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This booklet contains 24 printed pages.

Test Booklet Code

A

PAPER-1 : PHYSICS, CHEMISTRY & MATHEMATICS

Do not open this Test Booklet until you are asked to do so.

Read carefully the Instructions on the Back Cover of this Test Booklet.

Important Instructions :

1. Immediately fill in the particulars on this page of the Test Booklet with *Blue/Black Ball Point Pen. Use of pencil is strictly prohibited.*

2. The Answer Sheet is kept inside this Test Booklet. When you are directed to open the Test Booklet, take out the Answer Sheet and fill in the particulars carefully.

3. The test is of **3 hours** duration.

4. The Test Booklet consists of **90** questions. The maximum marks are **360.**

5. There are **three** parts in the question paper A, B, C consisting of **Physics, Chemistry** and **Mathematics** and having 30 questions in each part of equal weightage. Each question is allotted **4 (four)** marks for correct response.

6. *Candidates will be awarded marks as stated above in instruction No. 5 for correct response of each question. 1/4 (one fourth) marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.*

7. There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted accordingly as per instruction 6 above.

8. Use ***Blue/Black Ball Point pen only*** for writing particulars/marking responses on ***Side-1*** and ***Side-2*** of the Answer Sheet. ***Use of pencil is strictly prohibited.***

9. No candidate is allowed to carry any textual material, printed or written, bits of papers, pager, mobile phone, any electronic device, etc. except the Admit Card inside the examination room/hall.

10. Rough work is to be done on the space provided for this purpose in the Test Booklet only. This space is give at the bottom of each page and in **three** pages (Pages **21 - 23**) at the end of the booklet.

11. On completion of the test, the candidate must hand over the Answer Sheet to the Invigilator on duty in the Room/Hall. ***However, the candidates are allowed to take away this Test Booklet with them.***

12. The CODE for the Booklet is **C.** Make sure that the CODE printed on **Side-2** of the Answer Sheet and also tally the serial number of the Test Booklet and Answer Sheet are the same as that on this booklet. In case of discrepancy, the candidate should immediately report the matter to the Invigilator for replacement of both the Test Booklet and the Answer Sheet.

13. **Do not fold or make any stray marks on the Answer Sheet.**

Name of the Candidate (in Capital Letters): ____________________

Roll Number : In figures | | | | | | | | |

: in words ____________________

Examination Centre Number : | | | | | | |

Name of Examination Centre (in Capital letters) : ____________________

Candidate's Signature : ____________ 1. Invigilator's Signature : ____________

2. Invigilator's Signature : ____________

PART-A : 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%

Ans. **(3)**

Sol. Density $\rho = \frac{m}{\ell^3}$

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

Percentage error in $\rho = \left(\frac{\Delta m}{m} \times 100\right) + \left(3 \times \frac{\Delta\ell}{\ell} \times 100\right)$

= 1.5 + 3×1

= 4.5 %

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

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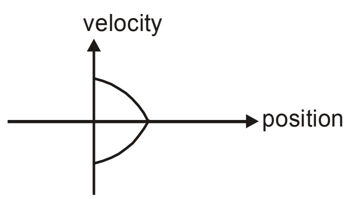

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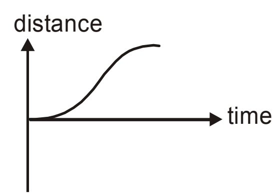

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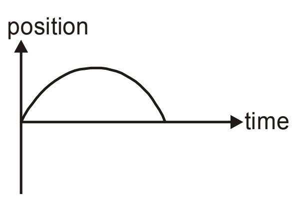

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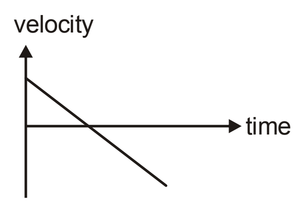
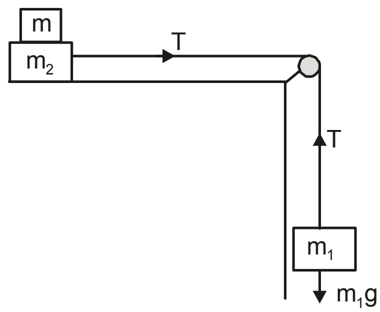


Ans. **(2)**

Sol. It is the case of motion under gravity.

