# JEE(ADVANCED)–2025 (EXAMINATION)

**(Held On Sunday 18th MAY, 2025)**

**PHYSICS** | **TEST PAPER WITH ANSWER AND SOLUTION**

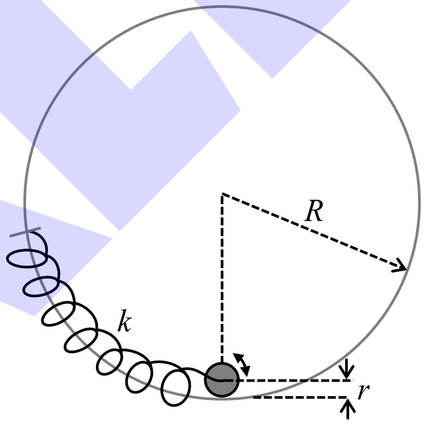
## PHYSICS

### SECTION-1 (Maximum Marks : 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated **according to the following marking scheme:**

*Full Marks* : +3 If **ONLY** the correct option is chosen;
*Zero Marks* : 0 If none of the options is chosen (i.e. the question is unanswered);
*Negative Marks* : −1 In all other cases.

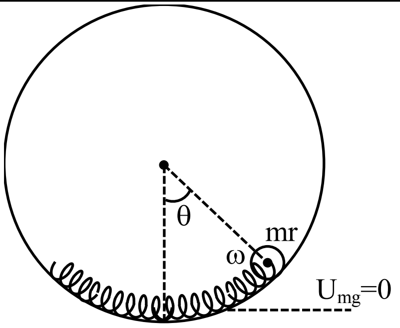
**1.** The center of a disk of radius $r$ and mass $m$ is attached to a spring of spring constant $k$, inside a ring of radius $R > r$ as shown in the figure. The other end of the spring is attached on the periphery of the ring. Both the ring and the disk are in the same vertical plane. The disk can only roll along the inside periphery of the ring, without slipping. The spring can only be stretched or compressed along the periphery of the ring, following the Hooke's law. In equilibrium, the disk is at the bottom of the ring. Assuming small displacement of the disc, the time period of oscillation of center of mass of the disk is written as $T = \frac{2\pi}{\omega}$. The correct expression for $\omega$ is ($g$ is the acceleration due to gravity):




(A) $\sqrt{\frac{2}{3}\left(\frac{g}{R-r}+\frac{k}{m}\right)}$ (B) $\sqrt{\frac{2g}{3(R-r)}+\frac{k}{m}}$ (C) $\sqrt{\frac{1}{6}\left(\frac{g}{R-r}+\frac{k}{m}\right)}$ (D) $\sqrt{\frac{1}{4}\left(\frac{g}{R-r}+\frac{k}{m}\right)}$

**Ans.** **(A)**

**Sol.**




$$E=\frac{1}{2}k(R-r)^2\theta^2+mg(R-r)(1-\cos\theta)+\frac{1}{2}mv^2+\frac{1}{2}\frac{mr^2}{2}\omega^2$$

Differentiating wrt t,

$$0=\frac{1}{2}k(R-r)^2\cdot 2\theta\frac{d\theta}{dt}+mg(R-r)\cdot\frac{d}{dt}\left(2\frac{\theta^2}{4}\right)+\frac{1}{2}m.2v\frac{dv}{dt}+\frac{mr^2}{4}\cdot 2\omega\frac{d\omega}{dt}$$

$$\Rightarrow 0=k(R-r)^2\theta\frac{d\theta}{dt}+mg(R-r)\theta\frac{d\theta}{dt}+mv\frac{dv}{dt}+\frac{mr^2}{2}\omega\frac{d\omega}{dt}$$

Also, $\frac{d\theta}{dt}=\frac{V}{(R-r)}$ $\Rightarrow \frac{d^2\theta}{dt^2}=\frac{1}{(R-r)}\frac{dv}{dt}=\frac{1}{R-r}a$

$$\therefore k(R-r)^2\cdot\theta\frac{V}{R-r}+mg(R-r)\theta\frac{V}{R-r}=-mv\alpha r-\frac{mr^2}{2}\frac{v}{r}\alpha$$

$$\Rightarrow k(R-r)+mg\theta=-\frac{3}{2}mr\alpha$$

$$\Rightarrow -[k(R-r)+mg]\theta=\frac{3}{2}m(R-r)\frac{d^2\theta}{dt^2}$$

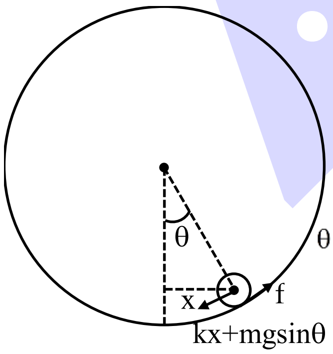
$$\Rightarrow -\frac{2}{3}\left[\frac{k}{m}+\frac{g}{R-r}\right]=\frac{d^2\theta}{dt^2}$$

Compering with standard equation of SHM

$$\omega=\sqrt{\frac{2}{3}\left[\frac{k}{m}+\frac{g}{R-r}\right]}$$

Hence answer is option(A)

**OR**




$\theta=\frac{x}{(R-r)}$

kx + mgsinθ – f = ma

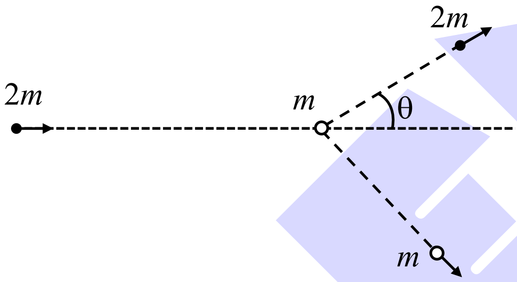
$$\Rightarrow kx + mg\frac{x}{(R-r)} - f = ma$$

$$fr = \frac{mr^2}{2}\cdot\alpha \Rightarrow f = \frac{ma}{2}$$

$$\therefore \left(\alpha + \frac{mg}{R-r}\right)x = \frac{3ma}{2}$$

$$\therefore \omega = \sqrt{\frac{2}{3}\left[\frac{k}{m} + \frac{g}{R-r}\right]}$$

