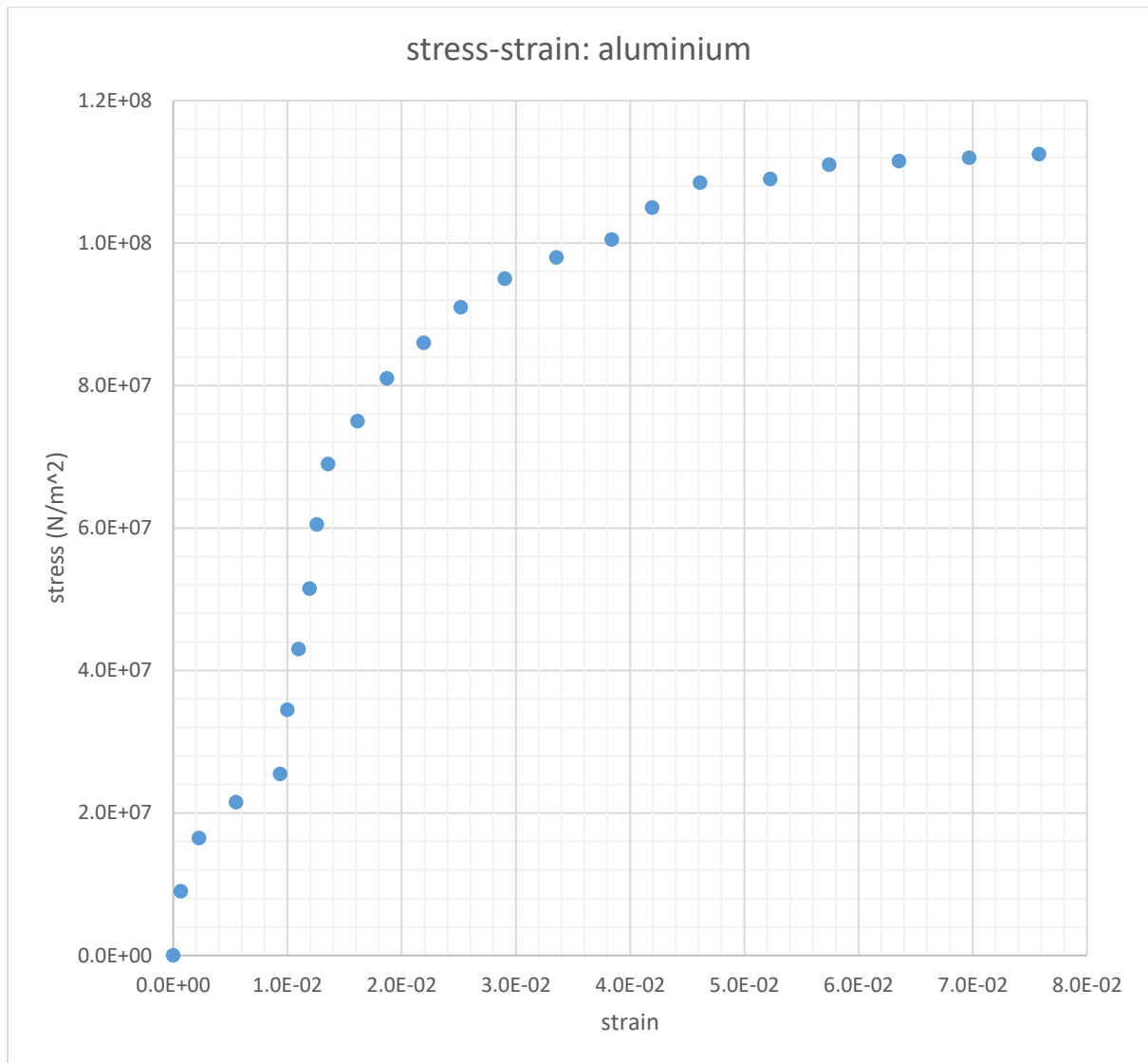


This graph analysis suggests that the gradient is $1.40 \times 10^{10} \text{ N/m}^2$.

Since the gradient is calculated as being stress/strain, this also is the experimental value for Young's Modulus for this material.

