PHYSICS

1. The density of a material in the shape of a cube is determined by measuring three sides of the cube and its mass. If the relative errors in measuring the mass and length are respectively 1.5% and 1%, the maximum error in determining the density is:

(1) 2.5% (2) 3.5% (3) 4.5% (4) 6%

Answer key : (3)

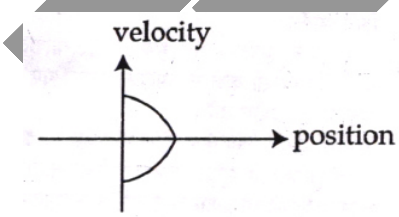
$$\rho = \frac{m}{v} = \frac{m}{\ell^3}$$

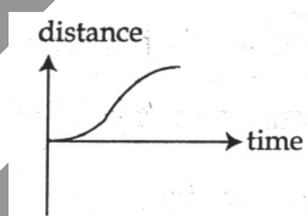
$$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 3\frac{\Delta\ell}{\ell}$$

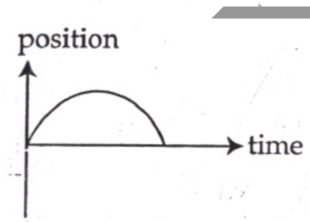
$$\frac{\Delta\rho}{\rho}\times 100 = \frac{\Delta m}{m}\times 100 + 3\frac{\Delta\ell}{\ell}\times 100$$

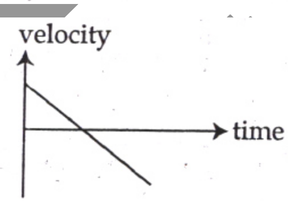
% error in density = $1.5 + 3\times 1 = 4.5\%$

2. All the graphs below are intended to represent the same motion. One of them does it incorrectly. Pick it up.

(1)


(2)


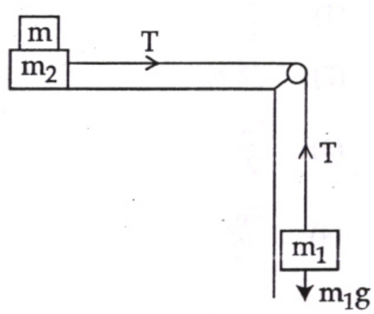
(3)


(4)


Answer key : (2)

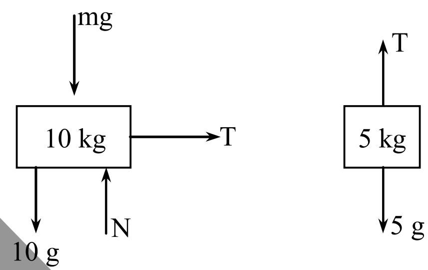
Graph 1, 3 & 4 are consistent. As velocity decreases with time, so slope of distance time graph should decrease as motion starts, but in graph 2 slope increases. So, graph 2 is incorrect.

3. Two masses $m_1 = 5$ kg and $m_2 = 10$ kg, connected by an inextensible string over a frictionless pulley, are moving as shown in the figure. The coefficient of friction of horizontal surface is 0.15. the minimum weight m that should be put on top of m_2 to stop the motion is:



(1) 18.3 kg (2) 27.3 kg (3) 43.3 kg (4) 10.3 kg

Answer key : (2)



$T = 5g$

$N = mg + 10g$

For no relative slipping

$\mu N \geq T$

$0.15\ (mg + 10\ g) \geq 5g$

$0.15(10 + m) \geq 5$

$10 + m \geq \frac{100}{3}$

$m \geq \frac{70}{3}$

$m \geq 23.33$ kg

The closet option is (2) for 27.3 kg.

