

JEE-MAIN EXAMINATION – APRIL 2025

(HELD ON TUESDAY 08th APRIL 2025)

TIME : 3:00 PM TO 6:00 PM

PHYSICS

TEST PAPER WITH SOLUTION

SECTION-A

- 26.** Given below are two statements : one is labelled as **Assertion A** and the other is labelled as **Reason R**
Assertion A : Work done in moving a test charge between two points inside a uniformly charged spherical shell is zero, no matter which path is chosen.

Reason R : Electrostatic potential inside a uniformly charged spherical shell is constant and is same as that on the surface of the shell.

In the light of the above statements, choose the **correct** answer from the options given below

- (1) A is true but R is false
- (2) Both A and R are true and R is the correct explanation of A
- (3) A is false but R is true
- (4) Both A and R are true but R is NOT the correct explanation of A

Ans. (2)

Sol. Conceptual

- 27.** A rod of linear mass density ' λ ' and length 'L' is bent to form a ring of radius 'R'. Moment of inertia of ring about any of its diameter is :

- (1) $\frac{\lambda L^3}{16\pi^2}$
- (2) $\frac{\lambda L^3}{12}$
- (3) $\frac{\lambda L^3}{4\pi^2}$
- (4) $\frac{\lambda L^3}{8\pi^2}$

Ans. (4)

Sol. $L = 2\pi R$

$$I = \frac{MR^2}{2} = \frac{\lambda \times L}{2} \times \left(\frac{L}{2\pi} \right)^2 = \frac{\lambda L^3}{8\pi^2}$$

- 28.** A 3 m long wire of radius 3 mm shows an extension of 0.1 mm when loaded vertically by a mass of 50 kg in an experiment to determine Young's modulus. The value of Young's modulus of the wire as per this experiment is $P \times 10^{11} \text{ Nm}^{-2}$, where the value of P is : (Take $g = 3\pi \text{ m/s}^2$)

- (1) 5
- (2) 10
- (3) 25
- (4) 2.5

Ans. (1)

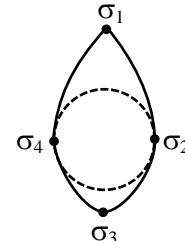
Sol.
$$\frac{50g}{\pi r^2} = y \cdot \frac{\Delta\ell}{\ell}$$

$$\frac{50 \times 3\pi}{\pi \times (3 \times 10^{-3})^2} = P \times 10^{11} \times \frac{0.1 \times 10^{-3}}{3}$$

$$\Rightarrow P = \frac{50 \times 3 \times 3}{3^2 \times 10^{-6} \times 10^{11} \times 0.1 \times 10^{-3}}$$

$$P = 5$$

- 29.** Electric charge is transferred to an irregular metallic disk as shown in figure. If σ_1 , σ_2 , σ_3 and σ_4 are charge densities at given points then, choose the correct answer from the options given below:



- (A) $\sigma_1 > \sigma_3 ; \sigma_2 = \sigma_4$
- (B) $\sigma_1 > \sigma_2 ; \sigma_3 > \sigma_4$
- (C) $\sigma_1 > \sigma_3 > \sigma_2 = \sigma_4$
- (D) $\sigma_1 < \sigma_3 < \sigma_2 = \sigma_4$
- (E) $\sigma_1 = \sigma_2 = \sigma_3 = \sigma_4$
- (1) A, B and C Only
- (2) A and C Only
- (3) D and E Only
- (4) B and C Only

Ans. (1)

Sol.
$$\sigma \propto \frac{1}{ROC}$$

$$(ROC)_1 < (ROC)_3 < (ROC)_2 = (ROC)_4$$

$$\sigma_1 > \sigma_3 > \sigma_2 = \sigma_4$$



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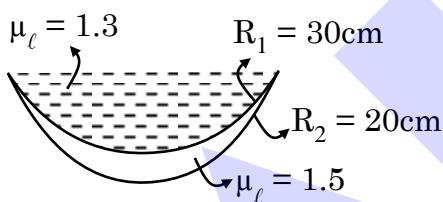
Ans. (4)

