Chapter 2
Units and Measurements

One mark questions

1. **What is a physical quantity?**
   Any quantity which can be measured is called a physical quantity.

2. **What is a unit?**
   A certain basic, arbitrarily chosen, internationally accepted standard of reference for making measurements of a physical quantity is called a unit.

3. **Which are fundamental or basic units?**
   The unit of fundamental quantities is called fundamental units

4. **What are derived units?**
   The units of derived quantities that can be expressed as combination of basic units are called derived units.

5. **What is meant by SI system?**
   SI system means the international system of units, containing seven basic units.

6. **Name the system of units accepted internationally.**
   SI system,

7. **Give the basic units of length in CGS / MKS / FPS / SI system.**
   Centimeter / meter / foot / meter respectively.

8. **Given the base units of mass in CGS / MKS / FPS / SI system.**
   gram / kilogram / pound / kilogram respectively.

9. **Name the unit of time in all systems.**
   seconds

10. How many base units are there in SI system?

There are seven basic units in SI system.

11. Name the SI unit of current / temperature / amount of a substance / luminous intensity.

ampere / Kelvin / mole / candela.

12. Name the SI unit of angle in a plane.

radian

13. Name the SI unit of solid angle.

steradian

14. **Express the relation for angle in a plane**.

angle (dθ) = $\frac{length\ of\ arc\ (ds)}{radius\ (r)}$

15. Express the relation for solid angle.

A: solid angle (dΩ) = $\frac{\boldsymbol{area\ (dA) of\ spherical\ surface}}{\boldsymbol{square\ of\ radius\ (r^2)}}$

16. Mention some direct method of measuring length

Using metallic scale, vernier scale or screw gauge.

17. Name the method of measuring long distances.

Parallax method

18. What is parallax?

The change in position of an object with respect to a point when viewed with left and right eye.

19. What is basis?

The distance between the two points of observation is called the basis.

20. What is meant by parallax angle?

The angle between two directions of observation of a point (object) is called parallax angle.

21. Which are the shorter units of length? Express them in meters.

fermi and angstrom

1 fermi = 10^{-15} m and 1 angstrom = 10^{-10} m

22. Name the larger units of length.

Astronomical unit (AU) and light year (ly), parsec (pc)

23. What is meant by light year?

The distance travelled by light in one year of time.

24. Define unified atomic unit.

One unified atomic mass unit is equal to $1/12^{th}$ of the mass of an atom of carbon – 12 isotope including the mass of electron.

25. Which is the instrument used to measure small masses like atom?

: Mass spectrograph.

26. What is the basis of working of cesium clock or atomic clock?

Periodic vibration of cesium atom.

27. Name the type of clock which gives accurate time.

Cesium atom clock.

28. What is error?

The uncertainty in measurement is called error.

29. What is meant by accuracy?

The accuracy is the measure of how close the measured value is to the true value of the quantity.

30. What is meant by precision?

Precision means, to what resolution or limit of the instrument, the quantity is measured. It is given by least count

31. What are the types of error?

Systematic and random error.

32. Why does a measurement give approximate value ?

It is due to error.

33. What is meant by systematic error?

The systematic errors are that tend to be in one direction and affects each measurement by same amount.

34. What are random errors?

The random errors are those errors which occur irregularly due to random and unpredictable fluctuations in experimental conditions.

35. What is least count?

The smallest value that can be measured by an instrument is called the least count.

36. What is least count error?

It is the error associated with the resolution of the instrument.

37. What is absolute error?

The magnitude of the difference between the individual measurement and the true value of the physical quantity is called absolute error. It is always positive.

38. How would you determine the true value of a quantity measured several times ?

By taking arithmetic mean

39. What is relative error?

The relative error is the ratio of the mean absolute error to the mean value of the quantity measured.

40. **Write the relation for relative error**.

relative error = $\frac{\Delta \text{a mean}}{\text{a mean}}$

41. What is percentage error?

The relative error expressed in percentage is called percentage error.