4. A particle is moving in a circular path of radius a under the action of an attractive potential $U = -\frac{k}{2r^2}$. It's total energy is:

(1) $-\frac{k}{4a^2}$ (2) $\frac{k}{2a^2}$ (3) Zero (4) $-\frac{3}{2}\frac{k}{a^2}$

Answer key : (3)

$U = \frac{-K}{2r^2}$

$F = \frac{-dU}{dr} = -\frac{K}{r^3}$

This force will provide centripetal force

$\frac{K}{r^3} = \frac{mv^2}{r}$

$\Rightarrow mv^2 = \frac{K}{r^2}$

So, $\frac{1}{2}mv^2 = \frac{K}{2r^2}$

So, kinetic energy $= \frac{K}{2r^2}$

Total energy = kinetic energy + Potential energy $= \frac{K}{2r^2} - \frac{K}{2r^2} = 0$

5. In a collinear collision, a particle with an initial speed v_0 strikes a stationary particle of the same mass. If the final total kinetic energy is 50% greater than the original kinetic energy, the magnitude of the relative velocity between the two particles, after collision, is:

(1) $\frac{v_0}{4}$ (2) $\sqrt{2}\,v_0$ (3) $\frac{v_0}{2}$ (4) $\frac{v_0}{\sqrt{2}}$

Answer key : (2)

If velocity of two balls after collision is v_1 & $v_1 + \Delta v$, then Δv is our answer.

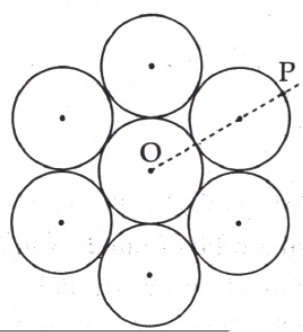
$$mv_0 = mv_1 + m(v_1 + \Delta v)$$

And $\frac{3}{2} \times \left(\frac{1}{2}mv_0^2\right) = \frac{1}{2}mv_1^2 + \frac{1}{2}m(v_1 + \Delta v)^2$

Eliminating v_1 from the above two equations, we get,

$\Delta v = \sqrt{2}v_0$.

6. Seven identical circular planar disks, each of mass M and radius R are welded symmetrically as shown. The moment of inertia of the arrangement about the axis normal to the plane and passing through the point is:



(1) $\frac{19}{2}MR^2$ (2) $\frac{55}{2}MR^2$ (3) $\frac{73}{2}MR^2$ (4) $\frac{181}{2}MR^2$

Answer key : (4)

First calculate moment of inertia of each disc about axis passing through O & perpendicular to plane.

$$I_0 = \frac{MR^2}{2} + 6\left[\frac{MR^2}{2} + M(2R)^2\right]$$

(Using parallel axis theorem)

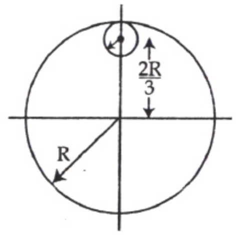
$$= \frac{55}{2}MR^2$$

Now by using parallel axis theorem again between axis passing through 'O' & axis passing through P.

$$I_P = I_0 + 7M(3R)^2$$

$$= \frac{55}{2}MR^2 + 7M(9R^2) = \frac{181}{2}MR^2$$

7. From a uniform circular disc of radius R and mass 9 M, a small disc of radius $\frac{R}{3}$ is removed as shown in the figure. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through centre of disc is:



(1) $4MR^2$ (2) $\frac{40}{9}MR^2$ (3) $10MR^2$ (4) $\frac{37}{9}MR^2$

Answer key : (1)

Mass of bigger disc = 9 M.

Mass of unit area = $\frac{9M}{\pi R^2}$

Mass of removed disc = $\frac{9M}{\pi R^2}\times\pi\left(R/3\right)^2 = M$

Moment of inertia of bigger disc about axis passing through center before cutting $= I_0 = \frac{9MR^2}{2}$

Moment of inertia of cutted disc about center = $I_1 = \frac{M\left(R/3\right)^2}{2} + M\left(2R/3\right)^2$

