Measurement is essential in daily life to quantify the characteristics of objects and phenomena. These measurable characteristics are called **physical quantities**. Physical quantities help solve practical problems by providing precise, standardized values.

Key Situations and Physical Quantities

The chapter highlights various situations where physical quantities are measured. Below is a completed table based on the scenarios provided in the text:

Situation	**Physical Quantity**
Measuring the depth of a pit	Length
Measuring the weight of vegetables	Mass
Taking measurements by a tailor	Length
Using a stopwatch in a race	Time
Measuring blood pressure	Pressure
Measuring body heat	Temperature

Explanation:

- **Length** is used to measure distances, such as the depth of a pit or body measurements by a tailor.
- **Mass** quantifies the amount of matter, as in weighing vegetables.
- **Time** is measured in races using a stopwatch.
- **Pressure** is used in medical contexts like blood pressure measurement.
- **Temperature** quantifies body heat.

Additional Physical Quantities:

- Area (e.g., surface area of a wall for painting)
- Volume (e.g., amount of liquid in a container)
- Density (e.g., mass per unit volume of a substance)
- Force (e.g., pushing or pulling an object)
- Speed (e.g., rate of motion)

Direct vs. Indirect Measurement

- **Direct Measurement**: Some physical quantities, like length, mass, and time, can be measured directly using instruments (e.g., ruler, weighing scale, stopwatch).
- **Indirect Measurement**: Quantities like area, volume, and density are derived from fundamental quantities. For example:

- **Area** = Length × Breadth
- **Volume** = Length × Breadth × Height
- **Density** = Mass ÷ Volume

2. Fundamental and Derived Quantities

Fundamental Quantities

Fundamental quantities are independent and cannot be expressed in terms of other quantities. There are seven fundamental quantities in the International System of Units (SI):

Fundamental Quantity	SI Unit	Symbol
Length	Metre	m
Mass	Kilogram	kg
Time	Second	s
Electric Current	Ampere	A
Temperature	Kelvin	K
Amount of Substance	Mole	mol
Luminous Intensity	Candela	cd

Definition: Fundamental quantities exist independently and form the basis for measuring other quantities.

Derived Quantities

Derived quantities are expressed in terms of fundamental quantities. Examples include:

Derived Quantity	Equation	Unit
Area	Length × Breadth	m^2
Volume	Length × Breadth × Height	m^3
Density	Mass ÷ Volume	kg/m^3
Speed	Distance ÷ Time	m/s
Force	Mass × Acceleration	$kg{\cdot}m/s^2$ (Newton, N)

Definition: Derived quantities are calculated using fundamental quantities and their units are combinations of fundamental units.

3. Units of Physical Quantities

A **unit** is a standardized reference used universally to measure a physical quantity. The **International System of Units (SI)** ensures measurements are consistent worldwide.

Importance of Standardized Units

- **Consistency**: Using the same unit (e.g., metre for length) ensures measurements are the same globally.
- **Accuracy**: Standardized units reduce errors compared to traditional units like foot, cubit, or hand span.
- **Universal Application**: SI units allow parts manufactured in different countries to be assembled seamlessly.

Problems with Traditional Units

- **Low Accuracy**: Units like cubit vary between individuals.
- **Regional Differences**: Difficult for people in other regions to interpret measurements.

4. Units of Length

The SI unit of length is the **metre (m)**. Other units include:

Unit	Relationship with Metre
Kilometre (km)	1 km = 1000 m
Centimetre (cm)	1 m = 100 cm
Millimetre (mm)	1 m = 1000 mm
Micrometre (µm)	1 m = 1,000,000 µm
Astronomical Unit (AU)	1 AU ≈ 150,000,000 km
Light Year	1 light year ≈ 9.46×10^{12} km

Applications:

- **Small Measurements**: Micrometre (e.g., thickness of plastic bags, 30 µm).
- **Large Measurements**: Kilometre (e.g., distances on traffic signs), Astronomical Unit (e.g., distance from Earth to Sun), Light Year (e.g., distances in space).

5. Units of Mass

The SI unit of mass is the **kilogram (kg)**. Other units include:

Unit	Relationship with Kilogram
Milligram (mg)	1 kg = 1,000,000 mg

Gram (g)	1 kg = 1000 g
Quintal	1 quintal = 100 kg
Tonne	1 tonne = 1000 kg

Applications:

- **Small Masses**: Milligram (e.g., medicines), Gram (e.g., toothpaste).
- **Large Masses**: Quintal, Tonne (e.g., truck loads).

Ascending Order of Mass Units:

- Milligram < Gram < Kilogram < Quintal < Tonne

6. Units of Time

The SI unit of time is the **second (s)**. Other units include:

Unit	Relationship with Second
Minute	1 minute = 60 s
Hour	1 hour = 3600 s

7. Units of Volume

The SI unit of volume is the **cubic metre (m^3)**. Other units include:

Unit	Relationship
Litre (L)	1 L = 1000 cm^3
Millilitre (mL)	1 L = 1000 mL

Measurement Example:

- Volume of a stone can be measured by water displacement in a measuring jar.
- **Formula**: Volume = Final water level - Initial water level.

