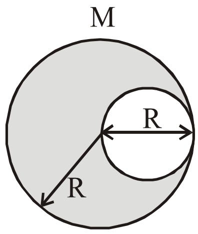
1. From a disc of radius R and mass M, a circular hole of diameter R, whose rim passes through the centre is cut. What is the moment of inertia of the remaining part of the disc about a perpendicular axis, passing through the centre ?

(1) $15\ MR^2/32$ (2) $13\ MR^2/32$

(3) $11\ MR^2/32$ (4) $9\ MR^2/32$

Ans. **2**

Sol.



$$I_{\text{Total disc}} = \frac{MR^2}{2}$$

$$M_{\text{Removed}} = \frac{M}{4} \quad (\text{Mass} \propto \text{area})$$

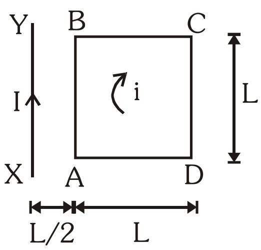
I_{Removed} (about same Perpendicular axis)

$$= \frac{M}{4}\frac{(R/2)^2}{2} + \frac{M}{4}\left(\frac{R}{2}\right)^2 = \frac{3MR^2}{32}$$

$$I_{\text{Remaing disc}} = I_{\text{Total}} - I_{\text{Removed}}$$

$$= \frac{MR^2}{2} - \frac{3}{32}MR^2 = \frac{13}{32}MR^2$$

2. A square loop ABCD carrying a current i, is placed near and coplanar with a long straight conductor XY carrying a current I, the net force on the loop will be :-



(1) $\frac{2\mu_0 Ii}{3\pi}$

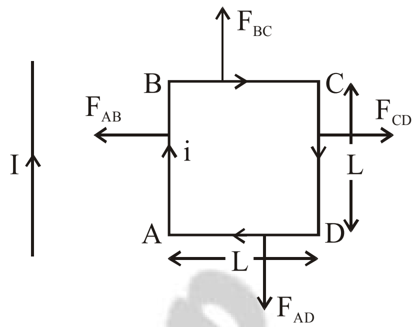
(2) $\frac{\mu_0 Ii}{2\pi}$

(3) $\frac{2\mu_0 IiL}{3\pi}$

(4) $\frac{\mu_0 IiL}{2\pi}$

Ans. **1**

Sol.



$F_{AB} = i\ell B$ (Attractive)

$$F_{AB} = i(L).\frac{\mu_0 I}{2\pi\left(\frac{L}{2}\right)}\ (\leftarrow) = \frac{\mu_0 iI}{\pi}\ (\leftarrow)$$

$F_{BC}\ (\uparrow)$ and $F_{AD}\ (\downarrow) \Rightarrow$ cancels each other

$F_{CD} = i\ell B$ (Repulsive)

$$F_{CD} = i(L)\frac{\mu_0 I}{2\pi\left(\frac{3L}{2}\right)}\ (\rightarrow) = \frac{\mu_0 iI}{3\pi}\ (\rightarrow)$$

$$\Rightarrow F_{net} = \frac{\mu_0 iI}{\pi} - \frac{\mu_0 iI}{3\pi} = \frac{2\mu_0 iI}{3\pi}$$

3. The magnetic susceptibility is negative for :

(1) diamagnetic material only

(2) paramagnetic material only

(3) ferromagnetic material only

(4) paramagnetic and ferromagnetic materials

Ans. **1**

Sol. Magnetic susceptibility = χ

it is negative for dia-magnetic materials only

4. A siren emitting a sound of frequency 800 Hz moves away from an observer towards a cliff at a speed of $15 ms^{-1}$. Then, the frequency of sound that the observer hears in the echo reflected from the cliff is :

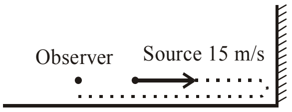
(Take velocity of sound in air = $330\ ms^{-1}$)

(1) 765 Hz (2) 800 Hz

(3) 838 Hz (4) 885 Hz

Ans. 3

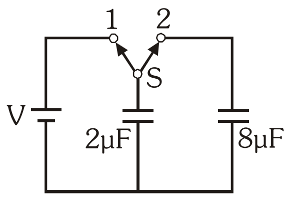
Sol.



$$n' = \frac{v}{v - v_s} n_0$$

$$n' = \frac{330}{330 - 15}(800) = \frac{330 \times 800}{315} = 838 \text{ Hz}$$

5.