$= \frac{MR^2}{18} + \frac{4MR^2}{9} = \frac{MR^2}{2}$

Moment of inertial of remaining portion

$I = I_0 - I_1$

$= \frac{9MR^2}{2} - \frac{MR^2}{2} = 4MR^2$

8. A particle is moving with a uniform speed in a circular orbit of radius R in a central force inversely proportional to the n[th] power of R. If the period of rotation of the particle is T, then:

(1) $T \propto R^{3/2}$ for any n (2) $T \propto R^{\frac{n}{2}+1}$ (3) $T \propto R^{(n+1)/2}$ (4) $T \propto R^{n/2}$

Answer key : (3)

Let $F = \frac{K}{r^n}$

$\Rightarrow \frac{K}{r^n} = \frac{mv^2}{r}$

$\Rightarrow v = \sqrt{\frac{K}{m r^{n-1}}}$

$T = \frac{2\pi r}{v} = 2\pi r\sqrt{\frac{mr^{n-1}}{K}}$

$= 2\pi\sqrt{\frac{m}{K}}\, r^{\frac{n+1}{2}}$

$\Rightarrow T \propto r^{\frac{n+1}{2}}$

9. A solid sphere of radius r made of a soft material of bulk modulus K is surrounded by a liquid in a cylindrical container. A massless piston of area a floats on the surface of the liquid, covering entire cross section of cylindrical container. When a mass m is placed on the surface of the piston to compress the liquid, the fractional decrement in the radius of the sphere, $\left(\frac{dr}{r}\right)$, is:

(1) $\frac{Ka}{mg}$ (2) $\frac{Ka}{3mg}$ (3) $\frac{mg}{3Ka}$ (4) $\frac{mg}{Ka}$

Answer key : (3)

Bulk modulus $= -\frac{\Delta P \cdot V}{\Delta V}$

$$K = \frac{\left(\frac{mg}{a}\right)\left(\frac{4}{3}\pi r^3\right)}{\left(4\pi r^2\ dr\right)}$$

$$K = \frac{mg}{3a}\frac{r}{dr}$$

$$\frac{dr}{r} = \frac{mg}{3Ka}$$

10. Two moles of an ideal monoatomic gas occupies a volume V at 27°C. The gas expands adiabatically to a volume 2 V. Calculate (a) the final temperature of the gas and (b) change in its internal energy.

(1) (a) 189 K (b) 2.7 KJ (2) (a) 195 K (b) – 2.7 KJ

(3) (a) 189 K (b) –2.7 KJ (4) (a) 195 K (b) 2.7 KJ

Answer key : (3)

For adiabatic process

$$TV^{\gamma-1} = K$$

$$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$$

$$T_2 = \left(\frac{V_1}{V_2}\right)^{\gamma-1} T_1$$

$$T_2 = \left(\frac{1}{2}\right)^{\frac{5}{3}-1}(300)$$

$$T_2 = \frac{300}{1.587} = 189.03 \approx 189\ \text{K}.$$

$$\Delta U = Q - W \qquad (Q = 0)$$

$$\Delta U = -W$$

$$W = \frac{nR(T_1 - T_2)}{\gamma - 1} = \frac{2 \times 8.314 \times (300 - 189)}{\frac{5}{3} - 1}$$

$= 2768.56$ J

Hence $\Delta U = -2.7$ KJ

11. The mass of a hydrogen molecule is 3.32×10^{-27} kg. If 10^{23} hydrogen molecule strike, per second, a fixed wall of area 2 cm^2 at an angle of 45° to the normal, and rebound elastically with a speed of 10^3 m/s, then the pressure on the wall is nearly:

(1) 2.35×10^3 N/m^2 (2) 4.70×10^3 N/m^2 (3) 2.35×10^2 N/m^2 (4) 4.70×10^2 N/m^2

Answer key : (1)

