Experiment 1

Young's Modulus

Objectives:

i) To find the relationship between tensile stress and strain for the given materials.

ii) To ascertain modulus of elasticity, elastic region, plastic region, yield point and the break point parameters from a plot of stress versus strain.

iii) To understand the type and sources of experimental errors.

iv) To clearly and correctly report measurements and the uncertainties in those measurements.

Result:

Material Type:				**Average**	**Error**
Number of measurement	**1**	**2**	**3**		
Gage length BEFORE testing, $L_0 \pm 0.01$ (mm)	78.68	78.81	78.12	78.54	±0.22
Gage length AFTER testing, Lf ± 0.01 (mm)	79.42	79.80	79.7	79.64	±0.12
Extension, δ = Lf - L0 (mm)	1.10				±0.26
Percentage elongation (PE)	1.40%				-
Width of specimen BEFORE testing, ± 0.01 (mm)	4.00	3.99	4.16	4.05	±0.06
Thickness of specimen BEFORE testing, ± 0.01 (mm)	0.23	0.21	0.27	0.24	±0.03
Width of specimen AFTER testing, ± 0.01 (mm)	3.83	3.95	3.92	3.90	±0.04
Thickness of specimen AFTER testing, ± 0.01 (mm)	0.28	0.24	0.24	0.25	±0.02
Cross Section Area BEFORE testing (A/mm^2)	0.972				±0.123
Cross Section Area AFTER testing (A/mm^2)	0.975				±0.079
Percent reduction in area (PRA)	-0.31%				-

Analysis: (Graphs)

