JEE (Main)

PAPER-1 (B.E./B. TECH.)

2021

COMPUTER BASED TEST (CBT)

Memory Based Questions & Solutions

Date: 27 July, 2021 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: PHYSICS

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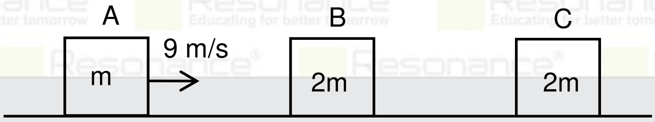
PART : PHYSICS

1. In the given arrangement, block A of mass m moving with speed 9m/s. strikes with block B of mass 2m elastically. Then block B strikes with block C of mass 2m perfect in-elastically. Find the final speed of block C?



(1) 3 m/s (2) 4 m/s (3) 5 m/s (4) 6 m/s

Ans. **(1)**

Sol. $9m = mv_A + 2mv_B$

$9 = v_A + 2v_B$ ....(1)

$9 = v_B - v_A$ ....(2)

Thus $v_B = 6$ m/s

Collision between B & C

$2mv_B = 4mv_C$

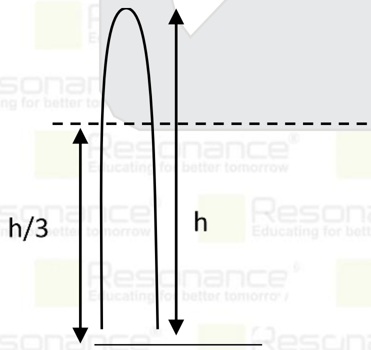
$v_C = 3$ m/s

2. A particle is thrown upward at $t = 0$. It attains maximum height of h. It is found at height h/3 at $t = t_1$ & $t = t_2$. Find t_1/t_2 :

(1) $\frac{\sqrt{3}-1}{\sqrt{3}+1}$ (2) $\frac{1}{3}$ (3) $\frac{\sqrt{6}-\sqrt{5}}{\sqrt{6}+\sqrt{5}}$ (4) $\frac{1}{2}$

Ans. **(3)**

Sol.



$V = \sqrt{2gh}$

$\frac{h}{3} = \sqrt{2gh}t - \frac{1}{2}gt^2$

$$gt^2 - 2\sqrt{2gh}t + \frac{2h}{3} = 0$$

$$t = \frac{2\sqrt{2gh} \pm \sqrt{8gh - 4g \times \frac{2h}{3}}}{2g} = \frac{2\sqrt{2gh} \pm \sqrt{\frac{16gh}{3}}}{2g}$$

$$= \frac{2\sqrt{2gh} \pm 4\sqrt{\frac{gh}{3}}}{2g}$$

$$\frac{t_1}{t_2} = \frac{2\sqrt{2gh} - 4\sqrt{\frac{gh}{3}}}{2\sqrt{2gh} + 4\sqrt{\frac{gh}{3}}}$$

$$= \frac{2\sqrt{2} - \frac{4}{\sqrt{3}}}{2\sqrt{2} + \frac{4}{\sqrt{3}}} = \frac{\sqrt{3} - \sqrt{2}}{\sqrt{3} + \sqrt{2}}$$

3. In YDSE, if the light-used is shifted from orange to blue then which of the following is correct.

(1) Fringe width first increases then decreases (2) Fringe width increase

(3) Fringe width decreases (4) Fringe width first decreases than increases

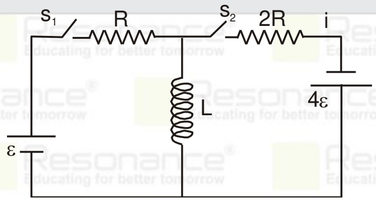
Ans. (3)

Sol. $\beta = \frac{\lambda D}{d}$

$\lambda_{blue} < \lambda_{orange}$

$\beta_{blue} < \beta_{orange}$

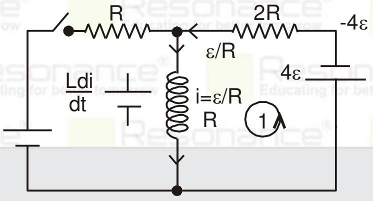
4. In the circuit shown in the figure, S_1 remains closed for a long time and S_2 remains open. Now S_2 is closed and S_1 is opened. Find out the di/dt just after that moment.