Change in momentum of one molecule

$$\Delta P = 2mv\cos\theta$$

$\therefore$ change in momentum of n molecules

$\Delta P_{total} = n(2mv\cos\theta)$

this change in momentum of n molecule took place in 1 s

$\therefore$ force exerted on the wall will be

$F = \frac{\Delta P_{total}}{1s} = 2nmv\cos\theta$

Pressure = $F/A = 2nmv\cos\theta / A$

$P = 2.35\times10^3$ N/m^2

12. A silver atom in a solid oscillates in simple harmonic motion in some direction with a frequency of 10^{12}/sec. What is the force constant of the bonds connecting one atom with the other? (Mole wt. of silver = 108 and Avagadro number = 6.02×10^{23} gm mole^{-1})

(1) 6.4 N/m (2) 7.1 N/m (3) 2.2 N/m (4) 5.5 N/m

Answer key : (2)

Mass of one silver atom will be

$m = \frac{M}{N_A}$ gm

$m = \frac{M}{N_A}\times10^{-3}$ kg

Now = $f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{K}{m}}$

$f^2 = \frac{1}{4\pi^2}\times\frac{K}{m}$

$K = 4\pi^2 f^2 m$, $K = 7.1$ N/m

13. A granite rod of 60 cm length is clamped at its middle point and is set into longitudinal vibrations. The density of granite is 2.7×10^3 kg/m^3 and its Young's modulus is 9.27×10^{10} Pa. What will be the fundamental frequency of the longitudinal vibrations?

(1) 5 kHz (2) 2.5 kHz (3) 10 kHz (4) 7.5 kHz

Answer key : (1)

$v = \sqrt{\frac{Y}{\rho}}$, $\frac{\lambda}{2} = \ell$

$f_0 = \frac{v}{\lambda}$

$f_0 = \frac{1}{2\ell}\sqrt{\frac{Y}{\rho}}$

$f_0 = 5$ kH

14. Three concentric metal shells A, B and C of respective radii a, b and c (a < b < c) have surface charge densities $+\sigma$, $-\sigma$ and $+\sigma$ respectively. The potential of shell B is:

(1) $\frac{\sigma}{\varepsilon_0}\left[\frac{a^2-b^2}{a}+c\right]$ (2) $\frac{\sigma}{\varepsilon_0}\left[\frac{a^2-b^2}{b}+c\right]$ (3) $\frac{\sigma}{\varepsilon_0}\left[\frac{b^2-c^2}{b}+a\right]$ (4) $\frac{\sigma}{\varepsilon_0}\left[\frac{b^2-c^2}{c}+a\right]$

Answer key : (2)

The potential of shell B will be superposition of potential due to charge distribution on shell A, B & C independently.

$V_B = V_1 + V_2 + V_3$

Now,

$V_1 = \frac{4\pi a^2\sigma}{4\pi\varepsilon_0 b} = \frac{a^2\sigma}{\varepsilon_0 b}$

$V_2 = \frac{-4\pi b^2\sigma}{4\pi\varepsilon_0 b} = \frac{-b^2\sigma}{\varepsilon_0 b}$

$V_3 = \frac{4\pi c^2\sigma}{4\pi\varepsilon_0 c} = \frac{c\,\sigma}{\varepsilon_0}$

$\therefore V_B = \frac{\sigma}{\varepsilon_0}\left(\frac{a^2-b^2}{b}+c\right)$

15. A parallel plate capacitor of capacitance 90 pF is connected to a battery of emf 20 V. If a dielectric material of dielectric constant $K = \frac{5}{3}$ is inserted between the plates, the magnitude of the induced charge will be:

(1) 1.2 nC (2) 0.3 nC (3) 2.4 nC (4) 0.9 nC

Answer key : (1)

$C = 90 \times 10^{-12}$ F

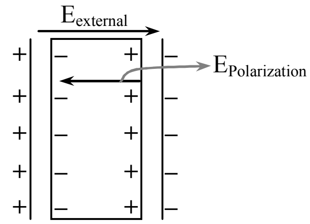
$V = 20$ V

$K = \frac{5}{3}$

Now, charge on the capacitor will be

$Q = KCV$

Now, if a dielectric slab is inserted between the plates of a capacitor.



