SECTION B: Very Short Answer Type Questions

Q.19 Why do we have different units for the same physical quantity?

Answer: The value of any physical quantity may vary over a wide range, therefore different units are required for convenience. For example, length of a pen (cm), height of a tree (m), distance between cities (km), distance between celestial bodies (light year).

Q.20 The radius of atom is of the order of 1 Å and radius of nucleus is of the order of fermi. How many magnitudes higher is the volume of atom as compared to the volume of nucleus?

Answer: Radius of atom = 1 Å = 10^{-10} m Radius of nucleus = 1 fermi = 10^{-15} m Volume ratio = $(R_a/R_n)^3 = (10^{-10}/10^{-15})^3 = 10^{15}$

Q.21 Name the device used for measuring the mass of atoms and molecules.

Answer: Mass spectrograph.

Q.22 Express unified atomic mass unit in kg.

Answer: 1 amu = (1/12) × mass of ${}_6C^{12}$ atom Mass of one mole of ${}_6C^{12}$ = 12 g 1 amu = (1/12) × (12 g)/(6.023 × 10^{23}) = 1.67 × 10^{-24} g = 1.67 × 10^{-27} kg

Q.23 A function f(θ) is defined as $f(\theta) = 1 - \theta + \theta^2/2! - \theta^3/3! + \theta^4/4! + \ldots$

Why is it necessary for f(θ) to be a dimensionless quantity?

Answer: Since f(θ) is a sum of different powers of θ, by principle of homogeneity, all terms must be dimensionless, hence θ must be dimensionless.

Q.24 Why length, mass and time are chosen as base quantities in mechanics?

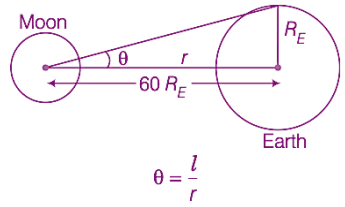
Answer: (i) Length, mass and time cannot be derived from one another - they are independent. (ii) All other mechanical quantities can be expressed in terms of length, mass and time.

SECTION C: Short Answer Type Questions

Q.25 (a) The earth-moon distance is about 60 earth radius. What will be the diameter of the earth (approximately in degrees) as seen from the moon?

Answer: Angle subtended = $l/r = R_e/(60R_e) = 1/60$ rad = (1/60) × (180/π)° ≈ 1° Diameter of earth as seen from moon = 2°

(b) Moon is seen to be of (1/2)° diameter from the earth. What must be the relative size compared to the earth?



$\theta = \frac{l}{r}$

Answer: Diameter ratio = (2°)/((1/2)°) = 4 Therefore, $D_{earth}/D_{moon} = 4$

(c) From parallax measurement, the sun is found to be at a distance of about 400 times the earth-moon distance. Estimate the ratio of sun-earth diameters.

Answer: Since sun and moon appear same size from earth: $D_{sun}/D_{moon} = r_{sun}/r_{moon} = 400$ From part (b): $D_{earth}/D_{moon} = 4$ Therefore: $D_{sun}/D_{earth} = 100$

Q.26 Which of the following time measuring devices is most precise?

(a) A wall clock (b) A stop watch (c) A digital watch (d) An atomic clock

Answer: (d) An atomic clock Reason: Atomic clock precision is 1s in 10^{13} s, much more precise than other devices.

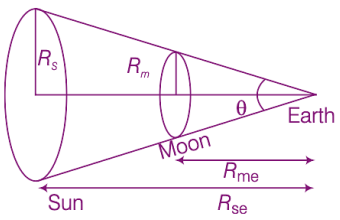
Q.27 The distance of a galaxy is of the order of 10^{25} m. Calculate the order of magnitude of time taken by light to reach us from the galaxy.

Answer: Time = Distance/Speed = $10^{25}/(3 \times 10^8) \approx 3.33 \times 10^{16}$ s

Q.28 The vernier scale of a travelling microscope has 50 divisions which coincide with 49 main scale divisions. If each main scale division is 0.5 mm, calculate the minimum inaccuracy in the measurement of distance.

Answer: 1 VSD = (49/50) MSD Minimum inaccuracy = 1 MSD - 1 VSD = (1/50) MSD = (1/50) × 0.5 mm = 0.01 mm

Q.29 During a total solar eclipse the moon almost entirely covers the sphere of the sun. Write the relation between the distances and sizes of the sun and moon.



Answer: For total eclipse: $\theta_{sun} = \theta_{moon}$ $R_s/R_{se} = R_m/R_{me}$ Therefore: $R_s/R_m = R_{se}/R_{me}$

Q.30 If the unit of force is 100 N, unit of length is 10 m and unit of time is 100 s, what is the unit of mass in this system of units?

Answer: $[F] = [MLT^{-2}] = 100$ N Substituting: $M \times 10 \times (100)^{-2} = 100$ $M = 100 \times 10^4/10 = 10^5$ kg

Q.31 Give an example of

(a) a physical quantity which has a unit but no dimensions (b) a physical quantity which has neither unit nor dimensions (c) a constant which has a unit (d) a constant which has no unit

Answer: (a) Plane angle $\theta = l/r$ (unit: radian, dimensionless) (b) Strain = $\Delta l/l$ (no unit, no dimensions) (c) Gravitational constant $G = 6.67 \times 10^{-11}$ $N \cdot m^2/kg^2$ (d) Reynolds number (dimensionless constant)

Q.32 Calculate the length of the arc of a circle of radius 31.0 cm which subtends an angle of π/6 at the centre.

Answer: $l = r\theta = 31 \times (\pi/6) = (31 \times 3.14)/6 = 16.22$ cm ≈ 16.2 cm

Q.33 Calculate the solid angle subtended by the periphery of an area of 1 cm^2 at a point situated symmetrically at a distance of 5 cm from the area.

Answer: Solid angle Ω = Area/$(\text{Distance})^2 = 1/(5)^2 = 1/25 = 4 \times 10^{-2}$ steradian

Q.34 The displacement of a progressive wave is represented by y = A sin(ωt - kx), where x is distance and t is time. Write the dimensional formula of (i) ω and (ii) k.

Answer: For ωt and kx to be dimensionless: (i) $[\omega][T] = 1 \Longrightarrow [\omega] = [T^{-1}]$ (ii) $[k][L] = 1 \Longrightarrow [k] = [L^{-1}]$

Q.35 Time for 20 oscillations of a pendulum is measured as t_1 = 39.6 s; t_2 = 39.9 s and t_3 = 39.5 s. What is the precision in the measurements? What is the accuracy of the measurement?

Answer: Mean time = (39.6 + 39.9 + 39.5)/3 = 39.7 s Absolute errors: |39.7 - 39.6| = 0.1 s, |39.7 - 39.9| = 0.2 s, |39.7 - 39.5| = 0.2 s Mean absolute error = (0.1 + 0.2 + 0.2)/3 = 0.17 ≈ 0.2 s Precision = Least count = 0.1 s Accuracy = ±0.2 s