(1) $-\frac{4\varepsilon}{L}$ (2) $-\frac{6\varepsilon}{L}$ (3) $-\frac{2\varepsilon}{L}$ (4) $-\frac{\varepsilon}{L}$

Ans. (2)

Sol. Before S_2 is closed and S_1 is opened current in the left part of the circuit = $\frac{\varepsilon}{R}$. Now when S_2 closed S_1 opened, current through the inductor cannot change suddenly, current $\frac{\varepsilon}{R}$ will continue to move in the inductor.



Applying KVL in loop 1.

$$L\frac{di}{dt} + \frac{\varepsilon}{R}(2R) + 4\varepsilon = 0$$

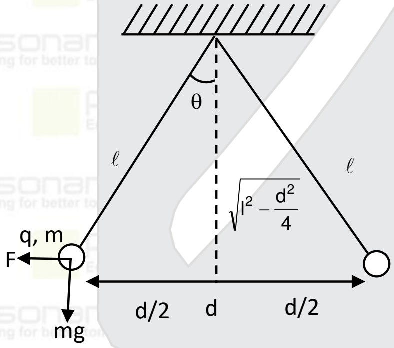
$$\frac{di}{dt} = -\frac{6\varepsilon}{L}$$

5. Two identical tennis balls of mass m and charge q are hinged by a common support with the help of a string of length 'ℓ'. If the system is in equilibrium, then find the distance between the balls? Ignore gravitational interactions between balls. (θ is very small)

(1) $\left(\frac{kq^2\ell}{mg}\right)^{1/3}$ (2) $\left(\frac{3kq^2\ell}{mg}\right)^{1/3}$ (3) $\left(\frac{2kq^2\ell}{mg}\right)^{1/3}$ (4) $\left(\frac{3kq^2\ell}{2mg}\right)^{1/3}$

Ans. **(3)**

Sol.



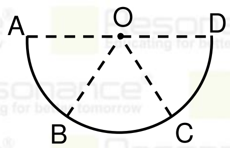
Force due to charge = $\frac{kq^2}{d^2}$

$$\tan\theta = \frac{\frac{kq^2}{d^2}}{mg} \approx \sin\theta$$

$$\frac{kq^2}{mgd^2} = \frac{d}{2\ell}$$

$$d^3 = \frac{2kq^2\ell}{mg} \Rightarrow d = \left(\frac{2kq^2\ell}{mg}\right)^{1/3}$$

6. For the given semicircle with centre O. choose the correct relation? If A, B, C & D are points on the semicircle such that $|\overrightarrow{AB}| = |\overrightarrow{BC}| = |\overrightarrow{CD}|$.



(1) $2|\overrightarrow{BO}| = 2|\overrightarrow{AO}| = |\overrightarrow{AD}|$ (2) $|\overrightarrow{BO}| = 2|\overrightarrow{AO}| = |\overrightarrow{AD}|$ (3) $2|\overrightarrow{BO}| = |\overrightarrow{AO}| = |\overrightarrow{AD}|$ (4) $|\overrightarrow{BO}| = |\overrightarrow{AO}| = |\overrightarrow{AD}|$

Ans. (1)

Sol. For the given semicircle

$|\overrightarrow{AO}| = |\overrightarrow{BO}| = |\overrightarrow{CO}| = |\overrightarrow{DO}|$ = radius of circle