$$E_{int} = E_{ext} - E_{pol}$$

$$E_{pol} = E_{ext} - E_{int}, \qquad K = \frac{E_{ext}}{E_{int}}$$

Now, if we consider induced charges on the plate to be q then

$$E_{pol} = \frac{q}{A\varepsilon_0}$$

$$\therefore E_{pol} = E_{ext}\left(1 - \frac{E_{int}}{E_{ext}}\right)$$

$$\frac{q}{A\varepsilon_0} = \frac{Q}{A\varepsilon_0}\left(1 - \frac{1}{K}\right)$$

$$q = KCV\left(1 - \frac{1}{K}\right)$$

q = 1.2 n C

16. In an a.c. circuit, the instantaneous e.m.f. and current are given by

$$e = 100\sin 30\,t$$

$$i = 20\sin\left(30t - \frac{\pi}{4}\right)$$

In one cycle of a.c., the average power consumed by the circuit and the wattles current are, respectively.

(1) 50, 100 (2) $\frac{1000}{\sqrt{2}}, 10$ (3) $\frac{50}{\sqrt{2}}, 0$ (4) 50, 0

Answer key : (2)

$$e = 100\sin 30t$$

$$i = 20\sin\left(30t - \pi/4\right)$$

Average power $= \frac{(i_0)(e_0)}{2}\cos\phi$

$$= \frac{(100)(20)}{2}\cos\left(\pi/4\right)$$

$$\vec{P} = \frac{1000}{\sqrt{2}}$$

Now for watt less current

$$= i_{rms}\sin\theta$$

$=\left(\frac{20}{\sqrt{2}}\right)\left(\sin\frac{\pi}{4}\right)$

$=\frac{20}{\sqrt{2}}\times\frac{1}{\sqrt{2}}=10\text{ A}$

17. Two batteries with e.m.f. 12 V and 13 V are connected in parallel across a load resistor of 10 Ω. The internal resistances of the two batteries are 1 Ω and 2 Ω respectively. The voltage across the load lies between:

(1) 11.6 V and 11.7 V (2) 11.5 V and 11.6 V (3) 11.4 V and 11.5 V (4) 11.7 V and 11.8 V

Answer key : (2)

$e_{eq}=\frac{12\times2+13\times1}{3}=12.33$

$\Delta V_{10\Omega}=i(10\Omega)=\left(\frac{12.33}{10+2/3}\right)(10\Omega)=11.56\text{ A}$

18. An electron, a proton and an alpha particle having the same kinetic energy and moving in circular orbits or radii r_e, r_P, r_α respectively in a uniform magnetic field B. The relation between r_e, r_P, r_α is:

(1) $r_e>r_P=r_\alpha$ (2) $r_e<r_P=r_\alpha$ (3) $r_e<r_P<r_\alpha$ (4) $r_e<r_\alpha<r_P$

Answer key : (2)

If K is kinetic energy

$r=\frac{\sqrt{2mK}}{qB}$

$r_e:r_p:r_\alpha=\frac{\sqrt{m_e}}{e}:\frac{\sqrt{m_p}}{e}:\frac{\sqrt{4m_p}}{2e}$

Hence, $r_e<r_P=r_\alpha$

19. The dipole moment of a circular loop carrying a current I, is m and the magnetic field at the centre of the loop is B_1. When the dipole moment is doubled by keeping the current constant, the magnetic field at the centre of the loop is B_2. The ratio $\frac{B_1}{B_2}$ is:

(1) 2 (2) $\sqrt{3}$ (3) $\sqrt{2}$ (4) $\frac{1}{\sqrt{2}}$

Answer key : (3)

To double dipole moment without changing current, radius must become $\sqrt{2}$ tims.