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

Ans. **(2)**

Sol. $T = m_1 g$

Also $T = (f_s)_{max} = \mu\,(m + m_2)g$

$\Rightarrow\ m_1 g = \mu\,(m + m_2)\,g$

$$\frac{m_1}{\mu} - m_2 = m$$

$$\left(\frac{5\times 100}{15} - 10\right) = m$$

$$\Rightarrow\ m = \frac{70}{3} = 23.33 \text{ kg}$$

Minimum mass is 23.33 kg. Any mass greater then this can stop the motion. Among given options, option (2) is correct

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

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

Ans. **(3)**

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

$$F = -\frac{dU}{dr} = \frac{k}{2}\times -2\times r^{-3} = -kr^{-3}$$

Now,

$$|F| = \frac{mv^2}{r}$$

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

$$\therefore \quad KE = \frac{1}{2}mv^2 = \frac{k}{2r^2}$$

$\therefore$ To energy = P.E. + K.E.

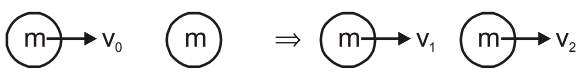
$$= -\frac{K}{2r^2} + \frac{K}{2r^2} = 0$$

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) $\frac{v_0}{\sqrt{2}}$

Ans. **(2)**

Sol.



$mv_1 + mv_2 = mv_0 \Rightarrow v_1 + v_2 = v_0$ ....(i)

$$\frac{1}{2}m\left(v_1^2 + v_2^2\right) = 1.5 \times \frac{1}{2}mv_0^2$$

$v_1^2 + v_2^2 = 1.5\, v_0^2$ ...(ii)

using equation (i) and (ii)

$$v_1^2 + v_2^2 + 2v_1v_2 = v_0^2$$

$$1.5v_0^2 + 2v_1v_2 = v_0^2$$

$$2v_1v_2 = -0.5\, v_0^2$$

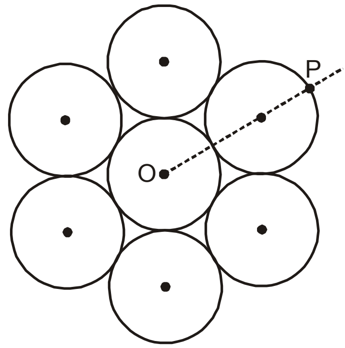
$$\left(v_2 - v_1\right)^2 = v_2^2 + v_1^2 - 2v_1v_2$$

$$= 1.5v_0^2 + 0.5v_0^2$$

$$= 2v_0^2$$

$$v_2 - v_1 = \sqrt{2}\, v_0$$

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 P is :



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

Ans. (4)

Sol. M.I. passing through O perpandicular to plane

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

$$I_0 = \frac{55\,MR^2}{2}$$

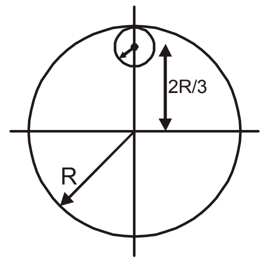
M.I. passing through P perpandicular to plane