$|\overrightarrow{AD}|$ = Diameter of circle

$|\overrightarrow{AD}| = 2|\overrightarrow{AO}| = 2|\overrightarrow{BO}|$

7. A monoatomic gas is kept in a 1 litre container at pressure 1 atm. If average energy per molecule is 2×10^{-9} J, find no. of molecules in the container :

(1) 0.75×10^{-6} (2) 0.75×10^{9} (3) 0.5×10^{11} (4) 0.75×10^{11}

Ans. (4)

Sol. Total energy = $\frac{f}{2}nRT = \frac{3}{2}PV$

According to question $\frac{3}{2}PV = N \times 2 \times 10^{-9}$ J

$\frac{3}{2} \times 10^{5} \times 1000 \times 10^{-6} = N \times 2 \times 10^{-9}$

$N = \frac{3}{4} \times \frac{10^{5} \times 10^{3} \times 10^{-6}}{10^{-9}} = \frac{3}{4} \times 10^{11} = 0.75 \times 10^{11}$

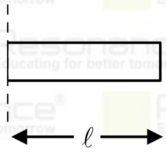
8. The relative permittivity of distilled water is 81. The velocity of light in it will be ($\mu_r = 1$)

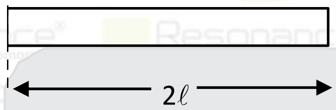
(1) 3.3×10^{7} (2) 5.3×10^{7} (3) 4.3×10^{7} (4) None

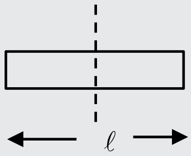
Ans. (1)

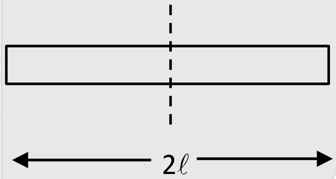
Sol. $v = \frac{c}{\sqrt{\mu_r \varepsilon_r}}$

9. Match the following column if all the rods have same density and same radius.

(i)  (a) $\frac{M\ell^2}{12}$

(ii)  (b) $\frac{M\ell^2}{3}$

(iii)  (c) $\frac{2M\ell^2}{3}$

(iv)  (d) $\frac{8M\ell^2}{3}$

(1) (i) b (ii) d (iii) a (iv) c
(2) (i) c (ii) d (iii) a (iv) d
(3) (i) a (ii) c (iii) b (iv) d
(3) (i) d (ii) a (iii) c (iv) b

Ans. (1)

Sol. (1) $\frac{M\ell^2}{3}$ (a)

(2) $\frac{2M(2\ell)^2}{3} \Rightarrow \frac{8M\ell^2}{3}$ (b)

(3) $\frac{M\ell^2}{12}$ (c)

(4) $\frac{2M4\ell^2}{12} \Rightarrow \frac{2M\ell^2}{3}$ (d)

10. A particle executing SHM having maximum kinetic energy 'E' and amplitude 'A'. Find displacement from mean position when its kinetic energy is $\frac{3E}{4}$:

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

Ans. (1)

Sol. $V = A\omega$, $\quad KE_{max} = \frac{1}{2}m\omega^2A^2$

$V = \omega\sqrt{A^2 - x^2}$ $\quad KE_X = \frac{1}{2}m\omega^2(A^2 - x^2)$

$\frac{3}{4}KE_{max} = KE_X$

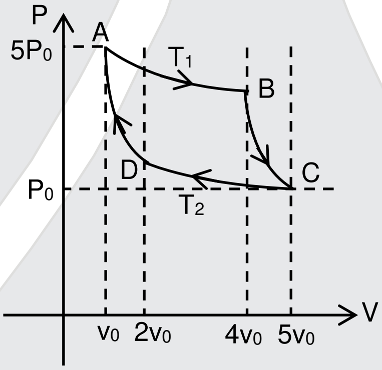
$\frac{3}{4}\frac{1}{2}m\omega^2A^2 = \frac{1}{2}m\omega^2(A^2 - x^2)$

