Experiment Title: Comparison of Measurement Tools

Objective

1. To compare the accuracy and precision of measurements using a screw gauge and a Vernier caliper by measuring the dimensions of a small object.
2. To compare the accuracy and precision of measurements using a Vernier caliper and a meter scale by measuring the dimensions of a larger object.

Apparatus Required

- Screw Gauge
- Vernier Caliper
- Meter Scale
- Small object (e.g., a small metallic sphere or wire)
- Larger object (e.g., a rod or block)

Theory

1. **Screw Gauge:**
   - Least Count = Pitch/Number of divisions on the circular scale.
   - Measures small dimensions like thickness with high precision (usually 0.01 mm).
2. **Vernier Caliper:**
   - Least Count = (Value of one main scale division - Value of one vernier scale division).
   - Measures internal, external dimensions, and depth (typically precise to 0.1 mm).
3. **Meter Scale:**
   - Least Count = 1 mm.
   - Measures larger dimensions with lower precision.

Procedure

Part A: Comparing Screw Gauge and Vernier Caliper

1. Measure the Length, breadth and height of the small object (e.g., a metallic sphere or block) using the screw gauge:
   - Note the pitch and least count of the screw gauge.

- Record the readings of the main scale and circular scale.

2. Measure the same Length, breadth and height using the Vernier caliper:
   - Note the least count of the Vernier caliper.
   - Record the main scale and Vernier scale readings.

Part B: Comparing Vernier Caliper and Meter Scale

1. Measure the length, breadth or height of the larger object (e.g., a metallic block) using the Vernier caliper:
   - Record the main scale and Vernier scale readings.
2. Measure the same dimensions using the meter scale:
   - Record the readings directly in centimeters or millimeters.

Observations

Screw Gauge Readings

Obs.	**MSR**	**HSR**	**Corrected HSR**	**Length (mm)** (MSR + Corrected HSR × LC)	**Average Length** ($\overline{x_i}$)	**Deviation**^{2} $(x_i - \overline{x_i})^2$	$\sigma_{\textbf{Length}} = \sqrt{\overline{(x_i - \overline{x_i})^2}}$
1							
2							
3							
⋮							

Mean Length: $\bar{d} = \ldots \pm \sigma_d$

3

Vernier Caliper Readings

Obs.	**MSR**	**VSR**	**Length (mm)** (MSR + VSR × LC)	**Average Length** ($\overline{x_i}$)	**Deviation**^{2} $(x_i - \overline{x_i})^2$	$\sigma_{\textbf{Length}} = \sqrt{\overline{(x_i - \overline{x_i})^2}}$
1						
2						
3						
⋮						

Screw Gauge Readings

Obs.	**MSR**	**HSR**	**Corrected HSR**	**Breadth (mm)** (MSR + Corrected HSR × LC)	**Average Breadth** ($\overline{x_i}$)	**Deviation**^{2} $(x_i - \overline{x_i})^2$	$\sigma_{\textbf{Breadth}} = \sqrt{\overline{(x_i - \overline{x_i})^2}}$
1							
2							
3 ⋮							

Mean Breadth: $\bar{d} = \ldots \pm \sigma_d$

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Vernier Caliper Readings

Obs.	**MSR**	**VSR**	**Breadth (mm)** (MSR + VSR × LC)	**Average Breadth** ($\overline{x_i}$)	**Deviation**^{2} $(x_i - \overline{x_i})^2$	$\sigma_{\textbf{Breadth}} = \sqrt{\overline{(x_i - \overline{x_i})^2}}$
1						
2						
3 ⋮						

Screw Gauge Readings

Obs.	**MSR**	**HSR**	**Corrected HSR**	**Height (mm)** (MSR + Corrected HSR × LC)	**Average Height** ($\overline{x_i}$)	**Deviation**^{2} $(x_i - \overline{x_i})^2$	$\sigma_{\textbf{Height}} = \sqrt{\overline{(x_i - \overline{x_i})^2}}$
1							
2							
3 ⋮							

Mean Height: $\bar{d} = \ldots \pm \sigma_d$

Vernier Caliper Readings

Obs.	**MSR**	**VSR**	**Height (mm)** (MSR + VSR × LC)	**Average Height** ($\overline{x_i}$)	**Deviation**^{2} $(x_i - \overline{x_i})^2$	$\sigma_{\textbf{Height}} = \sqrt{\overline{(x_i - \overline{x_i})^2}}$
1						
2						
3 ⋮						

0.1 Measurement using meter scale

Obs.	**Height (mm)**	**Average Height** $(\overline{x_i})$	**Deviation**^{2} $(x_i - \overline{x_i})^2$	$\sigma_{\textbf{Height}} = \sqrt{\overline{(x_i - \overline{x_i})^2}}$
1				
2				
3				
⋮				

Obs.	**Length (mm)**	**Average Length** $(\overline{x_i})$	**Deviation**^{2} $(x_i - \overline{x_i})^2$	$\sigma_{\textbf{Length}} = \sqrt{\overline{(x_i - \overline{x_i})^2}}$
1				
2				
3				
⋮				

Obs.	**Breadth (mm)**	**Average Breadth** $(\overline{x_i})$	**Deviation**^{2} $(x_i - \overline{x_i})^2$	$\sigma_{\textbf{Breadth}} = \sqrt{\overline{(x_i - \overline{x_i})^2}}$
1				
2				
3				
⋮				

Calculations

- Least count calculations for the screw gauge and Vernier caliper.
- Error analysis and comparison of precision.

1 Error Analysis

For a set of measurements we estimate the error of the measured value using standard deviation σ which is nothing but

$$\sigma_x = \sqrt{\overline{(x_i - \overline{x})^2}} \tag{1}$$

1.1 Error associated with measurement using Vernier Calipers

... .

1.2 Error associated with measurement using Screw Gauge

Result

1. **For small object:** The screw gauge provides higher precision compared to the Vernier caliper for measuring small dimensions.
2. **For larger object:** The Vernier caliper provides better precision compared to the meter scale.

Conclusion

- Screw gauge is more precise for smaller objects, while the Vernier caliper is versatile for medium dimensions.
- Meter scales are less precise and suitable only for approximate measurements of larger objects.

Precautions

- Avoid parallax error while taking readings.
- Ensure zero error correction for both screw gauge and Vernier caliper.
- Handle the instruments carefully to avoid damage.