Lab Report

Name of the Experiment : Introduction to Measurement and Statistical Error

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Instructor's comments:

Data Tables:

Table 1: Ruler measurements

Data No.	Length, L (cm)	Radius, R (cm)	$\bar{L}$ (cm)	$\bar{R}$ (cm)
1	3.7	0.3	3.73	0.3
2	3.7	0.3		
3	3.8	0.3		
4	3.8	0.3		
5	3.7	0.3		
6	3.7	0.3		

Table 2: Finding Length using Vernier Scale

Vernier constant: 0.005 cm $VC = \frac{\text{smallest MSR}}{20} = \frac{0.1\text{cm}}{20} = 0.005\text{cm}$

Data No.	Main Scale reading (cm)	Vernier scale division, d	Length (cm)	$\bar{L}$ (cm)	$(\bar{L} - L_i)^2$ (cm^2)	σ_L (cm)
1	3.8	1	3.8005	3.8018	1.69×10^{-6}	9.615×10^{-6}
2	3.8	1	3.8005		1.69×10^{-6}	
3	3.8	2	3.801		6.4×10^{-7}	
4	3.8	1	3.8005		1.69×10^{-6}	
5	3.8	2	3.8011		6.4×10^{-7}	
6	3.8	14	3.807		2.704×10^{-5}	

$L = M.S.R + (V.S.D \times V.C)$

$\therefore L_1 = 3.8 + (1 \times 0.005)$
$= 3.8005\ cm$

$\bar{L} = 3.8018\ cm$

$(\bar{L} - L_i)^2 = (3.8018 - 3.8005)^2 = 1.69 \times 10^{-6}\ cm^2$

$\sigma_L = 9.615 \times 10^{-6}\ cm$ (using calculator)

$\left[\sigma_L = \sqrt{\frac{1}{N-1}\sum_{i=1}^{n}(L - L_i)^2}\right]$

Table-3: Data for the radius of the cylinder

Least count, LC= 0·001 cm $L.C. = \frac{\text{Pitch of screw}}{\text{no. of Div}} = \frac{0.5\text{mm}}{50} = 0.01\text{mm} = 0.001\text{cm}$

Instrumental error (if any) = +2×0·001 cm $= +0.002\text{cm}$

Data	Linear scale reading, x (cm)	Circular scale reading, $y = d \times L_c$ (cm)	Diameter x + y (cm)	Instrumental error (cm)	Corrected diameter, D (cm)	Radius, $r = \frac{D}{2}$ (cm)	Mean radius, $\bar{r}$ (cm)	$(\bar{r} - r_i)^2$ (cm^2)	σ_r (cm)
1	0.55	0.047	0.597	±0.002	0.599	0.2995	0.3	2.5×10^{-7}	1.1785×10^{-7}
2	0.55	0.048	0.598		0.6	0.3		0	
3	0.55	0.048	0.598		0.6	0.3		0	
4	0.55	0.049	0.599		0.601	0.3005		2.5×10^{-7}	
5	0.55	0.048	0.598		0.6	0.3		0	
6	0.55	0.048	0.598		0.6	0.3		0	

$x = 0.55$ cm

$y = d \times L_c$

$= (47 \times 0.001)$ cm

$= 0.047$ cm

Diameter, $D = x + y = (0.55 + 0.047)$ cm

$= 0.597$ cm

$\bar{r} = 0.3$ cm

Standard Deviation, $\sigma_r = 1.1785\times10^{-7}$ cm $\left[\sigma_r = \sqrt{\frac{1}{N-1}\sum_{i=1}^{n}(\bar{r} - r_i)^2}\right]$

Calculation for Volume and its error:

Volume of a cylinder = $\pi r^2 l$

1. Using the ordinary ruler: Volume of the cylindrical rod, $V_1 = \pi r^2 l$

$= \pi \times (0.3)^2 \times 3.73$ | $r = 0.3\,cm$

$= 1.055\,cm^3$ | $l = 3.73\,cm$

2. Using the Vernier scale and screw gauge: Volume of the cylinder, $V_2 = \pi r^2 l$

$= \pi \times (0.3)^2 \times 3.8018$ | $r = 0.3\,cm$

$= 1.075\,cm^3$ | $l = 3.8018\,cm$

3. Error in volume calculation from Vernier ruler and screw gauge measurement (use **propagation of error**, equations 6,7),

$$\sigma_V = |V_2| \times \sqrt{2 \times \left(\frac{6r}{r}\right)^2 + \left(\frac{6l}{l}\right)^2}$$

$$= 1.075 \times \sqrt{2 \times \left(\frac{1.1785 \times 10^{-7}}{0.3}\right)^2 + \left(\frac{9.615 \times 10^{-6}}{3.8018}\right)^2}$$

$$= 2.784 \times 10^{-6}\,cm^3 \text{ (ans.)}$$

4. Final result, $V_2 \pm \sigma_V =$

$$V_2 + 6_V = 1.075 + 2.784 \times 10^{-6}$$

$$= 1.075002784\,cm^3$$

$$V_2 - 6_V = 1.075 - 2.784 \times 10^{-6}$$

$$= 1.074997216\,cm^3$$

Results:

$$1.075002784\,cm^3 > V_2 > 1.074997216\,cm^3$$

Questions:

1. How many of the length readings lie in the interval $L_{av} \pm \sigma_L$?

$L_{av} = 3.8018\,cm$

$\sigma_L = 0.615 \times 10^{-6}\,cm$

$\therefore L_{av} + \sigma_L = (3.8018 + 0.615 \times 10^{-6}) = 3.80180$

$\therefore L_{av} - \sigma_L = (3.8018 - 0.615 \times 10^{-6}) = 3.80179$

2 readings.

2. What fraction of the 6 readings is this?

$\frac{2}{6} = \frac{1}{3}$ <ans.>

3. How does the percentage compare with 68.3 %?

$\frac{2}{6} \times 100\% = \frac{1}{3} \times 100\% = 33.33\% < 68.3\%$

4. Which is a more precise measuring tool: ruler or Vernier caliper? Why?

Varnier caliper is more precise measuring tool because varnier caliper can provide high precesion measurement upto 0.005 cm (0.05 mm) where ruler can provide only upto 1mm (0.1cm) precision. So, varnier caliper is more precise.

Discussion:

In this experiment, we used different tools to measure a cylindrical item. We measured 6 time of the time to measure the accurate value. To measure, the length and diameter of a cylindrical rod we used a ruler, varnier caliper and screw gauge. Everytime 6 reading were taken to ~~calc~~ calculate an average value and minimizing the error. When, we try to measure length and radius of a cylindrical object by normal ruler, the values are consistent but lacks in precision, which shows limitation of normal ruler. On the other hand, the values by slide caliper, and screw gauge are more precise (upto 3 digits). But we encounter some error throughout this, if we can set the instrument properly and use tools carefully we could get more precise and accurate value. Our result was 33.33%.

-0.25