JEE–MAIN EXAMINATION – APRIL 2025

(HELD ON MONDAY 07th APRIL 2025) **TIME : 9:00 AM TO 12:00 NOON**

PHYSICS **TEST PAPER WITH SOLUTION**

SECTION-A

26. Two harmonic waves moving in the same direction superimpose to form a wave x = a cos (1.5t) cos (50.5t) where t is in seconds. Find the period with which they beat (close to nearest integer)

(1) 6 s (2) 4 s

(3) 1 s (4) 2 s

Ans. (4)

Sol. The given equation can be written as

$$x = \frac{a}{2}\cos[1.5 + 50.5]t + \frac{a}{2}\cos[50.5 - 1.5]$$

$$x = \frac{a}{2}\cos[52t] + \frac{a}{2}\cos[49t]$$

Here, $2\pi f_1$ & $2\pi f_2 = 49$

$$f_1 = \frac{52}{2\pi},\ f_2 = \frac{49}{2\pi}$$

$$\therefore\ f_{Beat} = f_1 - f_2 = \frac{3}{2\pi}\text{Hz}$$

$$\therefore\ T_{Beat} = \frac{1}{f_{Beat}} = \frac{2\pi}{3}\text{sec}$$

$= 2.09$ sec ≈ 2 sec

27. Two plane polarized light waves combine at a certain point whose electric field components are

$E_1 = E_0 \sin \omega t$

$E_2 = E_0 \sin(\omega t + \frac{\pi}{3})$

Find the amplitude of the resultant wave.

(1) 0.9 E (2) E_0

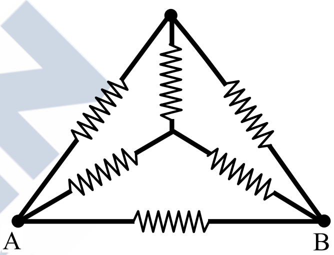
(3) 1.7 E_0 (4) 3.4 E_0

Ans. (3)

Sol. $$E = \sqrt{(E_0)^2 + (E_0)^2 + 2(E_0)(E_0)\cos\frac{\pi}{3}}$$

$$E = \sqrt{2E_0^2 + E_0^2} = \sqrt{3}E_0 = 1.73E_0$$

28. A wire of resistance R is bent into a triangular pyramid as shown in figure with each segment having same length. The resistance between points A and B is R/n. The value of n is :

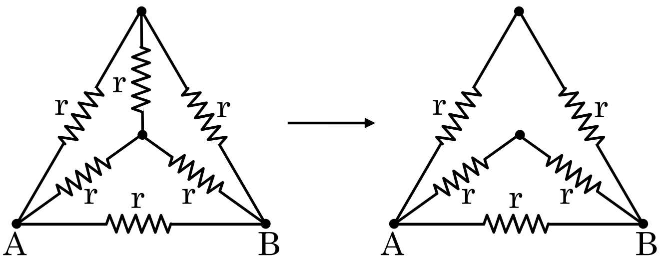


(1) 16 (2) 14

(3) 10 (4) 12

Ans. (4)

Sol. As $r = \frac{R}{6}$



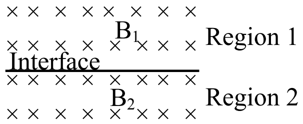
(As balanced wheat stone bridge is formed)

Now, Equivalent resistance between A and B can be written as

$$\frac{1}{R_{AB}} = \frac{1}{2r} + \frac{1}{2r} + \frac{1}{r} = \frac{2}{r}$$

$$R_{AB} = \frac{R}{12}$$

29. Uniform magnetic fields of different strengths (B_1 and B_2), both normal to the plane of the paper exist as shown in the figure. A charged particle of mass m and charge q, at the interface at an instant, moves into the region 2 with velocity v and returns to the interface. It continues to move into region 1 and finally reaches the interface. What is the displacement of the particle during this movement along the interface ?



