JEE (ADVANCED) 2025 PAPER-1

[PAPER ANSWER KEY WITH SOLUTION]

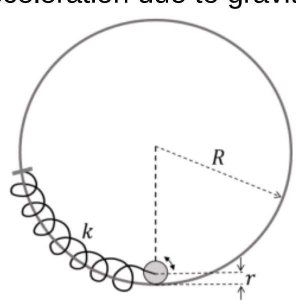
HELD ON SUNDAY 18TH MAY 2025

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.

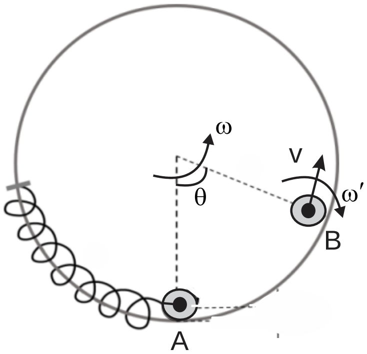
[Q.1] The center of a disk of radius r and mass m is attached to a spring of spring constant k, inside a ring of radius $R > r$ as shown in the figure. The other end of the spring is attached on the periphery of the ring. Both the ring and the disk are in the same vertical plane. The disk can only roll 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 ω 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

[:SOLN]



When disc is slightly displaced from A to B, elongation in spring $=(R-r)\theta$

For pure rolling of disc, $v=r\omega'$ & also $v=(R-r)\omega$

Total ME of system, $E=\frac{1}{2}mv^2+\frac{1}{2}I_{cm}\omega'^2+mg(R-r)(1-\cos\theta)+\frac{1}{2}k[(R-r)\theta]^2$

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

$=\frac{3}{4}m(R-r)^2\omega^2+mg(R-r)(1-\cos\theta)+\frac{1}{2}k(R-r)\theta^2$

Now, $\frac{dE}{d\theta}=\frac{3}{2}m(R-r)^2\omega\frac{d\omega}{dt}+mg(R-r)\sin\theta\omega+k(R-r)^2\theta\frac{d\theta}{dt}$

$0=\frac{3}{2}m(R-r)\alpha+mg(\theta)+k(R-r)\theta \quad \left[\text{putting}\frac{dE}{d\theta}=0\right]$

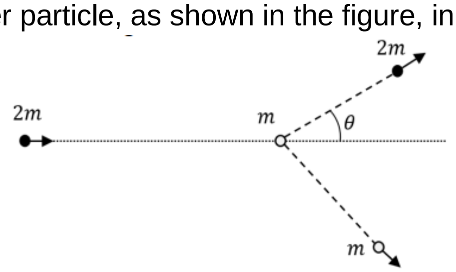
$\frac{3}{2}m(R-r)\alpha=-[mg+k(R-r)]\theta$

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

Clearly motion is angular SHM with angular frequency

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

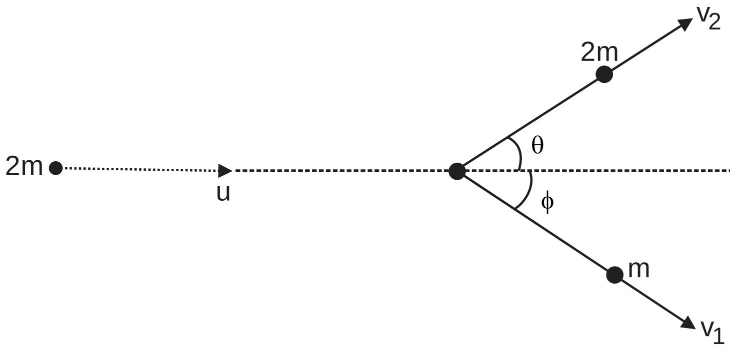
[Q.2] In a scattering experiment, a particle of mass $2m$ collides with another particle of mass m, which is initially at rest. Assuming the collision to be perfectly elastic, the maximum angular deviation θ of the heavier particle, as shown in the figure, in radians is:



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

[:ANS] **D**

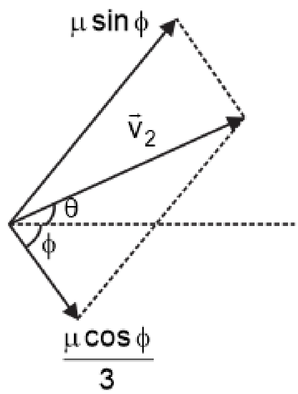
[:SOLN]



Since collision is oblique, mass m will only move along CN.

Velocity of 2m after collision along CN $= \frac{2m - m}{3m} u\cos\phi = \frac{u\cos\phi}{3}$

Velocity of 2m after collision along CT $= u\sin\phi$



$\tan(\theta+\phi) = 3\tan\phi \quad \Rightarrow \tan\theta = \frac{2\tan\phi}{1+3\tan^2\phi}$

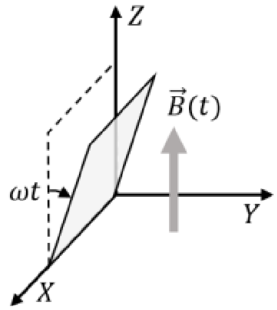
For θ to be maximum $\frac{d\theta}{d\phi} = 0$

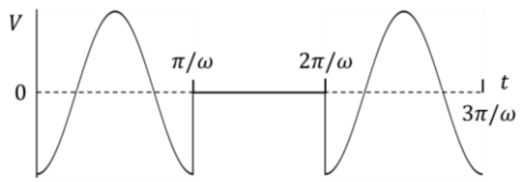
$$\Rightarrow \tan\phi = \frac{1}{\sqrt{3}}$$

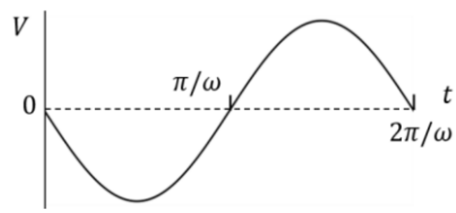
Now $\tan\theta_{max} = \frac{2\times\frac{1}{\sqrt{3}}}{1+3\times\frac{1}{3}} = \frac{1}{\sqrt{3}}$

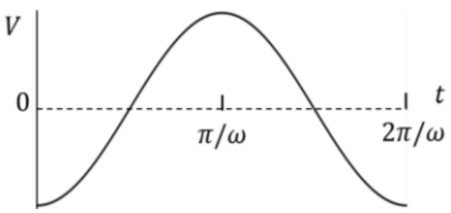
$$\theta_{max} = \frac{\pi}{6}$$

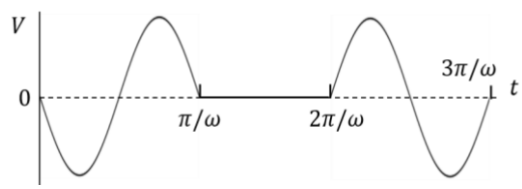
[Q.3] A conducting square loop initially lies in the XZ plane with its lower edge hinged along the X-axis. Only in the region $y \geq 0$, there is a time dependent magnetic field pointing along the Z-direction, $\vec{B}(t) = B_0(\cos\omega t)\hat{k}$, where B_0 is a constant. The magnetic field is zero everywhere else. At time $t = 0$, the loop starts rotating with constant angular speed ω 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**

[:SOLN] At time t angle b/w area vector of given plane with magnetic field = $\left(\frac{\pi}{2} - \omega t\right)$

Now flux linked with given plane

$\phi = B_0 \cos\omega t \cdot S\cos\left(\frac{\pi}{2} - \omega t\right)$ [Where S is area of loop]