**2.** In a scattering experiment, a particle of mass $2m$ collides with another particle of mass $m$, which is initially at rest. Assuming the collision to be perfectly elastic, the maximum angular deviation $\theta$ of the heavier particle, as shown in the figure, in radians is:




(A) $\pi$ (B) $\tan^{-1}\left(\frac{1}{2}\right)$ (C) $\frac{\pi}{3}$ (D) $\frac{\pi}{6}$

**Ans.** **(D)**

**Sol.** $2mv_1 = 2mv_{1f}\cos\theta + 2mv_{2f}\cos\phi$ ....(i)

$2m_{1f}\sin\theta = mv_{2f}\sin\phi$ ....(ii)

$$\frac{1}{2}(2m)v_1^2 + \frac{1}{2}m(0)^2 = \frac{1}{2}(2m)v_{1f}^2 + \frac{1}{2}mv_{2f}^2$$

$2v_1^2 = 2v_{1f}^2 + v_{2f}^2$ ....(iii)

From (i), (ii), (iii),

$$3v_{1f}^2 - 4v_1v_{1f}\cos\theta + v_1^2 = 0$$

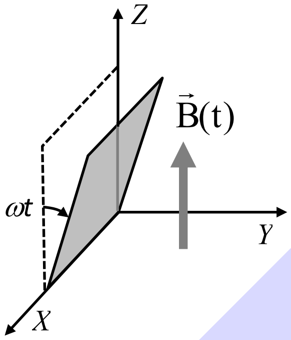
$$(-4v_1\cos\theta)^2 - 4(3)(v_1^2) \geq 0$$

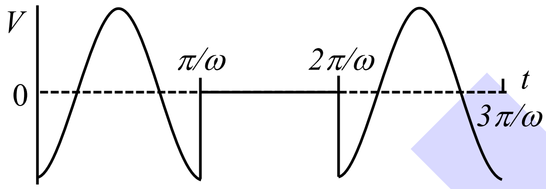
$$\cos^2\theta \geq \frac{3}{4}$$

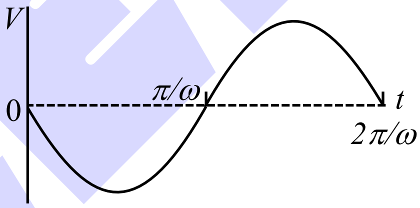
$$\cos^2\theta \geq \frac{\sqrt{3}}{2}$$

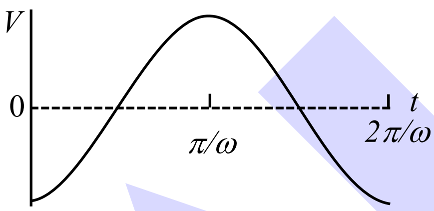
$$\therefore \theta = \frac{\pi}{6}$$

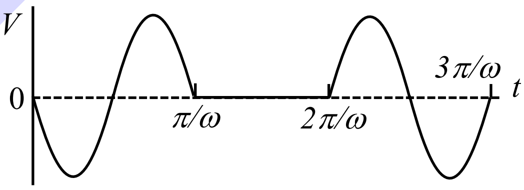
**3.** A conducting square loop initially lies in the *XZ* plane with its lower edge hinged along the *X*-axis. Only in the region $y \geq 0$, there is a time dependent magnetic field pointing along the *Z*-direction, $\vec{B}(t) = B_0(\cos \omega t)\hat{K}$, where $B_0$ is a constant. The magnetic field is zero everywhere else. At time $t = 0$, the loop starts rotating with constant angular speed $\omega$ about the *X* axis in the clockwise direction as viewed from the $+X$ axis (as shown in the figure). Ignoring self-inductance of the loop and gravity, which of the following plots correctly represents the induced e.m.f. (*V*) in the loop as a function of time:




(A) 


(B) 


(C) 


(D) 


**Ans.** **(A)**

**Sol.** $\phi = B_0 \cos \omega t A \sin \omega t = \dfrac{B_0 A \sin 2\omega t}{2}$

$\varepsilon = -\dfrac{d\phi}{dt} = -B_0 A \cos 2\omega t = \left(0 \leq t \leq \dfrac{\pi}{\omega}\right)$

$\varepsilon = 0 \quad \left(\dfrac{\pi}{\omega} \leq t \leq \dfrac{2\pi}{\omega}\right)$

Ans. Option (A)

**4.** Figure 1 shows the configuration of main scale and Vernier scale before measurement. Fig. 2 shows the configuration corresponding to the measurement of diameter $D$ of a tube. The measured value of $D$ is:

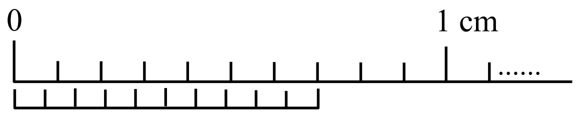



Fig.1

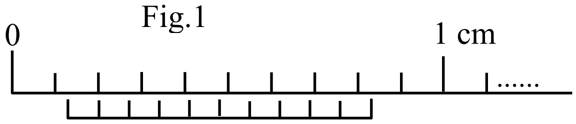



Fig.2

(A) 0.12 cm (B) 0.11 cm (C) 0.13 cm (D) 0.14 cm

**Ans.** **(C)**

**Sol.** 10 MSD = 1cm; 1 MSD = 0.1 cm

7 MSD = 10 VSD

1 VSD = 0.07 cm

Reading = 2 MSD – VSD

= 0.2 cm – 0.07 cm = 0.13 cm

Ans. Option (C)

**SECTION-2 : (Maximum Marks : 12)**

- This section contains **THREE (03)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated **according to the following marking scheme:**

*Full Marks* : +4 **ONLY** if (all) the correct option(s) is(are) chosen;

*Partial Marks* : +3 If all the four options are correct but **ONLY** three options are chosen;

*Partial Marks* : +2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;

*Partial Marks* : +1 If two or more options are correct but **ONLY** one option is chosen and it is a correct option;

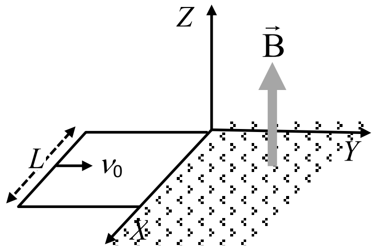
*Zero Marks* : 0 If none of the options is chosen (i.e. the question is unanswered);

*Negative Marks* : −2 In all other cases.