Aluminium

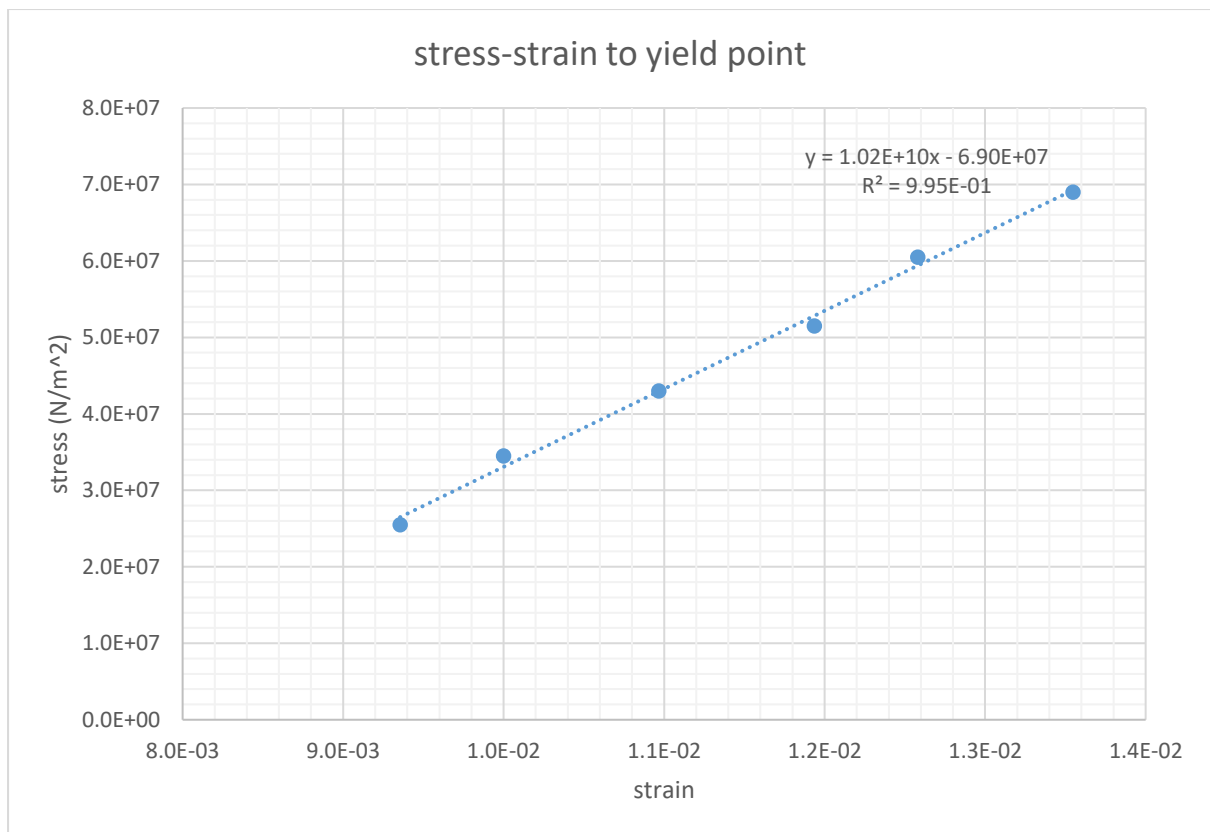
Load nut movement (mm)	Load nut movement (m)	Dial indicator (mm)	Dial indicator (m)	Original length (mm)	extension (mm)	extension (m)	Force (N)	Sample cross-sectional area (m ²)	Stress (N/m ²)	Strain	Young's Modulus (N/m ²)
0.0	0.0	0.00	0.00	31.0	0.00	0.0	0	2.E-06	0.0	0.0	"-"
0.2	2.0E-04	0.18	1.80E-04	31.0	0.02	2.0E-05	18	2.E-06	9.0E+06	6.5E-04	1.4E+10
0.4	4.0E-04	0.33	3.30E-04	31.0	0.07	7.0E-05	33	2.E-06	1.7E+07	2.3E-03	7.3E+09
0.6	6.0E-04	0.43	4.30E-04	31.0	0.17	1.7E-04	43	2.E-06	2.2E+07	5.5E-03	3.9E+09
0.8	8.0E-04	0.51	5.10E-04	31.0	0.29	2.9E-04	51	2.E-06	2.6E+07	9.4E-03	2.7E+09
1.0	1.0E-03	0.69	6.90E-04	31.0	0.31	3.1E-04	69	2.E-06	3.5E+07	1.0E-02	3.5E+09
1.2	1.2E-03	0.86	8.60E-04	31.0	0.34	3.4E-04	86	2.E-06	4.3E+07	1.1E-02	3.9E+09
1.4	1.4E-03	1.03	1.03E-03	31.0	0.37	3.7E-04	103	2.E-06	5.2E+07	1.2E-02	4.3E+09
1.6	1.6E-03	1.21	1.21E-03	31.0	0.39	3.9E-04	121	2.E-06	6.1E+07	1.3E-02	4.8E+09
1.8	1.8E-03	1.38	1.38E-03	31.0	0.42	4.2E-04	138	2.E-06 (Chart Area)	6.9E+07	1.4E-02	5.1E+09