42. Write the expression for percentage error.

δa (% error) = $\frac{\Delta \text{a mean}}{\text{a mean}}$ x 100

43. Define astronomical unit (AU)

The average distance between earth and sun is known as astronomical unit.

44. Define parsec.

One parsec is the distance at which an arc of length equal to one AU subtends an angle of one second at a point.

45. Express parsec in terms of light years.

1 parsec = 3.26 light year.

46. What are significant figures?

the reliable digits plus the first uncertain digit are known as significant figures.

47. Does the number of significant figures depend on the choice of unit?

No

48. State the number of significant figures in the following

a) 0.006 m^2 (b) 2.65 x 10^3 kg (c) 0.2309 m^{-3} (d) 6.320 J (e) 0.006032 m^2

(a) 1 (b) 3 (c) 3 (d) 4 (e) 4

49. Round off the following result to three significant figures

(a) 2.746 (b) 2.744 (3) 2.745 (4) 2.735

(a) 2.75 (b) 2.744 (c) 2.74 (d) 2.74

50. **Define dimension of a physical quantity**.

The dimensions of a physical quantity are the powers to which the base quantities are raised to represent that quantity.

51. Write the dimensions of work.

Work = $[M^1 L^2 T^{-2}]$. So dimensions of work are one in mass, two in length and -2 in time

52. Define dimensional formula of physical quantity.

The expression which shows how and which of the base quantities represent the dimensions of a physical quantity is called the dimensional formula.

53. Write the dimensional formula of volume.

$[V] = [M^0 L^3 T^0]$

54. Define dimensional equation of a physical quantity.

An equation obtained by equating a physical quantity with its dimensional formula is called the dimensional equation of the physical quantity.

55. Name a physical quantity which has no units and no dimensions

strain.

56. Name a physical quantity which has units but no dimensions.

Angle has unit i.e. radian but it is dimensionless.

57. Name a physical quantity which has neither unit nor dimension.

Relative density (specific gravity)

58. Can a physical quantity have dimension but no unit?

No

59. State the principle of homogeneity of dimensions.

It states that the dimensions of all the terms on either side of an equation must be the same

Two marks question

1. **Mention the base quantities in SI system**

   Length, mass , time, electric current, thermodynamic temperature, amount of substance and luminous intensity

2. **Name any two derive SI unit with the name of scientist.**

   newton , joule, watt etc (any two)

3. **What are sources of systematic error?**

   (i) Instrumental error (ii) imperfection in experimental procedure

   (iii) personal error

4. **Explain the method of reducing systematic error.**

   It can be minimized by improving experimental techniques, selecting better instruments and removing personal bias.

5. **Give any two methods of reducing least count error.**

   Least count error can be reduced by using instruments of higher precision, improving experimental techniques and taking mean of all observations.

6. **The distance 'D' of the sun from the earth is 1.496×10^{11} m. if sun's angular diameter is 9.31×10^{-3} rad as measured from earth, find the diameter of the sun.**

   Sun's diameter $d = \propto D$

   $$= (9.31 \times 10^{-3}) \times 1.496 \times 10^{11}$$

   $$= 1.39 \times 10^{9} \text{ m}$$

7. **State the rule to find the absolute error when two quantities are added or subtracted. Write the expression.**

   When two quantities are added or subtracted the absolute error in the final result is the sum of the absolute error in the individual quantities.

   $$\Delta Z = \Delta A + \Delta B$$

8. State the rule to find the relative error when two quantities are multiplied or divided. Write an expression.

when two quantities are multiplied or divided , the relative error in the result is the sum of the relative error in the multipliers

$$\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$

9. Find the relative error in Z ,if Z = A^3 $B^{1/2}$ / C $D^{3/2}$

the relative error in Z is $\frac{\Delta Z}{Z} = \frac{3\Delta A}{A} + \frac{1}{2}\frac{\Delta B}{B} + \frac{\Delta C}{C} + \frac{3}{2}\frac{\Delta D}{D}$

10. Explain scientific notation method of finding the number of significant figures.

in this notation, every number is expressed as a x 10^b, where ‘a’ is a number between 1 and 10, and ‘b’ is any power of 10. The number of digits in the decimal number gives significant figures.