- For example, in a question, if (A), (B) and (D) are the ONLY three options corresponding to correct answers, then

choosing ONLY (A), (B) and (D) will get +4 marks;
choosing ONLY (A) and (B) will get +2 marks;
choosing ONLY (A) and (D) will get +2 marks;
choosing ONLY (B) and (D) will get +2 marks;
choosing ONLY (A) will get +1 marks;
choosing ONLY (B) will get +1 marks;
choosing ONLY (D) will get +1 marks;
choosing no option (i.e. the question is unanswered) will get 0 marks; and
choosing any other combination of options will get –2 marks.

**5.** A conducting square loop of side $L$, mass $M$ and resistance $R$ is moving in the $XY$ plane with its edges parallel to the $X$ and $Y$ axes. The region $y \geq 0$ has a uniform magnetic field, $\vec{B} = B_0 k$. The magnetic field is zero everywhere else. At time $t = 0$, the loop starts to enter the magnetic field with an initial velocity $v_0 \hat{j}$ m/s, as shown in the figure. Considering the quantity $K = \frac{B_0^2 L^2}{RM}$ in appropriate units, ignoring self-inductance of the loop and gravity, which of the following statements is/are correct:




(A) If $v_0 = 1.5KL$, the loop will stop before it enters completely inside the region of magnetic field.

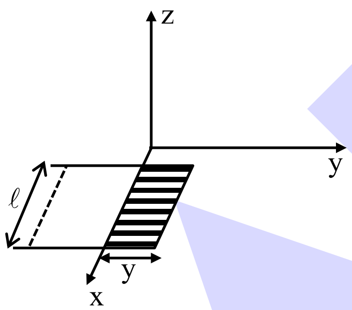
(B) When the complete loop is inside the region of magnetic field, the net force acting on the loop is zero.

(C) If $v_0 = \frac{KL}{10}$, the loop comes to rest at $t = \left(\frac{1}{K}\right) \ln \left(\frac{5}{2}\right)$.

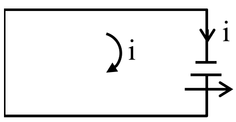
(D) If $v_0 = 3KL$, the complete loop enters inside the region of magnetic field at time $t = \left(\frac{1}{K}\right) \ln \left(\frac{3}{2}\right)$.

**Ans.** **(B,D)**

**Sol.**




$$\Rightarrow \frac{-d\phi}{dt} = \frac{d}{dt}(B_0 \times \ell \times y) = BV\ell$$




$$\vec{F} = B(\hat{i})(\ell)(-\hat{j})$$

$$ma = -B_0 \left[\frac{B_0 V \ell}{R}\right](\ell)$$

$$a = -\frac{B_0^2 \ell^2 V}{mR}$$

Also $K = \frac{B_0^2 \ell^2 V}{RM}$

So $[a = -kv]$

$$\frac{dv}{dt} = -kv$$

$$\int_{v_0}^{v} \frac{dv}{dt} = \int_0^t -kdt$$

$$\ell n \frac{v}{v_0} = -kt$$

$$[v = v_0 e^{-kt}] \qquad \ldots.(i)$$

$$\frac{dx}{dt} = v_0 e^{-kt} \qquad (x \leq \ell)$$

$$\int_0^x dx = \int_0^t v_0 e^{-kt} dt$$

$$= \frac{v_0}{k}(1 - e^{-kt})$$

When $x = \ell$

$$\ell = \frac{v_0}{k}(1 - e^{-kt})$$

Option (D) $(v_0 = 3k\ell)$

$$\ell = \frac{3k\ell}{k}(1 - e^{-kt})$$

$$\frac{1}{3} = 1 - e^{-kt}$$

$$f\frac{2}{3} = 2e^{-kt}$$

$$-kt = 8n\left(\frac{2}{3}\right)$$

$$t = \frac{1}{k}\ell n\left(\frac{2}{3}\right)$$

Complete loop will enter at $t = \frac{1}{k}\ell n\left(\frac{2}{3}\right)$

Option (B)

$$\frac{d\phi}{dt} = 0,\ \underline{e} = 0,\ i = 0,\ F = 0$$

Ans. B,D)

**6.** Length, breadth and thickness of a strip having a uniform cross section are measured to be 10.5 cm, 0.05 mm, and 6.0 μm, respectively. Which of the following option(s) give(s) the volume of the strip in $cm^3$ with correct significant figures:

(A) $3.2 \times 10^{-5}$ (B) $32.0 \times 10^{-6}$ (C) $3.0 \times 10^{-5}$ (D) $3 \times 10^{-5}$

**Ans.** **(D)**

**Sol.** L = 10.5 cm $\rightarrow$ 3 significant digits

b = 0.05 cm $\rightarrow$ 1 significant digit

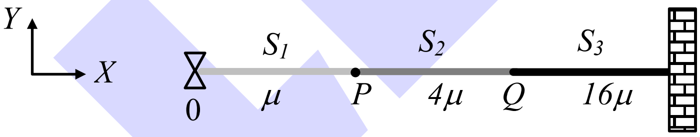
t = 6.0 μm $\rightarrow$ 2 significant digits

Volume, V = Lbt must have only 1 significant digit

$\Rightarrow V = 10.5 \times 0.05 \times 10^{-1} \times 6.0 \times 10^{-4}\ cm^3$

$= 3 \times 10^{-5}$ cc

**7.** Consider a system of three connected strings, $S_1$, $S_2$ and $S_3$ with uniform linear mass densities $\mu$ kg/m, $4\mu$ kg/m and $16\mu$ kg/m, respectively, as shown in the figure. $S_1$ and $S_2$ are connected at the point $P$, whereas $S_2$ and $S_3$ are connected at the point $Q$, and the other end of $S_3$ is connected to a wall. A wave generator O is connected to the free end of $S_1$. The wave from the generator is represented by $y = y_0 \cos(\omega t - kx)$ cm, where $y_0$, $\omega$ and $k$ are constants of appropriate dimensions. Which of the following statements is/are correct:




(A) When the wave reflects from $P$ for the first time, the reflected wave is represented by $y = \alpha_1 y_0 \cos(\omega t + kx + \pi)$ cm, where $\alpha_1$ is a positive constant.

