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IITJEE-2009

TS7 Paper 1

Physics Solutions

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Physics-Solutions Test Series – 7/Paper – I/ JEE – 2009

1. Moment of inertia of Disc + Pt. mass about PQ is equal to $\frac{mR^2}{4} + m\left(\frac{R}{4}\right)^2 + m\left(R+\frac{R}{4}\right)^2 = \frac{15}{8}mR^2$.

loss in GPE = gain in KE $\Rightarrow mg\left(\frac{R}{4}+\frac{R}{4}\right) + mg\left(\frac{5R}{4}+\frac{5R}{4}\right) = \frac{1}{2}\cdot\frac{15}{8}mR^2\omega^2$

$\Rightarrow \omega = \sqrt{\frac{16g}{5R}}$ $\Rightarrow$ velocity of point mass $= \omega \times \frac{5R}{4} = \sqrt{5gR}$

2. $9.99 = 10\left(1 + 1.1\times10^{-5}(\theta-20)\right)$ $\Rightarrow$ Ans: (A)

$\Rightarrow \theta = +20 - 90.91 \approx -71^\circ C$ $\Rightarrow$ Ans: (C)

3. restoring torque $= Ky\frac{L}{2} + K\frac{y}{2}\frac{L}{2} = \frac{5KL}{4}\cdot y = \frac{5KL^2}{4}\cdot\theta$ $\Rightarrow$ torque Constant $= \frac{5KL^2}{4}$

$\Rightarrow f = \frac{1}{2\pi}\sqrt{\frac{C}{I}} = \frac{1}{2\pi}\sqrt{\frac{15K}{4M}}$ $\Rightarrow$ Ans: (D) $\quad I = \frac{ML^2}{3}$

4. mass is proportional to no of moles $\Rightarrow \frac{m_1}{m_2} = \frac{n_1}{n_2} = \frac{P_1V_1}{P_2V_2}$

$\Rightarrow \frac{m_1}{m_2} = \frac{\left(P+\frac{4T}{R_1}\right)}{\left(P+\frac{4T}{R_2}\right)}\cdot\frac{4/3\pi R_1^3}{4/3\pi R_2^3} = \frac{(P+4T/R_1)\,R_1^3}{(P+4T/R_2)\,R_2^3}$ $\Rightarrow$ Ans: (C)

5. Let n_1 and n_2 are no. of loops in Hydrogen and in oxygen respectively $\Rightarrow \lambda_H = \frac{1}{n_1}$ & $\lambda_O = \frac{1}{n_2}$ as length of each column is $\frac{1}{2}$ m & length of one loop $= \frac{\lambda}{2}$.

Frequency $= \frac{c_1}{\lambda_1} = \frac{c_2}{\lambda_2} \Rightarrow 1100\,n_1 = 300\,n_2 \Rightarrow \frac{n_1}{n_2} = \frac{3}{11}$

$\Rightarrow$ frequency $= \frac{3300}{2}Hz = 1650\,Hz$ $\Rightarrow$ Ans: (B)

6. $V_P - V_Q = [\vec{v}\,\vec{B}\,\vec{l}\,] = (2m/s \cdot 2T \cdot \sin 90^\circ)\cdot 2\cos 60^\circ = 4\,V$ Ans: (B)

7. Let I: intensity of each source $\Rightarrow I_0 = 4I$

final intensity of $S_1 = I - 0.64I = 0.36I$ $\Rightarrow$ Ans: (A)(C)

$I_{max} = \left(\sqrt{I} + \sqrt{0.36I}\right)^2 = 2.56\,I = 0.64\,I_0$ $\Rightarrow \frac{I_{max}}{I_{min}} = 16$

$I_{min} = \left(\sqrt{I} - \sqrt{0.36I}\right)^2 = 0.16\,I = 0.04\,I_0$

8. Let A: area of cross-section & x: distance through which the surface is pushed down $\Rightarrow$ restoring force $= 2xA\rho g$ (2x: diff b/w (vertically) levels)

$m = lA\rho g$ $\Rightarrow k = 2A\rho g \Rightarrow$ SHM

$\Rightarrow T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{l}{2g}}$ $\Rightarrow$ Ans: (B)(D)

9. (C)(D)

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10. As X and Z are connected, they have same potential $\therefore$ p.d. b/w X and Y = p.d b/w Z and Y = V say. For XY, $E_1 = \frac{V}{2d} \Rightarrow a_{elec.} = \frac{Ve}{2m_e d}$ (electric field)

E_2 (for YZ) $= \frac{V}{d} \Rightarrow a_{prot.} = \frac{eV}{m_p d}$. The two particles have equal charges and move through the same p.d. They will therefore, acquire the same energy U. Also $U = p^2/2m \Rightarrow p = \sqrt{2mU}$ where p = momentum. For the same E, the particle with greater m has greater p. **Ans: (C)(D)**

11 **Ans: (A)** when the plates of a capacitor are moved further apart, the capacitance gets decreased. As battery remains connected, hence charge $q = CV$ on the plates is decreased and energy $U = \frac{1}{2}CV^2$ also decreases. Some charge from the plates flows to the battery. work done against electrostatic attraction between plates is used in the transference of energy and is dissipated in the form of heat energy in connection wires.

