Physical Quantities and Measurement Techniques

Describe how to measure a variety of lengths with appropriate precision using tapes, rulers and micrometers (including reading the scale on an analogue micrometer).

- The smallest measurement of an instrument is its accuracy
- Measurement of length:
  - Vernier Callipers: 0.01 cm: A pair of vernier calipers has a main scale and a sliding scale. It is a useful tool for measuring both the internal and external diameters of objects. In order to use it, push the slide onto the object till it can't use any more. The top scale represents millimetres and the bottom scale 1/10 of a millimetre.
  - Micrometre Screw Gauge: 0.01 mm: Turn the ratchet, which reduces the air pressure and causes the spindle to go down. When it can no longer move, take the measurement. There are two scales: a main scale, in millimetres, and a thimble scale, in 1/10 of a millimetre.
- Measuring Tape: >1 m
- Trundle wheel: ~1 kg

0 error: If the measurement is not 0 when the scale is completely closed, there is a 0 error. Subtract it from the final reading. (Zero error arises when the measuring instrument does not start from exactly zero.)

Digital Scales:

Advantages	**Disadvantages**
More accurate	More expensive
Easier to read	Subject to fluctuation

Describe how a student uses a measuring cylinder to find the volume of a stone (or any irregular object).

- Add the known volume of water into the measuring cylinder and this initial volume is noted down. The irregular stone is then gently and fully immersed in the water in the measuring cylinder.
- Measure the volume by reading the lower meniscus of water and note down the final volume.
- Find the volume of the stone by subtracting initial volume of the water from final volume of the water. ($V_F - V_I$)

Describe how to measure a variety of time intervals using clocks and digital timers.

- Analogue: 0.1 seconds
- Digital: 0.01 seconds

Most stopwatches can measure time to a precision of 0.01 secs. Digital stopwatches usually show readings upto two decimal places. However, we usually take readings to the nearest 2 decimal place. This is because, unlike the electronic sensors used in data loggers, stopwatches need to be

started and stopped by hand. This manual operation introduces a random error called human reaction time. Human reaction time is about 0.3-0.5 secs for most people.

Determine an average value for a small distance and for a short interval of time by measuring multiples (including the period of oscillation of a pendulum):

A simple pendulum is used to measure time. All time pieces use some kind of a periodic motion to measure time. Pendulum clocks keep time using a pendulum's periodic swing. It consists of a heavy object, called a bob attached to one end of a string. When a pendulum swings freely, it will move back and forth at regular intervals.

The period of a simple pendulum is the time taken for 1 to-and-fro movement that is 1 complete oscillation. The period depends on its length. Pendulum clocks can be calibrated to measure time accurately by adjusting the length. If we have a stopwatch and a pendulum and we have to measure the time, we start from the middle point. The swing is so fast that we take as many oscillations and divide them.

- Angular displacement: How much you pull it from the rest position.
- Rest position: Where the weight is when it is at rest.
- Time to complete one vibration/oscillation is measured by seeing how long it takes for the object to go from A → B → A, as shown in the diagram below.
- Reaction error: An error in your measurement due to your imperfect reflexes. To overcome this, the pendulum is allowed to swing 10/20 times.

To improve the accuracy of this experiment:

- The oscillation should be of a small amplitude and of 1 plane.
- Place a reference marker directly under the pendulum's rest position, and observe the pendulum as it repeatedly moves past the marker.
- Ensure that your line of sight to the marker is at right angles to the plane to which it oscillates.
- Time how long the pendulum takes to undergo a measured no. of oscillation. (20)
- Repeat the procedure and calculate the average time for 20 oscillations.
- To calculate the period T, divide the average time for the measured number of oscillations by the number of oscillations.
- In order to increase the accuracy, decrease the amplitude of displacement.
- It should be near the ground to prevent Gravity.
- No excessive air.
- There should be a fiducial mark to ensure you close the measurement at the correct time.

Scaler Quantity: it has magnitude (size) only. E.g. distance, speed, time, mass, energy and temperature.

Vector Quantity: it has magnitude (size) and direction. E.g. displacement, force, weight, velocity, acceleration, momentum, electric field strength and gravitational field strength.