Question 21. Is Avogadro's number a dimensionless quantity?
Answer: No, it has dimensions. In fact its dimensional formula is $[mol^{-1}]$.

Question 22. Can a physical quantity have dimensions but still have no units?
Answer: No, it is not possible.

Question 23. Are all constants dimensionless?
Answer: No, it is not true.

Question 24. What is $N\ m^{-1}\ s^{2}$ equal to?
Answer: $N\ m^{-1}\ s^{2}$ is nothing but SI unit of mass i.e., the kilogram.

Question 25. Express a joule in terms of fundamental units.
Answer: [Energy] = $[M\ L^{2}\ T^{-2}]$,
hence 1 joule = $1\ kg \times 1\ m^{2} \times 1\ s^{-2} = 1\ kg\ m^{2}\ s^{-2}$.

Question 26. What is the dimensional formula for torque?
Answer: $[M\ L^{2}\ T^{-2}]$.

Question 27. Is nuclear mass density dependent on the mass number? (Given: $r = r_0 A^{1/3}$)
Answer: No, since density = Mass/Volume

$$= \frac{A}{\frac{4}{3}\pi r^{3}} = \frac{A}{\frac{4}{3}\pi r_0^{3} A} \text{ is independent of } A.$$

Question 28. What does LASER stand for?
Answer: LASER stands for 'Light Amplification by Stimulated Emission of Radiation'.

II. Short Answer Type Questions
Question 1. A body travels uniformly a distance of (13.8 ± 0.2) m in a time (4.0 ± 0.3) s. What is the velocity of the body within error limits?
Answer:

Here, $S = (13.8 \pm 0.2)$ cm; $t = (4.0 \pm 0.3)$ s

$$\therefore \quad V = \frac{13.8}{4.0} = 3.45\ ms^{-1}$$

$$\text{Also} \quad \frac{\Delta V}{V} = \pm\left(\frac{\Delta S}{S} + \frac{\Delta t}{t}\right)$$

$$= \pm\left(\frac{0.2}{13.8} + \frac{0.3}{4.0}\right) = \pm 0.0895$$

$$\Delta V = \pm 0.3 \text{ (rounding off to one place of decimal)}$$

$$V = (3.45 \pm 0.3)\ ms^{-1}.$$

Question 2. What do you mean by order of magnitude? Explain.
Answer: The order of magnitude of a numerical quantity (N) is the nearest power of 10 to which its value can be written.For example. Order of magnitude of nuclear radius 1.5×10^{-14} m is -14.

Question 3. A laser signal is beamed towards the planet Venus from Earth and its echo is received 8.2 minutes later. Calculate the distance of Venus from the Earth at that time.
Answer:
We know that speed of laser light, $c = 3 \times 10^8 m/s$ Time of echo, t = 8.2 minutes = 8.2 x 60 seconds
If distance of Venus be d, then t = 2d/c
$d = 1/2ct = 1/2 \times 3 \times 10^8 \times 8.2 \times 60$ m
$= 7.38 \times 10^{10}$ m
$= 7.4 \times 10^{10}$ m.

Question 4. The parallax of a heavenly body measured from two points diameterically opposite on earth's equator is 60 second. If the radius of earth is 6.4×10^6 m, determine the distance of the heavenly body from the centre of earth. Convert this distance in A.U. Given 1 A.U. = 1.5×10^{11} m.
Answer:

Given, $R = 6.4 \times 10^6$ m

$$\therefore \quad D = 2R = 2 \times 6.4 \times 10^6 \text{ m} = 12.8 \times 10^6 \text{ m}$$

$$\theta = 60 \text{ second} = \frac{1^\circ}{60} = \frac{\pi}{180} \times \frac{1}{60} \text{ radian}$$

The distance of heavenly body from earth is given by

$$r = \frac{D}{\theta} = \frac{12.8 \times 10^6}{\pi} \times 180 \times 60 = \frac{12.8 \times 180 \times 60 \times 10^6}{3.142}$$

$$\Rightarrow \quad r = 4.399 \times 10^{10} \text{ m}$$

$$\text{or,} \quad r = \frac{4.399 \times 10^{10}}{1.5 \times 10^{11}} \text{ A.U.} = 0.293 \text{ A.U.}$$

Question 5. If the length and time period of an oscillating pendulum have errors of 1% and 2% respectively, what is the error in the estimate of g?
Answer:

$$\text{We know} \quad T = 2\pi\sqrt{\frac{l}{g}} \quad \text{or} \quad T^2 = 4\pi^2 \frac{l}{g}$$

$$\therefore \quad g = 4\pi^2 \frac{l}{T^2}$$

$$\therefore \quad \frac{\Delta g}{g} = \frac{\Delta l}{l} + 2\frac{\Delta T}{T}$$

% error in $g = 1\% + 2 \times 2\% = 5\%$.