A capacitor of 2μF is charged as shown in the diagram. When the switch S is turned to position 2, the percentage of its stored energy dissipated is:

(1) 0% (2) 20%

(3) 75% (4) 80%

Ans. 4

Sol. Initial energy stored in capacitor 2 μF

$$U_i = \frac{1}{2}2(V)^2 = V^2$$

Final voltage after switch 2 is ON

$$V_f = \frac{C_1V_1}{C_1 + C_2} = \frac{2V}{10} = 0.2\ V$$

Final energy in both the capacitors

$$U_f = \frac{1}{2}(C_1 + C_2)V_f^2 = \frac{1}{2}10\left(\frac{2V}{10}\right)^2 = 0.2\ V^2$$

So energy dissipated = $\frac{V^2 - 0.2V^2}{V^2} \times 100 = 80\%$

6. In a diffraction pattern due to a single slit of width 'a', the first minimum is observed at an angle 30° when light of wavelength 5000 Å is incident on the slit. The first secondary maximum is observed at an angle of :

(1) $\sin^{-1}\left(\frac{1}{4}\right)$ (2) $\sin^{-1}\left(\frac{2}{3}\right)$

(3) $\sin^{-1}\left(\frac{1}{2}\right)$ (4) $\sin^{-1}\left(\frac{3}{4}\right)$

Ans. 4

Sol. For first minima, $\sin 30° = \frac{\lambda}{a} = \frac{1}{2}$

First secondary maxima will be at

$$\sin\theta = \frac{3\lambda}{2a} = \frac{3}{2}\left(\frac{1}{2}\right) \Rightarrow \theta = \sin^{-1}\left(\frac{3}{4}\right)$$

7. At what height from the surface of earth the gravitation potential and the value of g are $-5.4 \times 10^7\ J\ kg^{-2}$ and $6.0\ ms^{-2}$ respectively ? Take the radius of earth as 6400 km :

(1) 2600 km (2) 1600 km

(3) 1400 km (4) 2000 km

Ans. 1

Sol. $V = \frac{-GM}{R + h} = -5.4 \times 10^7$ ..... (1)

and $g = \frac{GM}{(R + h)^2} = 6$ ..... (2)

dividing (1) and (2)

$$\Rightarrow \frac{5.4 \times 10^7}{(R + h)} = 6$$

$\Rightarrow$ R + h = 9000 km so h = 2600 km

8. Out of the following options which one can be used to produce a propagating electromagnetic wave ?

(1) A charge moving at constant velocity

(2) A stationary charge

(3) A chargeless particle

(4) An accelerating charge

Ans. 4

Sol. To generate electormagnetic waves we need accelerating charge particle.

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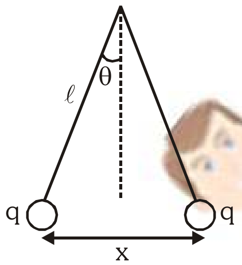
9. Two identical charged spheres suspended from a common point by two massless strings of lengths *l*, are initially at a distance d (d << *l*) apart because of their mutual repulsion. The charges begin to leak from both the spheres at a constant rate. As a result, the spheres approach each other with a velocity v. Then v varies as a function of the distance x between the spheres, as :

(1) $v \propto x^{\frac{1}{2}}$ (2) $v \propto x$

(3) $v \propto x^{-\frac{1}{2}}$ (4) $v \propto x^{-1}$

Ans. 3

Sol. $\tan\theta = \dfrac{F_e}{mg} \simeq \theta$



$\dfrac{Kq^2}{x^2 mg} = \dfrac{x}{2\ell}$

or $\boxed{x^3 \propto q^2}$ ..... (1)

or $x^{3/2} \propto q$ .... (2)

differentiate eq.(i) w.r.t. time

$3x^2\dfrac{dx}{dt} \propto 2q\dfrac{dq}{dt}$ but $\dfrac{dq}{dt}$ is constant

so $x^2(v) \propto q$ replace q from eq. (2)

$x^2(v) \propto x^{3/2}$ or $\boxed{v \propto x^{-1/2}}$

10. A uniform rope of length L and mass m_1 hangs vertically from a rigid support. A block of mass m_2 is attached to the free end of the rope. A transverse pulse of wavelength λ_1 is produced at the lower end of the rope. The wavelength of the pulse when it reaches the top of the rope is λ_2. The ratio λ_2/λ_1 is :

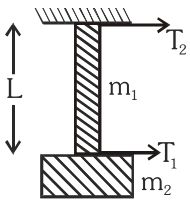
(1) $\sqrt{\dfrac{m_1}{m_2}}$ (2) $\sqrt{\dfrac{m_1+m_2}{m_2}}$

