UNIT 1

Measurement

INTRODUCTION

- **Unit**
  It is a standard quantity of the same kind with which a physical quantity is compared for measuring it.

- **Measurement of a physical quantity**
  The measurement of a physical quantity is done with the help of the following two parameters:
  (i) The unit (u) in which the physical quantity is expressed.
  (ii) The number (n) which tells how much the given unit is contained in the physical quantity.

  Thus, the physical quantity (P) is given by
  $$P = nu$$

- **Fundamental units**
  The physical quantities, like mass, length and time, which do not depend on each other are called fundamental physical quantities. The corresponding units of *fundamental physical quantities* are called *fundamental units*.

- **Derived units**
  The physical quantities which can be derived from the fundamental physical quantities are known as *derived physical quantities*. The corresponding units of derived physical quantities are called derived units. For example, speed, density, acceleration, force, etc. are derived physical qualities.

- **Important features of a standard unit**
  The unit should be well defined and easily accessible. It should be of proper size and widely acceptable all over the world.

- **International system of units**
  In 1960, the General conference of weights and measures introduced a new system of units called *SI unit*. It is a modified form of M.K.S. system. It is because of this reason that SI units are also known as the Rationalised M.K.S. System of units. The seven fundamental units in the SI units are given below:

Physical Quantity	Name of the unit	Symbol
1. Mass	kilogram	kg
2. Length	metre	m
3. Time	second	s
4. Temperature	kelvin	K
5. Luminous intensity	candela	cd
6. Electric current	ampere	A
7. Quantity of matter	mole	mol

- **Astronomical unit**
  The average distance between the earth and the sun is called Astronomical unit.
  $$1\,AU \approx 1.5 \times 10^{11}\,m$$

- **Light year**
  Light year is the unit of distance. It is equal of the distance travelled by light in one year.
  $$1\,ly = 9.46 \times 10^{15}\,m$$

- **Angstrom**
  Angstrom (Å) is the unit of length in which the wavelength of light is expressed.
  $$1 \text{ Å} = 10^{-10} \text{ m}$$
- **Micron**
  One micron is equal to 10^{-6} m. It is also called micrometre.
- **Weights and measures**
  A standard metre and a standard kilogram are preserved under temperature-controlled conditions in the International Bureau of weights and Measures at Sevres near Paris.
  In India, the job of maintaining the standard of measurements lies with the National Physical Laboratory at New Delhi.

SOLVED EXAMPLES

**Example 1.** Express light year in terms of metres.

Sol: The distance travelled by light in vacuum in one year is called a light year. It is denoted by ly.
1 ly = speed of light in vacuum × 1 year
$$= 3 \times 10^8 \text{ ms}^{-1} \times 365 \times 24 \times 60 \times 60 \text{ s}$$
$$= 3 \times 10^8 \times 365 \times 24 \times 60 \times 60 \text{ m}$$
$$= 9.46 \times 10^{15} \text{ m}$$
$\therefore$ $1 \text{ ly} = 9.46 \times 10^{15} \text{ m}$

Example 2. Define one parsec. Express it in terms of metres.

Sol: Parsec or parallactic second refers to the distance at which an arc of length equal to one astronomical unit subtends an angle of one second at a point.
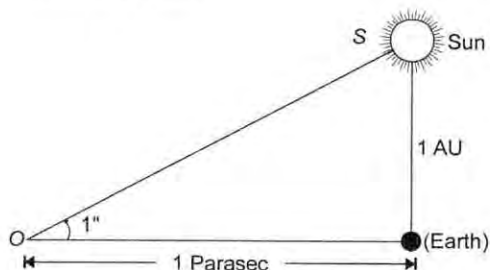
we know,
$$\theta = \frac{l}{r}$$

or $r = \dfrac{l}{\theta}$

$\therefore$ $1 \text{ parsec} = \dfrac{1 \text{AU}}{1''}$

1 AU is the average distance between the earth and the sun and is equal to 1.5×10^{11} m.

$$1 \text{ parsec} = \frac{1.5 \times 10^{11}}{\left(\dfrac{1}{3600}\right) \times \left(\dfrac{\pi}{180}\right)}$$

$$\simeq 3.1 \times 10^{16} \text{ m}$$

We can also prove that
$$1 \text{ parsec} = 3.26 \text{ ly}$$

Example 3. Express the following derived units in terms of the fundamental units of length, mass and time.