Sol. $mgh = ms\Delta T$

$$\Delta T = \frac{gh}{s} = \frac{10 \times 200}{4200} K = \frac{10}{21} K$$

Ans. (4)

Sol.



$$\begin{aligned}
 \frac{1}{f} &= \left(\frac{1.3 - 1}{1} \right) \left(\frac{1}{\infty} - \frac{1}{-30} \right) \\
 &= \left(\frac{1.5 - 1}{1} \right) \left(\frac{1}{-30} - \frac{1}{-30} \right) \\
 &= \frac{0.3}{30} + \frac{0.5}{60} = \frac{1}{100} + \frac{1}{120} \\
 &= \frac{6+5}{600} = \frac{11}{600} \\
 f &= \frac{600}{11} \text{ cm}
 \end{aligned}$$

32. An infinitely long wire has uniform linear charge density $\lambda = 2 \text{ nC/m}$. The net flux through a Gaussian cube of side length $\sqrt{3} \text{ cm}$, if the wire passes through any two corners of the cube, that are maximally displaced from each other, would be $x \text{ Nm}^2\text{C}^{-1}$, where x is :

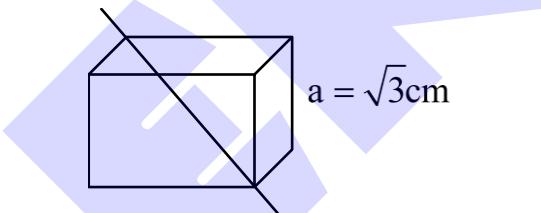
[Neglect any edge effects and use $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$

[SI units]

- (1) 0.72π (2) 1.44π
 (3) 6.48π (4) 2.16π

Ans. (4)

Sol.

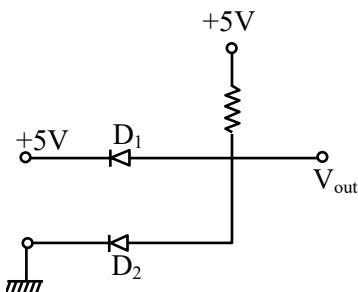


$$\phi = \frac{q_{enc}}{\epsilon_0} = \frac{\lambda \cdot \sqrt{3}a}{\epsilon_0}$$

$$= 2 \times 10^{-9} \times \sqrt{3} \times \sqrt{3} \times 10^{-2} \times 36\pi \times 10^9 \text{ Nm}^2\text{C}^{-1}$$

$$= 2.16\pi \text{ Nm}^2\text{C}^{-1}$$

33. The output voltage in the following circuit is
(Consider ideal diode case)



Ans. (2)



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Sol. Here D_1 is reverse biased and D_2 is forward biased. Therefore current flow through D_Q and 5V drop on resistor.

$$\text{So, } V_{\text{out}} = 0$$

- 34.** Two metal spheres of radius R and $3R$ have same surface charge density σ . If they are brought in contact and then separated, the surface charge density on smaller and bigger sphere becomes σ_1 and σ_2 , respectively. The ratio $\frac{\sigma_1}{\sigma_2}$ is.

$$(1) \frac{1}{9} \quad (2) 9$$

$$(3) \frac{1}{3} \quad (4) 3$$

Ans. (4)

