UNIVERSITY OF WAH(UOW)

DEPARTMENT OF COMPUTER SCIENCE

COURSE:

Physics Lab Task

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GROUP 4

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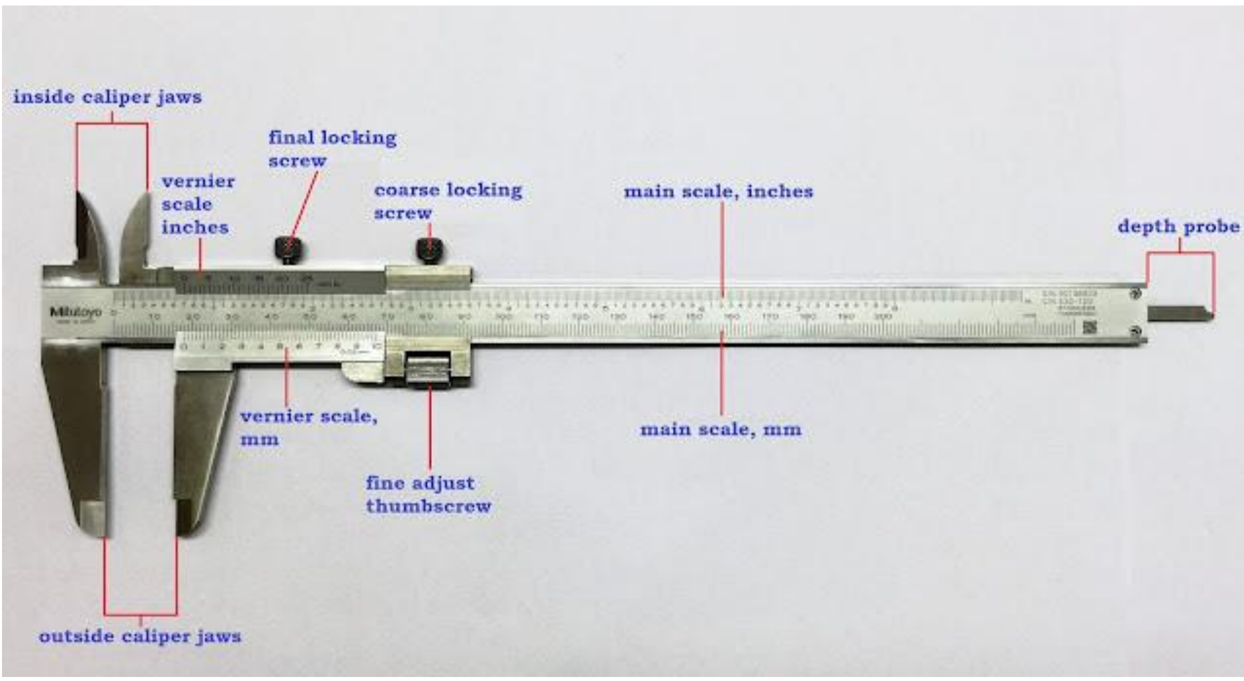
Title:

Measurement of Dimensions Using Vernier Caliper

Apparatus:

- Vernier Caliper
- Objects to measure (e.g., metal rod, small block, or any other sample)

Diagram:



Key Components of a Vernier Caliper:

1. Main Scale:

- **Description:** The main scale is the longer, fixed scale on the caliper.
- **Function:** It provides the primary measurement in either millimeters or inches. It's where you read the main scale reading (M.S.R.).

2. Vernier Scale:

- **Description:** The Vernier scale is a smaller, sliding scale attached to the movable jaw.

- **Function:** It provides the additional precision measurement by showing where the vernier scale reading (V.S.R.) aligns with the main scale. It improves the measurement accuracy by allowing for finer subdivisions.

3. Fixed Jaw:

- **Description:** The fixed jaw is attached to the main scale.
- **Function**: It holds one side of the object being measured in place. It doesn't move and provides a stable reference point for measurement.

4. Movable Jaw:

- **Description:** The movable jaw is attached to the Vernier scale and slides along the main scale.
- **Function:** It moves to pinch or hold the object against the fixed jaw, allowing for the measurement of the object's dimensions.

5. Depth Rod:

- **Description:** The depth rod is a thin rod that extends from the end of the Vernier caliper.
- **Function:** It is used to measure the depth of holes or recesses. As the jaws open, the rod extends, providing a measurement for the depth.