8. Density

Definition: Density is the mass of a substance per unit volume. **Formula**: Density = Mass ÷ Volume **Unit**: kg/m^3

Example:

- A cardboard box filled with sawdust and sand has the same volume but different masses, leading to different densities values.
- **Observation**: Higher mass for the same volume results in higher density.

9. Measuring Instruments

Instruments are used to measure physical quantities with precision. The **least count** is the smallest value an instrument can measure.

Physical Quantity	Instrument	Least Count	Unit
Length	Metre scale	0.1 cm (1 mm)	cm, m
Length	Measuring tape	0.1 cm (1 mm)	cm, m
Volume	Measuring jar	Varies (e.g., 1 mL)	mL, L
Time	Stopwatch	0.01 s	s

Examples:

- **Length of a pen**: Measured using a scale (e.g., 15 cm).
- **Height of a person**: Measured using a measuring tape (e.g., 150 cm).
- **Volume of a stone**: Measured by water displacement in a measuring jar.
- **Time for oscillations**: Measured using a stopwatch (e.g., 10 oscillations in 20 s).

Special Case:

- **Thickness of a paper**: Stack multiple papers, measure the total thickness, and divide by the number of papers to find the thickness of one paper.

10. Rules for Writing Units

To ensure clarity and consistency, SI units follow specific rules:

Rule	Correct Example	Incorrect Example	Explanation
Use lowercase for unit symbols	kg, m	KG, M	Symbols are lowercase unless derived from a person's name.
No plural for unit symbols	1.5 kg	1.5 kgs	Unit symbols do not take plural forms.
No mixing symbols and names	1000 kg/m³	1000 kg/cubic metre	Use either the symbol or the full name, not both.
No mixed units	1.5 kg	1 kg 500 g	Use a single unit for consistency.
Units named after people use uppercase symbols	N (Newton)	n	Symbols for units like Newton or Kelvin use uppercase.
No punctuation after symbols	60 cm	60 cm.	No full stop or comma after the symbol unless at the end of a sentence.
Use space or dot for compound units	N.m or N m	Nm	Use a space or dot to separate units in derived quantities.

11. SI Units and Their Characteristics

Characteristics of SI Units:

- **Standardized**: Universally accepted references.
- **International**: Used globally for consistency.
- **Foundation for Derived Units**: All other units are expressed in terms of fundamental units.

12. Conversions to SI Units

To convert measurements to SI units without changing their values:

Measurement	SI Unit Equivalent
2000 g	2 kg (1 kg = 1000 g)
1 h	3600 s (1 h = 3600 s)
1.5 km	1500 m (1 km = 1000 m)
200 cm	2 m (1 m = 100 cm)

13. Assessment Questions (Solved)

Question 1: Identify the odd one out and explain common features.

I. a) Kilogram, b) Kilometre, c) Second, d) Mole

- **Odd One Out**: Kilometre
- **Reason**: Kilogram, Second, and Mole are SI units of fundamental quantities (mass, time, amount of substance). Kilometre is a derived unit of length (1000 metres).

II. a) Time, b) Area, c) Mass, d) Electric current

- **Odd One Out**: Area
- **Reason**: Time, Mass, and Electric Current are fundamental quantities. Area is a derived quantity (Length × Breadth).

III. a) Metre, b) Kilogram, c) Second, d) Degree Celsius

- **Odd One Out**: Degree Celsius
- **Reason**: Metre, Kilogram, and Second are SI units of fundamental quantities (length, mass, time). Degree Celsius is not an SI unit; the SI unit for temperature is Kelvin.

Question 2: Fill in the table for units of length.

Unit	Relationship with Metre
Kilometre	1 km = 1000 m
Millimetre	1 m = 1000 mm

Centimetre 1 m = 100 cm

Question 3: Convert to SI units.

- a) 2000 g = 2 kg
- b) 1 h = 3600 s
- c) 1.5 km = 1500 m
- d) 200 cm = 2 m

Question 4: Arrange units of mass in ascending order.

- **Units**: Kilogram, Milligram, Quintal, Gram
- **Ascending Order**: Milligram, Gram, Kilogram, Quintal, Tonne

14. Extended Activities

1. **Identify Traditional Units**:
    - Research local units used in the past for length (e.g., cubit, hand span) and mass (e.g., seer, maund).
    - Compare their limitations with SI units.
2. **Seminar Paper on Rules for Writing Units**:
    - **Title**: Rules for Writing SI Units
    - **Content**:
        - Use lowercase for unit symbols (e.g., kg, not KG).
        - Avoid plurals for symbols (e.g., 1.5 kg, not 1.5 kgs).
        - Do not mix symbols and names (e.g., kg/m^3, not kg/cubic metre).
        - Use uppercase for units named after people (e.g., N for Newton).
        - Avoid punctuation after symbols unless at the end of a sentence.
        - Use space or dot for compound units (e.g., N.m or N m).