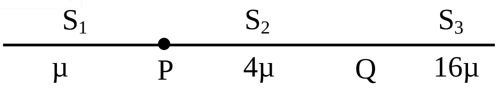
(B) When the wave transmits through $P$ for the first time, the transmitted wave is represented by $y = \alpha_2 y_0 \cos(\omega t - kx)$ cm, where $\alpha_2$ is a positive constant.

(C) When the wave reflects from $Q$ for the first time, the reflected wave is represented by $y = \alpha_3 y_0 \cos(\omega t - kx + \pi)$ cm, where $\alpha_3$ is a positive constant.

(D) When the wave transmits through $Q$ for the first time, the transmitted wave is represented by $y = \alpha_4 y_0 \cos(\omega t - 4kx)$ cm, where $\alpha_4$ is a positive constant.

**Ans.** **(A,D)**

**Sol.** (A)




$y_1 = y_0 \cos(\omega t - kx)$

when wave going from Rarer to Denser,

$y_r = A_r \cos(\omega t + kx + \pi)$

$y_r = a_1 y_0 \cos(\omega t + kx + \pi)$

option (A) correct

(B) For transmitted from point P

$y_t = A_t \cos[\omega t - k_1 x]$

$\frac{k_1}{k} = \sqrt{\frac{\mu_1}{\mu}} = \frac{k_1}{k} = \sqrt{\frac{4\mu}{\mu}}$

$k_1 = 2k$

$y_t = a_2 y_0 \cos[\omega t - 2kx]$

option (B) incorrect

(C) when reflected from Q

$y_i = a_2 y_0 \cos[\omega t - 2kx]$

$y_r = a_3 y_0 \cos[\omega t + 2kx + \pi]$

option (C) incorrect

(D) when transmitted from Q

$y_t = a_4 y_0 \cos[\omega t = k_2 x]$

$\frac{k_2}{2k} = \sqrt{\frac{16\mu}{4\mu}} \Rightarrow k_2 = 4k$

$y_t = a_4 y_0 \cos[\omega t - 4kx]$

option (D) correct

## SECTION-3 : (Maximum Marks : 24)

- This section contains **SIX (06)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value of the answer using the mouse and the onscreen virtual numeric keypad in the place designated to enter the answer.
- If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated **according to the following marking scheme:**

  *Full Marks* : +4 If **ONLY** the correct numerical value is entered in the designated place;

  *Zero Marks* : 0 In all other cases.

**8.** A person sitting inside an elevator performs a weighing experiment with an object of mass 50 kg. Suppose that the variation of the height $y$ (in m) of the elevator, from the ground, with time $t$ (in s) is given by $y = 8\left[1 + \sin\left(\frac{2\pi t}{T}\right)\right]$, where $T = 40\pi$ s. Taking acceleration due to gravity, $g = 10$ m/s$^2$, the maximum variation of the object's weight (in N) as observed in the experiment is _______.

**Ans.** **(2.00)**

**Sol.** $y = 8 + 8\sin\frac{2\pi t}{T}$

With respect to elevator, variation in weight will be

$\Delta W = m(\Delta a)_{max}$

$\Delta W = m \times 2\omega^2 A$

Here elevator is performing SHM

$$\Delta W = 2m \times \left(\frac{2\pi}{T}\right)^2 \times A \ \text{N}$$

$$\Delta W = 2 \times 50 \times \left(\frac{2\pi}{40\pi}\right)^2 \times 8 \ \text{N}$$

$$\Delta W = 2 \times 50 \times \frac{1}{400} \times 8 \ \text{N}$$

$$\Delta W = \frac{800}{400}\text{N} = 2\text{N}$$

Ans. is (B)

**9.** A cube of unit volume contains $35 \times 10^7$ photons of frequency $10^{15}$ Hz. If the energy of all the photons is viewed as the average energy being contained in the electromagnetic waves within the same volume, then the amplitude of the magnetic field is $\alpha \times 10^{-9}$ T. Taking permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ Tm/A, Planck's constant $h = 6 \times 10^{-34}$ Js and $\pi = \frac{22}{7}$, the value of $\alpha$ is____

**Ans.** **(22.98)**

**Sol.** Total energy in cube $= 35 \times 10^7 \times hf$

$= 35 \times 10^7 \times 6 \times 10^{-34} \times 10^{15}$

$= 2.1 \times 10^{-10}$ J

Total energy of EM waves = $\frac{B_0^2}{2\mu_0} \times \text{volume}$

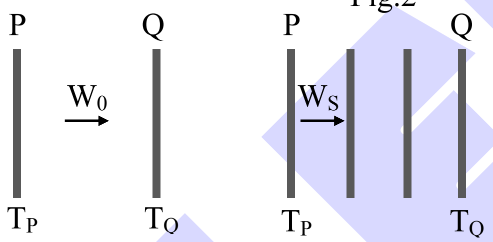
$$B_0^2 = \frac{2.1\times10^{-10}\times8\pi\times10^{-7}}{1^3}$$

$$\Rightarrow B_0 = 22.98 \times 10^{-9}\ \text{T}$$

Ans. 22.98

**10.** Two identical plates P and Q, radiating as perfect black bodies, are kept in vacuum at constant absolute temperatures $T_P$ and $T_Q$, respectively, with $T_Q < T_P$, as shown in Fig. 1. The radiated power transferred per unit area from P to Q is $W_0$. Subsequently, two more plates, identical to P and Q, are introduced between P and Q, as shown in Fig. 2. Assume that heat transfer takes place only between adjacent plates. If the power transferred per unit area in the direction from P to Q (Fig. 2) in the steady state is $W_S$, then the ratio $\frac{W_0}{W_S}$ is ___