(3) $\sqrt{\dfrac{m_2}{m_1}}$ (4) $\sqrt{\dfrac{m_1+m_2}{m_1}}$

Ans. 2

Sol. $T_1 = m_2 g$

$T_2 = (m_1 + m_2)g$



Velocity $\propto \sqrt{T}$

$\lambda \propto \sqrt{T}$

$\dfrac{\lambda_1}{\lambda_2} = \dfrac{\sqrt{T_1}}{\sqrt{T_2}}$

$\Rightarrow \dfrac{\lambda_2}{\lambda_1} = \sqrt{\dfrac{m_1+m_2}{m_2}}$

11. A refrigerator works between 4°C and 30°C. It is required to remove 600 calories of heat every second in order to keep the temperature of the refrigerated space constant. The power required is:

(Take 1 cal = 4.2 Joules)

(1) 2.365 W (2) 23.65 W

(3) 236.5 W (4) 2365 W

Ans. 3

Sol. $\beta = \dfrac{Q_2}{W} = \dfrac{T_2}{T_1 - T_2}$ (Where Q_2 is heat removed)

$\Rightarrow \dfrac{600 \times 4.2}{W} = \dfrac{277}{303-277}$

$\Rightarrow$ W = 236.5 joule

$\Rightarrow$ Power $= \dfrac{W}{t} = \dfrac{236.5\,\text{joule}}{1\,\text{sec}}$ = 236.5 watt.

12. An air column, closed at one end and open at the other, resonates with a tuning fork when the smallest length of the column is 50 cm. The next larger length of the column resonating with the same tuning fork is :

(1) 66.7 cm (2) 100 cm

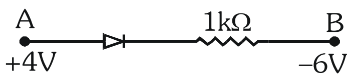
(3) 150 cm (4) 200 cm

Ans. 3

Sol. First minimum resonating length for closed organ pipe $= \dfrac{\lambda}{4} = 50\,\text{cm}$

$\therefore$ Next larger length of air column $= \dfrac{3\lambda}{4} = 150\,\text{cm}$

13. Consider the junction diode as ideal. The value of current flowing through AB is :



(1) 0 A (2) 10^{-2} A

(3) 10^{-1} A (4) 10^{-3} A

Ans. 2

Sol. Since diode is in forward bias

$i = \dfrac{\Delta V}{R} = \dfrac{4-(-6)}{1 \times 10^3} = \dfrac{10}{10^3} = 10^{-2}$ A

14. The charge flowing through a resistance R varies with time t as $Q = at - bt^2$, where a and b are positive constants. The total heat produced in R is:

(1) $\frac{a^3R}{6b}$ (2) $\frac{a^3R}{3b}$

(3) $\frac{a^3R}{2b}$ (4) $\frac{a^3R}{b}$

Ans. 1

Sol. $Q = at - bt^2$

$i = a - 2bt$ { for $i = 0 \Rightarrow t = \frac{a}{2b}$ }

From joule's law of heating

$dH = i^2Rdt$

$$H = \int_0^{a/2b} (a - 2bt)^2 R dt$$

$$H = \left.\frac{(a-2bt)^3 R}{-3 \times 2b}\right|_0^{\frac{a}{2b}} = \frac{a^3R}{6b}$$

15. A black body is at a temperature of 5760 K. The energy of radiation emitted by the body at wavelength 250 nm is U_1, at wavelength 500 nm is U_2 and that at 1000 nm is U_3. Wien's constant, $b = 2.88 \times 10^6$ nmK. Which of the following is correct?

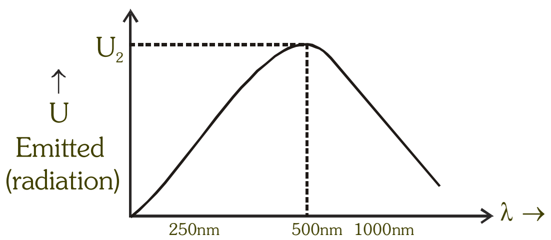
(1) $U_1 = 0$ (2) $U_3 = 0$

(3) $U_1 > U_2$ (4) $U_2 > U_1$

Ans. 4

Sol. Maximum amount of emitted radiation corresponding to $\lambda_m = \frac{b}{T}$

$$\lambda_m = \frac{2.88 \times 10^6 \text{nmK}}{5760\text{K}} = 500 \text{ nm}$$



From the graph $U_1 < U_2 > U_3$

16. Coefficient of linear expansion of brass and steel rods are α_1 and α_2. Lengths of brass and steel rods are ℓ_1 and ℓ_2 respectively. If $(\ell_2 - \ell_1)$ is maintained same at all temperatures, which one of the following relations holds good ?

