NEET II 2016
SOLVED PHYSICS PAPER

1. A solid sphere of mass M and radius R is rotating about its diameter. A solid cylinder of the same mass and same radius is also rotating about its geometrical axis with an angular speed twice that of the sphere. The ratio of their kinetic energies of rotation ($E_{sphere}/E_{cylinder}$) will be

(1) 1 : 5 (2) 1 : 4
(3) 3 : 1 (4) 2 : 3

Solution:

Kinetic energy (K.E.) for rotating sphere is $E_{sphere} = \frac{1}{2} I_s \omega^2$

Moment of inertia (M.O.I) of sphere is $I_s = \frac{2}{5} MR^2$

Therefore, $E_{sphere} = \frac{1}{2}\left(\frac{2}{5} MR^2\right)\omega^2$

K.E. for rotating cylinder is $E_{cylinder} = \frac{1}{2} I_c (2\omega)^2$ (angular speed of cylinder is twice as that of sphere)

M.O.I for cylinder $I_c = \frac{MR^2}{2}$

Therefore, $E_{cylinder} = \frac{1}{2} \times \frac{MR^2}{2} \times 4\omega^2$

So, $$\frac{E_{sphere}}{E_{cylinder}} = \frac{\frac{1}{2}(\omega^2)\frac{2}{5} MR^2}{\frac{1}{2} \times 4\omega^2 \times \frac{MR^2}{2}} = \frac{1}{5}$$

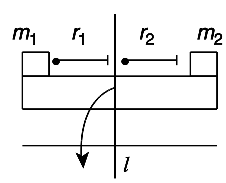
Hence, the correct answer is (1).

2. A light rod of length l has two masses m_1 and m_2 attached to its two ends. The moment of inertia of the system about an axis perpendicular to the rod and passing through the centre of mass is

(1) $\frac{m_1 + m_2}{m_1 m_2} l^2$ (2) $(m_1 + m_2)l^2$

(3) $\sqrt{m_1 m_2} l^2$ (4) $\frac{m_1 m_2}{m_1 + m_2} l^2$

Solution:



Centre of mass

$I = mr^2 = m_1 r_1^2 + m_2 r_2^2$

From centre of mass equation, we get r_1 and r_2 as

$$r_1 = \frac{m_2 l}{m_1 + m_2}, r_2 = \frac{m_1 l}{m_1 + m_2}$$

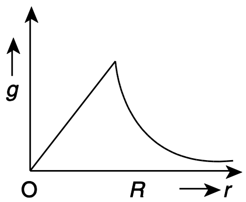
Now, total M.O.I is

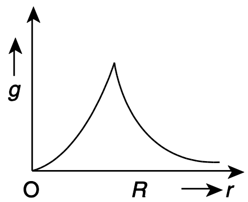
$$I = \frac{m_1 m_2^2 l^2}{(m_1 + m_2)^2} + \frac{m_1^2 m_2 l^2}{(m_1 + m_2)^2}$$

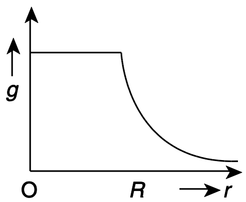
$$I = \frac{m_1 m_2}{m_1 + m_2} l^2$$

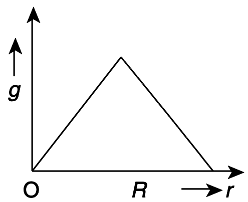
Hence, the correct answer is (4).

3. Starting from the centre of the earth having radius R, the variation of g (acceleration due to gravity) is shown by

(1)


(2)


(3)


(4)


Solution:

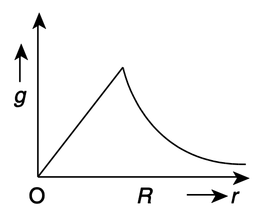
Inside the earth's crust

$$g \propto R$$

Above the earth's crust

$$g \propto \frac{1}{R^2}$$

Therefore, the relevant graph is



Hence, the correct answer is (1).

4. A satellite of mass m is orbiting the earth (of radius R) at a height h from its surface. The total energy of the satellite in terms of g_0, the value of acceleration due to gravity at the earth's surface, is

(1) $-\frac{mg_0R^2}{2(R+h)}$ (2) $\frac{2mg_0R^2}{R+h}$

(3) $-\frac{2mg_0R^2}{R+h}$ (4) $\frac{mg_0R^2}{R+h}$

Solution:

Total energy of the satellite about the earth's surface at height h

$$E = \frac{-GM_e m}{2(R+h)} \quad \text{(i)}$$

where M_e = mass of earth, m = mass of satellite, R = Radius of earth, h = height above surface.

We know that

$$g_0 = \frac{GM_e}{R^2}$$

Therefore, $M_e = \frac{g_0 R^2}{G}$

Using value of M_e is Eq. (i)

$$E = \frac{-mg_0 R^2}{2(R+h)}$$

Hence, the correct answer is (1).

5. A rectangular film of liquid is extended from (4 cm × 2 cm) to (5 cm × 4 cm). If the work done is 3×10^{-4} J, the value of the surface tension of the liquid is

(1) 0.125 Nm^{-1} (2) 0.2 Nm^{-1}
(3) 8.0 Nm^{-1} (4) 0.250 Nm^{-1}

Solution:

The increase in area

$$\Delta A = (5 \times 4) - (4 \times 2) = 12 \text{ cm}^2$$

The liquid film has 2 faces, therefore, total increase in area

$$2 \times 12 = 24 \text{ cm}^2$$

Work done = Surface Tension × total increase in area

$$3 \times 10^{-4} = T \times 24 \times 10^{-4} \text{ m}^2 \Rightarrow T = 0.125 \text{ Nm}^{-1}$$

Hence, the correct answer is (1).