Sol. For conducting sphere, $V = \frac{\sigma r}{\epsilon_0}$

$$\text{After contact, } V_1 = V_2$$

$$\sigma_1 r_1 = \sigma_2 r_2$$

$$\frac{\sigma_1}{\sigma_2} = \frac{r_2}{r_1}$$

$$\frac{\sigma_1}{\sigma_2} = 3$$

- 35.** A quantity Q is formulated as $X^{-2}Y^{\frac{3}{2}}Z^{-\frac{2}{5}}$. X , Y and Z are independent parameters which have fractional errors of 0.1, 0.2 and 0.5, respectively in measurement. The maximum fractional error of Q is

$$(1) 0.1 \quad (2) 0.8 \\ (3) 0.7 \quad (4) 0.6$$

Ans. (3)

$$\begin{aligned} \text{Sol. Fractional error} &= 2 \frac{\Delta X}{X} + \frac{3}{2} \frac{\Delta Y}{Y} + \frac{2}{5} \frac{\Delta Z}{Z} \\ &= 2(0.1) + \frac{3}{2}(0.2) + \frac{2}{5}(0.5) \\ &= 0.2 + 0.3 + 0.2 = 0.7 \end{aligned}$$

- 36.** A monoatomic gas having $\gamma = \frac{5}{3}$ is stored in a thermally insulated container and the gas is suddenly compressed to $\left(\frac{1}{8}\right)^{\text{th}}$ of its initial volume.

The ratio of final pressure and initial pressure is: (γ is the ratio of specific heats of the gas at constant pressure and at constant volume)

$$(1) 16 \quad (2) 40 \\ (3) 32 \quad (4) 28$$

Ans. (3)

$$\text{Sol. } P_i V_i^\gamma = P_f V_f^\gamma$$

$$\frac{P_f}{P_i} = \left(\frac{V_i}{V_f} \right)^\gamma = (8)^{5/3}$$

$$\frac{P_f}{P_i} = 32$$

- 37.** A convex lens of focal length 30 cm is placed in contact with a concave lens of focal length 20 cm. An object is placed at 20 cm to the left of this lens system. The distance of the image from the lens in cm is _____

$$(1) 30 \quad (2) 45 \\ (3) \frac{60}{7} \quad (4) 15$$

Ans. (4)

Sol. Equivalent focal length

$$\begin{aligned} \frac{1}{f} &= \frac{1}{f_1} + \frac{1}{f_2} \\ &= \frac{1}{30} + \frac{1}{-20} = \frac{2-3}{60} = -\frac{1}{60} \end{aligned}$$

$$f = -60 \text{ cm}$$

Lens formula

$$\begin{aligned} \frac{1}{v} - \frac{1}{u} &= \frac{1}{f} \\ \frac{1}{v} - \frac{1}{-20} &= \frac{1}{-60} \\ v &= -15 \text{ cm} \end{aligned}$$



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38. Two strings with circular cross section and made of same material, are stretched to have same amount of tension. A transverse wave is then made to pass through both the strings. The velocity of the wave in the first string having the radius of cross section R is v_1 , and that in the other string having radius of cross section $R/2$ is v_2 . Then $\frac{v_2}{v_1} =$

(1) $\sqrt{2}$

(2) 2

(3) 8

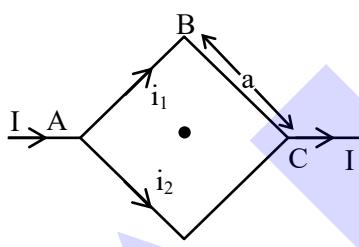
(4) 4

Ans. (2)

$$\text{Sol. } v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{T}{f\pi R^2}}$$

$$\frac{v_2}{v_1} = \frac{R_1}{R_2} = 2$$

39. Figure shows a current carrying square loop ABCD of edge length is 'a' lying in a plane. If the resistance of the ABC part is r and that of ADC part is $2r$, then the magnitude of the resultant magnetic field at centre of the square loop is