$B\propto\frac{1}{r}$

Hence, $\frac{B_1}{B_2}=\sqrt{2}$

20. For an RLC circuit driven with voltage of amplitude v_m and frequency $\omega_0=\frac{1}{\sqrt{LC}}$ the current exhibits resonance. The quality factor, Q is given b:

(1) $\frac{\omega_0 L}{R}$ (2) $\frac{\omega_0 R}{L}$ (3) $\frac{R}{(\omega_0 C)}$ (4) $\frac{CR}{\omega_0}$

Answer key : (1)

Standard value of quality factor is $\frac{\omega_0 L}{R}$, as mentioned in NCERT.

21. An EM wave from air enters a medium. The electric fields are $\vec{E}_1 = E_{01}\ \hat{x}\cos\left[2\pi v\left(\frac{z}{c}-t\right)\right]$ in air and $\vec{E}_2 = E_{02}\ \hat{x}\cos\left[k\left(2z-ct\right)\right]$ in medium, where the wave number k and frequency v refer to their values in air. The medium is non-magnetic. If $\in_{r_1}$ and $\in_{r_2}$ refer to relative permittivities of air and medium respectively, which of the following options is correct?

(1) $\frac{\in_{r_1}}{\in_{r_2}} = 4$ (2) $\frac{\in_{r_1}}{\in_{r_2}} = 2$ (3) $\frac{\in_{r_1}}{\in_{r_2}} = \frac{1}{4}$ (4) $\frac{\in_{r_1}}{\in_{r_2}} = \frac{1}{2}$

Answer key : (3)

Velocity in medium two.

$v_2 = \frac{kc}{2k}$

$= \frac{c}{2}$

$\therefore$ Refractive index of medium n = 2 and n = $\sqrt{\mu_2 \varepsilon_r}$

$\because$ n has become doubled.

ε_r must become four time.

$\therefore \varepsilon_{r_2} = 4\varepsilon_r$

option (3) is correct.

22. Unpolarized light of intensity I passes through an ideal polarizer A. Another identical polarizer B is placed behind A. The intensity of light beyond B is found to be $\frac{I}{2}$. Now another identical polarizer C is placed between A and B. The intensity beyond B is now found to be $\frac{I}{8}$. The angle between polarizer A and C is:

(1) 0° (2) 30° (3) 45° (4) 60°

Answer key : (3)

Since intensity is $\frac{1}{2}$ while using polarizer A & B, hence both must have same transmission axis.

Now, if C make angle θ with A,

Intensity After A = $\frac{I}{2}$

Intensity After $B = \frac{I}{2}\cos^2\theta$

Intensity After $C = \frac{I}{2}\cos^4\theta$

Hence, $\cos^4\theta = \frac{1}{4}$

$\cos\theta = \frac{1}{\sqrt{2}}$

$\theta = 45$

23. The angular width of the central maximum in a single slit diffraction patter in 60°. The width of the slit is 1μm. The slit is illuminated by monochromatic plane waves. If another slit of same width is made near it, Young's fringes can be observed on a screen placed at a distance 50 cm from the slits. If the observed fringe width is 1cm, what is the slit separation distance?

(i.e. distance between the centres of each slit).

(1) 25 μm (2) 50 μm (3) 75 μm (4) 100 μm

Answer key : (1)

$\lambda = b\sin\theta$

where $\theta = \frac{60}{2} = 30$

$\therefore \lambda = 10^{-6} \times \frac{1}{2}$

$= 5\times10^{-7}$ m

Fringe width

$\beta = \frac{\lambda D}{d}$

$\Rightarrow d = \frac{\lambda D}{\beta}$

$= \frac{5\times10^{-7}\times0.5}{10^{-2}}$

$= 25\mu\text{m}$

24. An electron from various excited states of hydrogen atom emit radiation to come to the ground state. Let λ_n, λ_g be the de Broglie wavelength of the electron in the n^{th} state and the ground state respectively. Let Λ_n be the wavelength of the emitted photon in the transition from the n^{th} state to the ground state. For large n, (A, B are constants)

(1) $\Lambda_n \approx A + \frac{B}{\lambda_n^2}$ (2) $\Lambda_n \approx A + B\lambda_n$ (3) $\Lambda_n^2 \approx A + B\lambda_n^2$ (4) $\Lambda_n^2 \approx \lambda$