(Consider the velocity of the particle to be normal to the magnetic field and $B_2 > B_1$)

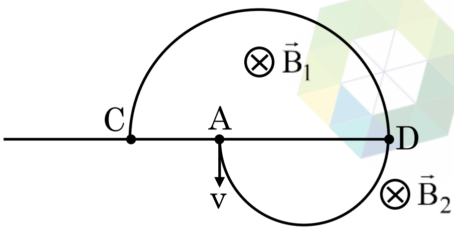
(1) $\frac{mv}{qB_1}\left(1-\frac{B_2}{B_1}\right)\times 2$ (2) $\frac{mv}{qB_1}\left(1-\frac{B_1}{B_2}\right)$

(3) $\frac{mv}{qB_1}\left(1-\frac{B_2}{B_1}\right)$ (4) $\frac{mv}{qB_1}\left(1-\frac{B_1}{B_2}\right)\times 2$

Ans. (4)

Sol. As $\vec{v}$ is $\perp$ to $\vec{B}$, so charge particle will move in circular path, whose radius is given by

$$R = \frac{mv}{qB}$$



Starting point $\rightarrow$ A

Ending point $\rightarrow$ C

$\therefore$ Net displacement = AC

AC = CD – AD

$$AC = \frac{2mv}{qB_1} - \frac{2mv}{qB_2}$$

$$AC = \frac{2mv}{qB_1}\left[1-\frac{B_1}{B_2}\right]$$

30. If $\in_0$ denotes the permittivity of free space and Φ_E is the flux of the electric field through the area bounded by the closed surface, then dimension of $\left(\in_0 \frac{d\phi_E}{dt}\right)$ are that of :

(1) Electric field (2) Electric potential

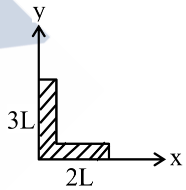
(3) Electric charge (4) Electric current

Ans. (4)

Sol. We know that formula for displacement current is given by

$$i_d = \varepsilon_0 \frac{d\phi_\varepsilon}{dt}$$

31. A rod of length 5 L is bent right angle keeping one side length as 2 L.



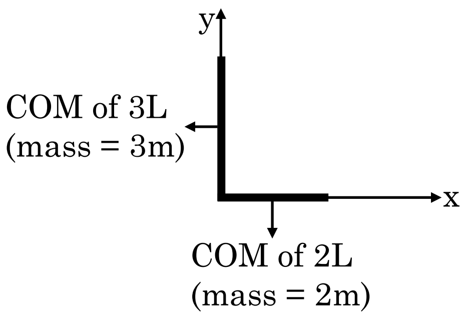
The position of the centre of mass of the system: (Consider L = 10 cm)

(1) $2\hat{i} + 3\hat{j}$ (2) $3\hat{i}+7\hat{j}$

(3) $5\hat{i}+8\hat{j}$ (4) $4\hat{i}+9\hat{j}$

Ans. (4)

Sol.



$$x_{com} = \frac{2m(10)+3m(0)}{5m} = 4cm$$

$$y_{com} = \frac{2m(0)+3m(15)}{5m} = 9cm$$

$$\vec{r}_{com} = 4\hat{i}+9\hat{j}$$

32. The percentage increase in magnetic field (B) when space within a current carrying solenoid is filled with magnesium (magnetic susceptibility $\chi_{mg} = 1.2 \times 10^{-5}$) is :

(1) $\frac{6}{5}\times10^{-3}\%$ (2) $\frac{5}{6}\times10^{-5}\%$

(3) $\frac{5}{6}\times10^{-4}\%$ (4) $\frac{5}{3}\times10^{-5}\%$

Ans. **(1)**

Sol. % change in $B = \frac{B_{new} - B_{old}}{B_{old}} \times 100\%$

$= \frac{\mu ni - \mu_0 ni}{\mu_0 ni} \times 100\% = \frac{(\mu - \mu_0)}{\mu_0} \times 100\%$

$= \frac{(\mu_0\mu_r - \mu_0)}{\mu_0} \times 100\%$

$= (\mu_r - 1) \times 100\%$

$= \chi_n \times 100\%$

$= 1.2 \times 10^{-3}\ \%$

33. A lens having refractive index 1.6 has focal length of 12 cm, when it is in air. Find the focal length of the lens when it is placed in water.
(Take refractive index of water as 1.28)