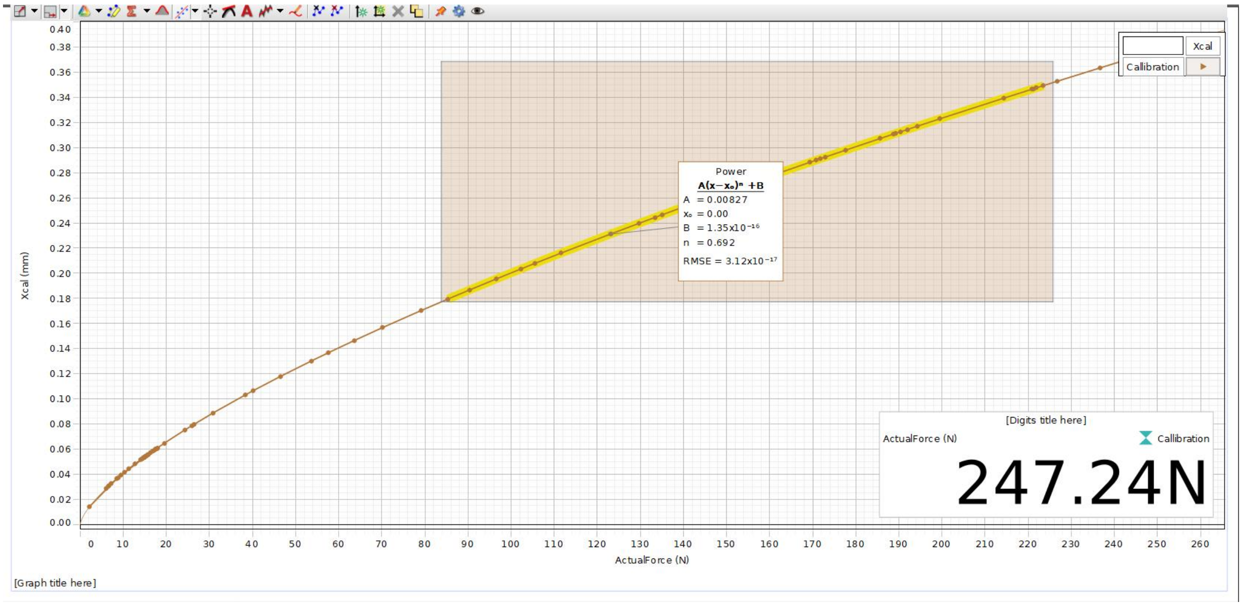


Figure 1. Calibration Graph

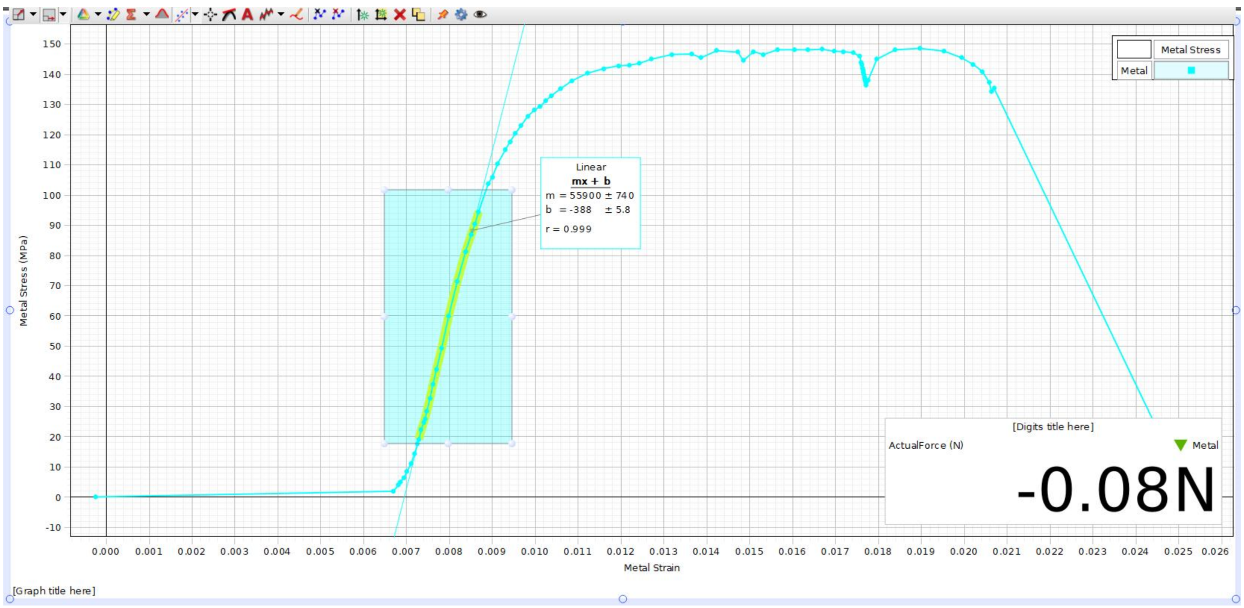


Figure 2. Stress vs Strain graph using PASCO Capstone

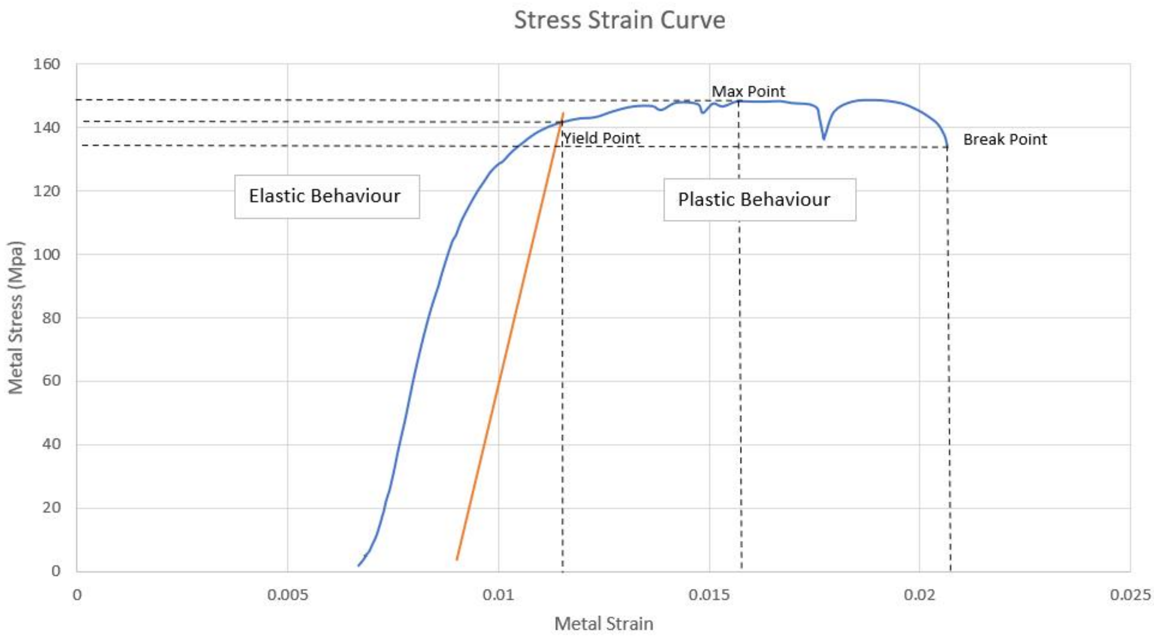


Figure 3. Stress vs Strain graph using Microsoft Excel

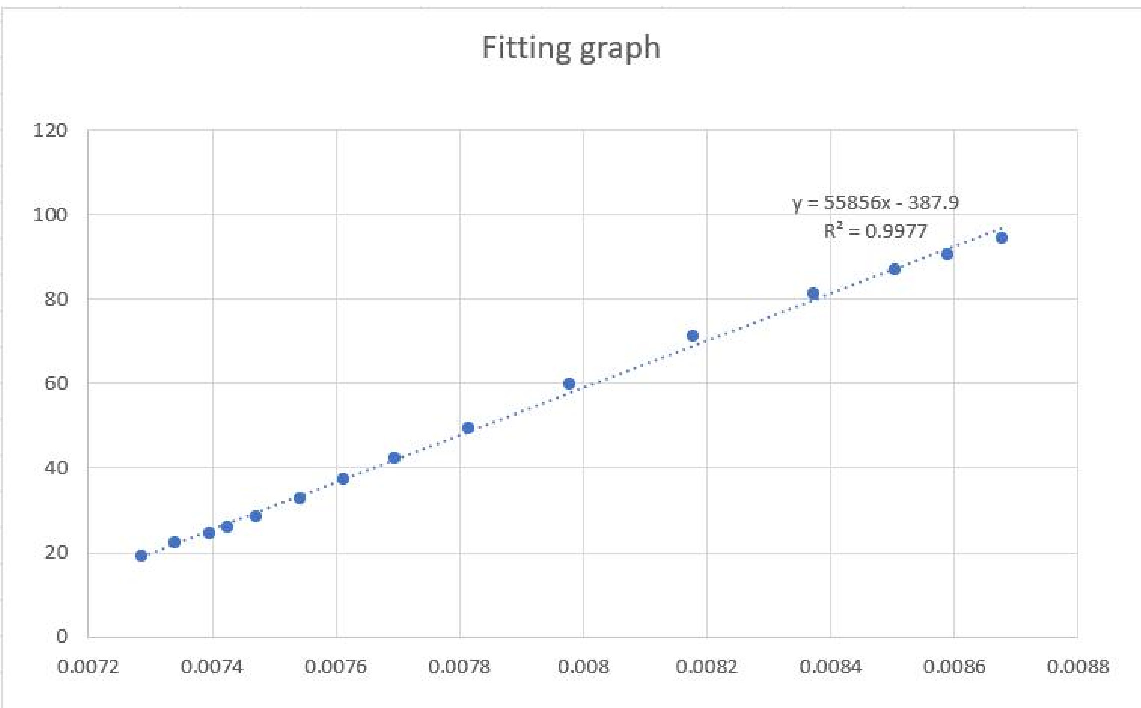


Figure 4. Fitting graph

Analysis: (Calculations)

Gage length BEFORE testing, L_0

i) Standard Error = $\sqrt{\frac{\sum_{i=1}^{n}(l_i - l_{mean})^2}{n(n-1)}}$

$= \sqrt{\frac{(78.68-78.54)^2 + (78.81-78.54)^2 + (78.12-78.54)^2}{3(2)}}$

= 0.212 mm

ii) System uncertainty = ±0.01 mm

iii) Combined uncertainty = ± $\sqrt{(Measurement\ Uncertainty)^2 + (System\ Uncertainty)^2}$

$= \pm\sqrt{(0.212)^2 + (0.01)^2}$

= ± 0.2122 mm ≈ 0.22 mm

Gage length AFTER testing, L_f

i) Standard Error = $\sqrt{\frac{\sum_{i=1}^{n}(l_i - l_{mean})^2}{n(n-1)}}$

$= \sqrt{\frac{(79.42-79.64)^2 + (79.80-79.64)^2 + (79.70-79.64)^2}{3(2)}}$

= 0.114 mm

ii) System uncertainty = ±0.01 mm

iii) Combined uncertainty = ± $\sqrt{(Measurement\ Uncertainty)^2 + (System\ Uncertainty)^2}$

$= \pm\sqrt{(0.114)^2 + (0.01)^2}$

= ± 0.114 mm ≈ 0.12 mm

Width of specimen BEFORE testing

i) Standard Error = $\sqrt{\frac{\sum_{i=1}^{n}(l_i - l_{mean})^2}{n(n-1)}}$

$= \sqrt{\frac{(4.00-4.05)^2 + (3.99-4.05)^2 + (4.16-4.05)^2}{3(2)}}$

= 0.055 mm

ii) System uncertainty = ±0.01 mm

iii) Combined uncertainty = $\pm\sqrt{(Measurement\ Uncertainty)^2 + (System\ Uncertainty)^2}$