6. Three liquids of densities ρ_1, ρ_2 and ρ_3 (with $\rho_1 > \rho_2 > \rho_3$), having the same value of surface tension T, rise to the same height in three identical capillaries. The angles of contact θ_1, θ_2 and θ_3 obey

(1) $0 \le \theta_1 < \theta_2 < \theta_3 < \frac{\pi}{2}$ (2) $\frac{\pi}{2} < \theta_1 < \theta_2 < \theta_3 < \pi$

(3) $\pi > \theta_1 > \theta_2 > \theta_3 > \frac{\pi}{2}$ (4) $\frac{\pi}{2} > \theta_1 > \theta_2 > \theta_3 \ge 0$

Solution:

We know that, rise in the height of the liquid in capillary is

$$h = \frac{2T\cos\theta}{\rho g r}$$

In this case r, h, t is constant for all liquids

Therefore, $\frac{\cos\theta}{\rho} = \text{constant}$

$$\frac{\cos\theta_1}{\rho_1} = \frac{\cos\theta_2}{\rho_2} = \frac{\cos\theta_3}{\rho_3}$$

Given $\rho_1 > \rho_2 > \rho_3$

Therefore, $\cos\theta_1 > \cos\theta_2 > \cos\theta_3$

So, $\theta_1 < \theta_2 < \theta_3$

As water rises, θ must be an acute angle.

Therefore, $0 \le \theta_1 < \theta_2 < \theta_3 < \frac{\pi}{2}$

Hence, the correct answer is (1).

7. Two identical bodies are made of a material for which the heat capacity increases with temperature. One of these is at 100°C, while the other one is at 0°C. If the two bodies are brought into contact, then, assuming no heat loss, the final common temperature is

(1) more than 50°C. (2) less than 50°C but greater than 0°C.

(3) 0°C. (4) 50°C.

Solution:

Let T be the final common temperature, S_c and S_h be the average heat capacities of the cold and hot (initially) bodies respectively ($S_c < S_h$). From the principle of calorimetric, we have

$$\text{Heat lost} = \text{Heat gained}$$

$$S_h\,(100° - \theta) = S_c\,\theta$$

$$\theta = \frac{S_h}{S_h + S_c} \times 100°\text{C} = \frac{100°\text{C}}{(1 + S_c/S_h)}$$

As $\frac{S_c}{S_h} < 1$. Therefore, $1 + \frac{S_c}{S_h} < 2$

$$T > \frac{100°\text{C}}{2} \Rightarrow T > 50°\text{C}$$

Hence, the correct answer is (1).

8. A body cools from a temperature $3T$ to $2T$ in 10 min. The room temperature is T. Assume that Newton's law of cooling is applicable. The temperature of the body at the end of next 10 min will be

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

(3) T (4) $\frac{7}{4}T$

Solution:

Newton's law of cooling states that the rate of change of temperature of an object is directly proportional to the difference between its own temperature and the ambient temperature.

Therefore, $$\frac{T_1 - T_2}{t} = k\left(\frac{T_1 + T_2}{2} - T\right)$$

$$\frac{3T - 2T}{10} = k\left(\frac{5T - 2T}{2}\right)$$

$$\frac{T}{10} = k\left(\frac{3T}{2}\right) \quad (1)$$

Similarly $$\frac{2T - T'}{10} = k\left(\frac{2T - T'}{2} - T\right)$$

$$\frac{2T - T'}{10} = k\left(\frac{T'}{2}\right) \quad (2)$$

From Eq. (1) and Eq. (2), we get

$$T' = \frac{3}{2}T$$

Hence, the correct answer is (1).

9. One mole of an ideal monatomic gas undergoes a process described by the equation PV^3 = constant. The heat capacity of the gas during this process is

(1) $\frac{5}{2}R$ (2) $2R$

(3) R (4) $\frac{3}{2}R$

Solution:

We know that

$$PV^x = \text{constant (Polytropic process)}$$

Heat capacity $C = C_V + \frac{R}{(1-x)}$

Here, PV^3 = constant, so, $x = 3$

For monatomic gas $f = 3$.

$$C = \frac{fR}{2} + \frac{R}{1-x}$$

$$C = \frac{3}{2}R - \frac{R}{2} = R$$

Hence, the correct answer is (3).

10. The temperature inside a refrigerator is t_2°C and the room temperature is t_1°C. The amount of heat delivered to the room for each joule of electrical energy consumed ideally will be

(1) $\frac{t_1+273}{t_1-t_2}$ (2) $\frac{t_2+273}{t_1-t_2}$

(3) $\frac{t_1+t_2}{t_1+273}$ (4) $\frac{t_1}{t_1-t_2}$

Solution:

Let the heat supplied be Q_1 and heat removed be Q_2.

Therefore,

$$\text{Coefficient of performance} = \frac{t_2+273}{t_1-t_2} = \frac{Q_2}{W}$$

$$\Rightarrow \frac{Q_1-W}{W} = \frac{Q_1}{W} - 1$$

$$\Rightarrow \frac{Q_1}{W} = 1 + \frac{t_2+273}{t_1-t_2} = \frac{t_1+273}{t_1-t_2}$$

Hence, the correct answer is (2).