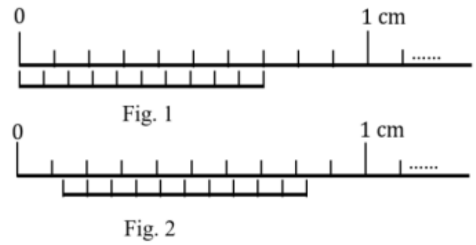
$$\phi = \frac{B_0 S}{2}(\sin 2\omega t)$$

$$e = -\frac{d\phi}{dt} = -B_0 S\omega|\cos 2\omega t|$$

The induced emf will appear in time intervals $\left(o \to \frac{\pi}{\omega}\right), \left(\frac{2\pi}{\omega} \to \frac{3\pi}{\omega}\right), \left(\frac{4\pi}{\omega} \to \frac{5\pi}{\omega}\right), \ldots$

and in the intervals $\left(\frac{\pi}{\omega} \to \frac{2\pi}{\omega}\right), \left(\frac{3\pi}{\omega} \to \frac{4\pi}{\omega}\right), \left(\frac{5\pi}{\omega} \to \frac{6\pi}{\omega}\right)$ loop is outside the magnetic field and hence no emf will be induced.

[Q.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:



[:A] 0.12 cm [:B] 0.11 cm [:C] 0.13 cm [:D] 0.14 cm

[:ANS] **C**

[:SOLN] From figure I :

10 VSD = 7 MDS

1 VSD = 0.7 MSD = 0.7 × 0.1 cm = 0.07 cm

There is no any zero error.

From figure II :

Reading = 2 MSD – 1 VSD = (0.2 – 0.07) cm = 0.13 cm

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 mark;

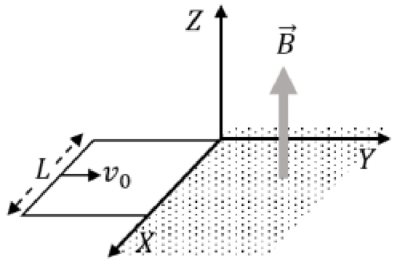
  choosing ONLY (B) will get +1 mark;

  choosing ONLY (D) will get +1 mark;

  choosing no option (i.e. the question is unanswered) will get 0 marks; and

  choosing any other combination of options will get −2 marks.

[Q.5] 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, $\vec{B} = B_0\hat{k}$. 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 $K = \frac{B_0^2L^2}{RM}$ 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**

[:SOLN] $e = B_0Lv$ (Instantaneous value)

$$I = \frac{B_0Lv}{R}$$

$$F_m = ILB_0$$

$$F_m = -\frac{B_0{}^2L^2v}{R} \quad \text{[As per Lenz's Law]}$$

$$a = -\frac{B_0{}^2L^2}{mR}v$$

$a = -kv$

$$\frac{vdv}{ds} = -kv \qquad\qquad \frac{dv}{dt} = -kv$$

$dv = -k\,ds$

$\int_{v_0}^{v} dv = -k\int_0^s ds$

$v - v_0 = -ks$

$v = v_0 - ks$ ...(i)

Minimum velocity needed to just enter

the region of magnetic field $(V_0)_{min} = KL$

for any $v_0 > KL$

the loop will enter completely within

the region of field and then start moving

with constant velocity.

When loop will be fully within the field

e = 0 / I = 0 / Fm = 0

i.e. the loop will experience no force

afterwards.