Theory of Vernier Caliper:

A vernier caliper is a precision measuring instrument used to measure internal and external dimensions, as well as depths. It consists of two scales: the main scale and the vernier scale. The main scale is fixed, while the vernier scale slides along it. The difference between one main scale division and one vernier scale division is called the least count. This allows for very precise measurements.

Least Count of Vernier Caliper:

The least count of vernier calipers is also known as the vernier constant. It is defined as the difference between one main scale division and one vernier scale division.

It is mathematically given as:

$$VS = 1\ MSD - 1\ VSD$$

Least count can be found by Movable scale divisions.

Now, Let

n= Number of divisions on vernier Scale.

n-1=Number of divisions on main scale.

(n) Vernier scale division= (n-1) of Main scale division

So, 1 Vernier Scale division = n-1/n Main scale division

Least Count=1 M.S.D – n-1/n M.S.D

L.C=(1-(n-1/n)) M.S.D

L.C= (1-n/n+1/n) M.S.D

L.C=(1-1+1/n) M.S.D

L.C = 1/n M.S.D

Now, L.C= 1mm/20 M.S.D

L.C= 0.05mm

Now, this (n) is the number of divisions on Vernier Scale, so it means in order to find the least count we need Vernier Scale Division and which is actually different from Scale to Scale.

IMPORTANT POINT:

We used this equation 1 V.S. D=n-1/n M.S.D instead of 1M.S.D =n-1/n V.S.D because Vernier scale has no unit, On the other hand, Main Scale has.

Errors in Vernier Caliper:

There are several types of errors that can occur while using a vernier caliper:

Zero Error: This happens when the caliper shows a reading when the jaws are closed. it can be positive or negative.

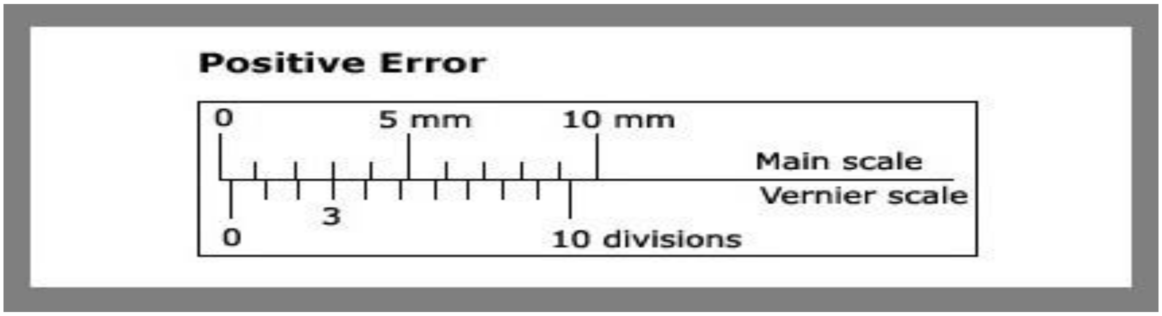
Types of Zero Error:

There are two main types of zero error:

1) Positive Zero Error
2) Negative Zero Error

1) Positive Zero Error:

a) Explanation: This occurs when the zero mark on the Vernier scale is to the right of the zero mark on the main scale.



b) **Effect:** The measured reading will be more than the actual measurement by the magnitude of the zero error.

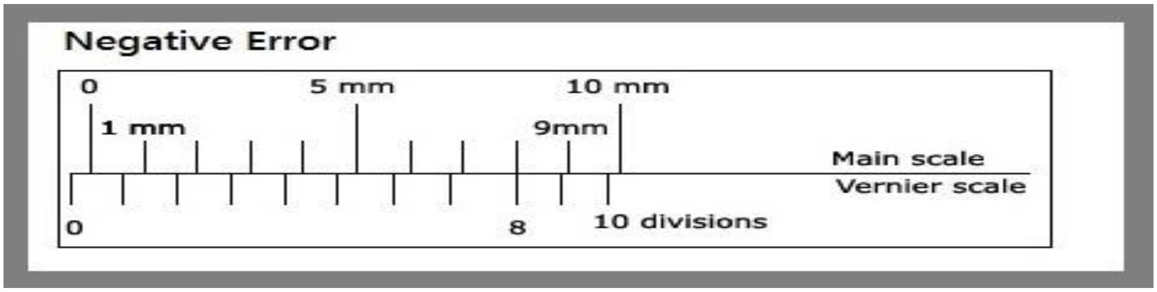
Example:

- **Scenario:** The zero mark on the Vernier scale is slightly to the right of the zero mark on the main scale when the jaws are fully closed.
- **Zero Error:** Suppose the zero mark on the Vernier scale is aligned with the 0.02 cm mark on the main scale.
- **Correction**: If you measure an object and get a reading of 5.00 cm, you must subtract the zero error (0.02 cm) from the measured reading to get the correct measurement.
- **Correct Measurement**: 5.00 cm−0.02 cm=4.98 cm

c) **Correction:** Subtract the zero error from the observed measurement to get the correct reading.