(1) $\alpha_1\ell_2 = \alpha_2\ell_1$

(2) $\alpha_1\ell_2^2 = \alpha_2\ell_1^2$

(3) $\alpha_1^2\ell_2 = \alpha_2^2\ell_1$

(4) $\alpha_1\ell_1 = \alpha_2\ell_2$

Ans. 4

Sol. Change in length for both rods should be same

$\Delta\ell_1 = \Delta\ell_2$

$\ell_1\alpha_1\Delta T = \ell_2\alpha_2\Delta T$

$\ell_1\alpha_1 = \ell_2\alpha_2$

17. A npn transistor is connected in common emitter configuration in a given amplifier. A load resistance of 800 Ω is connected in the collector circuit and the voltage drop across it is 0.8 V. If the current amplification factor is 0.96 and the input resistance of the circuit is 192Ω, the voltage gain and the power gain of the amplifier will respectively be :

(1) 4, 3.84 (2) 3.69, 3.84

(3) 4, 4 (4) 4, 3.69

Ans. 1

Sol. Given $\alpha = 0.96$

so, $\beta = \frac{\alpha}{1-\alpha} = \frac{0.96}{0.04} \Rightarrow \boxed{\beta = 24}$

Voltage gain for common emitter configuration

$$A_v = \beta . \frac{R_L}{R_i} = 24 \times \frac{800}{192} = 100$$

Power gain for common emitter configuration

$P_v = \beta A_v = 24 \times 100 = 2400$

Voltage gain for common base configuration

$$A_v = \alpha . \frac{R_L}{R_P} = 0.96 \times \frac{800}{192} = 4$$

Power gain for common base configuration

$P_v = A_v\alpha = 4 \times 0.96 = 3.84$

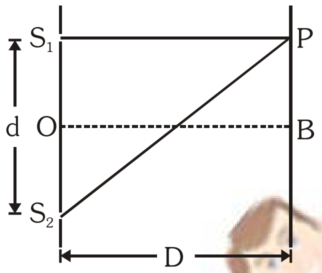
***In the question it is asked about common emitter configuration but we got above answer for common base configuration.**

18. The intensity at the maximum in a Young's double slit experiment is I_0. Distance between two slits is $d = 5\lambda$, where λ is the wavelength of light used in the experiment. What will be the intensity in front of one of the slits on the screen placed at a distance D = 10 d ?

(1) I_0 (2) $\frac{I_0}{4}$ (3) $\frac{3}{4}I_0$ (4) $\frac{I_0}{2}$

Ans. **4**

Sol. Path difference



$= S_2P - S_1P$

$= \sqrt{D^2 + d^2} - D$

$= D\left(1 + \frac{1}{2}\frac{d^2}{D^2}\right) - D$

$= D\left[1 + \frac{d^2}{2D^2} - 1\right] = \frac{d^2}{2D}$

$\Delta x = \frac{d^2}{2 \times 10d} = \frac{d}{20} = \frac{5\lambda}{20} = \frac{\lambda}{4}$

$\Delta\phi = \frac{2\pi}{\lambda}.\frac{\lambda}{4} = \frac{\pi}{2}$

So, intensity at the desired point is

$I = I_0\cos^2\frac{\phi}{2} = I_0\cos^2\frac{\pi}{4} = \frac{I_0}{2}$

19. A uniform circular disc of radius 50 cm at rest is free to turn about an axis which is perpendicular to its plane and passes through its centre. It is subjected to a torque which produces a constant angular acceleration of 2.0 rad s^{-2}. Its net acceleration in ms^{-2} at the end of 2.0 s is approximately :

(1) 8.0 (2) 7.0 (3) 6.0 (4) 3.0

Ans. **1**

Sol. Particle at periphery will have both radial and tangential acceleration

$a_t = R\alpha = 0.5 \times 2 = 1\ m/s^2$

$\omega = \omega_0 + \alpha t$

$\omega = 0 + 2 \times 2 = 4$ rad/sec

$a_c = \omega^2 R = (4)^2 \times 0.5 = 16 \times 0.5 = 8\ m/s^2$

$a_{total} = \sqrt{a_p^2 + a_c^2} = \sqrt{1^2 + 8^2} \approx 8\,m/s^2$

***In this question we have assumed the point to be located at periphery of the disc.**

20. An electron of mass m and a photon have same energy E. The ratio of de-Broglie wavelengths associated with them is :

(1) $\frac{1}{c}\left(\frac{E}{2m}\right)^{\frac{1}{2}}$ (2) $\left(\frac{E}{2m}\right)^{\frac{1}{2}}$

(3) $c(2mE)^{\frac{1}{2}}$ (4) $\frac{1}{xc}\left(\frac{2m}{E}\right)^{\frac{1}{2}}$

(c being velocity of light)

Ans. **1**

Sol. For electron $\lambda_e = \frac{h}{\sqrt{2mE}}$

for Photon E = pc $\Rightarrow \lambda_{Ph} = \frac{hc}{E}$

$\Rightarrow \frac{\lambda_e}{\lambda_{Ph}} = \frac{h}{\sqrt{2mE}} \times \frac{E}{hc} = \left(\frac{E}{2m}\right)^{1/2}\frac{1}{c}$

21. A disk and a sphere of same radius but different masses roll off on two inclined planes of the same altitude and length. Which one of the two objects gets to the bottom of the plane first ?