(1) 355 mm (2) 288 mm

(3) 555 mm (4) 655 mm

Ans. **(2)**

Sol. As we know,

$$\frac{1}{f} = \left[\frac{\mu_L}{\mu_m} - 1\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

For air $\mu_m = 1$

$$\frac{1}{12} = [1.6 - 1]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{12} = \frac{6}{10}\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\left[\frac{1}{R_1} - \frac{1}{R_2}\right] = \frac{10}{72}$$

For water

$$\frac{1}{f} = \left[\frac{1.6}{1.28} - 1\right]\left[\frac{10}{72}\right] = \frac{32}{128} \times \frac{10}{72}$$

$$\frac{1}{f} = \frac{1}{4} \times \frac{10}{72}$$

$f = 28.8$ cm

$f = 288$ mm

34. An ac current is represented as

$$i = 5\sqrt{2} + 10\cos\left(650\pi t + \frac{\pi}{6}\right) \text{Amp}$$

The r.m.s value of the current is

(1) 50 Amp (2) 100 Amp

(3) 10 Amp (4) $5\sqrt{2}$ Amp

Ans. **(3)**

Sol. $i = 5\sqrt{2} + 10\cos\left(650\pi t + \frac{\pi}{6}\right)$

$$i^2 = 50 + 100\cos^2\left(650\pi t + \frac{\pi}{6}\right)$$

$$+ (2)(5\sqrt{2})(10)\cos\left(650\pi t + \frac{\pi}{6}\right)$$

$$< i^2 > = 50 + \frac{100}{2} + 0$$

$< i^2 > = 100$

$< i > = 10$ Amp.

35. Two thin convex lenses of focal lengths 30 cm and 10 cm are placed coaxially, 10 cm apart. The power of this combination is :

(1) 5 D (2) 1 D

(3) 20 D (4) 10 D

Ans. **(4)**

Sol. $f_1 = 30$ cm, $f_2 = 10$ cm

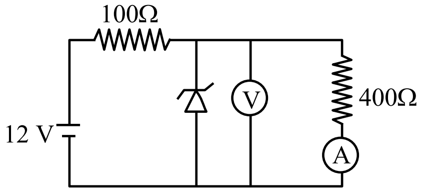
$$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$, d = distance between lens

$$\frac{1}{f_{eq}} = \frac{1}{0.3} + \frac{1}{0.1} - \frac{0.1}{(0.3)(0.1)}$$

$$\frac{1}{f_{eq}} = \frac{1}{0.1}$$

$$\text{Power} = \frac{1}{f_{eq}} = 10\,D$$

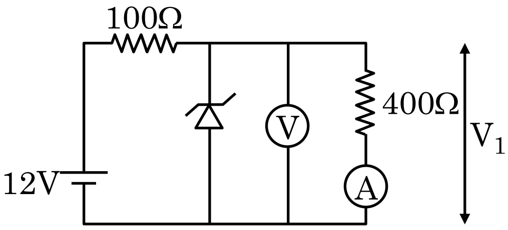
36. In the following circuit, the reading of the ammeter will be (Take Zener breakdown voltage = 4 V)



(1) 24 mA
(2) 80 mA
(3) 10 mA
(4) 60 mA

Ans. **(3)**

Sol.



$$V_1 = \frac{400}{100+400}\times 12V = \frac{4}{5}\times 12 = \frac{48}{5}V$$

here, $V_1 > V_z$, (V_z = Zener Voltage)

So, Zener breakdown will be take place

So, voltage across 400Ω will be 4V

$$I = \frac{4}{400}A = \frac{1}{100A} = 10mA$$

37. Two projectiles are fired from ground with same initial speeds from same point at angles (45° + α) and (45° – α) with horizontal direction. The ratio of their times of flights is

(1) 1
(2) $\frac{1-\tan\alpha}{1+\tan\alpha}$
(3) $\frac{1+\sin 2\alpha}{1-\sin 2\alpha}$
(4) $\frac{1+\tan\alpha}{1-\tan\alpha}$