$= \pm\sqrt{(0.055)^2 + (0.01)^2}$

= ± 0.056 mm ≈ 0.06 mm

Width of specimen AFTER testing

i) Standard Error = $\sqrt{\frac{\sum_{i=1}^{n}(l_i - l_{mean})^2}{n(n-1)}}$

$= \sqrt{\frac{(3.83-3.90)^2 + (3.95-3.90)^2 + (3.92-3.90)^2}{3(2)}}$

= 0.036 mm

ii) System uncertainty = ±0.01 mm

iii) Combined uncertainty = $\pm\sqrt{(Measurement\ Uncertainty)^2 + (System\ Uncertainty)^2}$

$= \pm\sqrt{(0.036)^2 + (0.01)^2}$

= ± 0.037 mm ≈ 0.04 mm

Thickness of specimen BEFORE testing

i) Standard Error = $\sqrt{\frac{\sum_{i=1}^{n}(l_i - l_{mean})^2}{n(n-1)}}$

$= \sqrt{\frac{(0.23-0.24)^2 + (0.21-0.24)^2 + (0.27-0.24)^2}{3(2)}}$

= 0.018 mm

ii) System uncertainty = ±0.01 mm

iii) Combined uncertainty = $\pm\sqrt{(Measurement\ Uncertainty)^2 + (System\ Uncertainty)^2}$

$= \pm\sqrt{(0.018)^2 + (0.01)^2}$

= ± 0.021mm ≈ 0.03 mm

Thickness of specimen AFTER testing

i) Standard Error = $\sqrt{\frac{\sum_{i=1}^{n}(l_i - l_{mean})^2}{n(n-1)}}$

$= \sqrt{\frac{(0.28-0.25)^2 + (0.24-0.25)^2 + (0.24-0.25)^2}{3(2)}}$

= 0.014 mm

ii) System uncertainty = ±0.01 mm

iii) Combined uncertainty = $\pm\sqrt{(Measurement\ Uncertainty)^2 + (System\ Uncertainty)^2}$

$= \pm\sqrt{(0.014)^2 + (0.01)^2}$

= ± 0.017mm ≈ 0.02 mm

Cross Section Area BEFORE testing

Error of propagation:

Area = Width x Thickness (W x T)

$$\frac{\sigma_f}{|f|} = \sqrt{(\frac{\sigma_x}{x})^2 + (\frac{\sigma_y}{y})^2}$$

$$\frac{\sigma_A}{|A|} = \sqrt{(\frac{\Delta W}{W})^2 + (\frac{\Delta T}{T})^2}$$

$$= \sqrt{(\frac{0.06}{4.05})^2 + (\frac{0.03}{0.24})^2}$$

= 0.126 = 12.6%

σ_A = 0.972 x 12.6%

= 0.1224 ≈ 0.123 mm

Cross Section Area AFTER testing

Error of propagation:

Area = Width x Thickness (W x T)

$$\frac{\sigma_f}{|f|} = \sqrt{(\frac{\sigma_x}{x})^2 + (\frac{\sigma_y}{y})^2}$$

$$\frac{\sigma_A}{|A|} = \sqrt{(\frac{\Delta W}{W})^2 + (\frac{\Delta T}{T})^2}$$

$$= \sqrt{(\frac{0.04}{3.90})^2 + (\frac{0.02}{0.25})^2}$$

= 0.0807 = 8.07%

σ_A = 0.975 x 8.07%

= 0.0786 ≈ 0.079 mm

Questions

1. **Determine the type of materials being tested – Is it brittle or ductile? Explain why.**

   The type of material being used is brittle. This is because the material tends to break suddenly with very little plastic deformation, instead it does not have obvious change in cross section area with only a percentage reduction of 0.31% difference. Thus, it shows that the material does not undergo too much necking before reaching a breaking point and does not exhibit large deformation but likewise breaks apart.

2. **Compare the modulus for the as-obtained experimental value with the sample value provided in Appendix 1.2 with respect to their Young's Modulus and yield points. Include an explanation on the changes occurred to the gauge length at the atomic level.**

   The Young's Modulus obtained from experiment has a value of 55856MPa compared with the sample value of 69000MPa. The percentage error calculated is 19.05% as shown below. The reason this error obtained from the experiment may due to several factors, it may because of the experiment set up which differs to the theoretical setup. Besides, it may because it has some errors while plotting the graph that is hard to obtain the exact or ideal data from it.