$\frac{3}{4}A^2 = A^2 - x^2$

$x^2 = \frac{A^2}{4}$

$x = \pm\frac{A}{2}$

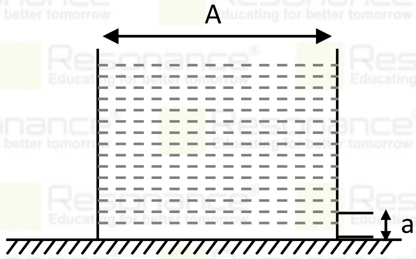
11. For given PV diagram AB is isothermal at T_1 temperature, CD is also isothermal at T_2 temperature. given that $T_1 > T_2$. Then which one of the following is correct.



(1) $W_{AB} > W_{BC}$ (2) $W_{BC} = W_{AD}$ (3) $W_{AB} < W_{BC}$ (4) $W_{AB} = W_{BC}$

Ans. **(1)**

12. A container of area 'A' filled with liquid, a small hole of area 'a' is made at the bottom of curved surface as shown. Find the coefficient of friction between container and ground in order to prevent it from sliding.



(1) $\frac{a}{A}$ (2) $\frac{2a}{A}$ (3) $\frac{a}{2A}$ (4) $\frac{3a}{2A}$

Ans. (2)

Sol. Force exerted by leaving water on the container,

$$F = \left(\frac{dm}{dt}\right)v = (\rho a v)v$$

$$= \rho a v^2$$

By conservation of energy $v = \sqrt{2gh}$

$$\mu mg = \rho a(2gh)$$

$$\mu\rho(Ah)g = \rho a 2gh$$

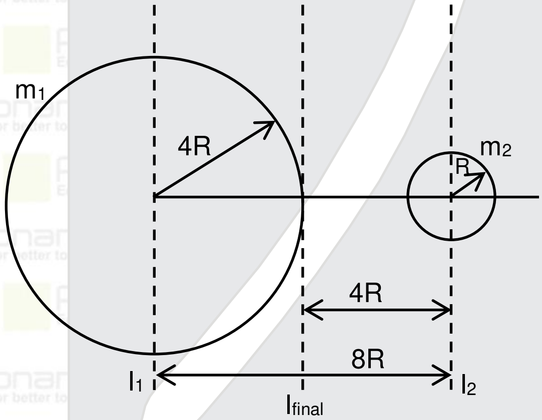
$$\mu = \frac{2a}{A}$$

13. Two solid spheres of radius 4R and R and having same mass density ρ kept at a distance of 8 R. Find Moment of Inertia of the system about the axis passes through centre of line joining their centres.

(1) $\frac{9660}{5}\pi\rho R^5$ (2) $\frac{5800}{3}\pi\rho R^5$ (3) $\frac{9664}{4}\pi\rho R^5$ (4) $\frac{9664}{3}\pi\rho R^5$

Ans. (2)

Sol.



Let mass density = ρ

$$m_2 = \frac{4}{3}\pi R^3\rho$$

$$m_1 = \frac{4}{3}\pi(4R)^3\rho$$

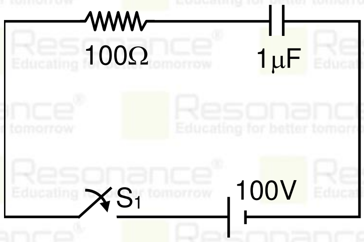
$m_1 = 64\, m_2$

$I_{final} = [I_2 + m_2 (4R)^2] + [I_1 + m_1(4R)^2]$

$$= \frac{2}{5}m_2R^2 + 16m_2R^2 + \frac{2}{5}m_1(4R)^2 + m_1(4R)^2$$

$$= \frac{2}{5}m_2R^2 + 16m_2R^2 + \frac{2}{5}64m_2(4R)^2 + 64\,m_2(4R)^2 = \frac{5800}{3}\pi\rho R^5$$