Ans. **(4)**

Sol. $\theta_1 = 45+\alpha$; $\theta_2 = 45-\alpha$

Time of flight, $T = \frac{2v\sin\theta}{g}$

$$\frac{T_1}{T_2} = \frac{\sin(45+\alpha)}{\sin(45-\alpha)}$$

$$\frac{T_1}{T_2} = \frac{\frac{1}{\sqrt{2}}\cos\alpha + \frac{1}{\sqrt{2}}\sin\alpha}{\frac{1}{\sqrt{2}}\cos\alpha - \frac{1}{\sqrt{2}}\sin\alpha}$$

$$\frac{T_1}{T_2} = \frac{\cos\alpha+\sin\alpha}{\cos\alpha-\sin\alpha} = \frac{1+\tan\alpha}{1-\tan\alpha}$$

38. Match the **List-I** with **List-II**

List-I		List-II	
A.	Triatomic rigid gas	I.	$\frac{C_P}{C_V} = \frac{5}{3}$
B.	Diatomic non-rigid gas	II.	$\frac{C_P}{C_V} = \frac{7}{5}$
C.	Monoatomic gas	III.	$\frac{C_P}{C_V} = \frac{4}{3}$
D.	Diatomic rigid gas	IV	$\frac{C_P}{C_V} = \frac{9}{7}$

Choose the **correct** answer from the options given below :

(1) A-III, B-IV, C-I, D-II
(2) A-III, B-II, C-IV, D-I
(3) A-II, B-IV, C-I, D-III
(4) A-IV, B-II, C-III, D-I

Ans. **(1)**

Sol. $\gamma = 1+\frac{2}{f}$

f = 6, Triatomic rigid gas

f = 7, Diatomic non-rigid gas

f = 5, Diatomic rigid gas

f = 3, monoatomic rigid gas

$\gamma = 1+\frac{2}{6} = \frac{4}{3}$ (Triatomic)

$\gamma = 1+\frac{2}{7} = \frac{9}{7}$ (Diatomic, non-rigid)

$\gamma = 1+\frac{2}{5} = \frac{7}{5}$ (Diatomic, rigid)

$\gamma = 1+\frac{2}{3} = \frac{5}{3}$ (Monoatomic, rigid)

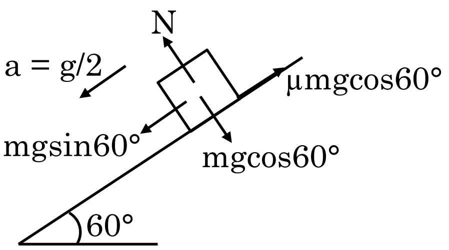
A-III, B-IV, C-I, D-II

39. A cubic block of mass m is sliding down on an inclined plane at 60° with an acceleration of $\frac{g}{2}$, the value of coefficient of kinetic friction is

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

Ans. **(1)**

Sol.



$$mg\sin 60° - \mu mg\cos 60° = ma$$

$$g\sin 60 - \mu g\cos 60 = \frac{g}{2}$$

$$\frac{\sqrt{3}}{2} - \frac{\mu}{2} = \frac{1}{2}$$

$$\mu = \sqrt{3}-1$$

40. In a hydrogen like ion, the energy difference between the 2nd excitation energy state and ground is 108.8 eV. The atomic number of the ion is

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

Allen Ans. (4)
NTA Ans. (2)