$\frac{dv}{v} = -kdt$

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

$\ln\frac{v}{v_0} = -kt$ ...(ii)

$t = \frac{1}{k}\ln\frac{v_0}{v}$ ...(iii)

from eq^n (ii) $\therefore$ $v = v_0 e^{-kt}$

it shows velocity cann't be zero in finite time.

when = v_0 = 3 KL from (i) velocity of loop

at the time when it completely enters

Into the field, v = 3KL – KL = 2 KL

Now from (iii) time taken by loop to enter

the field, $t = \frac{1}{k}\ell n\frac{3}{2}$

[Q.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:

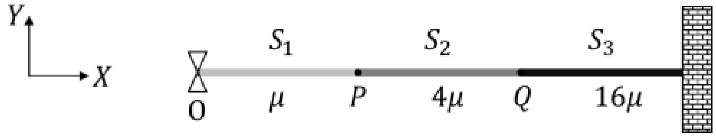
[:A] 3.2×10^{-5} [:B] 32.0×10^{-6} [:C] 3.0×10^{-5} [:D] 3×10^{-5}

[:ANS] **D**

[:SOLN] Volume $= (10.5\,cm)\times(0.05\times10^{-1}cm)\times(6.0\times10^{-4}cm) = 3.15\times10^{-5}cm^3$

$= 3\times10^{-5}cm^3$ (with regard to significant figures)

[Q.7] Consider a system of three connected strings, S_1, S_2 and S_3 with uniform linear mass densities μ kg/m, 4μ kg/m and 16μ 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, ω 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 α_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 α_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 α_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 α_4 is a positive constant.

[:ANS] **A, D**

[:SOLN] At P

$y_r = A_r \cos(wt + kx + \pi)$

$y_t = A_t \cos(wt - 2kx)$

At Q

$y_r = A_r' \cos(wt + 2kx + \pi)$

$y_t = A_t' \cos(wt - 4kx)$

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 on screen 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.

[Q.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, m/s^2, the maximum variation of the object's weight (in N) as observed in the experiment is ________ .

[:ANS] **2.00**

[:SOLN] $y = 8\left[1 + \sin\left(\frac{2\pi t}{T}\right)\right]$

Velocity of elevator

$$v = \frac{dy}{dt} = 8\left(\frac{2\pi}{T}\right)\cos\left(\frac{2\pi t}{T}\right)$$

Acceleration of elevator

$$a = \frac{dv}{dt} = -8\left(\frac{2\pi}{T}\right)^2 \sin\left(\frac{2\pi t}{T}\right)$$

$$a_{max} = \pm\left(\frac{8}{400}\right) m/s^2$$

$$N_{max} = mg + ma_{max} = 500 + 50 \times \frac{8}{400} = 501N$$

$$N_{min} = mg - ma_{max} = 500 - 1 = 499N$$

Now $\Delta N = 501 - 499 = 2N$

[Q.9] A cube of unit volume contains 35 × 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 α is____

[:ANS] **22.98**

[:SOLN] $22.9782 \approx 23$

$$\frac{B_0^2}{2\mu_0} = n(hv)$$

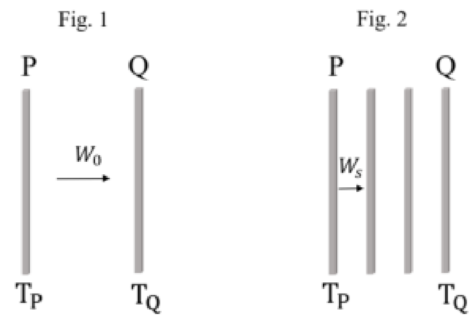
$$B_0 = \sqrt{2\mu_0 nhv}$$

$$= \sqrt{2 \times 4 \times \frac{22}{7} \times 10^{-7} \times 35 \times 10^7 \times 6 \times 10^{-34} \times 10^{15}}$$

$$= 22.9782 \times 10^{-9} T$$

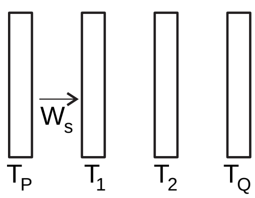
$$\approx 23 \times 10^{-9} T$$

[Q.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 ___



[:ANS] **3.00**

[:SOLN] $W_0 = \sigma\left(T_P^4 - T_Q^4\right)$ ...(i)



at steady state,

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

$\Rightarrow T_P^4 = 2T_1^4 - T_2^4$ ....(i)