2.0	2.0E-03	1.50	1.50E-03	31.0	0.50	5.0E-04	150	2.E-06	7.5E+07	1.6E-02	4.7E+09
2.2	2.2E-03	1.62	1.62E-03	31.0	0.58	5.8E-04	162	2.E-06	8.1E+07	1.9E-02	4.3E+09
2.4	2.4E-03	1.72	1.72E-03	31.0	0.68	6.8E-04	172	2.E-06	8.6E+07	2.2E-02	3.9E+09
2.6	2.6E-03	1.82	1.82E-03	31.0	0.78	7.8E-04	182	2.E-06	9.1E+07	2.5E-02	3.6E+09
2.8	2.8E-03	1.90	1.90E-03	31.0	0.90	9.0E-04	190	2.E-06	9.5E+07	2.9E-02	3.3E+09
3.0	3.0E-03	1.96	1.96E-03	31.0	1.04	1.0E-03	196	2.E-06	9.8E+07	3.4E-02	2.9E+09
3.2	3.2E-03	2.01	2.01E-03	31.0	1.19	1.2E-03	201	2.E-06	1.0E+08	3.8E-02	2.6E+09
3.4	3.4E-03	2.10	2.10E-03	31.0	1.30	1.3E-03	210	2.E-06	1.1E+08	4.2E-02	2.5E+09
3.6	3.6E-03	2.17	2.17E-03	31.0	1.43	1.4E-03	217	2.E-06	1.1E+08	4.6E-02	2.4E+09
3.8	3.8E-03	2.18	2.18E-03	31.0	1.62	1.6E-03	218	2.E-06	1.1E+08	5.2E-02	2.1E+09
4.0	4.0E-03	2.22	2.22E-03	31.0	1.78	1.8E-03	222	2.E-06	1.1E+08	5.7E-02	1.9E+09
4.2	4.2E-03	2.23	2.23E-03	31.0	1.97	2.0E-03	223	2.E-06	1.1E+08	6.4E-02	1.8E+09
4.4	4.4E-03	2.24	2.24E-03	31.0	2.16	2.2E-03	224	2.E-06	1.1E+08	7.0E-02	1.6E+09
4.6	4.6E-03	2.25	2.25E-03	31.0	2.35	2.4E-03	225	2.E-06	1.1E+08	7.6E-02	1.5E+09



