

Measurements and Experimentation

- The ancient people use hand-span, foot-span, finger width, palm length, the distance of a step, etc. as a units of measurements. All of them are non- standard methods of measurement.
- This types of measurements are not accurate.
- The measurement of a quantity is expressed in two parts, one part is a number and the other part is the **unit** of measurement.
- To measure various quantities such as distance, height, width, weight, etc., a standard system of measurement is needed.

- The ancient people use hand-span, foot-span, finger width, palm length, the distance of a step, etc. as units of measurements. These are known as non-standard methods of measurement.

Bigger Units:

- For length, the bigger units use are:

(i) Astronomical unit (A.U.): It is the mean distance between Earth and Sun. $1 \text{ A.U.} = 1.496 \times 10^{11} \text{ m}$

(ii) Light year (ly): It is the distance travelled by light in vacuum, in one year. $1 \text{ ly} = 9.46 \times 10^{12} \text{ km}$

(iii) Parsec: $1 \text{ Parsec} = 3.26 \text{ ly}$

- For mass, the bigger units use are:

(i) quintal: $1 \text{ quintal} = 100 \text{ kg}$

(ii) metric tonne: $1 \text{ metric tonne} = 1000 \text{ kg} = 10 \text{ quintal}$

- For time:

(i) lunar month: $1 \text{ lunar month} = 29.5 \text{ days}$

(ii) Leap year

(iii) Decade

(iv) Century

(v) Millennium

Zero error—

Fundamental units — Can neither be derived nor be broken down into other units

Derived units — Can be obtained by the combination of one or more fundamental units

System of units

- **C.G.S. System** — centimetre, gram, and second
- **M.K.S. System** — metre, kilogram, and second
- **S.I. System** — Standard International System (m, kg, and s)

Standard form of expression — $1390000000 \text{ m} = 1.39 \times 10^9 \text{ m}$

Degree of accuracy — How far a quantity can be measured without error

Vernier Callipers

- Invented by Pierre Vernier
- Accuracy — 0.01 cm
- **Parts** —

1. Main scale

1. Vernier scale

1. External jaw

1. Internal jaw

- **Pitch** — Smallest value of length or any other unit, which can be read directly from a main scale accurately
- **Least count** — Magnitude of the smallest measurement, which can be measured by an instrument accurately

$$\text{L.C.} = 1 \text{ M.S.D.} - 1 \text{ V.S.D.}$$

$$\text{Pitch} = \frac{\text{Smallest value of one M.S.D.}}{\text{Number of V.S.D.}}$$

- **Vernier Formula—**

$$\text{Length} = (\text{Pitch} \times \text{Main Scale Division}) + (\text{Least Count} \times \text{Vernier Scale Division})$$

- **Zero error** — Error when zeroes of M.S. and V.S. do not coincide
- **Positive zero error**

$$\text{Correction} = - \text{Coinciding division of V.S.} \times \text{L.C.}$$

- **Negative zero error**

$$\text{Correction} = (n - \text{Coinciding division of V.S.}) \times \text{L.C.}$$

Micrometer Screw Gauge

- Principle — It works on the principle of a screw.
- Accuracy — 0.001 cm
- Parts —

- | | |
|---------------------------------|------------------------------------|
| 1. U-Frame | 1. Base line |
| 2. Nut and Screw | 2. Circular scale or thimble scale |
| 3. Thimble or circular cylinder | 3. Ratchet |
| 4. Sleeve cylinder | |

- **Pitch** — Distance between two consecutive threads of the screw

$$\text{Pitch} = \frac{\text{Distance moved by thimble on M.S.}}{\text{Number of rotations of thimble}}$$

- **Least count** — Smallest distance moved by its tip when the screw turns through 1 division marked on it

$$\text{L.C.} = \frac{\text{Pitch}}{\text{Number of C.S. divisions}}$$

$$\text{Observed diameter} = \text{Main scale reading} + \text{Circular scale reading} \times \text{L.C.}$$

$$\text{True diameter} = \text{Observed diameter} \pm \text{Zero error}$$

- **Zero error**— When zero of main scale does not coincide with that of circular scale
- **Positive zero error**— When zero line on circular scale is below the reference line on main scale

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- **Backlash error**— It is due to wear and tear of threads of a screw and occurs when the tip of the screw does not start moving in the opposite direction on reversing the direction of rotation of the thimble at once and remains stationary for a part of rotation.

Time measurement

1. Time-measuring device – watch or clock
2. Motion of hands of clock is periodic.
3. Motion of pendulum is periodic and oscillatory (to-and-fro).
4. Techniques - Electrical oscillators, electronic oscillators, quartz crystal clocks, atomic clocks.

Time period

1. It is the time taken by a pendulum to complete one oscillation. It is given as
T equals 1 over f.
2. Basic unit of time is second (s).