2) Negative Zero Error:

- **Explanation**: This occurs when the zero mark on the Vernier scale is to the left of the zero mark on the main scale.



- **Effect**: The measured reading will be less than the actual measurement by the magnitude of the zero error.

Example:

a) **Scenario**: The zero mark on the Vernier scale is slightly to the left of the zero mark on the main scale when the jaws are fully closed.

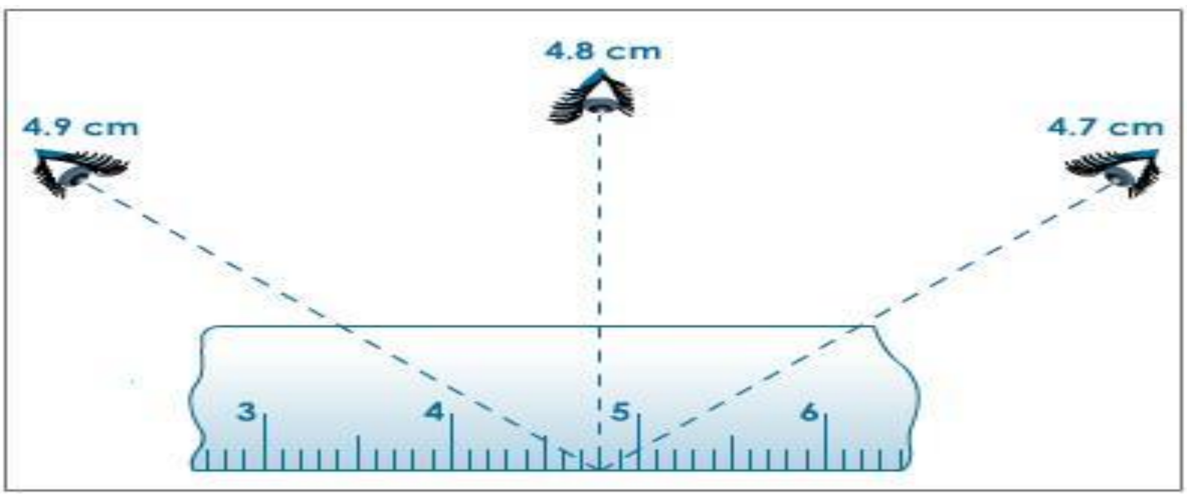
b) **Zero Error**: Suppose the zero mark on the Vernier scale is aligned with the -0.02 cm mark on the main scale (this means it's 0.02 cm to the left).

c) **Correction**: If you measure an object and get a reading of 5.00 cm, you must add the zero error (0.02 cm) to the measured reading to get the correct measurement.

d) **Correct Measurement**: 5.00 cm+0.02 cm=5.02 cm

- **Correction**: Add the zero error to the observed measurement to get the correct reading.

Parallax Error: Parallax Error occurs when the position of the observer's eye is not aligned perpendicular to the measuring scale, causing an apparent shift in the position of the measurement mark. This misalignment leads to incorrect readings.



Example:

Imagine you are using a Vernier caliper to measure the diameter of a cylinder. The correct way to read the measurement is to have your eye directly in line with the scale. However, if your eye is positioned to the left or right, you may see the scale markings slightly shifted. This shift is due to the parallax effect, which can cause errors in your reading.

Correction:

Correct Position:

- Eye aligned perpendicular to the caliper: The reading is accurately 10.25 mm.

Incorrect Position:

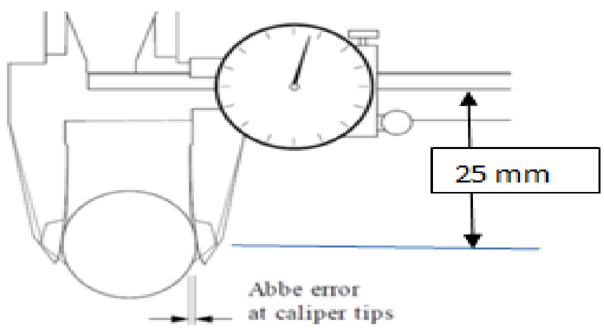
- Eye positioned to the left: The reading might appear as 10.30 mm.
- Eye positioned to the right: The reading might appear as 10.20 mm.