(1) Disk

(2) Sphere

(3) Both reach at the same time

(4) Depends on their masses

Ans. **2**

Sol. $a = \frac{g\sin\theta}{1 + \frac{K^2}{R^2}}$

for disc ; $\frac{K^2}{R^2} = \frac{1}{2} = 0.5$

for sphere ; $\frac{K^2}{R^2} = \frac{2}{5} = 0.4$

a(sphere) > a(disc)

$\therefore$ sphere reaches first

22. The angle of incidence for a ray of light at a refracting surface of a prism is 45°. The angle of prism is 60°. If the ray suffers minimum deviation through the prism, the angle of minimum deviation and refractive index of the material of the prism respectively, are :

(1) 45°, $\frac{1}{\sqrt{2}}$ (2) 30°, $\sqrt{2}$

(3) 45°, $\sqrt{2}$ (4) 30°, $\frac{1}{\sqrt{2}}$

Ans. 2

Sol. i = 45°; A = 60°; $\delta_m = 2i - A = 30°$

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin A/2} = \frac{\sin 45°}{\sin 30°} = \frac{1}{\sqrt{2}}.\frac{2}{1} = \sqrt{2}$$

23. When an α-particle of mass 'm' moving with velocity 'v' bombards on a heavy nucleus of charge 'Ze', its distance of closest approach from the nucleus depends on m as :

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

Ans. 1

Sol. At closest distance of approach, the kinetic energy of the particle will convert completely into electrostatic potential energy.

$$\Rightarrow \frac{1}{2}mv^2 = \frac{KQq}{d} \Rightarrow d \propto \frac{1}{m}$$

24. A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to 8×10^{-4} J by the end of the second revolution after the beginning of the motion?

(1) 0.1 m/s^2 (2) 0.15 m/s^2
(3) 0.18 m/s^2 (4) 0.2 m/s^2

Ans. 1

Sol. $\frac{1}{2}mv^2 = E \Rightarrow \frac{1}{2}\left(\frac{10}{1000}\right)v^2 = 8 \times 10^{-4}$

$\Rightarrow v^2 = 16 \times 10^{-2} \Rightarrow v = 4 \times 10^{-1} = 0.4$ m/s

Now,

$v^2 = u^2 + 2a_t s$ (s = 4πR)

$$\Rightarrow \frac{16}{100} = 0^2 + 2a_t\left(4 \times \frac{22}{7} \times \frac{6.4}{100}\right)$$

$$\Rightarrow a_t = \frac{16}{100} \times \frac{7 \times 100}{8 \times 22 \times 6.4} = 0.1 \text{ m/s}^2$$

25. The molecules of a given mass of a gas have r.m.s. velocity of 200 ms^{-1} at 27°C and 1.0×10^5 Nm^{-2} pressure. When the temperature and pressure of the gas are respectively, 127°C and 0.05×10^5 Nm^{-2}, the r.m.s. velocity of its molecules in ms^{-1} is :

(1) $100\sqrt{2}$ (2) $\frac{400}{\sqrt{3}}$ (3) $\frac{100\sqrt{2}}{3}$ (4) $\frac{100}{3}$

Ans. 2

Sol. $v \propto \sqrt{T} \Rightarrow \frac{v}{200} = \sqrt{\frac{400}{300}} \Rightarrow v = \frac{200 \times 2}{\sqrt{3}}$ m/s

$\Rightarrow v = \frac{400}{\sqrt{3}}$ m/s

26. A long straight wire of radius a carries a steady current I. The current is uniformly distributed over its cross-section. The ratio of the magnetic fields B and B', at radial distances $\frac{a}{2}$ and 2a respectively, from the axis of the wire is :

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

(3) 1 (4) 4

Ans. 3

Sol. For points inside the wire

$B = \frac{\mu_0 I r}{2\pi R^2}$ (r ≤ R)

For points outside the wire

$B = \frac{\mu_0 I}{2\pi r}$ (r ≥ R)

according to the question

$$\frac{B}{B'} = \frac{\frac{\mu_0 I(a/2)}{2\pi a^2}}{\frac{\mu_0 I}{2\pi(2a)}} = 1 : 1$$

27. A particle moves so that its position vector is given by $\vec{r} = \cos\omega t\,\hat{x} + \sin\omega t\,\hat{y}$. Where ω is a constant. Which of the following is true ?