Question 6. If $x = at^2 + bt + c$; where x is displacement as a function of time. Write the dimensions of a, b and c.
Answer: All the terms should have the same dimension

$$\therefore \qquad [a] = \left[\frac{x}{t^2}\right] = [LT^{-2}]$$

$$[b] = \left[\frac{x}{t}\right] = [LT^{-1}]$$

$$[c] = [x] = [L]$$

Question 7. The number of particles crossing per unit area perpendicular to x-axis in unit time N is given by N= -D(n_2-n_1/x_2-x_1), where n_1 and n_2 are the number of particles per unit volume at x_1 and x_2 respectively. Deduce the dimensional formula for D.
Answer:

$$D = -N\left(\frac{x_2 - x_1}{n_2 - n_1}\right)$$

$$[N] = \frac{N_0}{[L^2T]} = [L^{-2}\,T^{-1}]$$

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

$$[x_2] = [x_1] = [L]$$

$$\text{and} \qquad [n_2] = [n_1] = \frac{N_0}{[L^3]} = [L^{-3}]$$

Question 8. An experiment measured quantities a, b, c and then x is calculated by using the relation ab^{2}x =ab^2/c^3. If the percentage errors in measurements of a, b and c are ± 1%, ±2% and ± 1.5% respectively, then calculate the maximum percentage error in value of x obtained.
Answer:

$$\text{Given} \qquad x = \frac{ab^2}{c^3}$$

$$\therefore \qquad \left(\frac{\Delta x}{x}\right)_{\max} = \frac{\Delta a}{a} + 2\frac{\Delta b}{b} + 3\frac{\Delta c}{c}$$

$$\text{But} \qquad \frac{\Delta a}{a} = \pm 1\%, \quad \frac{\Delta b}{b} = \pm 2\% \quad \text{and} \quad \frac{\Delta c}{c} = \pm 1.5\%$$

$$\therefore \qquad \left(\frac{\Delta x}{x}\right)_{\max} = 1\% + 2 \times 2\% + 3 \times 1.5\%$$

$$= (1 + 4 + 4.5)\% = 9.5\%.$$

Question 9. If instead of mass, length and time as fundamental quantities, we choose velocity, acceleration and force as fundamental quantities and express their dimensions by V, A and F respectively, show that the dimensions of Young's modulus can be expressed as [FA^2 V^{-4}].

Answer:
We know that the usual dimensions of Y are $[MLT^{--2}]/[L^2]$ i.e.,$[M L^{-2}T^{-2}]$
To express these in terms of F, A and V, we must express, M, L and T in terms of these new 'fundamental' quantities.
Now, $[V] = [LT^{-1}]$, $[A] = [LT^{-2}]$ and $[F] = [MLT^{-2}]$
It follow that M = FA-1, T = VA~X, L = V2 A-1
$[Y] = [ML^{-1}T^{-2}]$
$= [FA^{-1}] [V^2 A^{-1}]^{-1}[VA^{-1}]^{-2}$
$= FA^2V^{-4}$ Thus the 'new' dimensions of Young's modulus are $[FV^{-4} A^2]$

Question 10. The density of a cylindrical rod was measured by using the formula $\rho=4m/\pi D^2l$. The percentage errors in m, D and l are 1%, 1.5% and 0.5%. Calculate the percentage error in the calculated value of density.
Answer:

$$\because \quad \text{Density } \rho = \frac{4m}{\pi D^2 l}$$

$$\therefore \quad \left(\frac{\Delta\rho}{\rho}\right)_{\max} = \frac{\Delta m}{m} + 2\frac{\Delta D}{D} + \frac{\Delta l}{l}$$

But $\frac{\Delta m}{m} = 1\%$, $\frac{\Delta D}{D} = 1.5\%$ and $\frac{\Delta l}{l} = 0.5\%$

$\therefore$ Maximum percentage error in calculated value of density

$$\left(\frac{\Delta\rho}{\rho}\right)_{\max} = 1\% + 2 \times 1.5\% + 0.5\%$$
$$= (1 + 3 + 0.5)\% = 4.5\%.$$

*********** END **********