Chapter 1: Measurements and Experimentation

◆ 1. Meaning of Measurement

- **Measurement** is comparing a physical quantity with a known standard.
- **Unit** is a fixed quantity used to measure other quantities.
- **Formula:**
  Physical Quantity = Numerical Value × Unit (e.g., 5 kg)

◆ 2. Characteristics of a Good Unit

- Convenient size
- Reproducible
- Universally accepted
- Precisely defined

◆ 3. Types of Units

- **Fundamental Units:** Cannot be derived from other units
  E.g., metre (m), kilogram (kg), second (s), kelvin (K), mole, ampere (A), candela (cd)
- **Derived Units:** Derived from fundamental units
  E.g., m^2 (area), m^3 (volume)

◆ 4. Systems of Units

- **CGS:** centimetre, gram, second (French)
- **FPS:** foot, pound, second (British)
- **MKS/SI:** metre, kilogram, second (Metric & Standard)

◆ 5. Units of Measurement

Length

- SI Unit: **metre (m)**
- Redefined in 1983: Distance light travels in 1/299,792,458 second

- **Sub-units:** cm, mm, micron, nanometre
- **Multiples:** km, AU, light year, parsec
- Special units: 1 Å = 10^{-10} m, 1 fermi = 10^{-15} m

Mass

- SI Unit: **kilogram (kg)**
- Redefined using **Planck's constant** via Kibble balance
- **Sub-units:** gram (g), milligram (mg)
- **Multiples:** quintal (100 kg), metric tonne (1000 kg)
- Other units: amu = 1.66×10^{-27} kg, Solar mass = 2×10^{30} kg

Time

- SI Unit: **second (s)**
- Defined by 9,192,631,770 vibrations of Cs-133 atom
- **Sub-units:** ms (10^{-3} s), µs (10^{-6} s), ns, shake (10^{-8} s)
- **Multiples:** minute, hour, day, month, year, decade, century, millennium
  (1 year ≈ 3.1536×10^{7} s)

◆ 6. Rules for Writing Units

- Symbols in lowercase unless named after scientists (e.g., N, J, W)
- Unit names are written in lowercase (e.g., metre, not Metre)
- Compound units written as N·m, N m, or N×m

◆ 7. Measurement of Length

➤ Least Count

- Smallest value that can be measured by an instrument
  e.g., Meter scale LC = 1 mm

➤ Vernier Callipers

- Used for internal/external diameters, depths, etc.
- **Least Count:**
  L.C. = Value of 1 main scale division / No. of vernier divisions
- **Zero Error Types:**
  - **Positive:** Vernier zero is right of main scale zero

- **Negative:** Vernier zero is left of main scale zero
- **Correction:**
  Correct Reading = Observed – Zero error (with sign)

◆ 8. Screw Gauge

➤ Working Principle:

- Based on screw motion
- **Pitch** = Distance moved in one rotation
- **Least Count (L.C.)** = Pitch / No. of circular scale divisions
- **Accuracy:** Up to 0.001 cm or 0.0001 cm
- **Zero Errors:**
  - Positive: Zero mark below base line
  - Negative: Zero mark above base line
- **Correction:**
  Correct Reading = Observed – Zero error (with sign)

◆ 9. Measurement of Time (Using Pendulum)

➤ Simple Pendulum

- Point mass on a string oscillating freely
- **Oscillation:** One to-and-fro motion
- **Time Period (T):** Time for one oscillation
- **Frequency (f):** Oscillations per second, f = 1/T
- **Amplitude:** Maximum displacement from mean position
- **Effective Length (l):** From suspension point to bob's center

➤ T^2 vs l Graph

- A straight line showing $T^2 \propto l$ (directly proportional)

➤ Time Period Formula:

$$T=2\pi\sqrt{\frac{l}{g}}$$

➤ **Factors Affecting Time Period:**

- Directly ∝ √length
- Inversely ∝ √g
- Independent of mass & amplitude

➤ **Seconds Pendulum:**

- Time period = 2s, Length = 1m, g = 9.8 m/s²