11. A given sample of an ideal gas occupies a volume V at a pressure P and absolute temperature T. The mass of each molecule of the gas is m. Which of the following gives the density of the gas?

(1) $Pm/(kT)$ (2) $P/(kTV)$

(3) mkT (4) $P/(kT)$

Solution:

We have

$$\frac{P}{\rho} = \frac{RT}{M_W}$$

Since, $M_w = mN_A$, $R = kN_A$

Therefore, $\rho = \frac{PM_w}{RT} = \frac{P \times (mN_A)}{kN_A T} \Rightarrow \rho = \frac{Pm}{kT}$

Hence, the correct answer is (1).

12. A body of mass *m* is attached to the lower end of a spring whose upper end is fixed. The spring has negligible mass. When the mass *m* is slightly pulled down and released, it oscillates with a time period of 3 s. When the mass *m* is increased by 1 kg, the time period of oscillations becomes 5 s. The value of *m* in kg is

(1) $\frac{4}{3}$ (2) $\frac{16}{9}$

(3) $\frac{9}{16}$ (4) $\frac{3}{4}$

Solution:

The time period for one oscillation of spring is $T = 2\pi\sqrt{\frac{m}{k}}$

From first condition we have

$$3 = 2\pi\sqrt{\frac{m}{k}} \quad (1)$$

From second condition we have

$$5 = 2\pi\sqrt{\frac{m+1}{k}} \quad (2)$$

From Eq. (1) and Eq. (2), we get

$$\frac{3^2}{5^2} = \frac{m/k}{(m+1)/k} \Rightarrow \frac{9}{25} = \frac{m}{m+1} \Rightarrow m = \frac{9}{16}$$

Hence, the correct answer is (3).

13. The second overtone of an open organ pipe has the same frequency as the first overtone of a closed pipe *L* metre long. The length of the open pipe will be

(1) 2*L* (2) $\frac{L}{2}$

(3) 4*L* (4) *L*

Solution:

Second overtone in open organ pipe, $3\lambda/2 = l_o$ (third harmonic)

Therefore,

$$\lambda = \frac{2l_o}{3}$$

For first overtone in closed organ pipe (third harmonic)

$$\frac{3\lambda}{4} = l_c \Rightarrow \lambda = \frac{4l_o}{3} = \frac{4L}{3} \Rightarrow \frac{2l_o}{3} = \frac{4L}{3} \Rightarrow l_o = 2\text{L}$$

Hence, the correct answer is (1).

14. Three sound waves of equal amplitudes have frequencies $(n - 1)$, n, $(n + 1)$. They superimpose to give beats. The number of beats produced per second will be

(1) 4 (2) 3

(3) 2 (4) 1

Solution:

Net beat frequency is given by LCM of individual beat frequencies

= LCM (beats produced by (n, n – 1), beats produced by (n, n + 1), beats produced by (n – 1, n + 1))

= LCM of ((n – (n – 1)), (n + 1 – n), (n + 1 – (n – 1))) = LCM of (1, 1, 2) = 2 Hz

Therefore, number of beats per second = 2

Hence, the correct answer is (3).

15. An electric dipole is placed at an angle of 30° with electric field intensity 2×10^5 N C^{-1}. It experiences a torque equal to 4 N m. The charge on the dipole, if the dipole length is 2 cm, is

(1) 2 mC (2) 5 mC

(3) 7 μC (4) 8 mC

Solution:

Torque on a dipole placed in an electric field is

$$\tau = PE \sin \theta$$

$$\Rightarrow \tau = qlE \sin\theta$$

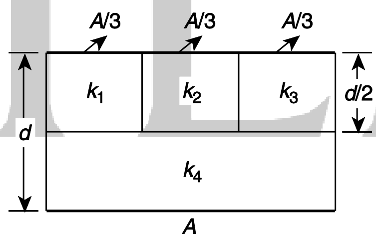
Substituting the values, get

$$4 = q \times 2 \times 16^{-3} \times 2 \times 10^5 \sin 30°$$

$$\Rightarrow q = 2 \text{ mC}$$

Hence, the correct answer is (1).

16. A parallel-plate capacitor of area A, plate separation d and capacitance C is filled with four dielectric materials having dielectric constants k_1, k_2, k_3 and k_4 as shown in the figure below. If a single dielectric material is to be used to have the same capacitance C in this capacitor, then its dielectric constant k is given by

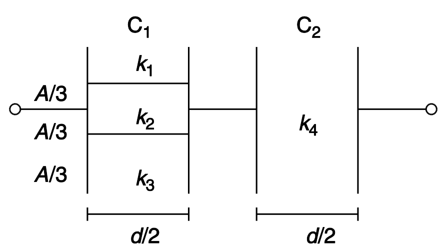


(1) $k = \frac{2}{3}(k_1 + k_2 + k_3) + 2k_4$ (2) $\frac{2}{k} = \frac{3}{k_1 + k_2 + k_3} + \frac{1}{k_4}$

(3) $\frac{1}{k} = \frac{1}{k_1} + \frac{1}{k_2} + \frac{1}{k_3} + \frac{3}{2k_4}$ (4) $k = k_1 + k_2 + k_3 + 3k_4$

Solution:

The combinations of dielectric can be shown as



So the combination of dielectric is

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

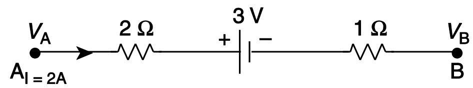
where C_1 is the combined capacitance of dielectric constants k_1, k_2 and k_3. C_2 is the capacitance of dielectric constant k_4.

$$\frac{d}{A\varepsilon_0 k} = \frac{1}{\left(\frac{A}{3}\right)\varepsilon_0\left(\frac{k_1+k_2+k_3}{d/2}\right)} + \frac{1}{\left(\frac{A\varepsilon_0 k_4}{d/2}\right)}$$

$$\frac{2}{k} = \frac{3}{k_1+k_2+k_3} + \frac{1}{k_4}$$

Hence, the correct answer is (2).