Sol:

(i) $\text{Speed} = \dfrac{\text{Distance}}{\text{Time}} = \dfrac{\text{Length}}{\text{Time}}$

(ii) $\text{Area} = \text{Length} \times \text{Breadth} = \text{Length} \times \text{Length}$
$= (\text{Length})^2$

(iii) $\text{Acceleration} = \dfrac{\text{Velocity}}{\text{Time}}$

$= \dfrac{\text{Displacement}}{\text{Time} \times \text{Time}} = \dfrac{\text{Length}}{(\text{Time})^2}$

(iv) $\text{Density} = \dfrac{\text{Mass}}{\text{Volume}}$

$= \dfrac{\text{Mass}}{\text{Length} \times \text{Length} \times \text{Length}} = \dfrac{\text{Mass}}{\text{Length}^3}$

(v) $\text{Volume} = \text{Length} \times \text{Breadth} \times \text{Height}$
$= \text{Length} \times \text{Length} \times \text{Length}$
$= (\text{Length})^3$

EXERCISE

I. True or false Statements
State whether the following statements are True (T) or False (F).

1. Light year is the unit of time
2. One micron is equal to 10^{-3} m.
3. National Physical Laboratory is situated at Kolkata.
4. The prefix used for 10^9 is nano.
5. The prefix used for 10^3 is kilo.
6. In C.G.S. system, gram is the unit of mass.
7. Kg is the unit of mass in the M.K.S. system.
8. India adopted metric system of units in 1947.

II. Fill in the Blanks

Fill in the following blanks using suitable word(s).

1. Density is a _____ physical quantity.
2. Mass is a _____ physical quantity.
3. Physical quantity = _____ × unit.
4. The units of fundamental physical quantities are known as _____ units.
5 Light year is a unit of _____ .
6. One angstrom is equal to _____ .
7. The prefix used for 10^6 is _____ .

MULTIPLE CHOICE QUESTIONS

Tick (✓) the correct choice amongst the following:

1. Which of the following is different from others?
   - (a) micron
   - (b) light year
   - (c) mole
   - (b) angstrom
2. Which of the following is different from others?
   - (a) mass
   - (b) length
   - (c) time
   - (d) density
3. Which of the following is different from others?
   - (a) speed
   - (b) density
   - (c) force
   - (d) time
4. Light year is the unit of
   - (a) time
   - (b) distance
   - (c) speed of light
   - (d) intensity of light
5. Angstrom is the unit used to express
   - (a) length
   - (b) mass
   - (c) time
   - (d) none of these
6. 1 m is equal to
   - (a) 10^{-6} micron
   - (b) 10^6 micron
   - (c) 10^{-3} micron
   - (d) 10^3 micron
7. 1 fermi is equal to
   - (a) 10^{-15} m
   - (b) 10^{15} m
   - (c) 10^{-12} m
   - (d) 10^{12} m