(1) Velocity and acceleration both are perpendicular to $\vec{r}$.
(2) Velocity and acceleration both are parallel to $\vec{r}$
(3) Velocity is perpendicular to $\vec{r}$ and acceleration is directed towards the origin
(4) Velocity is perpendicular to $\vec{r}$ and acceleration is directed away from the origin

Ans. **3**

Sol. $\vec{r} = \cos\omega t\ \hat{x} + \sin\omega t\,\hat{y}$

$\vec{v} = -\omega\sin\omega t\ \hat{x} + \omega\cos\omega t\,\hat{y}$

$\vec{a} = -\omega^2\cos\omega t\ \hat{x} + \omega\sin\omega t\,\hat{y} = -\omega^2\vec{r}$

$\vec{r}.\vec{v} = 0$ hence $\vec{r} \perp \vec{v}$

$\vec{a}$ is directed towards the origin.

28. What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that it can complete the loop ?

(1) $\sqrt{gR}$ (2) $\sqrt{2gR}$
(3) $\sqrt{3gR}$ (4) $\sqrt{5gR}$

Ans. **4**

Sol. When minimum speed of body is $\sqrt{5gR}$, then **no matter from where it enters the loop, it will complete full vertical loop.**

29. When a metallic surface is illuminated with radiation of wavelength λ, the stopping potential is V. If the same surface is illuminated with radiation of wavelength 2λ, the stopping potential is $\frac{V}{4}$. The threshold wavelength for the metallic surface is :-

(1) 4λ (2) 5λ (3) $\frac{5}{2}\lambda$ (4) 3λ

Ans. **4**

Sol. $eV = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$ ...(i)

$eV/4 = \frac{hc}{2\lambda} - \frac{hc}{\lambda_0}$ ...(ii)

From equation (i) and (ii)

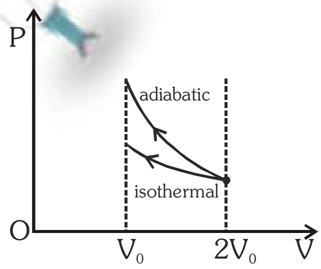
$\Rightarrow 4 = \frac{\frac{1}{\lambda} - \frac{1}{\lambda_0}}{\frac{1}{2\lambda} - \frac{1}{\lambda_0}}$ On solving $\lambda_0 = 3\lambda$

30. A gas is compressed isothermally to half its initial volume. The same gas is compressed separately through an adiabatic process until its volume is again reduced to half. Then :-

(1) Compressing the gas isothermally will require more work to be done.
(2) Compressing the gas through adiabatic process will require more work to be done.
(3) Compressing the gas isothermally or adiabatically will require the same amount of work.
(4) Which of the case (whether compression through isothermal or through adiabatic process) requires more work will depend upon the atomicity of the gas.

Ans. **2**

Sol.



W_{ext} = negative of area with volume-axis

W(adiabatic) > W(isothermal)

31. A potentiometer wire is 100 cm long and a constant potential difference is maintained across it. Two cells are connected in series first to support one another and then in opposite direction. The balance points are obtained at 50 cm and 10 cm from the positive end of the wire in the two cases. The ratio of emf's is :-

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

Ans. **4**

Sol. $\frac{E_1 + E_2}{E_1 - E_2} = \frac{50}{10}$

$\Rightarrow \frac{2E_1}{2E_2} = \frac{50+10}{50-10} \Rightarrow \frac{E_1}{E_2} = \frac{3}{2}$

32. A astronomical telescope has objective and eyepiece of focal lengths 40 cm and 4 cm respectively. To view an object 200 cm away from the objective, the lenses must be separated by a distance :-

(1) 37.3 cm (2) 46.0 cm

(3) 50.0 cm (4) 54.0 cm

Ans. **4**

Sol. Using lens formula for objective lens

$$\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0} \Rightarrow \frac{1}{v_0} = \frac{1}{f_0} + \frac{1}{u_0}$$

$$\Rightarrow \frac{1}{v_0} = \frac{1}{40} + \frac{1}{-200} = \frac{+5-1}{200}$$

$\Rightarrow v_0 = 50$ cm

Tube length $\ell = |v_0| + f_e = 50 + 4 = 54$ cm.