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

$= \frac{55MR^2}{2} + 7M\,(3R)^2$

$= \frac{181}{2}MR^2$

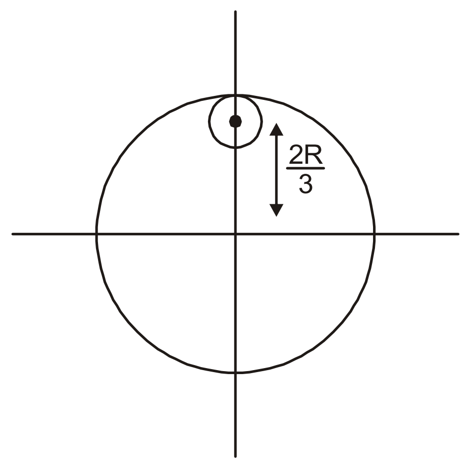
7. From a uniform circular disc of radius R and mass 9 M, a small disc of radius $\frac{R}{3}$ is removed as shown in the figure. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through centre of disc is :



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

Ans. (1)

Sol. Mass of small disc (Removed part)



$= \frac{9M}{\pi R^2}\pi\frac{R^2}{9} = M$

M.I. of this small disc about centre

$= \frac{1}{2}\frac{MR^2}{9} + M\frac{4R^2}{9}$

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

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

M.I. of complete disc about C = $\frac{9\ MR^2}{2}$.

So M.I. of Remaining part of disc. will be

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

$= 4\ MR^2$

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 :

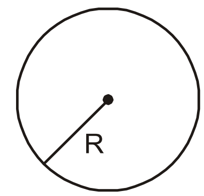
(1) $T \propto R^{3/2}$ for any n (2) $T \propto R^{\frac{n}{2}+1}$ (3) $T \propto R^{(n+1)/2}$ (4) $T \propto R^{n/2}$

Ans. (3)

Sol. According to question force acting on the particle is

$F \propto \frac{1}{R^n}$ ...(i)

As we know for circular motion net force along the radius towards the centre must be



$F = m\omega^2 R$ ...(ii)

From both the equation be get

$$m\omega^2 R = \frac{k}{R^n}$$

or $m\omega^2 = \frac{k}{R^{n+1}}$

or $\omega = \frac{k'}{R^{\frac{n+1}{2}}}$

or $\frac{2\pi}{T} = \frac{k'}{R^{\frac{n+1}{2}}}$

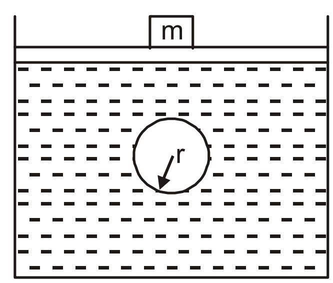
$\Rightarrow T \propto R^{\frac{n+1}{2}}$

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) $\frac{Ka}{3\,mg}$ (3) $\frac{mg}{3\,Ka}$ (4) $\frac{mg}{Ka}$

Ans. (3)

Sol. increase in pressure



$dP = \frac{mg}{a}$ .... (i)

$\frac{dV}{V} = \frac{4\pi r^2 dr}{\frac{4}{3}\pi r^3} = \frac{3dr}{r}$ ....(ii)

Now, $K = \frac{dP}{\left(-\frac{dV}{v}\right)}$ ...(iii)

from (i), (ii) & (iii) $\frac{-dr}{r} = \frac{mg}{3ka}$

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

Ans. (3)

Sol. $TV^{\gamma-1} = \text{constant}$

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

$$T_2 = (300K)\left(\frac{V}{2V}\right)^{\frac{5}{3}-1} \cong 189\text{ K}$$

Charge in internal energy $\Delta U = nC_v\Delta T$

$$= \frac{2\times3\times8.314}{2}(189-300)$$

$$\cong -2.7\text{ kJ}$$

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

Ans. (1)

Sol. $P = \dfrac{2mv\cos\theta\cdot N}{A} = 2.35\times10^3\text{ N/m}^2$

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

Ans. (2)

Sol. $k = 4\pi^2\nu^2 m$

= 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 modules 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

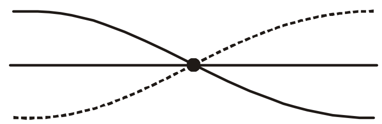
Ans. (1)

