AVIRAL CLASSES
IIT-JEE | NEET | FOUNDATIONS

PHYSICS
CRASH COURSE

LECTURE - 01

TOPICS : Units & Measurement Error Analysis

1. If the energy, $E = G^p h^q c^r$, where G is the universal gravitational constant, h is the Planck's constant and c is the speed of light, then the values of p, q and r are, respectively.

(a) $\frac{-1}{2}, \frac{1}{2}$ and $\frac{5}{2}$ (b) $\frac{1}{2}, \frac{-1}{2}$ and $\frac{-5}{2}$

(c) $\frac{-1}{2}, \frac{1}{2}$ and $\frac{3}{2}$ (d) $\frac{1}{2}, \frac{-1}{2}$ and $\frac{-3}{2}$

2. The density of a cube is measured by measuring its mass and the length of its side. If the maximum errors in the measurements of mass and length are 3% and 2% respectively, then the maximum error in the measurement of density is

(a) 7% (b) 5%

(c) 9% (d) 3%

3. Turpentine oil is flowing through a tube of length l and radius r. The pressure difference between the two ends of the tube is P. The viscosity of oil is given by. $\eta = \frac{P(r^2 - x^2)}{4\upsilon l}$, where υ is the velocity of oil at a distance x from the axis of the tube. The dimension of η is

(a) $[M^0L^0T^0]$ (b) $[MLT^{-1}]$

(c) $[ML^2T^{-2}]$ (d) $[ML^{-1}T^{-1}]$

4. The relation between force F and density d is $F = \frac{x}{\sqrt{d}}$. The dimensions of x are

(a) $[L^{-1/2} M^{3/2} T^{-2}]$ (b) $[L^{-1/2} M^{1/2} T^{-2}]$

(c) $[L^{-1/2} M^{3/2} T^{-2}]$ (d) $[L^{-1} M^{1/2} T^{-2}]$

5. In the formula, $X = 3YZ^2$; X has dimensions of capacitance and Z has dimensions of magnetic induction. The dimensions of Y are

(a) $[M^{-3} L^{-2} T^{-2} A^4]$

(b) $[ML^{-2} T^2 A^2]$

(c) $[M^{-3} L^{-2} T^{-4} A^4]$

(d) $[M^{-3} L^{-2} T^8 A^4]$

6. If E, m, l and G denote energy, mass, angular momentum and gravitational constant respectively, the quantity (El^2/m^5G^2) has the dimensions of

(a) angle (b) length

(c) mass (d) time

7. Which two of the following five physical parameters have the same dimenions ?

1. Energy density
2. refractive index
3. dielectric constant
4. young's modulus

(a) 1 and 4 (b) 1 and 5

(c) 2 and 4 (d) 3 and 5

8. In a new system of units, unit of mass is 10 kg, unit of length is 1 km and unit of time is 1 minute. The value of 1 joule in this new hypothetical system is

(a) 3.6×10^{-4} new units

(b) 6×10^7 new units

(c) 10^{11} new units

(d) 1.67×10^{-4} new units

9. The ratio of the dimensions of Planck constant and that of moment of inertia is the dimensions of

(a) time

(b) frequency

(c) angular momentum

(d) velocity

10. The dimensions of resistance × capacitance are same as that of

(a) current

(b) energy

(c) frequency

(d) time-period

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TOPICS : Units & Measurement Error Analysis (SOLUTION)

1. **(a) :** $E = G^p h^q c^r$ ...(i)

Equating dimensions on both sides of equation (i), we get

$[M^1L^2T^{-2}] = [M^{-1}L^3T^{-2}]^p[ML^2T^{-1}]^q[LT^{-1}]^r$

$= [M^{-p+q}L^{3p+2q+r}T^{-2p-q-r}]$

Applying principle of homogeneity of dimensions, we get

$-p + q = 1$ ...(ii)

$3p + 2q + r = 2$ ...(iii)

$-2p - q - r = -2$ ...(iv)

Adding (iii) and (iv), we get

$p + q = 0$ ...(v)

Adding (ii) and (v), we get

$2q = 1$ or $q = \frac{1}{2}$

From (ii), $p = q - 1 = \frac{1}{2} - 1 = -\frac{1}{2}$

Substituting the values of p and q in equation (iii), we get

$-\frac{3}{2} + 1 + r = 2$ or $r = \frac{5}{2}$

Hence, $p = -\frac{1}{2}, q = \frac{1}{2}, r = \frac{5}{2}$

2. **(c) :** $\because \quad \rho = \frac{M}{L^3}$,

$\therefore \quad \frac{\Delta\rho}{\rho} = \frac{\Delta M}{M} + 3\frac{\Delta L}{L} = 3\% + 3(2\%) = 9\%.$