Answer key : (1)

For de Broglie wavelength in n^{th} state

$L = mvr = pr$

$\Rightarrow P = \frac{L}{r} = \frac{nh}{2\pi r}$

$\lambda_n = \frac{h}{P}$

$= \frac{2\pi r}{n}$

$\left[\because r \propto n^2\right]$

$\lambda_n \propto n$ ...(1)

$$\frac{1}{\Lambda_n} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$$

$$\Lambda_n = \frac{1}{R\left(1 - \frac{1}{n^2}\right)}$$

$$= \frac{1}{R}\left(1 - \frac{1}{n^2}\right)^{-1}$$

$\because$ n is very large.

We can use binomial approximation

$$\Lambda_n = \frac{1}{R}\left(1 + \frac{1}{n^2}\right)$$

$$= \frac{1}{R} + \frac{1}{Rn^2}$$

Using (1)

$$= a + \frac{B}{\lambda_n^2}$$

$\therefore$ option (1) is correct.

25. If the series limit frequency of Lyman series is ν_L, then the series limit frequency of the Pfund series is:

(1) $25\,\nu_L$ (2) $16\,\nu_L$ (3) $\nu_L/16$ (4) $\nu_L/25$

Answer key : (4)

For series limit of Lyman

$$\Delta E_L = \frac{13.6}{(n=1)^2} \quad ...(1)$$

For series limit of P-fund

$$\Delta E_P = \frac{13.6}{(n=5)^2} \quad ...(2)$$

from (1) & (2)

$$\Delta E_P = \frac{\Delta E_\ell}{25}$$

& $\Delta E \propto$ frequency

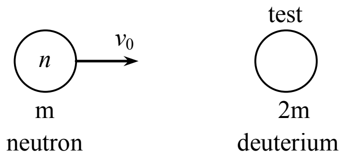
$$\therefore \nu_p = \frac{\nu_L}{25}$$

$\therefore$ option (4) is correct.

26. It is found that if a neutron suffers an elastic collinear collision with deuterium at rest, fractional loss of its energy is p_d; while for its similar collision with carbon nucleus at rest, fractional loss of energy is p_c. The values of p_d and p_c are respectively:

(1) $(\cdot 89,\ \cdot 28)$ (2) $(\cdot 28,\ \cdot 89)$ (3) (0, 0) (4) (0,1)

Answer key : (1)



Velocity of neutron after collision is given by the formula

$$v=\frac{mv_0+0+2m(0-v_0)}{3m}$$

$$=-\frac{v_0}{3}$$

$\therefore$ loss in kinetic energy

$$=\frac{1}{2}mv_0^2-\frac{1}{2}\frac{mv_0^2}{9}$$

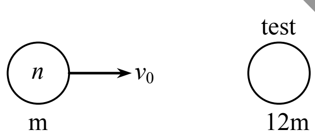
$$=\frac{8}{9}\times\frac{1}{2}mv_0^2$$

$\therefore$ fractional loss $=\frac{K.E_{\text{lost}}}{K.E_{\text{initial}}}$

$$p_d=\frac{8}{9}=0.89$$

$\because$ only one option contains 0.89 as first option we can mark option (1) as correct option without calculating P_C.

But for our own interest we can calculate P_C in a similar way.



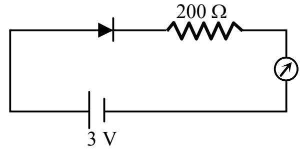
$$v_n=\frac{mv_0+0+12m(0-v_0)}{13m}$$

$$=\frac{-11}{13}v^2$$

$$\therefore \text{K.E}_{\text{lost}}=\therefore K.E_{lost}=\frac{1}{2}mv_0^2\left(1-\frac{11^2}{13^2}\right)$$

$$\therefore P_C=0.28$$

27. The reading of the ammeter of a silicon diode in the given circuit is:



(1) 0 (2) 15 mA (3) 11.5 mA (4) 13.5 mA

Answer key : (3)

For silicon forward bias potential drop is 0.7 V.

$$i=\frac{3-0.7}{200}$$

$= 11.5\,\text{mA}$

28. A telephonic communication service is working at carrier frequency of 10 GHz. Only 10% of it is utilized for transmission. How many telephonic channels can be transmitted simultaneously if each channel requires a bandwidth of 5 kHz?