$\& \ T_Q^4 = 2T_2^4 - T_1^4$ ...(ii)

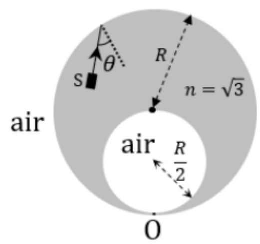
from (i) $\times 2 +$ (ii)

$$\frac{-2T_2^4 + T_Q^4}{3} = T_1^4$$

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

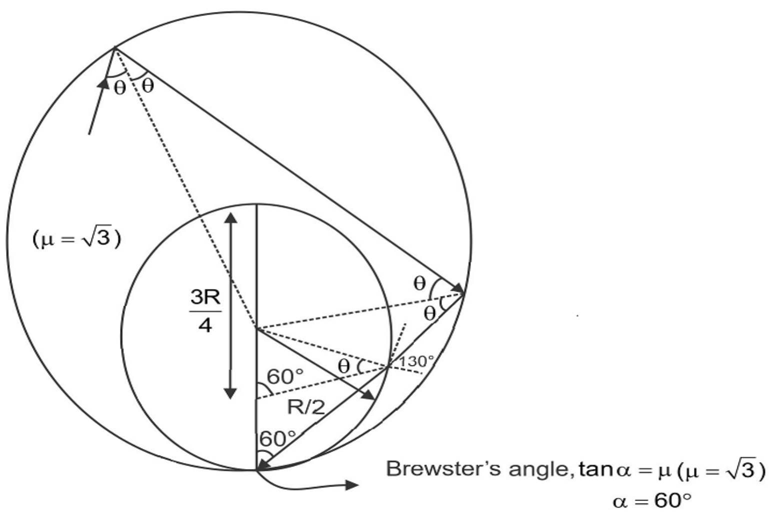
$$\Rightarrow \frac{W_0}{W_s} = 3$$

[Q.11] A solid glass sphere of refractive index $n=\sqrt{3}$ and radius R contains a spherical air cavity of radius $\frac{R}{2}$, 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 θ. The value of sin θ is ____



[:ANS] **0.75**

[:SOLN]



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

$$\sin\theta = 0.75$$

[Q.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 λ is the wavelength. D and d are measured with scales of least count of 1 cm and 1 mm, respectively. The values of λ and m are known precisely to be 600 nm and 3, respectively. The absolute error (in μm) 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**

[:SOLN] $\frac{bd}{D} = m\lambda$

$$b = \frac{mD\lambda}{d} = \frac{3 \times 1m \times 600 \times 10^{-9}}{5 \times 10^{-3}} = 3.6 \times 10^{-4}$$

for absolute error

$$\frac{\Delta b}{b} = \frac{\Delta D}{D} + \frac{\Delta d}{d} = \frac{1}{100} + \frac{1}{5}$$

$$\Delta b = 3.6 \times 10^{-4}\left(\frac{1}{100} + \frac{1}{5}\right) = 0.756 \times 10^{-4}$$

$$\Delta b = 75.6 \times 10^{-6} = 75.6\mu m$$

$\Rightarrow$ another possibility,

$$b' = \frac{m\lambda D}{d} = \frac{3 \times 600 \times 10^{-9} \times 1.01}{4 \times 10^{-3}} = 4.545 \times 10^{-4}$$

So, $\Delta b = b' - b = (4.545 - 3.6) \times 10^{-4}$

$$\Delta b = 0.945 \times 10^{-4} = 94.50 \times 10^{-6}$$

[Q.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 $T = \frac{Z^2h^2}{\alpha\pi^2 a_0^2 m_N k_B}$, (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 α is ___