The YIELD POINT is assessed at being at the data point (6.9×10^7 , 1.4×10^{-2}).

There is a discrepancy between the first four data points and the rest of the data points. This will be discussed later.

These four points will be discounted, and a new graph will be plotted showing only data up to and including the YIELD POINT.

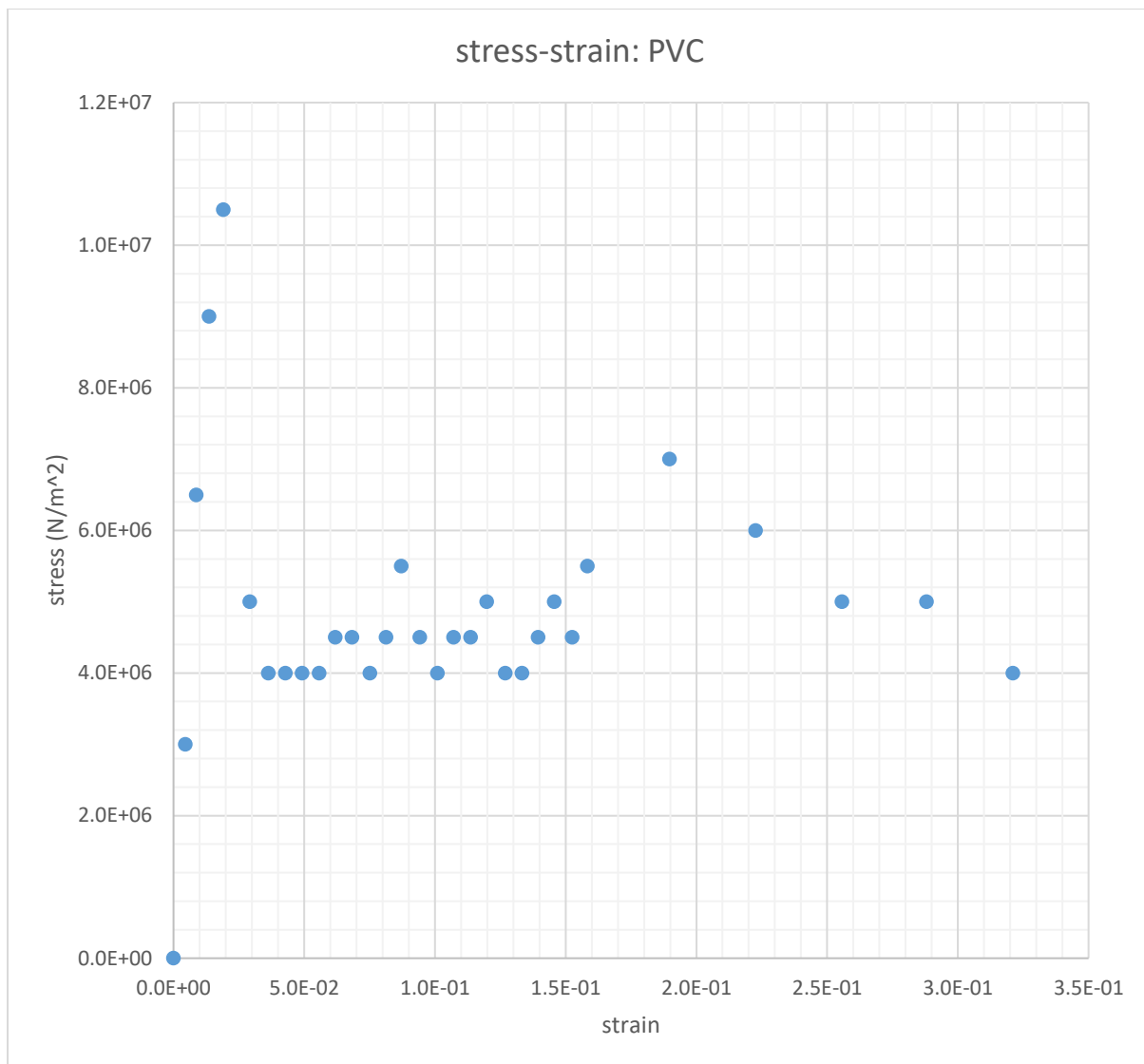


This graph analysis suggests that the gradient is $1.02 \times 10^{10} \text{ N/m}^2$.

Since the gradient is calculated as being stress/strain, this also is the experimental value for Young's Modulus for this material.