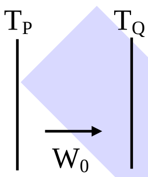
Fig.1 Fig.2




**Ans.** **(3.00)**

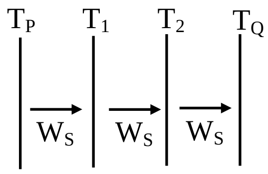
**Sol.** Initially :

$$W_0 = \sigma\left(T_P^4 - T_Q^4\right)$$




Finally :

Putting heat currents equal in steady state :




$$\sigma\left(T_P^4 - T_1^4\right) = \sigma\left(T_1^4 - T_2^4\right)$$

$$\sigma\left(T_1^4 - T_2^4\right) = \sigma\left(T_2^4 - T_Q^4\right)$$

Adding :

$$T_P^4 - T_1^4 = T_2^4 - T_Q^4$$

$$\Rightarrow T_1^4 + T_2^4 = T_P^4 + T_Q^4$$

and $$\Rightarrow T_1^4 - T_2^4 = T_P^4 - T_1^4$$

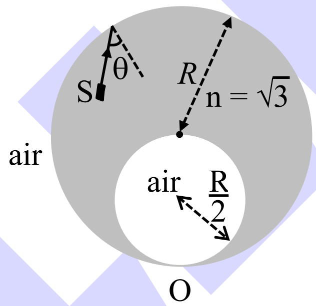
Adding : $T_1^4 = \dfrac{2T_P^4 + T_Q^4}{3}$

So $W_S = \sigma\left(T_P^4 - T_1^4\right)$

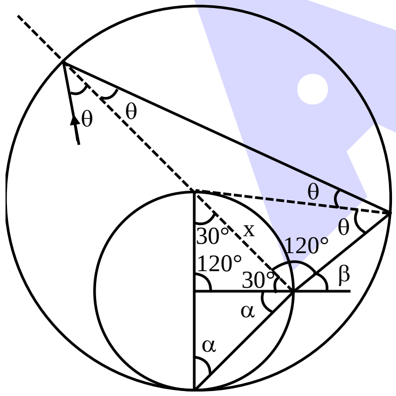
$$= \sigma\left(T_P^4 - \left(\frac{2T_P^4 + T_Q^4}{3}\right)\right) = \sigma\left(\frac{T_P^4 - T_Q^4}{3}\right)$$

hence $\dfrac{W_S}{W_0} = 3$

**11.** A solid glass sphere of refractive index $n = \sqrt{3}$ and radius $R$ contains a spherical air cavity of radius $\dfrac{R}{2}$, as shown in the figure. A very thin glass layer is present at the point O so that the air cavity (refractive index $n$ = 1) remains inside the glass sphere. An unpolarized, unidirectional and monochromatic light source $S$ emits a light ray from a point inside the glass sphere towards the periphery of the glass sphere. If the light is reflected from the point O and is fully polarized, then the angle of incidence at the inner surface of the glass sphere is $\theta$. The value of $\sin\theta$ is ____




**Ans.** **(0.75)**




**Sol.**

$\tan\alpha = \sqrt{3}$

$\alpha = 60°$

$\sqrt{3}\sin\beta = 1\times\sin\alpha \Rightarrow \beta = 30°$

$\frac{R}{2\sin 30°} = \frac{x}{\sin 120°}$

$\frac{R}{\sin 120°} = \frac{R\sqrt{3}}{2\times\sin\theta} \Rightarrow \sin\theta = \frac{\sqrt{3}}{2}\times\frac{\sqrt{3}}{2}$

$\sin\theta = \frac{3}{4}$

**12.** A single slit diffraction experiment is performed to determine the slit width using the equation, $\frac{bd}{D} = m\lambda$, where $b$ is the slit width, $D$ the shortest distance between the slit and the screen, $d$ the distance between the $m^{th}$ diffraction maximum and the central maximum, and $\lambda$ is the wavelength. $D$ and $d$ are measured with scales of least count of 1 cm and 1 mm, respectively. The values of $\lambda$ and $m$ are known precisely to be 600 nm and 3, respectively. The absolute error (in $\mu$m) in the value of $b$ estimated using the diffraction maximum that occurs for $m = 3$ with $d = 5$ mm and $D = 1$ m is ___

**Ans.** **(75.60 OR 94.50)**

**Sol.** **Solution-1**

If we can consider

$\frac{\Delta b}{b} = \frac{\Delta m}{m} + \frac{\Delta\lambda}{\lambda} + \frac{\Delta D}{D} + \frac{\Delta d}{d}$

$\frac{\Delta b}{b} = 0 + 0 + \frac{1cm}{1m} + \frac{1mm}{5mm} = 0.21$

$b = \frac{m\lambda D}{d} = \frac{3\times 600\times 10^{-3}\times 1}{5\times 10^{-3}}\,\mu m = 360\ \mu m$

$\Rightarrow \Delta b = 360 \times 0.21\ \mu m = 75.6\ \mu m$

However, error in d is too large (20%) for the solution-1 to be correct. Hence, we propose solution-2

**Solution-2**

$b = \frac{m\lambda D}{d} = 360\ \mu m$

$b_{max} = \frac{3\times 600\times 10^{-3}\times 1.01}{4\times 10^{-3}}\,\mu m = 454.5\ \mu m$

$b_{min} = \frac{3\times 600\times 10^{-3}\times 0.99}{6\times 10^{-3}}\,\mu m = 297\ \mu m$