[:ANS] **72.00**

[:SOLN] $a_0 = \frac{h^2}{4\pi m_e kze^2}$

$$a_0^2 = \frac{h^4}{16\pi^2 m_e^2 k^2 z^2 e^4} \quad \text{.... (i)}$$

$$\because \ V_n = \frac{2kze^2}{nh}$$

$$\therefore \ p_e = \frac{2m_c kze^2}{3h}$$

$$\because \ \lambda_e = \lambda_N$$

$$p_e = p_N$$

$$\frac{2m_e kze^2}{3h} = \sqrt{2m_N k_B T}$$

$$T = \frac{2m_e^2 k^2 z^2 e^4}{9h^2 m_N k_B} \quad \text{.... (ii)}$$

From (i) × (ii) :-

$$Ta_0^2 = \frac{2m_e^2 k^2 z^2 e^4}{9h^2 m_N k_B} \times \frac{h^2}{16\pi^2 m_e^2 k^2 z^2 e^4}$$

$$= \frac{2h^2}{9 \times 16 m_N k_B \pi^2}$$

$$= \frac{h^2}{72 m_N k_B \pi^2}$$

$$\therefore \quad \alpha = 72$$

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:**

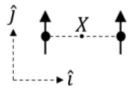
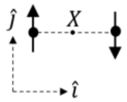
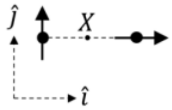
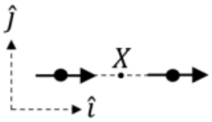
Full Marks : +4 **ONLY** if the option corresponding to the correct combination is chosen;

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

Negative Marks : −1 In all other cases.

[Q.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.

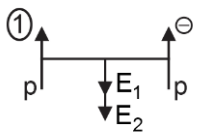
List-I	List-II
(P) 	(1) $\vec{E}=0$
(Q) 	(2) $\vec{E}=-\frac{p}{2\pi\epsilon_0 r^3}\hat{j}$
(R) 	(3) $\vec{E}=-\frac{p}{4\pi\epsilon_0 r^3}(\hat{i}-\hat{j})$
(S) 	(4) $\vec{E}=\frac{p}{4\pi\epsilon_0 r^3}(2\hat{i}-\hat{j})$
	(5) $\vec{E}=\frac{p}{\pi\epsilon_0 r^3}\hat{i}$

Codes :

[: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

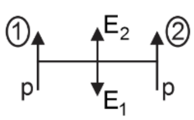
[ANS] **C**

[SOLN] (P) 

$$E_x = E_1 + E_2$$

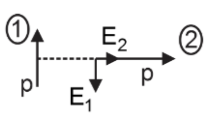
$$= \frac{kp}{r^3} + \frac{kp}{r^3} = \frac{2kp}{r^3}(-\hat{j})$$

$\boxed{P \to 2}$

(Q) 

$$E_x = E_1 - E_2 = 0$$

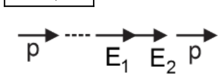
$\boxed{Q \to 1}$

(R) 

$$E_1 = \frac{kp}{r^3} \quad E_2 = \frac{2kp}{r^3}$$

$$\vec{E} = \frac{kp}{r^3}(2\hat{i}-\hat{j})$$

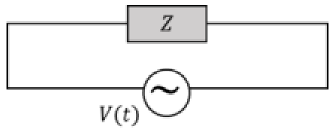
$\boxed{R \to 4}$

(S) 

$$E_x = E_1 + E_2 = \frac{4kp}{r^3}\hat{i}$$

$\boxed{S \rightarrow 5}$

[Q.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.



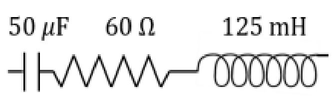
Choose the option that describes the correct match between the entries in List-I to those in List-II.