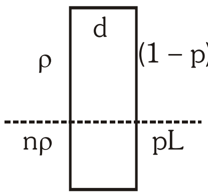
33. Two non-mixing liquids of densities ρ and nρ (n > 1) are put in a container. The height of each liquid is h. A solid cylinder of length L and density d is put in this container. The cylinder floats with its axis vertical and length pL(p < 1) in the denser liquid. The density d is equal to :-

(1) {1 + (n + 1)p}ρ (2) {2 + (n + 1)p}ρ

(3) {2 + (n – 1)p}ρ (4) {1 + (n – 1)p}ρ

Ans. **4**

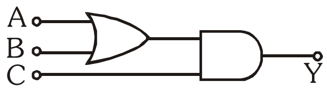
Sol.



L A d g = (pL) A (nρ)g + (1 – p) L A ρ g

$\Rightarrow$ d = (1 – p)ρ + pn ρ = [1 + (n – 1)p]ρ

34. To get output 1 for the following circuit, the correct choice for the input is



(1) A = 0, B = 1, C = 0

(2) A = 1, B = 0, C = 0

(3) A = 1, B = 1, C = 0

(4) A = 1, B = 0, C = 1

Ans. **4**

Sol. (A + B) C = 1 $\Rightarrow$ C = 1

35. A piece of ice falls from a height h so that it melts completely. Only one-quarter of the heat produced is absorbed by the ice and all energy of ice gets converted into heat during its fall. The value of h is :

[Latent heat of ice is 3.4×10^5 J/kg and g = 10 N/kg]

(1) 34 km (2) 544 km (3) 136 km (4) 68 km

Ans. **3**

Sol. $\frac{mgh}{4} = mL$

$$\Rightarrow h = \frac{4L}{g} = \frac{4 \times 3.4 \times 10^5}{10} = 136 \text{ km.}$$

36. The ratio of escape velocity at earth (v_e) to the escape velocity at a planet (v_p) whose radius and mean density are twice as that of earth is :-

(1) 1 : 2 (2) 1 : $2\sqrt{2}$

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

Ans. **2**

Sol. $Ve = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2G}{R} \cdot \left(\frac{4}{3}\pi R^3 \rho\right)} \propto R\sqrt{\rho}$

$\therefore$ Ratio = 1 : $2\sqrt{2}$

37. If the magnitude of sum of two vectors is equal to the magnitude of difference of the two vectors, the angle between these vectors is :-

(1) 0° (2) 90°
(3) 45° (4) 180°

Ans. 2

Sol. $|\vec{A}+\vec{B}| = |\vec{A}-\vec{B}|$ = θ = 90°.

38. Given the value of Rydberg constant is $10^7 m^{-1}$, the wave number of the last line of the Balmer series in hydrogen spectrum will be :-

(1) $0.025 \times 10^4\ m^{-1}$ (2) $0.5 \times 10^7\ m^{-1}$
(3) $0.25 \times 10^7\ m^{-1}$ (4) $2.5 \times 10^7\ m^{-1}$

Ans. 3

Sol. $\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_2^2}-\frac{1}{n_1^2}\right) = 10^7 \times 1^2\left(\frac{1}{2^2}-\frac{1}{\infty^2}\right)$

$\Rightarrow$ wave number $= \frac{1}{\lambda} = 0.25 \times 10^7\ m^{-1}$

39. A body of mass 1 kg begins to move under the action of a time dependent force $\vec{F} = (2t\,\hat{i} + 3t^2\hat{j})N$, where $\hat{i}$ and $\hat{j}$ are unit vectors along x and y axis. What power will be developed by the force at the time t ?

(1) $(2t^2 + 3t^3)W$ (2) $(2t^2 + 4t^4)W$
(3) $(2t^3 + 3t^4)W$ (4) $(2t^3 + 3t^5)W$

Ans. 4

Sol. $\vec{F} = 2t\hat{i} + 3t^2\hat{j}$

$m\frac{d\vec{v}}{dt} = 2t\hat{i} + 3t^2\hat{j}$ (m = 1 kg)

$\Rightarrow \int_0^{\vec{v}} d\vec{v} = \int_0^t (2t\hat{i} + 3t^2\hat{j})dt \Rightarrow \vec{v} = t^2\hat{i} + t^3\hat{j}$

Power $= \vec{F}.\vec{v} = (2t^3 + 3t^5)W$

40. An inductor 20 mH, a capacitor 50 μF and a resistor 40Ω are connected in series across a source of emf V = 10 sin 340 t. The power loss in A.C. circuit is :-

(1) 0.51 W (2) 0.67 W
(3) 0.76 W (4) 0.89 W

Ans. 1

Sol. $X_C = \frac{1}{\omega C} = \frac{1}{340 \times 50 \times 10^{-6}} = 58.8\ \Omega$