Sol. $$\Delta E = 13.6z^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$$

$$(13.6)z^2\left[\frac{1}{1}-\frac{1}{9}\right] = 108.8$$

$$\frac{(13.6)(8)}{9}(z^2) = 108.8$$

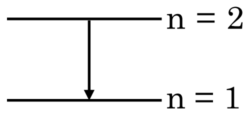
$$z = 3$$

41. For a hydrogen atom, the ratio of the largest wavelength of Lyman series to that of the Balmer series is.

(1) 5 : 36 (2) 5 : 27
(3) 3 : 4 (4) 27 : 5

Ans. **(2)**

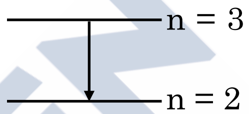
Sol. **Lyman**



$$\frac{1}{\lambda_1} = R\left[\frac{1}{1}-\frac{1}{4}\right] = \frac{3R}{4}$$

$$\lambda_1 = \frac{4}{3R} \quad ...(1)$$

and **Balmer**

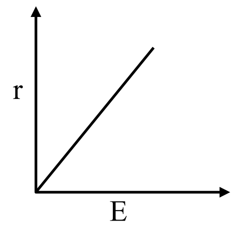


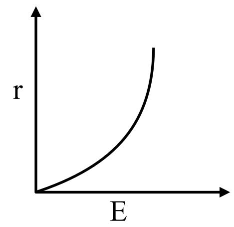
$$\frac{1}{\lambda_2} = R\left[\frac{1}{4}-\frac{1}{9}\right] = \frac{5R}{36}$$

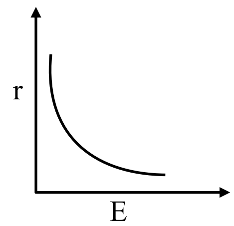
$$\lambda_2 = \frac{36}{5R}$$

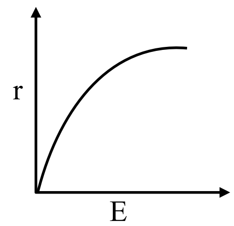
Then, $\frac{\lambda_1}{\lambda_2} = \frac{5}{27}$

42. A particle of charge q, mass m and kinetic energy E enters in magnetic field perpendicular to its velocity and undergoes a circular arc of radius(r). Which of the following curves represents the variation of r with E?

(1)


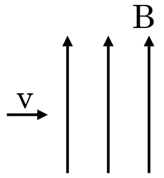
(2)


(3)


(4)


Ans. **(4)**

Sol.



$$\frac{mv^2}{r} = qvB$$

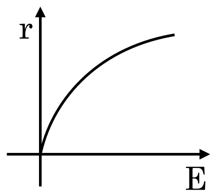
$mv = qBr$

$$E = \frac{1}{2}mv^2$$

$$E = \frac{1}{2}m\left(\frac{q^2B^2r^2}{m^2}\right) = \frac{q^2B^2r^2}{2m}$$

$$E = \left(\frac{q^2B^2}{2m}\right)r^2$$

$r^2 \propto E$



43. An object of mass 1000 g experiences a time dependent force $\vec{F} = \left(2t\hat{i} + 3t^2\hat{j}\right)N$. The power generated by the force at time t is :

(1) $(2t^2 + 3t^3)$ W
(2) $(2t^2 + 18t^3)$ W
(3) $(3t^3 + 5t^5)$ W
(4) $(2t^3 + 3t^5)$ W

Ans. **(4)**

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

$m = 1000$ gm $= 1$ kg

$\vec{F} = m\vec{a}$, $\vec{a} = 2t\hat{i} + 3t^2\hat{j}$

$$\frac{d\vec{v}}{dt} = 2t\hat{i} + 3t^2\hat{j}$$

$\vec{v} = t^2\hat{i} + t^3\hat{j}$

Power, $P = \vec{F} \cdot \vec{v}$

$P = (2t\hat{i} + 3t^2\hat{j}) \cdot (t^2\hat{i} + t^3\hat{j})$

$P = (2t^3 + 3t^5)W$

44. Two wires A and B are made of same material having ratio of lengths $\frac{L_A}{L_B} = \frac{1}{3}$ and their diameters ratio $\frac{d_A}{d_B} = 2$. If both the wires are stretched using same force, what would be the ratio of their respective elongations?

