电子科技大学
格拉斯哥学院
Glasgow College, UESTC

Physics Experiment 04

Lab Report

Experiment Title: Measurement of the Young's Modulus of Wire by Elongating

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Instructor: Jing Wu

Teaching Assistant: Hao Wen

Date Performed: 2018.06.28

Final Mark:

Score

Abstract (About 100 words, 10 points)

The purpose of this experiment is to let us digest what is Young's modulus and how to get it by measuring and calculation. To get the Young's modulus, not only do we need to master the optical elongation, but also we should know how we operate and read the equipment, like the vernier caliper and micrometer caliper during the experiment procedure. The most subtle method used in this experiment is the optical lever amplification. Besides, the correct analysis of all kinds of data is also really important in this experiment, including using the propagation of uncertainty.

Score

Calculations and Results (Calculations, data tables and figures; 15 points)

1. Data Tables

DATA TABLE 4-1(*purpose*: To record the instrument parameters)

Unit: mm

diameter, d_i	zero reading, d_0	-0.01	Instrument Error, $\Delta_{instr.}$			0.01	Reading error, Δ_{Read}			0.002
	Trial	1	2	3	4	5	6	7	8	9
	Readings, d_i'	0.575	0.575	0.575	0.575	0.575	0.575	0.575	0.575	0.575
	Corrected value $d_i = d_i' - d_0$	0.585	0.585	0.585	0.585	0.585	0.585	0.585	0.585	0.585

instrument error of tape, Δ_{tape}=(0.2×reading/1000+0.3)				length of the optical lever	
L_0 (original reading)	654.0	D_0 (original reading)	1490.0	b_0(original reading)	63.5
Instrument error, $\Delta_{L\text{-}tape}$	0.43	Instrument error, $\Delta_{D\text{-}tape}$	0.60	Instrument error, $\Delta_{b\text{-}vernier}$	0.05
Evaluating error, $\Delta_{L\text{-}eval.}$	2	Evaluating error, $\Delta_{D\text{-}eval.}$	5	Evaluating error, $\Delta_{b\text{-}eval}$	0.2
L(after rounding to an integer)	654	D(after rounding to an integer)	1490	b (after rounding to one decimal place)	63.5

DATA TABLE 4-2(*purpose*: To record the meter stick readings observed from the telescope when loading and unloading)

g_{local}= 9.79m/s^2 (Chengdu), Instrument error, $\Delta_{\Delta n\text{-stick}}$= 0.5 mm, reading error, $\Delta_{\Delta n\text{-read}}$= 0.2 mm

Trial	0	1	2	3	4	5	6	7
Total mass of the weights, *M* (kg)	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00
Meter stick reading, loading n_i'/mm	0	79	150	224	300	370	448	520
Meter stick reading, unloading n_i''/mm	10	96	167	245	310	382	450	520
Mean, $n_i = \frac{1}{2}(n_i' + n_i'')$(mm)	5	88.5	158.5	234.5	305	376	449	520

2. Calculations

(1) Compute the diameter of the wire.

So $\bar{d} = \frac{1}{9}(d_1 + d_2 + \cdots + d_9) = \frac{1}{9}(0.585 + 0.585 + 0.585 + 0.585 + 0.585 + 0.585 + 0.585 + 0.585 + 0.585) = 0.585mm$

(2) Use the following equation to compute the change in length after loading 4 kg weights.

So $\overline{\Delta n} = \frac{1}{4}[(n_7 - n_3) + (n_6 - n_2) + (n_5 - n_1) + (n_4 - n_0)] = \frac{1}{4}[(520 - 234.5) + (449 - 158.5) + (376 - 88.5) + (305 - 5)] = 290.875mm$

(3) Use the following equation to compute the Young's modulus of the measured wire.

$$\bar{E} = \frac{8FLD}{\pi \bar{d}^2 b \overline{\Delta n}} = \frac{8\times4\times9.79\times0.654\times1.49}{\pi(0.585\times0.001)^2\times0.0635\times0.290875} = 1.537\times10^{10}(N/m^2)$$

where $F=mg=4\times g$ (N)

(4) Use the propagation of uncertainties to compute the uncertainty of the measured Young's modulus.