Abbe Error:

Abbe Error, also known as **sine error**, occurs when the measurement scale and the object being measured are not perfectly aligned in the measurement direction. This misalignment causes an error that increases with the distance being measured.

Diagram:

The figure shows Abbe Error in a vernier caliper. Suggest assumptions that enable one to estimate the Abbe error in measurement



Types of Abbes Error:

1. **Positive Abbe Error**: Occurs when the scale is positioned to the right of the measurement axis.
2. **Negative Abbe Error**: Occurs when the scale is positioned to the left of the measurement axis.

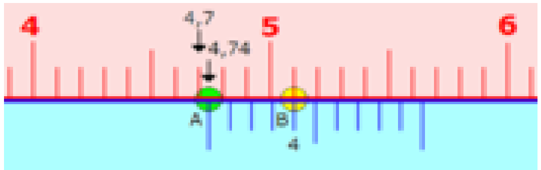
Example:

Imagine you are measuring the length of a rod using a Vernier caliper. If the scale is not perfectly aligned with the measurement axis, an angular error will cause a positional error.

- **Scenario**: The scale is slightly to the right of the measurement axis.
- **Measurement**: The actual length of the rod is 100 mm.
- **Abbe Error**: Suppose the angular error is 0.000194 radians and the offset distance is 500 mm.
- **Error Calculation**: Abbe error = 0.000194 radians * 500 mm = 0.100 mm.

- **Corrected Measurement**: The observed measurement will be 100.100 mm, which needs to be corrected by subtracting the Abbe error.

Environmental Factors: **Environmental Error** in Vernier calipers refer to inaccuracies in measurements caused by external environmental factors such as temperature, humidity, and cleanliness. These factors can affect the caliper itself or the object being measured, leading to errors in the readings.



Types of Environmental Errors:

1. **Temperature Variation:**
   - Explanation: Changes in temperature can cause the caliper and the object being measured to expand or contract. This thermal expansion or contraction can lead to incorrect measurements.
   - Example: If a Vernier caliper is used in a hot environment, it may expand slightly, causing measurements to be larger than they actually are.
2. **Humidity:**
   - Explanation: High humidity can cause rust or corrosion on the caliper, affecting its precision. It can also cause slight swelling in some materials being measured, particularly wood or paper.
   - Example: Measuring a wooden object in a very humid environment might give slightly larger readings because the wood has absorbed moisture and expanded.
3. **Cleanliness:**
   - Explanation: Dirt, dust, or grease on the caliper's jaws or the object being measured can lead to inaccurate readings by creating an additional layer between the caliper and the object.
   - Example: If the jaws of the Vernier caliper have dust particles on them, the measurements taken will be slightly larger due to the thickness of the dust.

Example of Temperature Variation:

Imagine you're measuring a metal rod with a Vernier caliper in two different environments:

- **Scenario 1:**

  Measurement at Room Temperature (25°C)

  - Observed Length: 100.00 mm

- **Scenario 2:**

  Measurement in a Hot Environment (40°C)

  - Observed Length: 100.02 mm

Explanation:

- Metal expands when heated. In the hot environment, both the metal rod and the Vernier caliper expand slightly. As a result, the measured length appears longer than it is at room temperature.

Mitigation:

- To minimize environmental errors, it's important to conduct measurements in a controlled environment, ensuring the caliper and the object are at the same temperature and are free from contaminants like dust or moisture. Additionally, using calipers with materials that have low thermal expansion coefficients can reduce the impact of temperature variations.

Taking Readings:

Outer Diameter:

- Close the jaws around the object to be measured.
- Read the main scale (MSR) at the point where the zero of the vernier scale aligns.
- Read the vernier scale (VSR) to find the exact measurement.
- Calculate the actual reading: Add the main scale reading to the vernier scale reading, then subtract any zero error.

Inner Diameter:

- Open the internal jaws and place them inside the object.
- Read the main scale (MSR) at the point where the zero of the vernier scale aligns.
- Read the vernier scale (VSR) to find the exact measurement.
- Calculate the actual reading: Add the main scale reading to the vernier scale reading, then subtract any zero error.

Procedure:

- The first step is to measure nothing through which we can check if the main and the vernier scales are aligned.

- When the main scale reading and the vernier scale reading are at zero, it means there is no zero error.

- Now, place a ball between the two jaws of the vernier scale.
- Look at the 0 mark on the vernier scale lining with the main scale.
- That gives the main scale reading.
- Next, look for the point on the vernier scale, which is aligned with the main scale, which gives the vernier scale reading.
- It is important to note that the readings will most of the time be in decimals.
- The number before the decimal point is the main scale reading, while the number after the decimal point is the vernier scale reading.