11. Write the dimension of universal gravitational constant.

$$F = \frac{G\, m_1 m_2}{d^2}$$

$$\therefore G = \frac{F\, d^2}{m_1 m_2}$$

writing the dimensions, $[G] = \frac{[M\, L\, T^{-2}]\,[L^2]}{[M][M]}$

$$= [\, M^{-1}\, L^{3}\, T^{-2}]$$

∴ dimensions are -1 in mass, 3 in length and -2 in time.

12. Mention two pairs of physical quantities which have the same dimensions.

(i) work and energy

(ii) pressure and stress.

13. Mention the physical quantities whose dimensions are (i) $[M^1\, L^{-1}\, T^{-2}]$ (ii) $[M^1\, L^2\, T^{-3}]$

(i) pressure (ii) power

14. What are the dimensions of a and b in the relation F = a$\sqrt{x}$ + bt^2 where F is force , *x* is distance and *t* is time.

By principle of homogeneity, dimensions of every term on RHS should be same as that on LHS i.e. force

$\therefore$ [a] = $\frac{[F]}{[\sqrt{x}]} = \frac{[M\,L\,T^{-2}]}{[L^{1/2}]}$ = [M L$^{1/2}$ T^{-2}]

[b] = $\frac{[F]}{[t^2]} = \frac{[M\,L\,T^{-2}]}{[T^2]}$ = [M L T^{-4}]

15. Mention any two constants which have dimensions.

Gravitational constant, Plank's constant.

16. Mention any two applications of dimensional analysis.

1) To check the correctness of a physical relation

2) to derive relationship between different physical quantities.

17. Mention any two limitations of dimensional analysis.

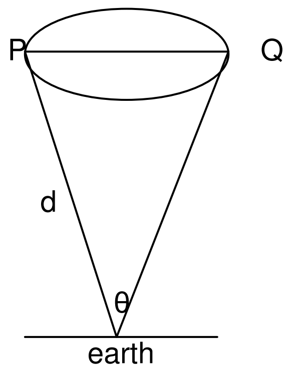
1) dimensionless constants in a relation cannot be determined by this method

2) it cannot derive the exact relationship between physical quantities in any equation.

5 mark questions :

1. **Explain parallax method of determining the size of moon.**

MOON



Let 'D' be the diameter of the moon, when moon is observed from a place 'E' on earth, let 'θ' be the angle made by two diametrically opposite ends P and Q of the moon called parallax angle. If 'd' is the distance of moon from earth , then

$\theta = \frac{PQ}{d} = \frac{D}{d}$ /

$\therefore$ D = d

Using this relation the size of moon can be determined

2. **The period of oscillation of a simple pendulum is T = 2π $\sqrt{L/g}$. the measured value of L is 20.0 cm known to 1 mm accuracy and time for 100 oscillations of the pendulum is found to be 90 s using a watch of 1s resolution. Find accuracy in % error**.

We have g = $4\pi^2 \frac{L}{T^2}$

Here, T = $\frac{t}{n}$ and $\Delta T = \frac{\Delta t}{n}$.

$\therefore \ \frac{\Delta T}{T} = \frac{\Delta t}{t}$

Here errors are least count errors

$\frac{\Delta g}{g} = \left(\frac{\Delta L}{L}\right) + 2\left(\frac{\Delta T}{T}\right)$

$= \frac{0.1}{20.0} + 2\left(\frac{1}{90}\right)$

= 0.027

Thus percentage error in g is 100 x $\frac{\Delta g}{g}$ = 100 x 0.027 = 2.7%

3. **Check the correctness of following equation by dimensional analysis.**

$\boldsymbol{x = x_0 + v_0 t + \frac{1}{2} at^2}$

For LHS , dimension of x = [L]

For RHS, dimension of x_0 = [L]

dimension of $v_0t = [LT^{-1}]\ [T] = [L]$

dimension of $\frac{1}{2}$ $at^2 = [LT^{-2}]\ [T^2] = [L]$ here ½ is a constant having no dimension.