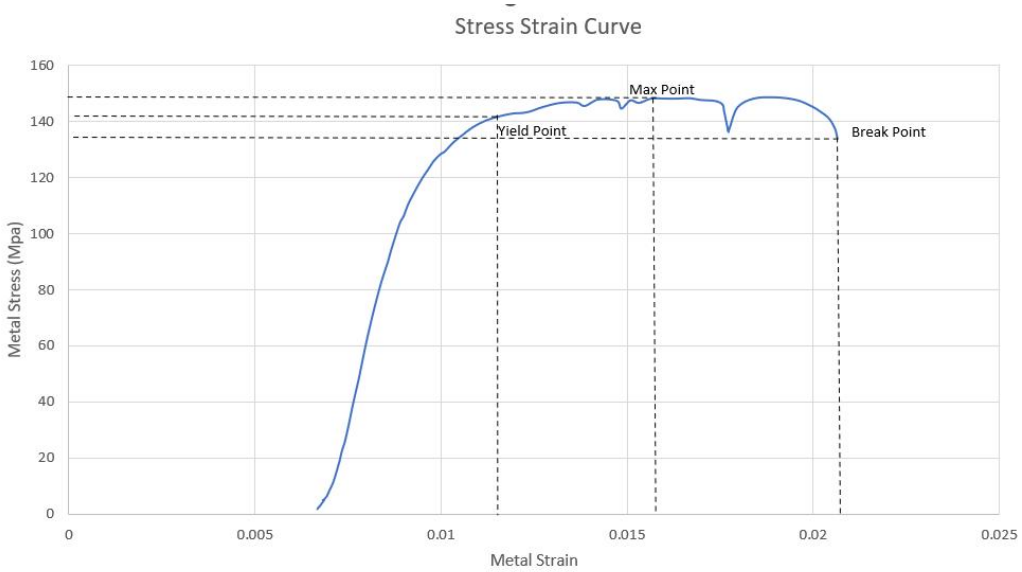
   Percentage error (%) $= \frac{X_{measured} - X_{true}}{X_{true}}$ x 100%

   $= \frac{55856MPa - 69000MPa}{69000MPa}$ x 100%

   = 19.05%

3. Define mechanical stress in your own words and include a sketch. Discuss what is physically happening to a coupon when it is experiencing stress.

Mechanical stress is a measure of force applied to a material per unit area. As the force is applied, the coupon experiences stress. The stress is distributed over the entire cross-sectional area. Thus, these internal forces lead to deformation, which is a change in the shape or size of the material and even break when it reaches break point.



4. Identify the part of the samples with large deformation or damage or broken, try to explain why this part is the weak point of the sample.

The part of the samples which is damage or broken is at the middle part of it. This is because the middle part may experience the highest tensile stress, which results the sample to fracture suddenly during the experiment. Besides, it may also due to the symmetry and uniform length of the sample, since both of its ends is symmetry and the force applied are the same, the force will resulting to be the highest at the middle where it reaches the critical point.

Conclusion

To summarize this experiment, the first objective is to find the relationship between tensile stress and strain for the given materials. Using the Pasco CAPSTONE and Microsoft excel to plot graph (stress-strain curve) using data obtained, we are able to plot a relationship between tensile stress and strain, where we can obtain a straight line (linear region) proportional to the graph to find the Young's Modulus and yield point, indicating the deformation occurs and determine the max point and likewise break point when the material starts to fall apart. Next for the second objective, we are able to ascertain modulus of elasticity, elastic region, plastic region, yield point and the break point parameters from a plot of stress versus strain. Using **Figure 3** of the stress-strain curve, the elastic region is the region until it reaches the yield point, whereas the plastic region is the region until the breaking point. Besides, to find the yield point, we first plot the graph of **Figure 4** using the linear gradient and with 0.2 offset, the intersection of the line with the curve is known as yield point. For the third objective, I have also understood the type and sources of experimental errors. The combined uncertainty is used in Gage length, Width and Thickness of specimen before and after testing with standard error as the measurement uncertainty, ±0.01mm as the system uncertainty. Whereas the error of propagation is used in Extension, Cross Section Area before and after testing as the area is used with the formula: CSA = Width x Thickness. Finally, I am able to clearly and correctly report measurements and the uncertainties in those measurements. The combined uncertainty for Gage length before and after are (±0.22 and ±0.12) mm respectively, combined uncertainty for width before and after are (±0.06 and ±0.04) mm respectively and likewise combined uncertainty for thickness before and after are (±0.03 and ±0.02) mm respectively. The error of propagation for extension, cross section area before and after are (±0.26, ±0.123, ±0.079) mm respectively. The reason we obtained these errors during the experiment might due to the experiment setup is not ideal compared with theoretical, besides the force applied while using the stress-strain apparatus may vary with the theoretical. Furthermore, it may contain some human errors or uncertainty while obtaining different data from the graph plotted as the decimals used may not enough to plot an ideal stress-strain curve.