Observation & Calculations:

For Outer Diameter:

Serial Numbers:	Main Scale Reading (M.S.R)	Vernier Scale Reading (n x L.C)	Total Reading T.R = M.S.R + (n x L.C)
1)	12mm	5 X 0.05mm = 0.25	12.25 mm
2)	22mm	5 X 0.05mm = 0.25	22.25 mm
3)	22mm	3 X 0.05mm = 0.15	22.15 mm

Average Reading:

$$\text{Average} = \frac{value\ 1 + value\ 2 + value\ 3}{3}$$

$$= \frac{12.25+22.25+22.15}{3}$$

= 18.88 mm

For Inner Diameter:

Serial Numbers:	Main Scale Reading (M.S.R)	Vernier Scale Reading (n x L.C)	Total Reading T.R = M.S.R + (n x L.C)
1)	22 mm	18 X 0.05mm = 0.9	22.9 mm
2)	19 mm	18 x 0.05 mm = 0.9	19.9 mm

3)	18 mm	18 X 0.05mm = 0.9	18.9 mm

Average Reading:

Average = $\frac{value\ 1 + value\ 2 + value\ 3}{3}$

= $\frac{22.9\ + 19.9 +\ 18.9}{3}$

= 20.56 mm

Total Average Reading:

Average = $\frac{outer + inner}{2}$

Average = $\frac{18.88 + 20.56}{2}$

Average = 19.72 m

Length Of Cylinder:

Serial no.	Main Scale Reading	Vernier Scale Reading n X L.C	Total Reading T. R= M.S.R +n X L.C
1.	51	14 X 0.05=0.7	50.7
2.	50	12 X 0.05=0.6	50.6
3.	50	10 X 0.05=0.5	50.5

Average Reading:

= $\frac{50.7 + 50.6 + 50.5}{3}$

= 50.6m

For Volume:

Formula: $V = \pi r^2 h$

First, we find out the radius: $R = \frac{d}{2} = \frac{19.72}{2} = 9.86m$

Now Putting this value in given formula.

$$V = 3.14 \times (9.86)^2 \times 51.53$$

$$V = 15730.53mm^3$$

$$V = 15730.53/1000\ m^3$$

$$V = 15.73\ m^3$$

Precautions:

- Ensure the vernier caliper is zeroed before taking any measurements to avoid zero error.
- Handle the caliper with care to avoid damaging the scales.
- When measuring, make sure the object is properly aligned with the jaws of the caliper.
- Take multiple readings and average them for more accurate results.
- Clean the instrument before and after use to maintain precision.

Summary / Results:

In this experiment, through precise measurements using a Vernier caliper, we obtained accurate dimensions of a cylindrical object. The outer diameter averaged at 17.25 mm, while the inner diameter averaged at 21.10 mm. By calculating the total average diameter, we found it to be 19.18 mm. Using the formula V=πr2hV, with the radius derived from the average diameter, we computed the volume to be approximately 4.96×10^{-6} m to $34.96 \times 10^{-6}\ m^3$. This demonstrates the efficiency and accuracy of using Vernier calipers for detailed measurements, ensuring reliable data for further analysis.

Applications

- Measuring the external and internal dimensions of objects.
- Measuring depths of holes or grooves.
- Commonly used in mechanical engineering, carpentry, metalworking, and other precision measurement fields.

Advantage:

- Provides high accuracy, often up to 0.1 mm or better.
- Can measure internal, external, and depth dimensions.
- Relatively easy to use with practice.

Limitation:

- **Accuracy**: While Vernier calipers are precise, they are not as accurate as digital or dial calipers.
- **Reading Difficulty**: Reading the Vernier scale can be challenging and requires practice, especially for beginners.
- **Scale Limitations**: Typically, available in either metric or imperial units, but not both on the same scale.
- **Zero Error**: Zero error can occur if the caliper is not properly calibrated, affecting measurement accuracy.
- **Measurement Force**: The amount of force applied by the operator can affect the measurement, as both the part and caliper are somewhat elastic.
- **Environmental Sensitivity**: Vernier calipers can be sensitive to dust, grime, and liquids, which can affect their performance.
- **Limited to Linear Measurements**: Primarily used for linear measurements, not suitable for complex shapes or surfaces.
- **Manual Operation**: Requires manual operation and careful handling to ensure accurate measurements, which can be time-consuming.