Sol. Velocity of longitudinal wave

$$v = \sqrt{\frac{\gamma}{\rho}}$$

$$v = \sqrt{\frac{9.27 \times 10^{10}}{2.7 \times 10^{3}}}$$

$v = 5.86 \times 10^3$ m/s



For fundamental frequency wavelenth is given by,

$$\frac{\lambda}{2} = L$$

$$\lambda = 2L = 1.2\text{m}$$

$$\therefore \nu_0 = \frac{v}{\lambda} = \frac{5.86 \times 10^3}{1.2}$$

= 4.88 kHz

Most appropriate option is (1)

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) $\frac{\sigma}{\epsilon_0}\left[\frac{a^2 - b^2}{a} + c\right]$

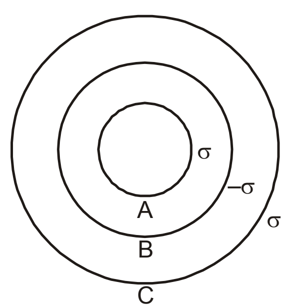
(2) $\frac{\sigma}{\epsilon_0}\left[\frac{a^2 - b^2}{b} + c\right]$

(3) $\frac{\sigma}{\epsilon_0}\left[\frac{b^2 - c^2}{b} + a\right]$

(4) $\frac{\sigma}{\epsilon_0}\left[\frac{b^2 - c^2}{c} + a\right]$

Ans. **(2)**

Sol. $$V_B = \frac{KQ_A}{b} - \frac{KQ_B}{b} + \frac{KQ_C}{c}$$



$$V_B = \frac{\sigma a^2}{\epsilon_0 b} - \frac{\sigma b^2}{\epsilon_0 b} + \frac{\sigma c^2}{\epsilon_0 c}$$

$$V_B = \frac{\sigma}{\epsilon_0}\left(\frac{a^2 - b^2}{b} + c\right)$$

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 plastes, the magntidue of the induced charge will be :

(1) 1.2 n C (2) 0.3 n C (3) 2.4 n C (4) 0.9 n C

Ans. (1)

Sol. Charge on plate $Q = KCV = \frac{5}{3} \times 90 \times 10^{-12} \times 20$

$Q = 3 \times 10^{-9} C = 3nC$

So $Q_{ind.} = Q\left(1 - \frac{1}{K}\right) = 3\left(1 - \frac{3}{5}\right)$

$= \frac{6}{5} nC = 1.2 nC$

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

$$e = 100 \sin 30t$$

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

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

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

Ans. (2)

Sol. $P_{avg.} = V_{rms} I_{rms} \cos\phi$

$= \frac{100}{\sqrt{2}} \times \frac{20}{\sqrt{2}} \times \cos\frac{\pi}{4}$

$= \frac{2000}{2\sqrt{2}} = \frac{1000}{\sqrt{2}} W$

Wattless current = $i_{rms} \times \sin\phi = \frac{20}{\sqrt{2}} \times \frac{1}{\sqrt{2}}$ = 10 A

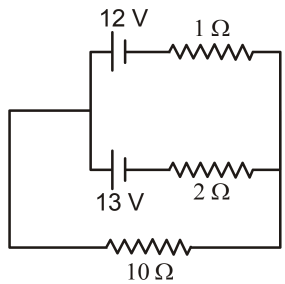
17. Two batteries with e.m.f. 12 V and 13 V are connected in parallel across a load resistor of 10Ω. The internal resistances of the two batteries are $1\,\Omega$ and $2\,\Omega$ respectively. The voltage across the load lies between :

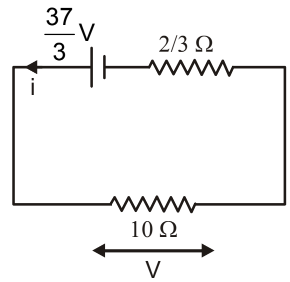
(1) 11.6 V and 11.7 V (2) 11.5 V and 11.6 V