14. For the given circuit, switch is closed at t = 0 find time after which voltage across capacitor becomes 50V



(1) 69.3 μsec (2) 60 μsec (3) 50 μsec (4) 40 μsec

Ans. (1)

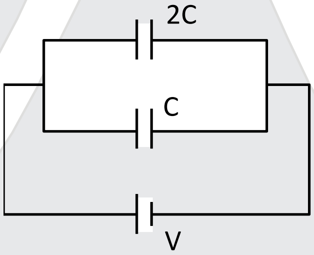
Sol. $V = V_0 e^{-\frac{t}{RC}}$

$50 = 100e^{-\frac{t}{RC}}$

$t = RC\ \ell n\ 2$

$= 100 \times 10^{-6}\ \ell n\ 2 = 10^{-4} \times 0.693\ \text{sec} = 69.3\ \mu\text{sec}$

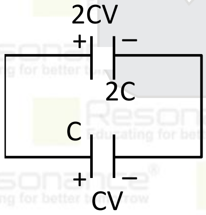
15. Figure shows two capacitors in steady state. Now the cell is removed and a dielectric of dielectric constant k is inserted between the plates of the capacitor of capacitance C. Find new potential difference across any of the capacitors :

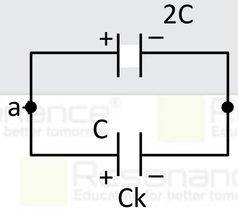


(1) $\frac{V}{2+k}$ (2) $\frac{2V}{2+k}$ (3) $\frac{3V}{2+k}$ (4) $\frac{V}{1+2k}$

Ans. (3)

Sol. Just after removing cell After inserting dielectric





Conservation of charge

$2CV + CV = 2C.\ V_{ab} + Ck\ V_{ab}$

$\therefore \quad V_{ab} = \frac{3CV}{2C + CK}$

$V_{ab} = \frac{3V}{2+K}$

16. A particle of mass 9.1×10^{-31} kg is moving with velocity 6 m/s. Momentum of photon is 2×10^{-27} kg m/s. If de–Broglie wavelength of the particle is K times of the wavelength of photon. Find value of K :

(1) 366 (2) 566 (3) 322 (4) 166

Ans. (1)

Sol. De–Broglie wavelength of particle

$$\lambda = \frac{h}{p} = \frac{h}{9.1 \times 10^{-31} \times 6}$$

Wavelength of photon

$$\lambda_{photon} = \frac{h}{p} = \frac{h}{2 \times 10^{-27}}$$

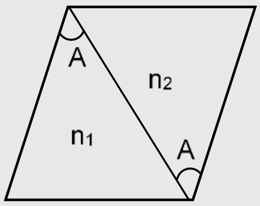
From question

$$K\lambda_{photon} = \lambda_{particle}$$

$$\Rightarrow \quad K = \frac{2 \times 10^{-27}}{9.1 \times 10^{-31} \times 6} = 366$$

17. Two prism of same angle of refraction are arranged as shown. If the light incident, on the system goes undeviated. Then find wave length of incident light

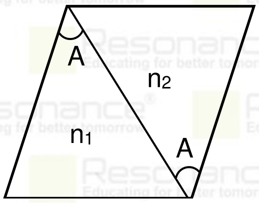
$$\left(\begin{aligned} \text{given } \eta_1 &= 1.2 + \frac{10.8 \times 10^{-14}}{\lambda^2} \\ \eta_2 &= 1.45 + \frac{1.8 \times 10^{-14}}{\lambda^2} \end{aligned} \right)$$



(1) 600 nm (2) 675 nm (3) 575 nm (4) 475 nm

Ans. (1)

Sol.