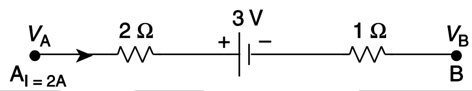
17. The potential difference ($V_A - V_B$) between the points A and B in the given figure is



(1) +3 V (2) +6 V
(3) +9 V (4) −3 V

Solution:

Kirchhoff's voltage law states that the algebraic sum of the products of the resistances of the conductors and the currents flowing through in them in a given circuit is equal to the total emf available in that circuit. Therefore, we have



$$V_A - V_B = 2\text{A} \times 2\Omega + 3\text{V} + 2\text{A} \times 1\Omega \Rightarrow V_A - V_B = 9\text{V}$$

Hence, the correct answer is (3).

18. A filament bulb (500 W, 100 V) is to be used in a 230 V main supply. When a resistance R is connected in series, it works perfectly and the bulb consumes 500 W. The value of R is

(1) 46 Ω (2) 26 Ω
(3) 13 Ω (4) 230 Ω

Solution:

We know that Power (P) = Voltage (V) × current (I)

Substituting for P and V, we get

$$500 = 100 \times I \Rightarrow I = 5\text{A}$$

Resistance of lamp (bulb) is $R_B = \frac{V}{I} = \frac{100}{I} = \frac{100}{5} = 20\,\Omega$

Now the circuit contain 230 V main supplies in series with above bulb and another resistor R and bulb requires 5 A current to flow.

Total resistance

$$R + 20\ \Omega = \frac{230}{5}$$

$$R + 20\ \Omega = 46\ \Omega$$

$$\Rightarrow R = 26\ \Omega$$

Hence, the correct answer is (2).

19. A long wire carrying a steady current is bent into a circular loop of one turn. The magnetic field at the centre of the loop is B. It is then bent into a circular coil of n turns. The magnetic field at the centre of this coil of n turns will be

(1) n^2B (2) $2nB$
(3) $2n^2B$ (4) nB

Solution:

Let l be the length of the long wire, R be the resistance of the circular loop and r be the radius of the circular coil.

We have

$$l = 2\pi R = n(2\pi r) \Rightarrow r = \frac{R}{n}$$

Magnetic field of a circular loop is $B = \mu_0 i/2R$

Now, magnetic field of circular coil having n turn is

$$B' = \frac{\mu_0 ni}{2r} \Rightarrow B' = \frac{\mu_0 n^2 i}{2R} = n^2 B$$

Hence, the correct answer is (1).

20. A bar magnet is hung by a thin cotton thread in a uniform horizontal magnetic field and is in equilibrium state. The energy required to rotate it by 60° is W. Now the torque required to keep the magnet in this new position is

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

Solution:

The torque on a bar magnet in the Magnetic field B is

$$\tau = MB \sin\theta$$

Therefore,

$$\tau = MB \sin 60° \quad (1)$$

The energy required to rotate the magnet by θ is

$$W = MB(1 - \cos\theta)$$

Therefore,

$$W = MB(1 - \cos 60°) \quad (2)$$

From Eq. (1) and Eq. (2), we have

$$\frac{\tau}{W} = \frac{MB \sin 60°}{MB(1-\cos 60°)} = \frac{\sqrt{3/2}}{1/2}$$

$$\frac{\tau}{W} = \sqrt{3} \Rightarrow \tau = \sqrt{3}W$$

Hence, the correct answer is (1).

21. An electron is moving in a circular path under the influence of a transverse magnetic field of 3.57 × 10^{-2} T. If the value of e/m is 1.76 × 10^{11} C kg^{-1}, the frequency of revolution of the electron is

(1) 100 MHz (2) 62.8 MHz
(3) 6.28 MHz (4) 1 GHz

Solution:

The frequency of revolution of an electron is $f = \frac{eB}{2\pi m}$

We have

$$e/m = 1.76 \times 10^{11} \text{ C kg}^{-1}, B = 3.57 \times 10^{-2} \text{ J}$$

Therefore,

$$f = \frac{1.76\times10^{11}\times3.57\times10^{-2}}{2\times3.14}\,\text{Hz} \Rightarrow f = 10^9 \text{ Hz} = 1 \text{ GHz}$$

Hence, the correct answer is (4).

22. Which of the following combinations should be selected for better tuning of an *LCR* circuit used for communication?

(1) $R = 25\ \Omega$, $L = 2.5$ H, $C = 45\ \mu$F
(2) $R = 15\ \Omega$, $L = 3.5$ H, $C = 30\ \mu$F
(3) $R = 25\ \Omega$, $L = 1.5$ H, $C = 45\ \mu$F
(4) $R = 20\ \Omega$, $L = 1.5$ H, $C = 35\ \mu$F

Solution:

For better tuning, Q factor must be high.