So $\sigma_E = \bar{E}\times\sqrt{(\frac{\sigma_L}{L})^2 + (\frac{\sigma_D}{D})^2 + (2\frac{\sigma_d}{d})^2 + (\frac{\sigma_b}{b})^2 + (\frac{\sigma_{\overline{\Delta n}}}{\overline{\Delta n}})^2} = 1.537\times10^{10}\times$
$\sqrt{(\frac{0.25}{654})^2 + (\frac{0.46}{1490})^2 + (2\frac{0.0029}{0.585})^2 + (\frac{0.029}{63.5})^2 + (\frac{0.29}{290.875})^2} = 1.537\times10^{10}\times$
$\sqrt{0.000000146 + 0.0000000953 + 0.0000983 + 0.000000209 + 0.000000994} =$
$1.537\times10^{10}\times0.009987 = 1.54\times10^{8}(N/m^2)$

(5) Give the final measurement result in the following form.

$$E = \bar{E} \pm \sigma_E\ (N\cdot m^{-2}) = (1.537 \pm 0.0154)\times10^{10}\ (N\cdot m^{-2})$$

Score

Conclusions (About 100 words, 5 points)

According to this experiment, we digested what is Young's modulus and how to get it by measuring and calculation. We used the optical lever amplification to obtain data, and also consolidated about how to read the value from instruments like the vernier caliper and micrometer caliper during the experiment procedure. Besides, we analyzed all kinds of data which is a really important part of this experiment, includes handling zero reading, instrument error and estimated error and using the propagation of uncertainty to get the final measurement value of the Young's modulus.

Score

Answers to Questions (10 points)

Question 1:

①In my opinion, the elongation of length is more critical. Since this value is very precise and the error could cause a huge change. Besides, in terms of the uncertainty, it is shown that the change of L has greater influence on the experiment and causes relative errors easily.

②The reason why the length of the wire is measured with a meter stick while a very sensitive length measuring device is required for the elongation is that the total length of wire is much longer than the elongation, which means a very small error influence the measurement of length hardly, but affect the elongation seriously. So we should use more sensitive equipment to measure the elongation.

Question 1:

①The initial load on the hanger is just used to make sure the wire straight so that we can get accurate data. It is excluded from our calculation completely.

②We can choose the initial load freely in this experiment since only the differences between loads are used to get the Young's Modulus, that ids to that the exact initial load does not influence the final result at all.

Appendix

(Scanned data sheets)

Data Table 3.4-1 ***Purpose*** **: To record the instrument parameters**

(Unit: mm)

Diameter, d_i	Zero reading, d_0	-0.01	Instrument error, $\Delta_{instr.}$		0.005	Reading error, Δ_{Read}			0.002
	Trials	Point 1			Point 2			Point 3	
		1	2	3	4	5	6	7	8	9
	Actual reading, d_i'	0.575	0.575	0.575	0.575	0.575	0.575	0.575	0.575	0.575
	Corrected reading $d_i = d_i' - d_0$	0.585	0.585	0.585	0.585	0.585	0.585	0.585	0.585	0.585

Instrument error of tape, Δ_{tape}=(0.2×reading/1000+0.3)				Length of the optical lever	
L_0 (original reading)	654	D_0 (original reading)	1490	b_0(original reading)	63.5
Instrument error, $\Delta_{L\text{-}tape}$	0.43	Instrument error, $\Delta_{D\text{-}tape}$	0.60	Instrument error, $\Delta_{b\text{-}vernier}$	0.05
Estimated error, $\Delta_{L\text{-}eval.}$	2	Estimated error, $\Delta_{D\text{-}eval.}$	5	Estimated error, $\Delta_{b\text{-}eval.}$	0.2
L (after rounding to an integer)	654	D (after rounding to an integer)	1490	b (after rounding to one decimal place)	63.5

Data Table 3.4-2 ***Purpose*** **: To record the meter stick readings observed from the telescope when loading and unloading**

g_{local}= 9.79m/s^2 (Chengdu), Instrument error, $\Delta_{\Delta n\text{-}stick}$=0.5mm, reading error, $\Delta_{\Delta n\text{-}read}$=0.2mm

Trial	0	1	2	3	4	5	6	7	8
Total mass of the weights, m/kg	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
Meter stick reading, loading n_i'/mm	0	79	150	224	300	370	448	520	
Meter stick reading, unloading n_i''/mm	10	96	167	245	310	382	450	520	
Mean, $n_i = \frac{1}{2}(n_i' + n_i'')$ /mm	5	88.5	158.5	234.5	305	376	449	520	

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