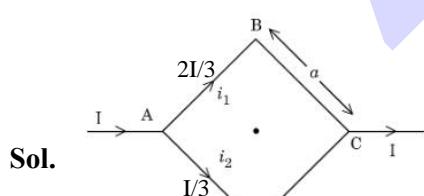


$$(1) \frac{3\pi\mu_0 I}{\sqrt{2}a}$$

$$(3) \frac{\sqrt{2}\mu_0 I}{3\pi a}$$

$$(2) \frac{\mu_0 I}{2\pi a}$$

$$(4) \frac{2\mu_0 I}{3\pi a}$$

Ans. (3)

$$\vec{B} = \vec{B}_{AB} + \vec{B}_{BC} + \vec{B}_{CD} + \vec{B}_{DA}$$

$$\vec{B} = \left[\frac{-\mu_0(2I/3)}{4\pi(a/2)} \sqrt{2} - \frac{\mu_0(2I/3)}{4\pi(a/2)} \sqrt{2} \right] \hat{k}$$

$$+ \frac{\mu_0(I/3)}{4\pi(a/2)} \sqrt{2} + \frac{\mu_0(I/3)}{4\pi(a/2)} \sqrt{2} \right] \hat{k}$$

$$\vec{B} = \left[\frac{-2\sqrt{2}\mu_0 I}{3\pi a} + \frac{\sqrt{2}\mu_0 I}{3\pi a} \right] \hat{k}$$

$$\vec{B} = \frac{-\sqrt{2}\mu_0 I}{3\pi a} \hat{k}$$

40. A body of mass 2 kg moving with velocity of $\vec{v}_{in} = 3\hat{i} + 4\hat{j} \text{ ms}^{-1}$ enters into a constant force field of 6N directed along positive z-axis. If the body remains in the field for a period of $\frac{5}{3}$ seconds, then velocity of the body when it emerges from force field is

$$(1) 4\hat{i} + 3\hat{j} + 5\hat{k}$$

$$(2) 3\hat{i} + 4\hat{j} + 5\hat{k}$$

$$(3) 3\hat{i} + 4\hat{j} - 5\hat{k}$$

$$(4) 3\hat{i} + 4\hat{j} + \sqrt{5}\hat{k}$$

Ans. (2)

$$\text{Sol. } \vec{a} = \frac{\vec{F}}{m} = \frac{6\hat{k}}{2} = 3\hat{k}, t = \frac{5}{3} \text{ s}$$

$$\vec{u} = 3\hat{i} + 4\hat{j}$$

$$\vec{v} = \vec{u} + \vec{a}t = 3\hat{i} + 4\hat{j} + 5\hat{k}$$

41. Two balls with same mass and initial velocity, are projected at different angles in such a way that maximum height reached by first ball is 8 times higher than that of the second ball. T_1 and T_2 are the total flying times of first and second ball, respectively, then the ratio of T_1 and T_2 is :

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

$$(2) 2 : 1$$

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

$$(4) 4 : 1$$

Ans. (1)

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Sol. Given, $(H_{\max})_1 = 8 \times (H_{\max})_2$

$$\frac{u^2 \sin^2 \theta_1}{2g} = 8 \times \frac{u^2 \sin^2 \theta_2}{2g}$$

$$\Rightarrow \sin \theta_1 = 2\sqrt{2} \sin \theta_2$$

$$\frac{T_1}{T_2} = \frac{2u \sin \theta_1 / g}{2u \sin \theta_2 / g} = \frac{\sin \theta_1}{\sin \theta_2} = 2\sqrt{2}$$

- 42.** The amplitude and phase of a wave that is formed by the superposition of two harmonic travelling waves, $y_1(x, t) = 4 \sin(kx - \omega t)$ and

$$y_2(x, t) = 2 \sin(kx - \omega t + \frac{2\pi}{3}), \text{ are :}$$

(Take the angular frequency of initial waves same as ω)

(1) $\left[6, \frac{2\pi}{3} \right]$

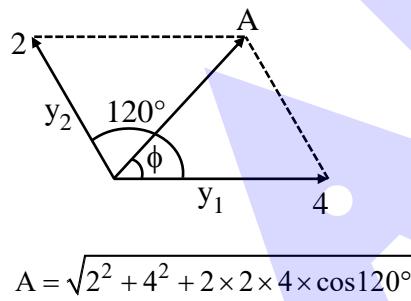
(2) $\left[6, \frac{\pi}{3} \right]$

(3) $\left[\sqrt{3}, \frac{\pi}{6} \right]$

(4) $\left[2\sqrt{3}, \frac{\pi}{6} \right]$

Ans. (4)