Maximum value of b gives error, $\Delta b_1 = 94.5\ \mu m$

Minimum value of b gives error, $\Delta b_2 = 63\ \mu m$

$\therefore$ We always report the largest error, hence correct answer should be 94.5μm

**13.** Consider an electron in the $n = 3$ orbit of a hydrogen-like atom with atomic number $Z$. At absolute temperature $T$, a neutron having thermal energy $k_B T$ has the same de Broglie wavelength as that of this electron. If this temperature is given by $T = \dfrac{Z^2h^2}{\alpha\pi^2 a_0^2 m_N k_B}$, (where $h$ is the Planck's constant, $k_B$ is the Boltzmann constant, $m_N$ is the mass of the neutron and $a_0$ is the first Bohr radius of hydrogen atom) then the value of $\alpha$ is ___

**Ans.** **(72.00)**

**Sol.** $$\frac{mv^2}{r} = \frac{KZe^2}{r^2}$$

$$mv^2r = \frac{1}{4\pi \in_0} Ze^2 \qquad \ldots (1)$$

$$mvr = \frac{nh}{2\pi} \qquad \ldots (2)$$

(1)/(2) gives

$$v = \frac{\dfrac{Ze^2}{4\pi \in_0}}{\dfrac{nh}{2\pi}} = \frac{Ze^2}{2 \in_0 nh}$$

$$\frac{h}{mv} = \frac{h}{\sqrt{2m_N \cdot K_B T}}$$

$$T = \frac{m^2Z^2e^4}{8 \in_0^2 n^2h^2m_NK_B}$$

$$n = 3 \Rightarrow T = \frac{m^2Z^2e^4}{72 \in_0^2 h^2m_NK_B}$$

$$\frac{(1)}{(2)^2} \Rightarrow \frac{1}{mr} = \frac{\dfrac{Ze^2}{4\pi \in_0}}{\dfrac{n^2h^2}{4\pi^2}}$$

$$r = \frac{n^2h^2 \in_0}{\pi Ze^2 \cdot m} \Rightarrow a_0 = \frac{h^2 \in_0}{\pi e^2 m}$$

$$a_0^2 = \frac{h^4 \in_0^2}{\pi^2e^4m^2}$$

$$Ta_0^2 = \frac{m^2Z^2e^4}{72 \in_0 h^2m_Nk_B} \cdot \frac{h^4 \in_0^2}{\pi^2e^4m^2}$$

$$T = \frac{h^2Z^2}{72\pi^2a_0^2m_Nk_B} \Rightarrow \alpha = 72$$

## SECTION-4 : (Maximum Marks : 12)

- This section contains **THREE (03)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists : **List-I** and **List-II**.
- **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated **according to the following marking scheme:**

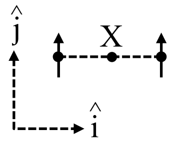
  *Full Marks* : +4 **ONLY** if the option corresponding to the correct combination is chosen;

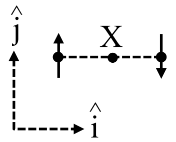
  *Zero Marks* : 0 If none of the options is chosen (i.e. the question is unanswered);

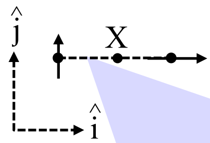
  *Negative Marks* : –1 In all other cases.

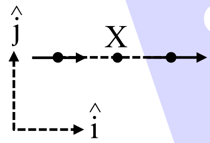
**14.** List-I shows four configurations, each consisting of a pair of ideal electric dipoles. Each dipole has a dipole moment of magnitude $p$, oriented as marked by arrows in the figures. In all the configurations the dipoles are fixed such that they are at a distance $2r$ apart along the $x$ direction. The midpoint of the line joining the two dipoles is $X$. The possible resultant electric fields $\vec{E}$ at $X$ are given in List-II. Choose the option that describes the correct match between the entries in **List-I** to those in **List-II**.

**List-I**

(P) 


(Q) 


(R) 


(S) 


**List-II**

(1) $\vec{E}=0$

(2) $\vec{E}=-\dfrac{p}{2\pi\epsilon_0 r^3}\hat{j}$

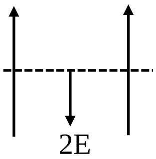
(3) $\vec{E}=-\dfrac{p}{4\pi\epsilon_0 r^3}\left(\hat{i}-\hat{j}\right)$

(4) $\vec{E}=\dfrac{p}{4\pi\epsilon_0 r^3}\left(2\hat{i}-\hat{j}\right)$

(5) $\vec{E}=\dfrac{p}{\pi\epsilon_0 r^3}\hat{i}$

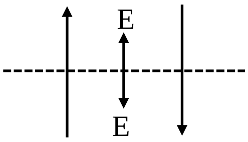
(A) P→3, Q→1, R→2, S→4
(B) P→4, Q→5, R→3, S→1
(C) P→2, Q→1, R→4, S→5
(D) P→2, Q→1, R→3, S→5

**Ans. (C)**

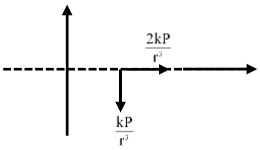
**Sol.** (P) 


$$E_{net} = \frac{-2kP}{r^3}\hat{j}$$

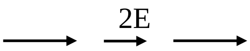
$$E_{net} = \frac{-P\hat{j}}{2\pi\in_0 r^3}$$

(Q) 


$$E_{net} = 0$$

(R) 


$$\frac{2P\hat{i}}{4\pi\in_0 r^3} - \frac{P\hat{j}}{4\pi\in_0 r^3}$$

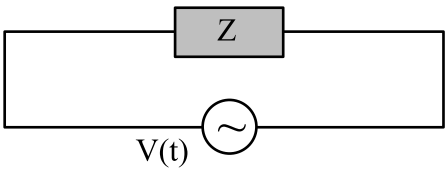
(S) 


$$E_{net} = \frac{4kP\hat{i}}{r^3}$$

$P \to 2, Q \to 1, R \to 4, S \to 5$

**Ans. (C)**

**15.** A circuit with an electrical load having impedance $Z$ is connected with an AC source as shown in the diagram. The source voltage varies in time as $V(t) = 300\sin(400t)$ V, where $t$ is time in s. List-I shows various options for the load. The possible currents $i(t)$ in the circuit as a function of time are given in List-II.