∴ [L] = [L] + [L] + [L] i.e. the dimensions of each term on both sides of the equation are the same . thus the equation is dimensionally correct.

4. **Check the correctness of following equation by dimensional analysis.**

F x = ½ mv^2 – ½ mv^2

Where F – force, x - distance, v_0 – initial velocity, v – final velocity

Consider Fx = ½ mv^2 – ½ mv_0^2

For LHS, dimensions of Fx = $[M\ L\ T^{-2}]\ [L] = [M\ L^2\ T^{-2}]$

For RHS, dimensions of ½ mv^2 = $[M]\ [L\ T^{-1}]^2 = [M\ L^2\ T^{-2}]$

Similarly , dimensions of ½ $mv_0^2 = [M]\ [L\ T^{-1}]^2 = [M\ L^2\ T^{-2}]$

Where ½ is a constant, has no dimension.

∴ $[M\ L^2\ T^{-2}] = [M\ L^2\ T^{-2}] - [M\ L^2\ T^{-2}]$

Since dimensions of each term on both sides of the equation are the same. Thus the equation is dimensionally correct.

5. **The period of oscillation of a simple pendulum depends on its length (l) , mass of the bob (m) and acceleration due to gravity (g) . derive the expression for its time period using method of dimensions.**

We can write $T \propto l^a\ m^b\ g^c$

$T = K\ l^a\ m^b\ g^c$ -----------(1)

Where K is dimensionless constant.

Writing the dimensions of all terms, we get

$[T] = [L]^a\ [M]^b\ [L\ T^{-2}]^c$

$[L^0\ M^0\ T^1] = [L^{a+c}\ M^b\ T^{-2c}]$

Equating the powers of L , M and T on both sides

We get, a + c = 0 ; b = 0 ; and -2c = 1

Thus , a = ½ ; b = 0 ; c = - ½

Substituting in equation (1) we get

$T = K\, l^{1/2} m^0 g^{-1/2}$

$T = K \sqrt{l/g}$

6. The centripetal force (F) acting on a particle moving uniformly in a circle depends upon its mass (m), velocity (v) and radius of circle (r). derive the expression for centripetal force using method of dimensions.

We can write , $F \propto m^a v^b r^c$

$$\therefore F = k\, m^a v^b r^c \quad \text{----- (1)}$$

where K is a constant having no dimension. Writing the dimensions of all terms in the equation ,

we get, $[M\, L\, T^{-2}] = [M]^a [L\, T^{-1}]^b [L]^c$

$\therefore [M\, L\, T^{-2}] = [M^a L^{b+c} T^{-b}]$

Equating the powers of M, L and T on both sides

We get, a =1, b+c = 1 and –b = -2

i.e. a = 1, b = 2 , c = -1

putting these values in equation (1)

$$F = K\, m^1 v^2 r^{-1} \quad \text{or} \quad F = K\, \frac{mv^2}{r}$$

7. Check the correctness of the relation , $S_n = u + \frac{a}{2}(2n - 1)$ where 'u' is the initial velocity, 'a' is the acceleration and 'S_n' is the distance travelled by the body in the n^{th} second.

$S_n = u + \frac{a}{2}(2n - 1)$

Writing the dimensions on the either side, we have

LHS = $S_n = \frac{distance}{time} = \frac{L}{T} = [M^0 L^1 T^{-1}]$

RHS = $u + \frac{a}{2}(2n - 1) = L\, T^{-1} + L\, T^{-2}\, (T)$

$= L\, T^{-1} + LT^{-1}$

$$= [M^0 L^1 T^{-1}]$$

Thus dimension of all terms are same.

$\therefore$ LHS = RHS dimensionally. So the relation is correct.