Sol.



$$A = \sqrt{2^2 + 4^2 + 2 \times 2 \times 4 \times \cos 120^\circ}$$

$$= \sqrt{12} = 2\sqrt{3}$$

$$\tan \phi = \frac{2 \sin 120^\circ}{4 + 2 \cos 120^\circ} = \frac{\sqrt{3}}{3} = \frac{1}{\sqrt{3}}$$

$$\phi = \frac{\pi}{6}$$

- 43.** In a Young's double slit experiment, the source is white light. One of the slits is covered by red filter and another by a green filter. In this case

- (1) There shall be an interference pattern for red distinct from that for green.
- (2) There shall be no interference fringes.
- (3) There shall be alternate interference fringes of red and green.
- (4) There shall be an interference pattern, where each fringe's pattern center is green and outer edges is red.

Ans. (2)

Sol. Different colours will have different fringe width. Within a few fringes of red, there will be several fringes of violet. Also, there will be overlapping of colours.

- 44.** For a nucleus of mass number A and radius R, the mass density of nucleus can be represented as

(1) A^3

(2) $A^{\frac{1}{3}}$

(3) $A^{\frac{2}{3}}$

(4) Independent of A

Ans. (4)

Sol. Conceptual

- 45.** A block of mass 2 kg is attached to one end of a massless spring whose other end is fixed at a wall. The spring-mass system moves on a frictionless horizontal table. The spring's natural length is 2 m and spring constant is 200 N/m. The block is pushed such that the length of the spring becomes 1 m and then released. At distance x m ($x < 2$) from the wall, the speed of the block will be :
- (1) $10[1-(2-x)]^{3/2}$ m/s
 - (2) $10[1-(2-x)^2]^{1/2}$ m/s
 - (3) $10[1-(2-x)^2]$ m/s
 - (4) $10[1-(2-x)^2]^2$ m/s

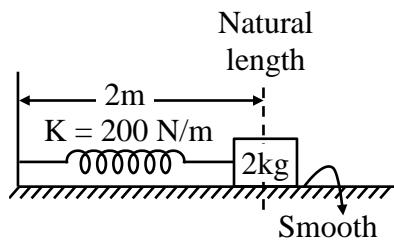
Ans. (2)



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Sol.



Given, Natural length of spring = 2m

Initial compression in spring (x_i) = 1m

Final compression in spring (x_f) = $(2 - x)$ m

Using energy conservation

$$K_i + U_i = K_f + U_f$$

$$0 + \frac{1}{2}Kx_i^2 = \frac{1}{2}mv^2 + \frac{1}{2}Kx_f^2$$

$$\frac{1}{2}mv^2 = \frac{1}{2}K(x_i^2 - x_f^2)$$

$$\frac{1}{2} \times 2 \times v^2 = \frac{1}{2} \times 200 \times (1^2 - (2 - x)^2)$$

$$v^2 = 100[1 - (2 - x)^2]$$

$$v = 10[1 - (2 - x)^2]^{1/2}$$

SECTION-B

46. An electron is released from rest near an infinite non-conducting sheet of uniform charge density ' $-\sigma$ '. The rate of change of de-Broglie wave length associated with the electron varies inversely as n^{th} power of time. The numerical value of n is _____.
Ans. (2)

Sol. Let the momentum of e^- at any time t is p and its de-broglie wavelength is λ .

$$\text{Then, } p = \frac{h}{\lambda}$$

$$\frac{dp}{dt} = \frac{-h}{\lambda^2} \frac{d\lambda}{dt}$$

$$ma = F = -\frac{h}{\lambda} \frac{d\lambda}{dt} \quad [m = \text{mass of } e^-]$$