We know

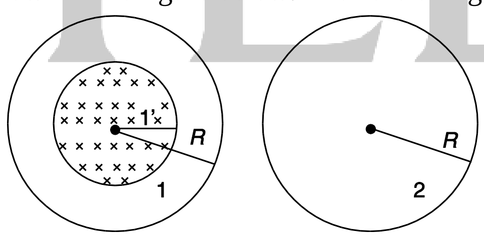
$$Q = \frac{\omega_0 L}{R} = \frac{1}{\sqrt{LC}}\left(\frac{L}{R}\right) \Rightarrow Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

R and C should be small and L should be high.
Therefore,

$$R = 15\ \Omega,\ L = 3.5 \text{ H},\ C = 30\ \mu\text{F}$$

Hence, the correct answer is (2).

23. A uniform magnetic field is restricted within a region of radius r. The magnetic field changes with time at a rate $\frac{d\vec{B}}{dt}$. Loop 1 of radius $R > r$ encloses the region r and loop 2 of radius R is outside the region of magnetic field as shown in the figure below. Then the emf generated is



(1) $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 1 and $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 2

(2) $-\frac{d\vec{B}}{dt}\pi R^2$ in loop 1 and zero in loop 2

(3) $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 1 and zero in loop 2

(4) zero in loop 1 and zero in loop 2

Solution:

The induced emf is

$$e_{\text{ind}} = \frac{-d\phi}{dt}$$

For loop 1, the emf induced is

$$e_{\text{ind}} = \frac{-d\phi}{dt} = \frac{-d}{dt}(A\vec{B}\cos\theta)$$

$$= -A\frac{d}{dt}\vec{B}\cos\theta$$

$$= -\pi r^2\left(\frac{d\vec{B}}{dt}\right)\cos 0 = -\pi r^2\left(\frac{d\vec{B}}{dt}\right)$$

For loop 2, $e_{ind} = 0$. This is because there is no flux linkage.

Hence, the correct answer is (3).

24. The potential differences across the resistance, capacitance and inductance are 80 V, 40 V and 100 V respectively in an *LCR* circuit. The power factor of this circuit is

(1) 0.5 (2) 0.8

(3) 1.0 (4) 0.4

Solution:

The power factor on an *LCR* circuit is $\cos\phi$

We know that in an *LCR* circuit

$$\tan\phi = \frac{V_L - V_C}{V_R}$$

$$= \frac{100-40}{80} = \frac{3}{4}$$

$$\phi = \tan^{-1}\left(\frac{3}{4}\right) = 37°$$

Putting the value of ϕ in power factor, we get

Power factor = cos 37° $= \frac{4}{5} = 0.8$

Hence, the correct answer is (2).

25. A 100 Ω resistance and a capacitor of 100 Ω reactance are connected in series across a 220 V source. When the capacitor is 50% charged, the peak value of the displacement current is

(1) 11 A (2) 4.4 A

(3) $11\sqrt{2}$ A (4) 2.2 A

Solution:

We know

$$\varepsilon_0 = I_0 Z$$

where ε_0 = Peak value of voltage, I_0 = Peak value of current, Z = Impedance.

Impedance is given by

$$Z = \frac{(\sqrt{R^2 + C^2})}{\sqrt{2}}$$

Therefore,

$$I_0 = \frac{220\sqrt{2}}{\sqrt{100^2 + 100^2}} \Rightarrow I_0 = 2.2\,\text{A}$$

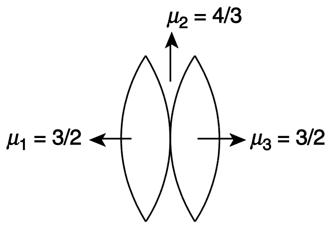
Hence, the correct answer is (4).

26. Two identical glass ($\mu_g = 3/2$) equiconvex lenses of focal length *f* each are kept in contact. The space between the two lenses is filled with water ($\mu_w = 4/3$). The focal length of the combination is

(1) *f* (2) 4*f*/3

(3) 3*f*/4 (4) *f*/3

Solution:



Relation between focal length and radius of curvature is $2f(\mu - 1) = R$
Now, focal length of the equiconvex lenses is

$$f_1 = f_3 = \frac{R}{2(3/2-1)} = R = f \text{ (given)}$$

Focal length of the middle portion liquid filling is

$$f_2 = \frac{-R}{2(4/3-1)} = \frac{-3}{2}R = \frac{-3}{2}f$$

Total focal length is

$$\frac{1}{f'} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$$

$$= \frac{1}{f} + \left(\frac{-2}{3f}\right) + \frac{1}{f}$$

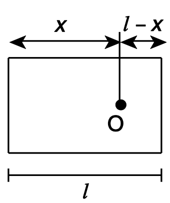
$$= \frac{4}{3f} \Rightarrow f' = \frac{3f}{4}$$

Hence, the correct answer is (3).

27. An air bubble in a glass slab with refractive index 1.5 (near normal incidence) is 5 cm deep when viewed from one surface and 3 cm deep when viewed from the opposite face. The thickness (in cm) of the slab is

(1) 10 (2) 12
(3) 16 (4) 8

Solution:



From apparent depth formula, we have

$$\frac{x}{\mu} = 5 \text{ cm} \quad (1)$$

Therefore, for the other side, we have

$$\frac{l-x}{\mu} = 3 \text{ cm} \quad (2)$$

$$l = (5 + 3)\,\mu = 12 \text{ cm}$$

Hence, the correct answer is (2).