(1) 1 : 6
(2) 1 : 12
(3) 3 : 4
(4) 1 : 3

Ans. **(2)**

Sol. $\frac{L_A}{L_B} = \frac{1}{3}$ and $\frac{d_A}{d_B} = 2$

$$\Delta L_A = \frac{F_A L_A}{A_A Y_A} \text{ and } \Delta L_B = \frac{F_B L_B}{A_B Y_B}$$

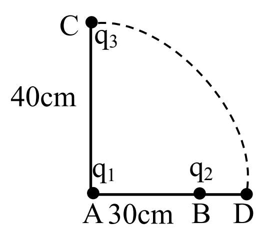
Given, $F_A = F_B$ and $Y_A = Y_B$

$$\frac{\Delta L_A}{\Delta L_B} = \frac{\frac{F_A L_A}{A_A Y_A}}{\frac{F_B L_B}{A_B Y_B}} = \left(\frac{L_A}{L_B}\right)\left(\frac{A_B}{A_A}\right)$$

$$\frac{\Delta L_A}{\Delta L_B} = \left(\frac{L_A}{L_B}\right)\left(\frac{\frac{\pi}{4}d_B^2}{\frac{\pi}{4}d_A^2}\right) = \left(\frac{L_A}{L_B}\right)\left(\frac{d_B}{d_A}\right)^2$$

$$\frac{\Delta L_A}{\Delta L_B} = \left(\frac{1}{3}\right)\left(\frac{1}{2}\right)^2 = \frac{1}{12}$$

45. Two charges q_1 and q_2 are separated by a distance of 30 cm. A third charge q_3 initially at 'C' as shown in the figure, is moved along the circular path of radius 40 cm from C to D. If the difference in potential energy due to movement of q_3 from C to D is given by $\frac{q_3K}{4\pi\epsilon_0}$, the value of K is :



(1) $8q_2$
(2) $6q_2$
(3) $8q_1$
(4) $6q_1$

Ans. **(1)**

Sol. Potential at C

$$V_C = \frac{kq_1}{0.4} + \frac{kq_2}{0.5}$$

Potential at D

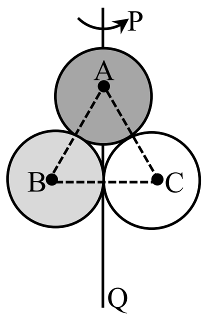
$$V_D = \frac{kq_1}{0.4} + \frac{kq_2}{0.1}$$

$$\Delta U = (V_D - V_C)(q_3) = \left(\frac{kq_2}{0.1} - \frac{kq_2}{0.5}\right)(q_3)$$

$$\Delta U = 8kq_2q_3 = \frac{8q_2q_3}{4\pi\varepsilon_0}$$

SECTION-B

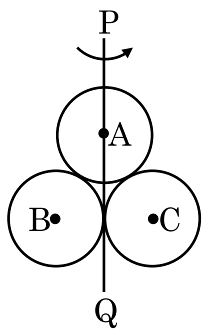
46. A,B and C are disc, solid sphere and spherical shell respectively with same radii and masses. These masses are placed as shown in figure.



The moment of inertia of the given system about PQ is $\frac{x}{15}I$, where I is the moment of inertia of the disc about its diameter. The value of x is_____.

Ans. **(199)**

Sol.



All bodies have same mass and same radius.

$A \rightarrow$ Disc

$B \rightarrow$ Solid sphere

$C \rightarrow$ Spherical shell

and, $I = \frac{MR^2}{4}$

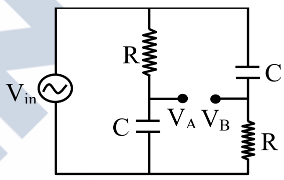
$$I_{PQ} = \frac{MR^2}{4} + \left(\frac{2}{5}MR^2 + MR^2\right) + \left(\frac{2}{3}MR^2 + MR^2\right)$$

$$I_{PQ} = \frac{15MR^2 + 24MR^2 + 60MR^2 + 40MR^2 + 60MR^2}{60}$$

$$I_{PQ} = \frac{199}{60}MR^2 = \frac{199}{15}\left(\frac{MR^2}{4}\right)$$

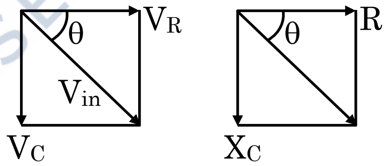
$$= \frac{199}{15}I$$

47. For ac circuit shown in figure, R = 100 kΩ and C = 100 pF and the phase difference between V_{in} and $(V_B - V_A)$ is 90°. The input signal frequency is 10^x rad/sec, where 'x' is _____