(3) 11.4 V and 11.5 V (4) 11.7 V and 11.8 V

Ans. (2)

Sol. $\xi_{eq} = \dfrac{\dfrac{\xi_1}{r_1}+\dfrac{\xi_2}{r_2}}{\dfrac{1}{r_1}+\dfrac{1}{r_2}} = \dfrac{\dfrac{12}{1}+\dfrac{13}{2}}{1+\dfrac{1}{2}} = \dfrac{37}{3}$





$r_{eq} = \dfrac{1\times 2}{1+2} = \dfrac{2}{3}$

$i = \dfrac{\dfrac{37}{3}}{10+\dfrac{2}{3}} = \dfrac{37}{32}$

$v = \dfrac{37}{32}\times 10 = 11.5624$

round offf = 11.6

voltage lie between 11.5 to 11.6 V

18. An electron, a proton and an alpha particle having the same kinetic energy are moving in circular orbits of 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) $r_e < r_\alpha < r_p$

Ans. (2)

Sol. electron proton α – particle

r_e r_p r_α

$\text{radius} = \dfrac{mv}{qB} = \dfrac{\sqrt{2mk}}{qB}$

$mv = \sqrt{2mk}$

$\text{radius} \propto \dfrac{\sqrt{m}}{q}$

$r_e < r_p = r_\alpha$

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) $\frac{1}{\sqrt{2}}$

Ans. **(3)**

Sol. Magnetic moment

$m = i \times \pi R^2$ ...(1)

and $2m = i \times \pi (R')^2$ ...(2)

Dividing $\frac{R'}{R} = \sqrt{2}$

But $B = \frac{\mu_0}{2} \cdot \frac{i}{R}$

Hence for two cases

$\frac{B_1}{B_2} = \frac{R'}{R} = \sqrt{2}$ (Since current is same)

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

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

Ans. **(1)**

Sol. For resonating circuit quality factor

$Q = \frac{X_L}{R}$ or $\frac{X_C}{R}$

$= \frac{\omega_0 L}{R}$ or $\frac{1}{\omega CR}$

Hence (1) is correct option.

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

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

Ans. **(3)**

Sol.

$$\vec{E}_1 = E_{0_1}\hat{x}\cos\left[2\pi\nu\left(\frac{z}{c}-t\right)\right]$$

$$\vec{E}_2 = E_{0_2}\hat{x}\cos\left[k(2z-ct)\right]$$

$$k_{medium} = 2k$$

$$\frac{1}{\lambda_m} = \frac{2}{\lambda_a}$$

$$\frac{\lambda_a}{\lambda_m} = 2$$

$$\mu = 2$$

$$\sqrt{\frac{\epsilon_{r_2}}{\epsilon_{r_1}}} = 2$$

$$\frac{\epsilon_{r_2}}{\epsilon_{r_1}} = 4$$

$$\frac{\epsilon_{r_1}}{\epsilon_{r_2}} = \frac{1}{4}$$

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^o (2) 30^o (3) 45^o (4) 60^o

Ans. **(3)**

Sol. Planes of A and B are parallel

$$\frac{I}{8} = \frac{I}{2}\cos^4\theta$$

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

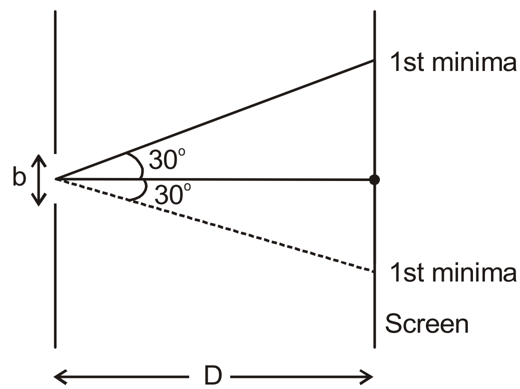
$$\theta = 45^\circ$$

23. The anuglar width of the central maximum in a single slit diffraction pattern is 60°. The width of the slit is $1\mu m$. 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 1 cm, what is slit separation distance ?
(i. e. distance between the centres of each slit.)