28. The interference pattern is obtained with, two coherent light sources of intensity ratio n. In the interference pattern, the ratio $\frac{I_{max} - I_{min}}{I_{max} + I_{min}}$ will be

(1) $\frac{2\sqrt{n}}{n+1}$ (2) $\frac{\sqrt{n}}{(n+1)^2}$

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

Solution:

Maximum and minimum intensity is

$$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2, I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$$

Now, we have

$$\frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{(\sqrt{I_1} + \sqrt{I_2})^2 - (\sqrt{I_1} - \sqrt{I_2})^2}{(\sqrt{I_1} + \sqrt{I_2})^2 + (\sqrt{I_1} - \sqrt{I_2})^2} = \frac{4\sqrt{I_1 I_2}}{2(I_1 + I_2)}$$

Given $\frac{I_1}{I_2} = \frac{n}{1}$

On dividing the numerator and denominator by I_2, we get the required ratio

$$\frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{2\sqrt{I_1 / I_2}}{(I_1 / I_2) + 1} = \frac{2\sqrt{n}}{n+1}$$

Hence, the correct answer is (1).

29. A person can see clearly objects only when they lie between 50 cm and 400 cm from his eyes. In order to increase the maximum distance of distinct vision to infinity, the type and power of the correcting lens, the person has to use, will be

(1) concave, −0.25 D. (2) concave, −0.2 D.

(3) convex, +0.15 D. (4) convex, +2.25 D.

Solution:

The person is detected to have Myopia.

Given that

$$v = -4 \text{ m}, u = -\infty, P = ?$$

Power of lens $P = \frac{1}{f}$; Focal length $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

Therefore,

$$\begin{aligned} P &= \frac{1}{f} \\ &= \frac{1}{v} - \frac{1}{u} \\ &= \frac{1}{-4} - \frac{1}{\infty} \\ \Rightarrow P &= -0.25\text{D} \end{aligned}$$

− Sign represents concave lens.

Hence, the correct answer is (1).

30. A linear aperture whose width is 0.02 cm is placed immediately in front of a lens of focal length 60 cm. The aperture is illuminated normally by a parallel beam of wavelength 5×10^{-5} cm. The distance of the first dark band of the diffraction pattern from the centre of the screen is

(1) 0.25 cm (2) 0.20 cm

(3) 0.15 cm (4) 0.10 cm

Solution:

Given F = 60 cm = D

From band width formula, we have

$$y = \frac{\lambda D}{a} = \frac{5\times10^{-7}\times60}{2\times10^{-2}\times10^{-2}} = 0.15\,\text{cm}$$

Hence, the correct answer is (3).

31. Electrons of mass m with de Broglie wavelength λ fall on the target in an X-ray tube. The cutoff wavelength (λ_0) of the emitted X-ray is

(1) $\lambda_0 = \frac{2h}{mc}$ (2) $\lambda_0 = \frac{2m^2c^2\lambda^3}{h^2}$

(3) $\lambda_0 = \lambda$ (4) $\lambda_0 = \frac{2mc\lambda^2}{h}$

Solution:

de Broglie wavelength can be calculated as

$$\lambda = \frac{h}{p} \Rightarrow p = \frac{h}{\lambda} \quad (1)$$

K.E. of electrons is

$$E = (p^2/2m) \quad (2)$$

From Eq. (1) and Eq. (2), we have

$$E = \frac{h^2}{2m\lambda^2}$$

The cut-off wavelength is

$$\lambda_0 = \frac{hc}{E} \Rightarrow \lambda_0 = \frac{2mc\lambda^2}{h}$$

Hence, the correct answer is (4).

32. Photons with energy 5 eV are incident on a cathode C in a photoelectric cell. The maximum energy of emitted photoelectrons is 2 eV. When photons of energy 6 eV are incident on C, no photoelectrons will reach the anode A, if the stopping potential of A relative to C is

(1) +4 V (2) −1 V

(3) −3 V (4) +3 V

Solution:

Maximum kinetic energy of a emitted photoelectron is

$$eV_s = \frac{1}{2}mv_{max}^2 = h\nu - \phi_0$$

$$2 = 5 - \phi_0 \Rightarrow \phi_0 = 3\text{eV}$$

For second case

$$eV_s = 6 - 3 = 3\text{ eV} \Rightarrow V_s = 3\text{V}$$

Therefore,

$$V_{AC} = -3\text{ V}$$

Hence, the correct answer is (3).

33. If an electron in a hydrogen atom jumps from the 3rd orbit to the 2nd orbit, it emits a photon of wavelength λ. When it jumps from the 4th orbit to the 3rd orbit, the corresponding wavelength of the photon will be

(1) $\frac{9}{16}\lambda$ (2) $\frac{20}{7}\lambda$

(3) $\frac{20}{13}\lambda$ (4) $\frac{16}{25}\lambda$

Solution:

For transaction 3 → 2, wavelength of emitted photon is

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right) \quad (1)$$

For transaction 4 → 3, wavelength is

$$\frac{1}{\lambda'} = RZ^2\left(\frac{1}{3^2} - \frac{1}{4^2}\right) \quad (2)$$

On dividing Eq. (1) by Eq. (2), we get

$$\frac{1/\lambda}{1/\lambda'} = \frac{RZ^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right)}{RZ^2\left(\frac{1}{3^2} - \frac{1}{4^2}\right)}$$

$$\frac{\lambda'}{\lambda} = \frac{20}{7} \Rightarrow \lambda' = \frac{20}{7}\lambda$$

Hence, the correct answer is (2).