8. The wavelength of light is usually expressed in
   - (a) micron
   - (b) fermi
   - (c) nanometer
   - (d) angstrom
9. The prefix used to represent 10^{-2} is called
   - (a) milli
   - (b) centi
   - (c) kilo
   - (d) deci
10. 1 AU is equal to
    - (a) 1.5×10^{11} m
    - (b) 1.5×10^{10} m
    - (c) 1.5×10^9 m
    - (d) 1.5×10^{-11} m
11. 1 light year is equal to
    - (a) 9.46×10^{-15} m
    - (b) 9.46×10^{15} m
    - (c) 9.46×10^{-13} m
    - (d) 9.46×10^{13} m
12. 1 parsec is equal to
    - (a) 3.1×10^{15} m
    - (b) 3.1×10^{-15} m
    - (c) 3.1×10^{16} m
    - (d) 3.1×10^{-16} m
13. 1 parsec is equal to
    - (a) 3.26 AU
    - (b) 3.26 ly
    - (c) 3.26 Å
    - (d) none of these
14. The symbol used for angstrom is
    - (a) A
    - (b) K
    - (c) Å
    - (d) M
15. Which of the following is the largest unit of length?
    - (a) Light year
    - (b) Astronomical unit
    - (c) Parsec
    - (d) Nothing can be decided
16. I light year is equal to
    - (a) 6.3×10^4 Å
    - (b) 6.3×10^4 A.U.
    - (c) 3.0×10^8 ms^{-1}
    - (d) 6.3×10^7 Å
17. Which of the following is the smallest unit?
    - (a) micron
    - (b) fermi
    - (c) millimetre
    - (d) kilometre
18. The average distance between the earth and the sun is called
    - (a) Astronomical unit
    - (b) Light year
    - (c) Parallactic second
    - (d) None of these
19. The amount of substance in the SI system of units is represented by
    - (a) candela
    - (b) mole
    - (c) weight
    - (d) kilogram
20. The SI unit of temperature is
    - (a) kelvin
    - (b) second
    - (c) mole
    - (d) candela

21. The National Physical Laboratory is situated at
    (a) Kolkata   (b) New Delhi
    (c) Bombay   (d) None of these
22. The SI unit of electric current is
    (a) ampere   (b) candela
    (c) mole   (d) none of these
23. The SI unit of luminous intensity is
    (a) ampere   (b) candela
    (c) mole   (d) none of these
24. India adopted metric system of units in
    (a) 1947   (b) 1950
    (c) 1956   (d) 2000
25. SI units were introduced in
    (a) 1960   (b) 1956
    (c) 1947   (d) none of these
26. Pound is the unit of—in the F.P.S. system.
    (a) mass   (b) length
    (c) time   (d) temperature
27. The unit of length in the F.P.S. system is
    (a) foot   (b) pound
    (c) metre   (d) none of these
28. How many fundamental units are present in the
    SI system of units?
    (a) 5   (b) 6
    (c) 7   (d) 3
29. 1 nano metre (1 nm) is equal to
    (a) 10^{-7}m   (b) 10^{-9}m
    (c) 10^{9} m   (d) none of these
30. 1 quintal is equal to
    (a) $\dfrac{1}{10}$ kg   (b) 10 kg
    (c) 100 kg   (d) 1000 kg

31. The time taken by earth to complete one rotation
    about its axis is
    (a) 12 hours   (b) 16 hours
    (c) 24 hours   (d) 365 days
32. The time interval between identical phases of
    the Moon is called
    (a) Mean Solar Day   (b) Solar Day
    (c) Lunar Month   (d) none of these

ANSWERS

I. True or False Statements

1. (F)   2. (F)   3. (F)   4. (F)   5. (T)
6. (T)   7. (T)   8. (F)

II. Fill in the blanks

1. Derived
2. Fundamental
3. Number
4. Fundamental
5. Distance
6. 10^{-10}m
7. Mega

Multiple Choice Type Questions

1. (c)	2. (d)	3. (d)	4. (b)	5. (a)
6. (b)	7. (a)	8. (d)	9. (b)	10. (a)
11. (b)	12. (c)	13. (b)	14. (c)	15. (c)
16. (b)	17. (b)	18. (a)	19. (b)	20. (a)
21. (b)	22. (a)	23. (b)	24. (c)	25. (a)
26. (a)	27. (a)	28. (c)	29. (b)	30. (c)
31. (c)	32. (c)			