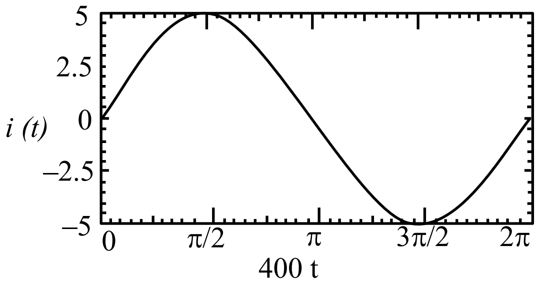


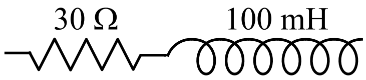

Choose the option that describes the correct match between the entries in **List-I** to those in **List-II.**

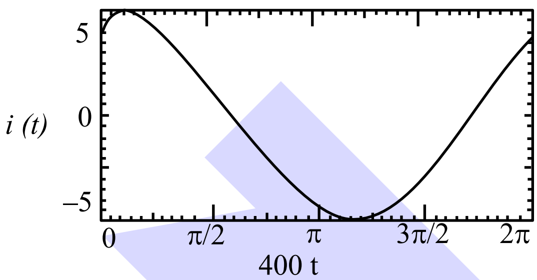
**List-I** | **List-II**

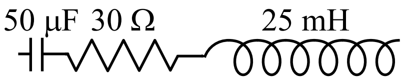
(P)

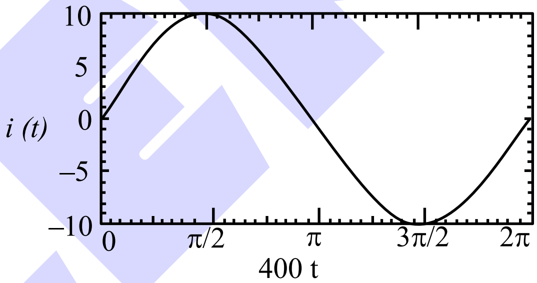


(1)



(Q)


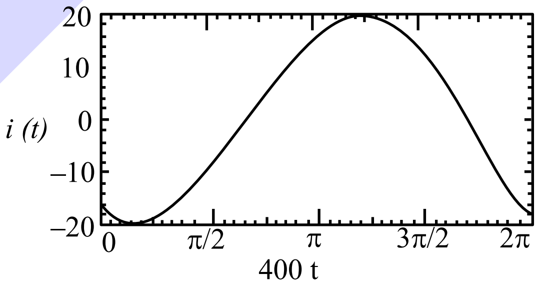

(2)


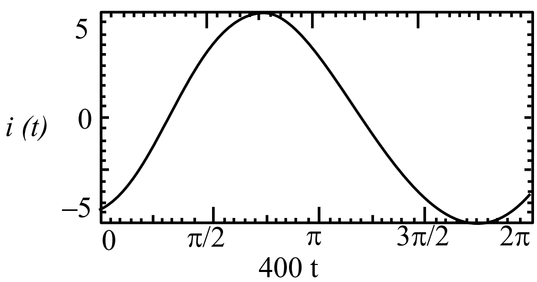

(R)



(3)



(S)



(4)



(5)



(A) P→3, Q→5, R→2, S→1
(B) P→1, Q→5, R→2, S→3
(C) P→3, Q→4, R→2, S→1
(D) P→1, Q→4, R→2, S→5

**Ans.** **(A)**

**Sol.** For P

$i = \frac{V}{R} = 10 \sin 400t \Rightarrow (3)$

For Q

$X_L = \omega L = 400 \times 100 \times 10^{-3} = 40\Omega$

$\therefore Z = 50\Omega$

$\therefore\ i = \frac{300}{50}\sin(400t - 53°)$ [current will lag by $\tan^{-1}\frac{X_L}{R}$ ] $\Rightarrow (5)$

For R

$X_C = \frac{10^6}{400 \times 50}\Omega = 50\Omega$ and $X_L = 400 \times 25 \times 10^{-3} = 10\Omega$

$\therefore Z = 50\Omega$

$\therefore\ i = \frac{300}{50}\sin(400t + 53°)$ [Current will lead by $\tan^{-1}\frac{X_C - X_L}{R}$ ] $\Rightarrow (2)$

For S

$X_C = 50\Omega$ and $X_L = 400 \times 125 \times 10^{-3} = 50\Omega$

$R = 60\Omega$

$\therefore i = \frac{300}{60}\sin(400t)$ $X_L = X_C \Rightarrow$ Resonance $\Rightarrow (1)$

**16.** List-I shows various functional dependencies of energy ($E$) on the atomic number ($Z$). Energies associated with certain phenomena are given in List-II.

Choose the option that describes the correct match between the entries in **List-I** to those in **List-II**.

| **List-I** | **List-II** |
|---|---|
| (P) $E \propto Z^2$ | (1) energy of characteristic x-rays |
| (Q) $E \propto (Z-1)^2$ | (2) electrostatic part of the nuclear binding energy for stable nuclei with mass numbers in the range 30 to 170 |
| (R) $E \propto Z(Z-1)$ | (3) energy of continuous x-rays |
| (S) $E$ is practically independent of $Z$ | (4) average nuclear binding energy per nucleon for stable nuclei with mass number in the range 30 to 170 |
| | (5) energy of radiation due to electronic transitions from hydrogen-like atoms |

(A) P→4, Q→3, R→1, S→2

(B) P→5, Q→2, R→1, S→4

(C) P→5, Q→1, R→2, S→4

(D) P→3, Q→2, R→1, S→5

**Ans.** **(C)**

**Sol.** (P) Energy of H-like atom is

$$E = -13.6\frac{Z^2}{n^2} \quad \text{So}$$

$E \propto Z^2$

$P \rightarrow (5)$

(Q) Energy of characteristic X-ray by moseley's correction

$$E = -13.6(Z-1)^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \text{ So}$$