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

Ans. **(1)**

Sol. For minima through a single slit



$$b\sin\theta = \lambda$$

$$\theta = 30^\circ$$

$$b \times \frac{1}{2} = \lambda$$

$$\lambda = \frac{b}{2}$$

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

$$d = \frac{\lambda D}{\beta} = \frac{b}{2} \times \frac{D}{\beta} = \frac{1\times10^{-6}\times50\times10^{-2}}{2\times1\times10^{-2}}$$

$$= 25\times10^{-6}$$

$$= 25\mu m$$

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) $\Lambda_n^2 \approx \lambda$

Ans. (1)

Sol. $2\pi r_n = n\,\lambda_n$ ....(i)

$2\pi r_0 = 1\times\lambda_g$ ....(ii)

Dividing (i) by (ii) , we get

$$n^2 = \frac{\lambda_n}{\lambda_g}n$$

$$\Rightarrow \frac{\lambda_n}{\lambda_g} = n \quad .....(iii)$$

For - H - atom

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

$$\Rightarrow \frac{1}{\Lambda_n} = R\left(1-\frac{1}{\left(\frac{\lambda_n}{\lambda_g}\right)^2}\right) \qquad \Rightarrow \frac{1}{\Lambda_n} = R\left(1-\left(\frac{\lambda_g}{\lambda_n}\right)^2\right)$$

$$\Rightarrow \Lambda_n = \frac{1}{R\left[1-\left(\frac{\lambda_g}{\lambda_n}\right)^2\right]} \qquad \Rightarrow \Lambda_n = \frac{1}{R}\left[1-\left(\frac{\lambda_g}{\lambda_n}\right)^2\right]^{-1}$$

Using Binomial expansion $\left(\frac{\lambda_g}{\lambda_n} << 1\right)$

$$\Rightarrow \Lambda_n = \frac{1}{R}\left[1+\left(\frac{\lambda_g}{\lambda_n}\right)^2\right] \qquad \Rightarrow \Lambda_n = \frac{1}{R}+\frac{1}{R}\frac{\lambda_g{}^2}{\lambda_n{}^2}$$

$$\Rightarrow \Lambda_n = A + \frac{B}{\lambda_n{}^2}$$

25. If the series limit frequency of the 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) $\nu_L / 25$

Ans. (4)

Sol. For series limit of Lymen series, transition is from $n = \infty$ to n = 1

$$\nu_L = RC\left(1-\frac{1}{\infty}\right)$$

For series limit of Pfund series, transition is from $n=\infty$ to n = 5

$$\nu_P = RC\left(\frac{1}{25}-\frac{1}{\infty}\right)$$

$$\frac{\nu_L}{\nu_P} = 25$$

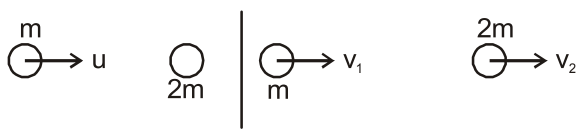
$$\nu_P = \frac{\nu_L}{25}$$

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) (.89, .28) (2) (.28, .89) (3) (0, 0) (4) (0, 1)

Ans. (1)

Sol.



$$mu = mv_1 + 2mv_2$$

$$u = v_1 + 2v_2 \qquad \text{...(i)}$$

Also, $e = 1 = \frac{v_2 - v_1}{u}$ ...(ii)

$$u = (v_2 - u) + 2v_2$$

$$u = 3v_2 - u$$

$$2u = 3v_2$$

$$v_2 = \frac{2u}{3}$$

$$f_1 = \frac{\frac{1}{2}2mv_2^2}{\frac{1}{2}mu^2} = \frac{2\times 4\,u^2}{9u^2} = \frac{8}{9} = 0.89$$