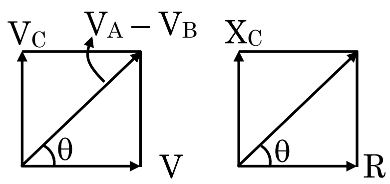


Ans. **(5)**

Sol. Input voltage



$V_A - V_B$:



$\theta + \theta = 90°$; $\theta = 45°$

$$\tan\theta = \frac{X_C}{R}$$

$$X_C = R \Rightarrow \frac{1}{W_C} = R$$

$$W = \frac{1}{R_C} = \frac{1}{100\times10^3\times100\times10^{-12}}$$

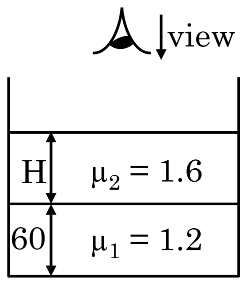
$$= \frac{10^{12}}{10^7} = 10^5$$

48. A container contains a liquid with refractive index of 1.2 up to a height of 60 cm and another liquid having refractive index 1.6 is added to height H above first liquid. If viewed from above, the apparent shift in the position of bottom of container is 40 cm. The value of H is___cm.

(Consider liquids are immisible)

Ans. (80)

Sol.



y = apparent depth of bottom

$$\frac{y}{1} = \frac{H}{1.6} + \frac{60}{1.2}$$

Shift = 40

$H + 60 - y = 40$

$$H + 60 - \frac{H}{1.6} - \frac{60}{1.2} = 40$$

$$\frac{6}{16}H = 30$$

H = 80 cm

49. A wire of length 10 cm and diameter 0.5 mm is used in a bulb. The temperature of the wire is 1727°C and power radiated by the wire is 94.2 W. Its emissivity is $\frac{x}{8}$ where x =_____

(Given $\sigma = 6.0 \times 10^{-8}$ W m^{-2} K^{-4}, $\pi = 3.14$ and assume that the emissivity of wire material is same at all wavelength.)

Ans. (5)

Sol. L = 10 cm, d = 0.5 mm, T = 1727°C = 2000 K

Power, P = 94.2 W

$P = \varepsilon\sigma AT^4$

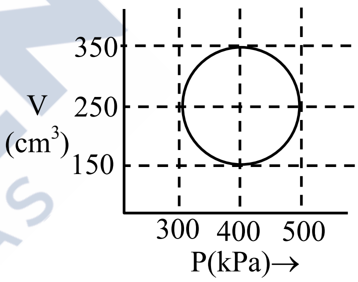
$94.2 = \varepsilon \times (6 \times 10^{-8})(\pi dL)(2000)^4$

$94.2 = \varepsilon \times (6 \times 10^{-8})\,(3.14)\,(0.5)\,(10^{-3})$
$(10 \times 10^{-2})(2000)^4$

$$\varepsilon = \frac{94.2}{(94.2)(16)} = \frac{5}{8}$$

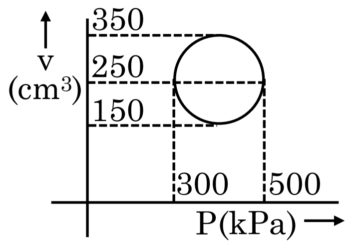
50. An ideal gas has undergone through the cyclic process as shown in the figure. Work done by the gas in the entire cycle is_____ $\times 10^{-1}$ J.

(Take $\pi = 3.14$)



Ans. (314)

Sol.



Area of circle, $W = \frac{\pi}{4}d_1d_2$

$$W = \frac{\pi}{4}(500-300)\times10^{3}(350-150)\times10^{-6}$$

W = 31.4 Joule

$W = 314 \times 10^{-1}$ Joule