3. **(d) :** Dimensions of $P = [ML^{-1}T^{-2}]$

Dimensions of $r = [L]$

Dimensions of $v = [LT^{-1}]$

Dimensions of $l = [L]$

$\therefore$ Dimensions of $\eta = \frac{[P][(r^2 - x)^2]}{[v][l]} = \frac{[ML^{-1}T^{-2}][L^2]}{[LT^{-1}][L]}$

$= [ML^{-1}T^{-1}]$

4. **(a) :** Given : $F = \frac{x}{\sqrt{d}}$

$\therefore \quad x = F\sqrt{d}$

$[x] = [L^1 M^1 T^{-2}][L^{-3} M^1 T^0]^{1/2}$

$= [L^1 M^1 T^{-2}][L^{-3/2} M^{1/2} T^0] = [L^{-1/2} M^{3/2} T^{-2}]$

5. **(d) :** As $q = CV$,

$\Rightarrow \quad C = \frac{q}{V} = \frac{q^2}{W} \quad \left[\text{as } V = \frac{W}{q}\right]$

$[X] \to [C] = \left[\frac{A^2T^2}{ML^2T^{-2}}\right] = [M^{-1}L^{-2}T^4A^2]$

$F = BIl\sin\theta, \ [B] = \left[\frac{F}{Il}\right]$

$[Z] \to [B] = \left[\frac{MLT^{-2}}{AL}\right] = [ML^0T^{-2}A^{-1}]$

Given: $X = 3YZ^2 \Rightarrow Y = X/(3Z^2)$

or $[Y] = \frac{[X]}{[Z^2]} = \frac{[M^{-1}L^{-2}T^4A^2]}{[ML^0T^{-2}A^{-1}]^2} = [M^{-3}L^{-2}T^8A^4]$

6. **(a) :** $[E] = [ML^2T^{-2}]$, $[m] = [M]$, $[l] = [ML^2T^{-1}]$, $[G] = [M^{-1}L^3T^{-2}]$

$\therefore \quad \left[\frac{El^2}{m^5G^2}\right] = \frac{[ML^2T^{-2}]\cdot[M^2L^4T^{-2}]}{[M^5]\cdot[M^{-2}L^6T^{-4}]} = [M^0L^0T^0]$

As angle has no dimension, this has the same dimension as the angle.

7. **(a) :** $[\text{Energy density}] = \left[\frac{\text{Work done}}{\text{Volume}}\right]$

$= \frac{[MLT^{-2}L]}{[L^3]} = [ML^{-1}T^{-2}]$

$[\text{Young's modulus}] = [Y] = \left[\frac{\text{Force}}{\text{Area}}\right] \times \frac{[l]}{[\Delta l]}$

$= \frac{[MLT^{-2}]}{[L^2]}\frac{[L]}{[L]} = [ML^{-1}T^{-2}]$

The dimensions of 1 and 4 are the same.

8. **(a) :** The dimensional formula of energy is $[ML^2T^{-2}]$.

$n_2 = 1\left[\frac{1\text{ kg}}{10\text{ kg}}\right]^1\left[\frac{1\text{ m}}{1\text{ km}}\right]^2\left[\frac{1\text{ s}}{1\text{ min}}\right]^{-2}$

$= \frac{1}{10} \times \frac{1}{10^6} \times \frac{1}{(60)^{-2}} = \frac{3600}{10^7} = 3.6 \times 10^{-4}$

9. **(b) :** Planck's constant, $h = \frac{E}{\upsilon}$

$= \frac{[ML^2T^{-2}]}{[T^{-1}]} = [ML^2T^{-1}]$

Moment of inertia, $I = [ML^2]$

$\frac{h}{I} = \frac{[ML^2T^{-1}]}{[ML^2]} = [T^{-1}] = \text{frequency}$

10. **(d) :** Resistance $= \frac{\text{voltage}}{\text{current}}$ and

Capacitance $= \frac{\text{charge}}{\text{voltage}}$

$\therefore$ Resistance × capacitance

$= \frac{\text{voltage}}{\text{current}} \times \frac{\text{charge}}{\text{voltage}} = \frac{\text{charge}}{\text{current}}$

$= \frac{\text{current} \times \text{time period}}{\text{current}} = \text{time period.}$