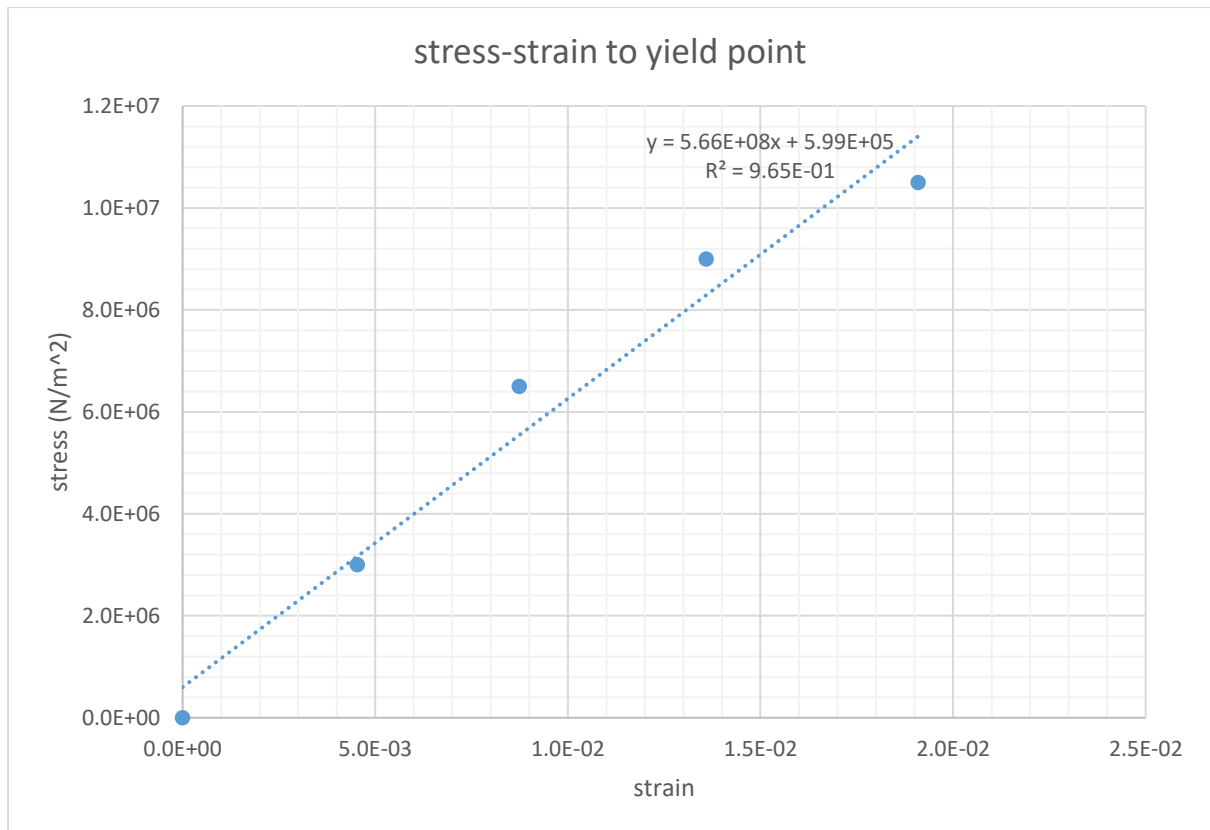
PVC

Load nut movement (mm)	Load nut movement (m)	Dial indicator (mm)	Dial indicator (m)	Original length (mm)	extension (mm)	extension (m)	Force (N)	Sample cross-sectional area (m ²)	Stress (N/m ²)	Strain	Young's Modulus (N/m ²)
0.0	0.0	0.00	0.00	30.9	0.00	0.0	0	2.E-06	0.0	0.0	"_"
0.2	2.0E-04	0.06	6.00E-05	30.9	0.14	1.4E-04	6	2.E-06	3.0E+06	4.5E-03	6.6E+08
0.4	4.0E-04	0.13	1.30E-04	30.9	0.27	2.7E-04	13	2.E-06	6.5E+06	8.7E-03	7.4E+08
0.6	6.0E-04	0.18	1.80E-04	30.9	0.42	4.2E-04	18	2.E-06	9.0E+06	1.4E-02	6.6E+08
0.8	8.0E-04	0.21	2.10E-04	30.9	0.59	5.9E-04	21	2.E-06	1.1E+07	1.9E-02	5.5E+08
1.0	1.0E-03	0.10	1.00E-04	30.9	0.90	9.0E-04	10	2.E-06	5.0E+06	2.9E-02	1.7E+08
1.2	1.2E-03	0.08	8.00E-05	30.9	1.12	1.1E-03	8	2.E-06	4.0E+06	3.6E-02	1.1E+08
1.4	1.4E-03	0.08	8.00E-05	30.9	1.32	1.3E-03	8	2.E-06	4.0E+06	4.3E-02	9.4E+07
1.6	1.6E-03	0.08	8.00E-05	30.9	1.52	1.5E-03	8	2.E-06	4.0E+06	4.9E-02	8.1E+07
1.8	1.8E-03	0.08	8.00E-05	30.9	1.72	1.7E-03	8	2.E-06	4.0E+06	5.6E-02	7.2E+07
2.0	2.0E-03	0.09	9.00E-05	30.9	1.91	1.9E-03	9	2.E-06	4.5E+06	6.2E-02	7.3E+07
2.2	2.2E-03	0.09	9.00E-05	30.9	2.11	2.1E-03	9	2.E-06	4.5E+06	6.8E-02	6.6E+07
2.4	2.4E-03	0.08	8.00E-05	30.9	2.32	2.3E-03	8	2.E-06	4.0E+06	7.5E-02	5.3E+07
2.6	2.6E-03	0.09	9.00E-05	30.9	2.51	2.5E-03	9	2.E-06	4.5E+06	8.1E-02	5.5E+07
2.8	2.8E-03	0.11	1.10E-04	30.9	2.69	2.7E-03	11	2.E-06	5.5E+06	8.7E-02	6.3E+07
3.0	3.0E-03	0.09	9.00E-05	30.9	2.91	2.9E-03	9	2.E-06	4.5E+06	9.4E-02	4.8E+07
3.2	3.2E-03	0.08	8.00E-05	30.9	3.12	3.1E-03	8	2.E-06	4.0E+06	1.0E-01	4.0E+07
3.4	3.4E-03	0.09	9.00E-05	30.9	3.31	3.3E-03	9	2.E-06	4.5E+06	1.1E-01	4.2E+07
3.6	3.6E-03	0.09	9.00E-05	30.9	3.51	3.5E-03	9	2.E-06	4.5E+06	1.1E-01	4.0E+07
3.8	3.8E-03	0.10	1.00E-04	30.9	3.70	3.7E-03	10	2.E-06	5.0E+06	1.2E-01	4.2E+07
4.0	4.0E-03	0.08	8.00E-05	30.9	3.92	3.9E-03	8	2.E-06	4.0E+06	1.3E-01	3.2E+07