Where, $-ve$ sign represents decrease in λ with time

$$ma = \frac{-h}{(h/p)^2} \frac{d\lambda}{dt}$$

$$a = -\frac{p^2}{mh} \frac{d\lambda}{dt}$$

$$a = -\frac{mv^2}{h} \frac{d\lambda}{dt}$$

$$\frac{d\lambda}{dt} = -\frac{ah}{mv^2} \quad \dots(1)$$

$$\text{here, } a = \frac{qE}{m} = \frac{e}{m} \frac{\sigma}{2\varepsilon_0}$$

$$a = \frac{\sigma e}{2m\varepsilon_0}$$

$$\text{and } v = u + at$$

$$v = at$$

Substituting values of a & v in equation (1)

$$\frac{d\lambda}{dt} = -\frac{2h\varepsilon_0}{\sigma et^2}$$

$$\Rightarrow \frac{d\lambda}{dt} \propto \frac{1}{t^2}$$

$$\Rightarrow n = 2$$

47. A sample of a liquid is kept at 1 atm. It is compressed to 5 atm which leads to change of volume of 0.8 cm^3 . If the bulk modulus of the liquid is 2 GPa , the initial volume of the liquid was _____ litre. (Take $1 \text{ atm} = 10^5 \text{ Pa}$)

Ans. (4)

Sol. Given, Initial pressure of liquid (P_i) = 1 atm

Final pressure of liquid (P_f) = 5 atm

Change in pressure (dP) = $P_f - P_i = 4 \text{ atm}$

$$= 4 \times 10^5 \text{ Pa}$$

Change in volume (dV) = -0.8 cm^3

Bulk modulus (B) = $2 \times 10^9 \text{ Pa}$

$$\text{Now, } B = \frac{-dP}{(dV/V)} \Rightarrow V = -B \left(\frac{dV}{dP} \right)$$

$$\Rightarrow V = -2 \times 10^9 \times \frac{(-0.8 \times 10^{-6})}{4 \times 10^5}$$

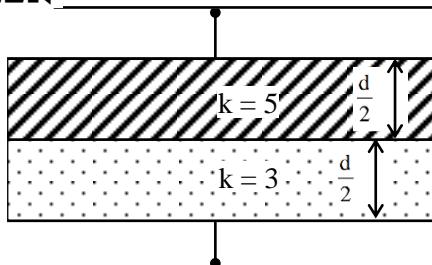
$$= 4 \times 10^{-3} \text{ m}^3 = 4 \text{ litre}$$



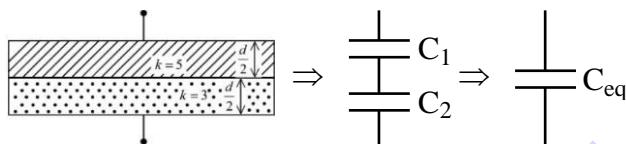
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48.



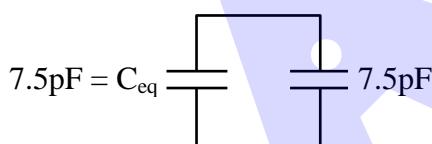
Space between the plates of a parallel plate capacitor of plate area 4 cm^2 and separation of (d) 1.77 mm, is filled with uniform dielectric materials with dielectric constants (3 and 5) as shown in figure. Another capacitor of capacitance 7.5 pF is connected in parallel with it. The effective capacitance of this combination is ____ pF.
(Given $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$)

Ans. (15)**Sol.**

$$C_1 = \frac{5 \times 4 \times 10^{-4} \times 8.85 \times 10^{-12}}{\frac{1.77}{2} \times 10^{-3}} = 20 \text{ pF}$$

$$C_2 = \frac{3 \times 4 \times 10^{-4} \times 8.85 \times 10^{-12}}{\frac{1.77}{2} \times 10^{-3}} = 12 \text{ pF}$$

$$C_{\text{eq}} = \frac{C_1 C_2}{C_1 + C_2} = \frac{12 \times 20}{12 + 20} = 7.5 \text{ pF}$$