34. The half-life of a radioactive substance is 30 min. The time (in minutes) taken between 40% decay and 85% decay of the same radioactive substance is

(1) 30 (2) 45

(3) 60 (4) 15

Solution:

Given, decay → 40% → 85%

Therefore, remaining 60% → 15%

Half-life is given by $100\% \xrightarrow{t_{1/2}} 50\% \xrightarrow{t_{1/2}} 25\%$

Similarly, $60\% \xrightarrow{t_{1/2}} 30\% \xrightarrow{t_{1/2}} 15\%$

Therefore,

$$t = \frac{2t_1}{2} = 60 \text{ min}$$

Hence, the correct answer is (3).

35. For CE transistor amplifier, the audio signal voltage across the collector resistance of 2 kΩ is 4 V. If the current amplification factor of the transistor is 100 and the base resistance is 1 kΩ, then the input signal voltage is

(1) 20 mV (2) 30 mV

(3) 15 mV (4) 10 mV

Solution:

Amplification factor is

$$\beta = 100,\ V_0 = 4 \text{ V},\ R_i = 10^3\ \Omega,\ R_0 = 2 \times 10^3\ \Omega$$

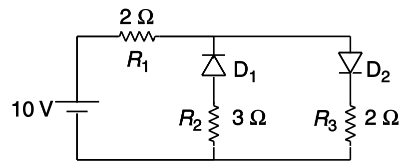
We know

$$A_v = \frac{V_0}{V_i} = \beta\frac{R_0}{R_i}$$

$$\frac{4}{V_i} = 100 \times \frac{2 \times 10^3}{10^3} \Rightarrow V_i = 20 \text{ mV}$$

Hence, the correct answer is (1).

36. The given circuit has two ideal diodes connected as shown in the figure below. The current flowing through the resistance R_1 will be



(1) 10.0 A (2) 1.43 A

(3) 3.13 A (4) 2.5 A

Solution:

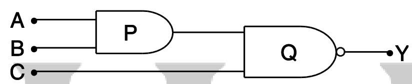
From figure, we can conclude that, current will not flow through D_1 because it is reverse biased whereas it will flow through all R_1, D_2, and R_3.

Therefore,

$$i = \frac{10}{2+2} = 2.5 \text{ A}$$

Hence, the correct answer is (4).

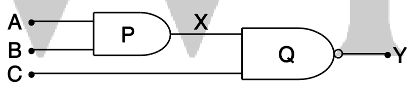
37. What is the output Y in the following circuit, when all the three inputs A, B, C are first 0 and then 1?



(l) 0, 0 (2) 1, 0

(3) 1, 1 (4) 0, 1

Solution:



A	B	C	X	Y
0	0	0	0	1
0	0	1	0	0
0	1	0	1	0
0	1	1	1	0
1	0	0	1	0
1	0	1	1	0
1	1	0	1	0
1	1	1	1	0

Therefore, for A = B = C = 0, y =1 and for A = B = C = 1, y = 0.

Hence, the correct answer is (2).

38. Planck's constant (h), speed of light in vacuum (c) and Newton's gravitational constant (G) are three fundamental constants. Which of the following combinations of these has the dimension of length?

(1) $\frac{\sqrt{hG}}{c^{5/2}}$ (2) $\sqrt{\frac{hc}{G}}$

(3) $\sqrt{\frac{Gc}{h^{3/2}}}$ (4) $\frac{\sqrt{hG}}{c^{3/2}}$

Solution:

We have

$$l \propto h^x g^y c^z$$

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

$$\Rightarrow [M^0L^1T^0] = [M^{x-y}L^{2x+3y+z}T^{-x-2y-z}]$$

On comparing the powers, we have

$$x - y = 0;\ 2x + 3y + z = 1;\ -x - 2y - z = 0$$

On solving the above equations, we get

$$x = \frac{1}{2}, y = \frac{1}{2}, z = -\frac{3}{2}$$

Therefore,

$$l \propto \frac{\sqrt{hG}}{c^{3/2}}$$

Hence, the correct answer is (4).

39. Two cars P and Q start from a point at the same time in a straight line and their positions are represented by $x_P(t) = at + bt^2$ and $x_Q(t) = ft - t^2$. At what time do the cars have the same velocity?

(1) $\frac{a+f}{2(b-1)}$ (2) $\frac{a+f}{2(1+b)}$

(3) $\frac{f-a}{2(1+b)}$ (4) $\frac{a-f}{1+b}$

Solution:

Given: $x_P(t) = at + bt^2$, $x_Q(t) = ft - t^2$

We know

$$v = \frac{dx}{dt}$$

Therefore,

$$v_P = \frac{dx_P}{dt} = a + 2bt;\ v_Q = \frac{dx_Q}{dt} = f - 2t$$

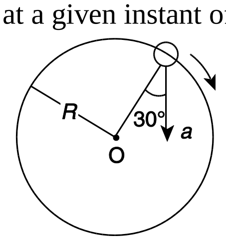
$$v_P = v_Q$$

$$a + 2bt = f - 2t$$

$$t = \frac{f-a}{2(1+b)}$$

Hence, the correct answer is (3).