4.2	4.2E-03	0.08	8.00E-05	30.9	4.12	4.1E-03	8	2.E-06	4.0E+06	1.3E-01	3.0E+07
4.4	4.4E-03	0.09	9.00E-05	30.9	4.31	4.3E-03	9	2.E-06	4.5E+06	1.4E-01	3.2E+07
4.6	4.6E-03	0.10	1.00E-04	30.9	4.50	4.5E-03	10	2.E-06	5.0E+06	1.5E-01	3.4E+07
4.8	4.8E-03	0.09	9.00E-05	30.9	4.71	4.7E-03	9	2.E-06	4.5E+06	1.5E-01	3.0E+07
5.0	5.0E-03	0.11	1.10E-04	30.9	4.89	4.9E-03	11	2.E-06	5.5E+06	1.6E-01	3.5E+07
6.0	6.0E-03	0.14	1.40E-04	30.9	5.86	5.9E-03	14	2.E-06	7.0E+06	1.9E-01	3.7E+07
7.0	7.0E-03	0.12	1.20E-04	30.9	6.88	6.9E-03	12	2.E-06	6.0E+06	2.2E-01	2.7E+07
8.0	8.0E-03	0.10	1.00E-04	30.9	7.90	7.9E-03	10	2.E-06	5.0E+06	2.6E-01	2.0E+07
9.0	9.0E-03	0.10	1.00E-04	30.9	8.90	8.9E-03	10	2.E-06	5.0E+06	2.9E-01	1.7E+07
10.0	1.0E-02	0.08	8.00E-05	30.9	9.92	9.9E-03	8	2.E-06	4.0E+06	3.2E-01	1.2E+07



The YIELD POINT cannot be assessed as the data points do not form a recognisable pattern.

However, it might be that there is a discernible pattern in just the first 5 data points. These will be plotted in the graph below.



This graph analysis suggests that the gradient is $5.66 \times 10^8 \text{ N/m}^2$.

Since the gradient is calculated as being stress/strain, this also is the experimental value for Young's Modulus for this material.

Conclusions

(306 words)

Part of the brief was to find the tensile stress and yield stress for each material.

The yield stress is defined as being stress value at the point where Hooke's law is no longer obeyed. In other words, the stress value at the point where the graph first stops being straight.

The tensile strength is defined as being the maximum stress before the material breaks.

Both of these values are found by looking at the relevant graph for each material:

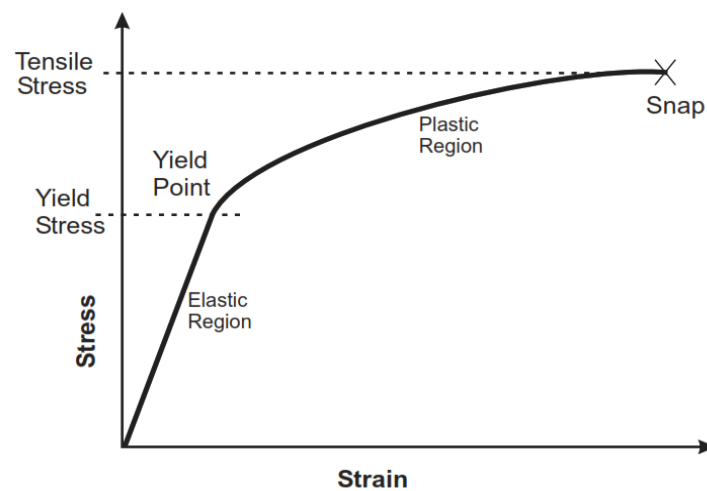


Figure 50 Stress and Strain chart

Experimental Values:

MATERIAL	YIELD STRESS (N/m²)	TENSILE STRENGTH (N/m²)
STEEL	1.4×10^8	2.7×10^8
DURALUMIN	1.4×10^8	1.9×10^8
ALUMINIUM	6.9×10^7	1.1×10^8
PVC	could not be determined	4.0×10^6

Researched Values: <https://www.matweb.com/>

MATERIAL	YIELD STRESS (N/m²)	TENSILE STRENGTH (N/m²)
STEEL	3.5×10^8	4.2×10^8
DURALUMIN	4.6×10^8	7.3×10^8
ALUMINIUM	2.7×10^8	3.1×10^8
PVC	3.45×10^6 to 7.31×10^7	1.43×10^7 to 5.52×10^7

From the analysis of the data and graphs, the following table is being produced for the experimental values for Young's modulus for each material. The table also includes actual values:

Experimental Values vs Actual Values:

https://www.engineeringtoolbox.com/young-modulus-d_417.html

MATERIAL	EXPERIMENTAL YOUNG'S MODULUS (N/m²)	ACTUAL YOUNG'S MODULUS (N/m²)
STEEL	1.81×10^{10}	2.00×10^{11} to 2.15×10^{11}
DURALUMIN	1.40×10^{10}	7.24×10^{10}
ALUMINIUM	1.02×10^{10}	6.9×10^{10}
PVC	5.66×10^8	2.4×10^9 to 4.1×10^9

Data trends seen within graphical results

1: Steel

The primary graph shows results in a format which was expected, and which matches classical results. The first part shows a linear relationship, up to the Yield Point, and then follows a reasonably consistent curve until the sample snapped.

2: Duralumin

In general, the primary graph shows results in a format which was expected, and which matches classical results. However, there is a clear discrepancy between the four and fifth point. Despite this, there were a reasonable number of data points showing a linear relationship which could be used for the secondary graph.

3: Aluminium

In general, the primary graph shows results in a format which was expected, and which matches classical results. However, there is a clear discrepancy between the four and fifth point. This only left six points showing a linear relationship which could be used for the secondary graph. This is not enough data points for an ideal result.

4: PVC

On first inspection, this graph does not seem to show a trend. But when looking at the first five points, it might possibly be inferred that they suggest a linear relationship, and that worthy the production of the secondary graph.

Evaluation

(142 words)

Measurement precision:

it is felt that the precision of measurements taken the experiment with more than sufficient to produce meaningful graphs.

Systematic errors:

There may have been errors in the techniques used during the experiment: The graphs for Duralumin and aluminium showed an anomaly which could be down to the human error in the method which might include the apparatus not being correctly manipulated. The graph for PVC did not produce discernible trends, and suggests that the experiment did not run as intended.

Evaluation of graphs:

Excel was used to evaluate the R^2 value for each of the secondary graphs for each of the four materials. The R^2 value shows how well the trendline fits the plotted data points. Despite the issues described above, the lowest of all the four R^2 values was 96.5%, which still suggests a reasonable level of confidence.

Further work

(144 words)

Repeated readings:

Due to time limitations, each experiment was only performed once. Ideally, each experiment should be repeated three or more times in order to improve accuracy and reliability of results.

It is suggested that the absolute minimum number of data points needed in order to produce meaningful graphical results is ten, whereas the preferred number of data points might be 30 or more.

Human error:

While the provided equipment was suitable to achieve the results required, automated testing equipment would reduce opportunities for human error and saw produce more reliable results.

Data trends:

If the experiment was to be repeated, it would be beneficial to record each new data point on the primary graph as the experiment proceeds. This would allow anomalies in the results to be spotted immediately, which would allow spare a mentor to monitor and alter experimental techniques as required.

References

A Modak, 19/12/2022 [Alloy Duralumin - Uses, Properties, and Benefits](#) Accessed 3/12/2024

<https://www.matweb.com/> Accessed 6/12/2024