$\delta_{net} = A(n_1 - 1) - A(n_2 - 1) = 0$

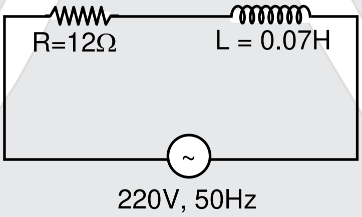
$\Rightarrow \quad n_1 = n_2$

$$\Rightarrow \quad 1.2 + \frac{10.8 \times 10^{-14}}{\lambda^2} = 1.45 + \frac{1.8 \times 10^{-14}}{\lambda^2}$$

$$\lambda^2 = \frac{(10.8 - 1.8) \times 10^{-14}}{(1.45 - 1.2)}$$

$\lambda = 600$ nm.

18. For the given circuit find current 'I' and the phase difference between V and I :

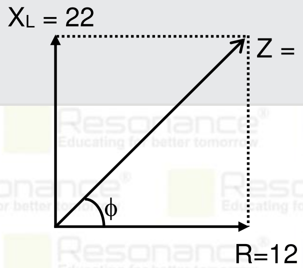


(1) 8.8A, $\tan^{-1} 1.83$ (2) 6.8A, $\tan^{-1} 2.83$ (3) 5.8A, $\tan^{-1} 0.83$ (4) 7.8A, $\tan^{-1} 2.53$

Ans. **(1)**

Sol. $\omega = 2\pi f = 100\pi$

Thus $x_L = \omega L = 100 \times \frac{22}{7} \times 0.07 = 22\Omega$



Impedance triangle

Thus, $z = \sqrt{R^2 + x_L^2}$

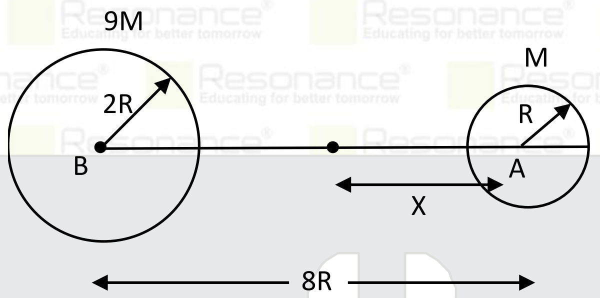
$z = \sqrt{(12)^2 + (22)^2}$

$z \approx 25.00$

$I = \frac{220}{25} = 8.8$

$\tan \phi = 22/12 = 1.83$

19. A particle of mass 'm' is projected from the surface of planet 'A' of mass M and radius R. What should be the velocity of projection such that particle reaches to another planet 'B', which is at a distance of 8R from planet 'A'. Planet 'B' has mass 9M and radius 2R.



(1) $\sqrt{\frac{1}{5}\frac{GM}{R}}$ (2) $\sqrt{\frac{4}{7}\frac{GM}{R}}$ (3) $\sqrt{\frac{2}{5}\frac{GM}{R}}$ (4) $\sqrt{\frac{7}{3}\frac{GM}{R}}$

Ans. **(2)**

Sol. Let at a distance 'X' from planet 'A', the net gravitational field becomes zero

$$\frac{GM}{X^2} = \frac{G\times 9M}{(8R-X)^2}$$

$$(3X)^2 = (8R - X)^2$$

$$X = 2R$$

Now, Particle should be projected such that it covers a minimum distance of '2R'.

Thus

$$\frac{1}{2}mv^2 - \frac{GMm}{R} - \frac{G(9M)m}{7R} = -\frac{GMm}{2R} - \frac{G(9M)m}{6R}$$

$$\frac{1}{2}v^2 = \frac{2}{7}\frac{GM}{R} \Rightarrow v = \sqrt{\frac{4}{7}\frac{GM}{R}}$$