For neutron and carbon

$$mu = mv_1 + 12mv_2$$

$$u = v_1 + 12v_2 \qquad \text{.....(i)}$$

Also, $\frac{v_2 - v_1}{u} = 1$,

$v_2 - v_1 = u$ .....(ii)

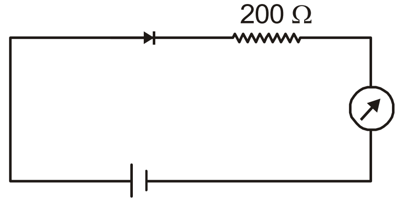
From (i) and (ii)

$u = (v_2 - u) + 12v_2$

$2u = 13v_2$

$v_2 = \frac{2u}{13}$, $f_2 = \frac{\frac{1}{2}12mv_2^2}{\frac{1}{2}mu^2} = \frac{48}{169} = 0.28$

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



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

Ans. **(3)**

Sol.

$I = \frac{3 - 0.7}{200} = \frac{2.3}{200} = 11.5\,mA$

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

Ans. **(3)**

Sol. $f_c = 10\,GHz$

$\text{band width} = (10 \times 10^9) \times 10\% = 10^9\,Hz$

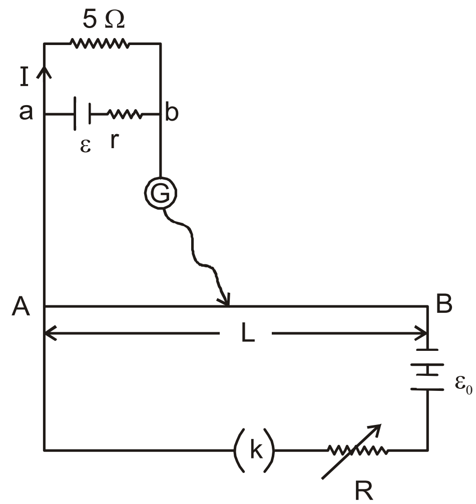
So, No. of channels $= \frac{10^9}{5 \times 10^3} = 2 \times 10^5$

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 5Ω, balanced is found when the cell is connected across 40 cm of the wire. Find the internal resistance of the cell.

(1) 1Ω (2) 1.5 Ω (3) 2 Ω (4) 2.5 Ω

Ans. (2)

Sol. $5I + rI - \varepsilon = 0$



$I = \frac{\varepsilon}{5+r}$

$\varepsilon = \frac{52}{L} v_0$ ....(i)

$5\frac{\varepsilon}{5+r} = \frac{40}{L} v_0$ .....(ii)

$(ii) \div (i)$

$\frac{5}{5+r} = \frac{40}{52}$

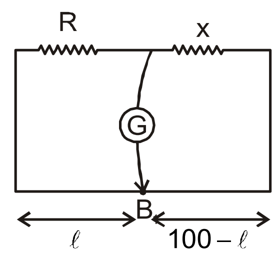
$13 = 10 + 2r \Rightarrow r = 1.5\Omega$

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

(1) 990Ω (2) 505Ω (3) 550Ω (4) 910Ω

Ans. (3)

Sol. $R + x = 1000$ ......(i)



$\frac{R}{x} = \frac{\ell}{100-\ell}$ .....(ii)

$\frac{x}{R} = \frac{\ell - 10}{100 - \ell + 10}$ .....(iii)

$(ii) \times (iii)$

$1 = \frac{\ell}{100-\ell} \times \frac{\ell-10}{110-\ell}$

$(100-\ell)(110-\ell) = (\ell - 10)\ell$

$11000 - 100\ell - 110\ell + \ell^2 = \ell^2 - 10\ell$

$200\ell = 11000$

$\ell = 55$

Put ℓ in eq. (ii)

$$\frac{R}{x} = \frac{55}{45}$$

$$R = \frac{11}{9}x$$

$$x = \frac{9}{11}R$$

$$R \times \frac{9}{11}R = 1000$$

$$20R = 11000$$

$$R = 550\Omega$$