List-I

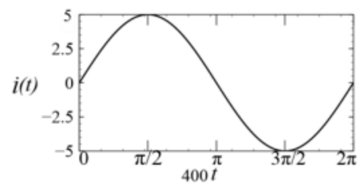
(P) 

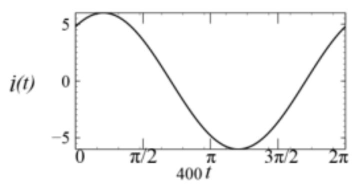
(Q) 

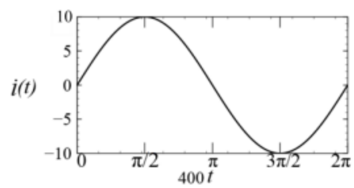
(R) 

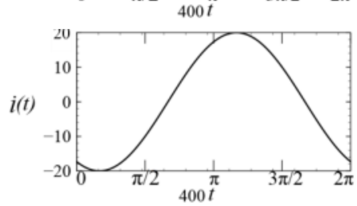
(S) 

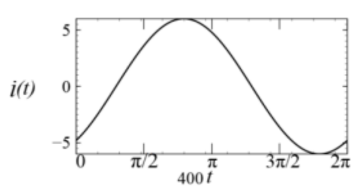
List-II

(1) 

(2) 

(3) 

(4) 

(5) 

Codes :

[: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**

[SOLN] (P) $Z = 30\,\Omega, \phi = 0$

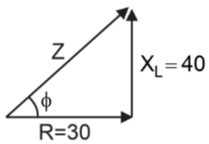
$$i = \frac{V}{Z} = \frac{300\sin(400t)}{30} = 10\sin 400t$$

$\boxed{P \to 3}$

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

$\therefore \quad Z = \sqrt{30^2 + 40^2} = 50\,\Omega$

$$\tan\phi = \frac{4}{3}$$



$$\therefore \quad i = \frac{300}{50}\sin\left(400t\tan^{-1}\frac{4}{3}\right) = 6\sin(400t - 53°)$$

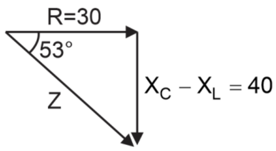
At t = 0

$$i = 6\sin 53° = 6 \times \frac{4}{5} = -4.8\text{ A}$$

$\boxed{Q \to 5}$

(R) $R = 30\,\Omega, X_a = \frac{1}{\omega C} = \frac{1}{400 \times 50 \times 10^{-6}} = 50\,\Omega$

$X_L = \omega L = 400 \times 25 \times 10^{-3} = 10\,\Omega$



$$Z = \sqrt{R^2 + (X_C - X_L)^2}$$
$$= \sqrt{30^2 + (50-10)^2} = 50\,\Omega$$

$i = 6\sin(400t + 53°)$

$\boxed{R \to 2}$

(S) $R = 60\,\Omega, X_C = \frac{1}{\omega C} = \frac{1}{400 \times 50 \times 10^{-6}} = 50\,\Omega$

$X_L = \omega L = 400 \times 125 \times 10^{-3} = 50\,\Omega$

Resonance

$X_L = X_C$

$\therefore \quad Z = 60\,\Omega$

$$I = \frac{V}{Z} = \frac{300}{60} = 5\text{ A}$$

$\phi = 0$

$\boxed{S \to 1}$

[Q.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

Codes :

[: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**

[SOLN] Energy of hydrogen like atom/ions –

$$E = \frac{-2\pi^2 m_e k^2 z^2 e^4}{n^2 h^2}$$

$\therefore \; E \propto Z^2$

$\boxed{P \to 5}$

Energy of characteristic x-ray –

$\nu \propto \sqrt{Z-1}$ for K_α

$\boxed{Q \to 1}$

Energy of a spherical nucleus with Z protons

$$E \approx \frac{3}{5}\frac{KZ(Z-1)e^2}{r}$$

$\boxed{R \to 2}$

$\therefore \; E \propto Z(Z-1)$

Energy of continuous x-ray varies from 0 to some maximum value (cutoff).

E independent of Z

$\boxed{S \to 3, 4}$