20. Circular scale divisions of a screw gauge is 50. Five full rotations advances circular scale by 5mm.

Statement-1 : Least count of screw gauge is 0.001 cm

Statement-2 : Least count $= \frac{\text{pitch}}{\text{Total no. of divisions}}$

(1) Statement-1 & 2 both are true

(2) Statement-1 & 2 both are true statement-2 is correct explant of statement-1

(3) Statement-1 is false Statement-2 is true

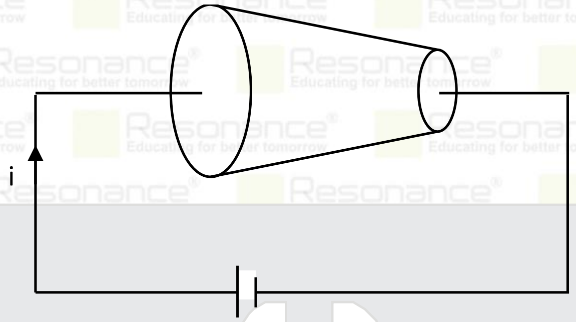
(4) Statement-2 is true Statement-1 is false.

Ans. **(3)**

Sol. LC = 1mm/50 = 0.02 mm

Statement –1 is wrong. Statement–2 is right

21. Figure shows a conductor of tapered cone shape. As one goes from left to right on conductor, choose correct option



(1) current decreases
(2) drift velocity of electron increases
(3) electric field inside conductor decreases
(4) All of the above

Ans. **(2)**

Sol. $i = nAev_d$

$\therefore$ v_d increases as area A decrease

22. A body cools down from 61°C to 49°C in 4 min. and the surrounding temperature is 30°C. Find the time taken by this body to cool down from 49°C to 37°C.

(1) 1.62 min (2) 1.25 min (3) 7.69 min (4) 0.92 min.

Ans. **(3)**

Sol. $$\frac{61-49}{4} = K\left[\frac{61+49}{2} - 30\right] \quad \ldots(1)$$

$$\frac{49-37}{t} = k\left[\frac{49+37}{2} - 30\right] \quad \ldots(2)$$

Dividing (1) and (2)

$$\frac{t}{4} = \frac{25}{13}$$

$$t = \frac{4 \times 25}{13} = 7.69$$

23. A bar–magnet of magnetic moment 9.85 A–m² and moment of inertia $I = 10^{-6}$ kg–m² makes 10 oscillations in 5 sec. in uniform magnetic field. Find intensity of magnetic field.

(Take $\pi^2 = 9.85$)

(1) 20 μT (2) 25 μT (3) 16 μT (4) 10 μT

Ans. **(3)**

Sol. $T = 2\pi\sqrt{\frac{I}{MB}}$

$\frac{1}{2} = 2\pi\sqrt{\frac{10^{-6}}{9.85 \times B}} = 2\pi\sqrt{\frac{10^{-6}}{\pi^2 \times B}}$

$B = 16 \times 10^{-6}$ T

$= 16\ \mu T$

24. If two discs are of same mass density but having different radii R and r.

I_1 = Moment of inertia of disc of radius R, about an axis perpendicular to the plane of disc and passing through its centre.

I_2 = Moment of inertia of disc of radius r. about one of its diameter. Then choose correct option

(1) $\frac{I_1}{I_2} = \frac{2r^4}{R^2}$ (2) $\frac{I_1}{I_2} = \frac{2R^4}{r^4}$ (3) $\frac{I_1}{I_2} = \frac{2r^2}{R^2}$ (4) $\frac{I_1}{I_2} = \frac{2r}{R}$

Ans. **(2)**

Sol. Let mass density be σ

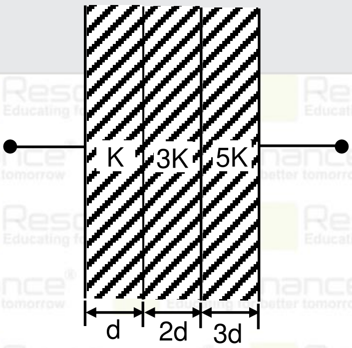
$M_1 = \pi R^2\sigma$, $M_2 = \pi r^2\sigma$