40. In the given figure, $a = 15$ ms^{-2} represents the total acceleration of a particle moving in the clockwise direction in a circle of radius $R = 2.5$ m at a given instant of time. The speed of the particle is



(1) 5.0 ms^{-1} (2) 5.7 ms^{-1}

(3) 6.2 ms^{-1} (4) 4.5 ms^{-1}

Solution:

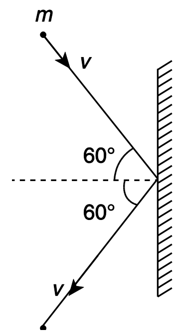
Centripetal acceleration is $a_c = \frac{v^2}{R} = a\cos 30°$

Therefore,

$$v = \sqrt{aR\cos 30°} = \sqrt{15 \times 2.5 \times \sqrt{3/2}} \Rightarrow v = 5.7 \text{ ms}^{-1}$$

Hence, the correct answer is (2).

41. A rigid ball of mass *m* strikes a rigid wall at 60° and gets reflected without loss of speed as shown in the figure below. The value of impulse imparted by the wall on the ball will be



(1) $2mv$ (2) $\frac{mv}{2}$

(3) $\frac{mv}{3}$ (4) mv

Solution:

Impulse

$$\Delta\vec{p} = m\Delta\vec{v} = m(2v\cos 60°) = mv$$

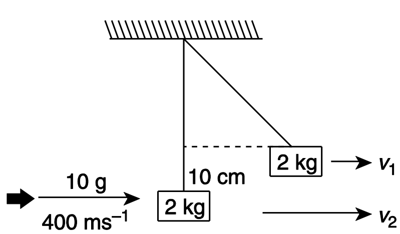
Hence, the correct answer is (4).

42. A bullet of mass 10 g moving horizontally with a velocity of 400 ms^{-1} strikes a wooden block of mass 2 kg which is suspended by a light inextensible string of length 5 m. As a result, the centre of gravity of the block is found to rise a vertical distance of 10 cm. The speed of the bullet after it emerges out horizontally from the block will be

(1) 80 ms^{-1} (2) 120 ms^{-1}

(3) 160 ms^{-1} (4) 100 ms^{-1}

Solution:



By the law of conservation of momentum, we have

$$10 \text{ g} \times 400 \text{ ms}^{-1} + 2 \text{ kg} \times 0 = 2 \text{ kg} \times v_1 + 10 \text{ g} \times v_2$$

$$\frac{10}{1000} \text{ kg} \times 400 \text{ ms}^{-1} + 2 \text{ kg} \times 0 = 2 \text{ kg} \times v_1 + 10 \text{ g} \times v_2$$

$$4 = 2v_1 + 0.01\,v_2 \quad (1)$$

By the work energy theorem for block, we have

$$W = \Delta\text{K.E.}$$

$$2 \times 10 \times 01 = \frac{1}{2} \times 2 \times v_1^2 \Rightarrow v_1 = \sqrt{2} = 1.4\ \text{ms}^{-1}$$

Using value of v_1 in Eq. (1), we get

$$4 = 2 \times 1.4 + 0.01 \times v_2 \Rightarrow v_2 = 120\ \text{ms}^{-1}$$

Hence, the correct answer is (2).

43. Two identical balls A and B having velocities of 0.5 ms^{-1} and −0.3 ms^{-1} respectively collide elastically in one dimension. The velocities of B and A after the collision respectively will be

(1) 0.5 ms^{-1} and −0.3 ms^{-1}
(2) −0.3 ms^{-1} and 0.5 ms^{-1}
(3) 0.3 ms^{-1} and 0.5 ms^{-1}
(4) −0.5 ms^{-1} and 0.3 ms^{-1}

Solution:

As the both balls are identical and collision is elastic. The velocity will be interchanged after collision.

Therefore,

$$v_A = -0.3\ \text{ms}^{-1},\ v_B = 0.5\ \text{ms}^{-1}$$

Hence, the correct answer is (1).

44. A particle moves from a point $(-2\hat{i} + 5\hat{j})$ to $(4\hat{j} + 3\hat{k})$ when a force of $(4\hat{i} + 3\hat{j})$ N is applied. How much work has been done by the force?

(1) 11 J (2) 5 J
(3) 2 J (4) 8 J

Solution:

Displacement of the particle is

$$\vec{s} = \vec{r}_f - \vec{r}_i \quad = 4\hat{j} + 3\hat{k} - (-2\hat{i}) - 5\hat{j} \quad \Rightarrow \vec{s} = 2\hat{i} - \hat{j} + 3\hat{k}$$

Now, work done by the force is

$$W = \vec{F} \cdot \vec{s} = (4\hat{i} + 3\hat{j}) \cdot [2\hat{i} - \hat{j} + 3\hat{k}] \quad = 8 - 3 = 5\ \text{J}$$

Hence, the correct answer is (2).

45. Two rotating bodies A and B of masses m and $2m$ with moments of inertia I_A and I_B ($I_B > I_A$) have equal kinetic energy of rotation. If L_A and L_B be their angular momenta respectively, then

(1) $L_A = 2L_B$ (2) $L_B > L_A$
(3) $L_A > L_B$ (4) $L_A = \frac{L_B}{2}$

Solution:

Relation between kinetic energy and angular momenta is

$$K = \frac{L^2}{2I}$$

Given

$$K_A = K_B$$

Therefore,

$$K_A = K_B = \frac{L_A^2}{2I_A} = \frac{L_B^2}{2I_B}$$

We know,

$$I_B > I_A$$

Therefore,

$$L_A^2 < L_B^2 \Rightarrow L_A < L_B$$

Hence, the correct answer is (2).