Case Study

Physics: Ch – 01 - Measurements

Case Study: Riya's Scientific Challenge

Riya, a Class 9 student, was preparing for the school science exhibition. Her project focused on measuring the **acceleration due to gravity (g)** using a **simple pendulum**. She set up a pendulum using a small spherical bob and an inextensible string. She ensured the **effective length** from the point of suspension to the bob's center was **100 cm**. Using a **stopwatch**, she measured the time for **20 oscillations** and recorded it as **40 seconds**.

To ensure precision, she conducted the experiment three times, calculating the **average time period (T)** using the formula:

$$T = \frac{\text{Total time for 20 oscillations}}{20}$$

She then applied the standard formula:

$$T = 2\pi\sqrt{\frac{L}{g}} \Rightarrow g = \frac{4\pi^2 L}{T^2}$$

She calculated 'g' as **9.87 m/s²**, quite close to the standard **9.8 m/s²**.

During documentation, Riya explained how different **measuring instruments** like **vernier calipers** and **screw gauges** offer higher precision due to smaller least counts. She highlighted **systematic**

errors like a faulty stopwatch and **personal errors** such as reaction delays.

Riya also used **significant figures** in her calculations, expressing final results with proper precision. She referred to **SI units** while presenting—using metre **(m)**, **second (s)**, and **metre/second² (m/s²)**.

Impressed by her clarity, the judges asked her about **derived units**, **scientific method**, and the **difference between fundamental and derived quantities**—questions Riya answered confidently.

Questions:

1. Identify and classify all quantities (fundamental or derived) used by Riya.
2. List all SI units used in the experiment. Why is SI usage important?
3. Calculate the value of g using Riya's data. Show all steps with correct significant figures.
4. What types of errors might have influenced Riya's result? How can they be minimized?
5. Explain how Riya followed the scientific method in her project.

Case Study: Aarav's Precision Measurement Experiment

Aarav, a Class 10 student, was conducting an experiment to measure the **diameter and volume of a metal sphere** with maximum accuracy. He used a **Vernier Calipers** and a **Screw Gauge** to compare the precision of both instruments.

Using the Vernier Calipers with a **least count of 0.01 cm**, he measured the **diameter** of the sphere as **2.45 cm**. He then used a **Micrometer Screw Gauge** with a **least count of 0.001 cm**, recording the diameter as **2.470 cm**. Aarav noticed that the screw gauge offered **higher precision**, as it had a **smaller least count**.

To find the **volume**, he used the formula for a sphere:

$$V = \frac{4}{3}\pi r^3$$

Using the screw gauge measurement:

$$r = \frac{2.470}{2} = 1.235\,\text{cm} \Rightarrow V = \frac{4}{3}\pi(1.235)^3 \approx 7.88\,\text{cm}^3$$

Aarav ensured **significant figures** were correctly applied in his result. He also explained **zero error correction** before using both instruments and noted how **systematic errors** (like zero error or backlash) and **personal errors** (like parallax) can impact results.

When asked, Aarav clearly differentiated between **accuracy and precision, fundamental and derived quantities**, and explained how **SI units** standardize all scientific measurements—such as **centimetre (cm)** for length and **cm³** for volume.

Questions:

1. Identify all physical quantities measured. Classify them as fundamental or derived.
2. Explain the significance of least count and how it affects measurement accuracy.
3. Aarav obtained two diameter values. Which is more precise and why?
4. Calculate the volume of the sphere using the screw gauge reading. Show proper significant figures.
5. List possible errors in using both Vernier Calipers and Screw Gauge. Suggest minimization methods.