$I_1 = \frac{1}{2}M_1R^2 = \frac{\pi\sigma R^4}{2}$

$I_2 = \frac{1}{4}M_2r^2 = \frac{\pi\sigma r^4}{4}$

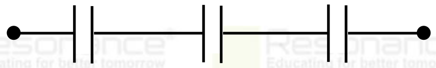
$\frac{I_1}{I_2} = \frac{2R^4}{r^4}$

25. Find the equivalent capacitance of shown arrangement if all the plates are identical having surface area A.



(1) $\frac{24}{15}\frac{A\varepsilon_0 K}{d}$ (2) $\frac{17}{15}\frac{A\varepsilon_0 K}{d}$ (3) $\frac{15}{34}\frac{A\varepsilon_0 K}{d}$ (4) $\frac{34}{15}\frac{A\varepsilon_0 K}{4d}$

Ans. **(3)**

Sol. 

$$C_1 = \frac{A\varepsilon_0 K}{d} \quad C_2 = \frac{3KA\varepsilon_0}{2d} \quad C_3 = \frac{5KA\varepsilon_0}{3d}$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$= \frac{d}{A\varepsilon_0 K} + \frac{2d}{3A\varepsilon_0 K} + \frac{3d}{5A\varepsilon_0 K}$$

$$= \frac{d}{A\varepsilon_0 K}\left(1 + \frac{2}{3} + \frac{3}{5}\right) = \frac{34}{15}\frac{d}{A\varepsilon_0 K}$$

Thus

$$C_{eq} = \frac{15}{34}\frac{A\varepsilon_0 K}{d}$$

26. An electron is revolving in a circular orbit of radius 0.5 m, with a speed of 2.2×10^{-6} m/s. Find equivalent current ?

(1) 1.12×10^{-25} A (2) 2.15×10^{-25} A (3) 1.12×10^{-15} A (4) 2.15×10^{-13} A

Ans. **(1)**

Sol. $i = \frac{q}{t} = \frac{q}{2\pi r / v}$

$$= \frac{1.6 \times 10^{-19} \times 2.2 \times 10^{-6}}{2\pi \times 0.5} = 1.12 \times 10^{-25} \text{ A}$$

27. A capacitor ($C = 100\ \mu F$) discharging against a resistor R, at same time a radioactive substance decays with mean life 30 ms, if the ratio of charge on capacitor and activity of substance remain same for all the time then, find the resistance :

(1) 300 Ω (2) 432 Ω (3) 450 Ω (4) 250 Ω

Ans. **(1)**

Sol. $q = q_0 e^{\frac{-t}{RC}}$ ...(1)

$A = A_0 e^{-\lambda t}$ ...(2)

Divide (1) & (2)

$$\Rightarrow \frac{q}{A} = \frac{q_0}{A_0}\frac{e^{\frac{-t}{RC}}}{e^{-\lambda t}} \Rightarrow -\lambda t = -\frac{-t}{RC}$$

$RC = 1/\lambda = 30 \times 10^{-3}$ sec

R = 300

28. A wire of length 0.1 m and area of cross section 0.04×10^{-4} m^2 is stretched by 0.001 m, its young's modulus is 0.5×10^9 pa. The energy stored in this wire is transferred completely as kinetic energy to a particle of mass 20 grams. Find speed of this particle.

(1) 0.5 m/s (2) 1 m/s (3) 1.5 m/s (4) 10 m/s

Ans. **(2)**

Sol. $U = \frac{1}{2}Kx^2$

$$= \frac{1}{2} \times \frac{AY}{L} \times (0.001)^2$$

$$= \frac{1}{2} \times \frac{0.04 \times 10^{-4} \times 0.5 \times 10^9}{0.1} \times 10^{-6} = \frac{1}{2}mv^2 = \frac{1}{2} \times 20 \times 10^{-3} \times v^2$$

$$\Rightarrow \quad v^2 = \frac{0.04 \times 10^{-4} \times 0.5 \times 10^3}{0.1 \times 20 \times 10^{-3}} = 1\,\text{m/s}$$

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