$X_L = \omega L = 340 \times 20 \times 10^{-3} = 6.8\ \Omega$

$Z = \sqrt{R^2 + (X_C - X_L)^2}$

$= \sqrt{40^2 + (58.8 - 6.8)^2} = \sqrt{4304}\ \Omega$

$P = i_{rms}^2 R = \left(\frac{V_{rms}}{Z}\right)^2 R$

$= \left(\frac{10/\sqrt{2}}{\sqrt{4304}}\right)^2 \times 40 = \frac{50 \times 40}{4304} = 0.47$ W

So best answer (nearest answer) will be (1)

41. If the velocity of a particle is $v = At + Bt^2$, where A and B are constants, then the distance travelled by it between 1s and 2s is :-

(1) $\frac{3}{2}A + 4B$ (2) 3A+7B

(3) $\frac{3}{2}A + \frac{7}{3}B$ (4) $\frac{A}{2} + \frac{B}{3}$

Ans. 3

Sol. $V = At + Bt^2 \Rightarrow \frac{dx}{dt} = At + Bt^2$

$\Rightarrow \int_0^x dx = \int_1^2 (At + Bt^2)dt$

$\Rightarrow x = \frac{A}{2}(2^2 - 1^2) + \frac{B}{3}(2^3 - 1^3) = \frac{3A}{2} + \frac{7B}{3}$

42. A long solenoid has 1000 turns. When a current of 4A flows through it, the magnetic flux linked with each turn of the solenoid is 4×10^{-3} Wb. The self inductance of the solenoid is :-

(1) 4H (2) 3H (3) 2H (4) 1H

Ans. 4

Sol. Flux linked with each turn = 4×10^{-3} Wb

$\therefore$ Total flux linked = $1000[4 \times 10^{-3}]$ Wb

$\phi_{total} = 4 \Rightarrow Li = 4 \Rightarrow L = 1H$

43. A small signal voltage $V(t) = V_0 \sin \omega t$ is applied across an ideal capacitor C :-

(1) Current I(t), lags voltage V(t) by 90°.

(2) Over a full cycle the capacitor C does not consume any energy from the voltage source.

(3) Current I(t) is in phase with voltage V(t).

(4) Current I(t) leads voltage V(t) by 180°.

Ans. 2

Sol. Power = $V_{rms} \cdot I_{rms} \cos\phi$

as $\cos\phi = 0$ (Because $\phi = 90°$)

$\therefore$ Power consumed = 0 (in one complete cycle)

44. Match the corresponding entries of **column-1** with **coloumn-2** (Where m is the magnefication produced by the mirror) :-

Column-1	**Column-2**
(A) $m = -2$	(a) Convex mirror
(B) $m = -\frac{1}{2}$	(b) Concave mirror
(C) $m = +2$	(c) Real image
(D) $m = +\frac{1}{2}$	(d) Virtual image

(1) A $\to$ b and c, B $\to$ b and c, C $\to$ b and d, D $\to$ a and d.

(2) A $\to$ a and c, B $\to$ a and d, C $\to$ a and b, D $\to$ c and d

(3) A $\to$ a and d, B $\to$ b and c, C $\to$ b and d, D $\to$ b and c

(4) A $\to$ c and d, B $\to$ b and d, C $\to$ b and c, D $\to$ a and d

Ans. 1

Sol. m = +ve $\Rightarrow$ virtual image

m = –ve $\Rightarrow$ real image

$|m| > 1 \Rightarrow$ magnified image

$|m| < 1 \Rightarrow$ diminished image

45. A car is negotiating a curved road of radius R. The road is banked at an angle θ. the coefficient of friction between the tyres of the car and the road is μ_s. The maximum safe velocity on this road is :-

(1) $\sqrt{gR^2 \frac{\mu_s + \tan\theta}{1-\mu_s \tan\theta}}$

(2) $\sqrt{gR \frac{\mu_s + \tan\theta}{1-\mu_s \tan\theta}}$

(3) $\sqrt{\frac{g}{R} \frac{\mu_s + \tan\theta}{1-\mu_s \tan\theta}}$

(4) $\sqrt{\frac{g}{R^2} \frac{\mu_s + \tan\theta}{1-\mu_s \tan\theta}}$

Ans. 2

Sol. $\frac{v^2}{Rg} = \left(\frac{\mu_s + \tan\theta}{1-\mu_s \tan\theta}\right)$

$\Rightarrow v = \sqrt{Rg\left[\frac{\mu_s + \tan\theta}{1-\mu_s \tan\theta}\right]}$