$E \propto (Z-1)^2$

$Q \rightarrow (1)$

(R) Electrostatics binding energy is proportional to $Z(Z-1)$

$R \rightarrow (2)$

(S) For stable nuclei with mass no. in range 30 to 170. Binding energy per nucleon is constant & graph is straight line

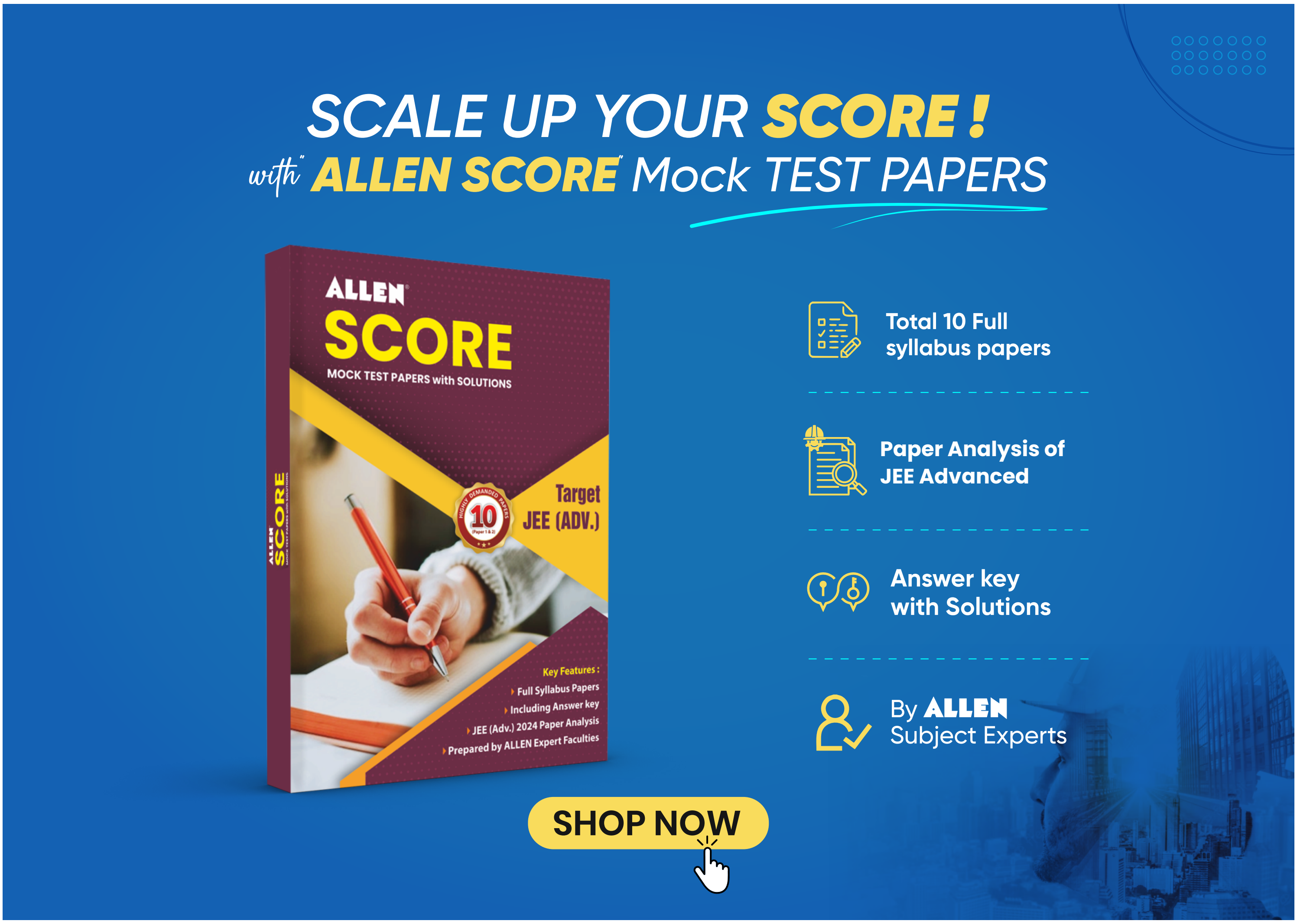
$S \rightarrow (4)$

Ans. (C) is correct


ALLEN KOTA
Are you an Ex-ALLENite or Qualified for JEE Adv. 2025 Examination?
JOIN LEADER PLUS COURSE
JEE (Main+Adv.) 2026
13 June & 02 July
Click to know more
AIR 1
JEE Adv. 2024
Ved Lahoti
CLASSROOM
Avail Scholarship upto 90% based on your JEE Adv. 2025 Performance


ALLEN ONLINE
Think JEE 2026 will be a better attempt?
Join the
JEE Leader Online Course
Up to
90% scholarship
based on your JEE Main 2025 score!
Batches starting 24th May & 5th June
Enrol Now


ALLEN
Get The Latest
IIT-JEE Special Books
at Your Door Steps...!!
JOIN THE JOURNEY OF LEARNING
with
HANDBOOKS | PHYSICS EXPRESS | SCORE PAPERS
JEE-MAIN PYQ's | JEE-Adv. PYQ's
SHOP NOW
HANDBOOKS
MAIN PYQ's
ADVANCED PYQ's
SCORE Mock Test Papers
PHYSICS EXPRESS
Available in
HINDI & ENGLISH


SCALE UP YOUR SCORE !
with ALLEN SCORE Mock TEST PAPERS
ALLEN
SCORE
MOCK TEST PAPERS with SOLUTIONS
Target JEE (ADV.)
Key Features :
Full Syllabus Papers
Including Answer key
JEE (Adv.) 2024 Paper Analysis
Prepared by ALLEN Expert Faculties
Total 10 Full syllabus papers
Paper Analysis of JEE Advanced
Answer key with Solutions
By ALLEN Subject Experts
SHOP NOW