Finally equivalent capacitance

$$(C_{\text{eq}})_{\text{final}} = 7.5 + 7.5 = 15 \text{ pF}$$

49. A thin solid disk of 1 kg is rotating along its diameter axis at the speed of 1800 rpm. By applying an external torque of $25\pi \text{ Nm}$ for 40s, the speed increases to 2100 rpm. The diameter of the disk is ____ m.

Ans. (40)**Sol.** Given, $m = 1 \text{ kg}$

$$\omega_i = 1800 \text{ rpm} = 1800 \times \frac{2\pi}{60} = 60\pi \frac{\text{rad}}{\text{sec}}$$

$$\omega_f = 2100 \text{ rpm} = 2100 \times \frac{2\pi}{60} = 70\pi \frac{\text{rad}}{\text{sec}}$$

$$\tau_{\text{ext}} = 25\pi \text{ Nm}$$

$$t = 40 \text{ sec}$$

Using equation of motion

$$\omega_f = \omega_i + \alpha t$$

$$70\pi = 60\pi + \alpha(40)$$

$$\alpha = \frac{\pi}{4} \text{ rad/sec}^2$$

$$\text{Also, } \tau = I\alpha$$

$$\tau = \frac{mR^2}{4}\alpha$$

$$25\pi = \frac{1 \times R^2}{4} \times \frac{\pi}{4}$$

$$R = 20 \text{ m}$$

Hence, diameter of disk = $2R = 2 \times 20 = 40 \text{ m}$

50. A cube having a side of 10 cm with unknown mass and 200 gm mass were hung at two ends of an uniform rigid rod of 27 cm long. The rod along with masses was placed on a wedge keeping the distance between wedge point and 200 gm weight as 25 cm. Initially the masses were not at balance. A beaker is placed beneath the unknown mass and water is added slowly to it. At given point the masses were in balance and half volume of the unknown mass was inside the water.

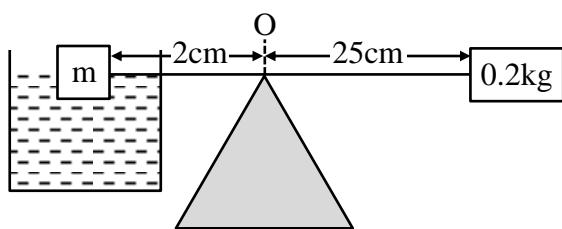
(Take the density of unknown mass is more than that of the water, the mass did not absorb water and water density is 1 gm/cm^3 .) The unknown mass is ____ kg.

Ans. (3)

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Sol.



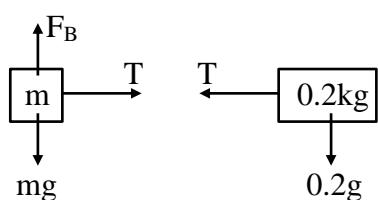
Given, volume of block = $(10 \times 10^{-2})^3 = 10^{-3} \text{ m}^3$

Let density of block = $\rho \text{ kg/m}^3$

mass of block = $\rho \times 10^{-3} \text{ kg}$

$$\text{Buoyant Force } (F_B) = 1000 \times \frac{10^{-3}}{2} \times 10 = 5 \text{ N}$$

F.B.D. of blocks



Balancing torque about point O, we get

$$mg(2 \times 10^{-2}) - F_B(2 \times 10^{-2}) = 0.2g(25 \times 10^{-2})$$

$$\rho \times 10^{-3} \times 10 \times 2 - 10 = 50$$

$$\rho = 3000 \text{ kg/m}^3$$

Hence, mass of block = $\rho \times 10^{-3}$

$$= 3000 \times 10^{-3} = 3 \text{ kg}$$



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