(1) 2×10^3 (2) 2×10^4 (3) 2×10^5 (4) 2×10^6

Answer key : (3)

Utilized carrier frequency $= 10\%$ of $10\,\text{GHz}$

$= 10^6\,\text{KHz}$

$\therefore$ no of channels $= \frac{10^6}{5}$

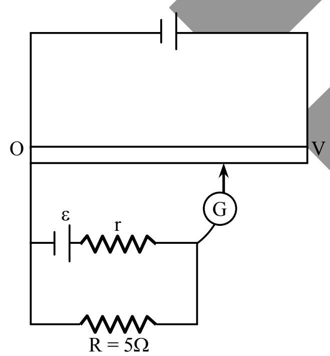
$= 2\times10^5$

29. In a potentiometer experiment, it is found that no current passes through the galvanometer when the terminals of the cell are connected across 52 cm of the potentiometer wire. If the cell is shunted by a resistance of 5 Ω, a balance is found when the cell is connected across 40 cm of the wire. Find the internal resistance of the cell.

(1) 1 Ω (2) 1.5 Ω (3) 2 Ω (4) 2.5 Ω

Answer key : (2)

Let $\ell_1 = 52\,\text{cm}$, $\ell_2 = 40\,\text{cm}$



In the first case

$$\varepsilon = \frac{V}{L}\ell_1 \qquad (1)$$

In the second case.

$$\frac{\varepsilon}{r+R}R = \frac{V}{L}\ell_2 \qquad (2)$$

dividing (1) by (2) we get

$$\frac{r+R}{R} = \frac{\ell_1}{\ell_2}$$

$$\frac{r}{R} = \frac{\ell_1}{\ell_2} - 1$$

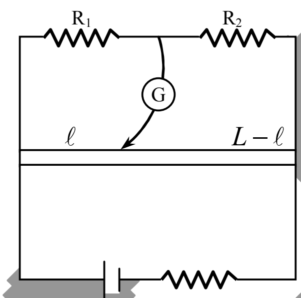
$$r = R\left(\frac{\ell_1}{\ell_2} - 1\right)$$

$$= 1.5\,\Omega$$

30. On interchanging the resistances, the balance point of a meter bridge shifts to the left by 10 cm. The resistance of their series combination is 1 kΩ. How much was the resistance on the left slot before interchanging the resistances?

(1) 990 Ω (2) 505 Ω (3) 550 Ω (4) 910 Ω

Answer key : (3)



$\therefore \frac{R_1}{R_2} = \frac{\ell}{L-\ell}$ ...(1)

On interchanging the resistances.

$\frac{R_2}{R_1} = \frac{\ell-10}{L-\ell+10}$ ...(2)

from (1) & (2)

$\frac{\ell}{L-\ell} = \frac{L-\ell+10}{\ell-10}$

$\Rightarrow \ell(\ell-10) = (L-\ell)^2 + 10(L-\ell)$

$\Rightarrow -10\ell = L^2 - 2L\ell + 10L - 10\ell$

$\Rightarrow L - 2\ell + 10 = 0$

$\Rightarrow \ell = \frac{L+10}{2}$

$= 55\,\text{cm}$

$\because R_1 + R_2 = 1000\,\Omega$

From (1)

$\frac{R_1}{1000-R_1} = \frac{55}{100-55} = \frac{11}{9}$

$\Rightarrow 9R_1 = 11000 - 11R_1$

$\Rightarrow R_1 = 550\,\Omega$

$\therefore$ option (3) is correct.