12. **Ans: (C)** The principle of super position does not state that the frequencies of the oscillations should be nearly equal. For beats to be heard the condition is that difference in frequencies of the two oscillations should not be more than 10 times per seconds for a normal human ear to recognise it. Hence we cannot recognise beats in case of two tuning forks vibrating at 256 Hz and 512 Hz respectively. The principle of super-position is valid when amplitudes are not large enough to cause permanent deformations of the medium.

13. **Ans: (A)** $\frac{GMm}{R^2} = m\omega^2 R$; $\omega = \frac{2\pi}{T} \Rightarrow T^2 = \frac{4\pi^2}{GM} \cdot R^3$

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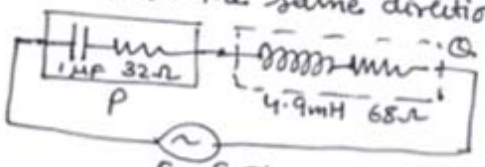
14. Ans:(B) two parallel conductors carrying currents in same directions attract each other. Parallel currents in various turns of solenoid flows in the same directions.

15.
16.
17.



$i_0 = \frac{E_0}{\sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}}$ is max when

$\omega L - \frac{1}{\omega C} = 0 \Rightarrow \omega = 10^5/7$ rad/sec

$\Rightarrow i_{max} = \frac{10}{32+68} = 0.1\,A$ $Z_p = \sqrt{R_1^2 + (\frac{1}{\omega C})^2} = 76\Omega$

$Z_a = \sqrt{R_1^2 + \omega^2 L^2} = 98\Omega \Rightarrow$ Ans:(A)

16. voltage across $P = i_0 Z_p = 7.6\,V \Rightarrow$ Ans:(C)

17. $\Rightarrow$ Ans:(B)

18. Path diff at O $= 2(\sqrt{D^2+d^2} - D) \approx d^2/D$ $(d << D) = \lambda/2, 3\frac{\lambda}{2}$ ... for destructive interference.

c) $d_{min} = \sqrt{\frac{\lambda D}{2}} \Rightarrow$ Ans:(B)

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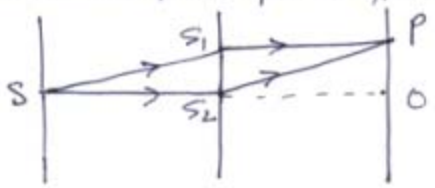
19. For min x, total path difference at P is zero. $\Rightarrow$ P is directly (horizontaly) in front of S_1 as S_2 is horizontally in front of S so that SS_1PS_2 is a parallelogram



$\Rightarrow x = OP = S_1S_2 = d \Rightarrow$ **Ans: (B)**

20. as O is point of min. & P is adjacent point of maxima

$\Rightarrow$ OP = half of fringe width $\Rightarrow \omega = 2d \Rightarrow$ **Ans: (C)**

21. For the cylinder, weight = Bouyant force $\Rightarrow L\frac{A}{5}Dg = \frac{3L}{4}\cdot\frac{A}{5}dg + \frac{L}{4}\cdot\frac{A}{5}\cdot 2dg$

$\Rightarrow D = 5d/4 \Rightarrow$ **Ans: (D)**

22. total pressure at bottom $= P_0 +$ $\frac{\text{total wt above base area}}{\text{base area}}$.

$$= P_0 + \frac{\frac{H}{2}dAg + \frac{H}{2}\cdot 2dAg + L\cdot\frac{A}{5}\cdot\frac{5d}{4}\cdot g}{A}$$

$$= P_0 + \left(\frac{3H}{2} + \frac{L}{4}\right)dg \Rightarrow$$ **Ans: (A)**

23. Apply Bernoulli's theorem at two points just inside & outside the hole.

$$\Rightarrow \frac{P_0 + dg\frac{H}{2} + 2dg\left(\frac{H}{2} - h\right)}{2dg} = \frac{P_0}{2d} + \frac{V_{eff}^2}{2g} \Rightarrow V_{eff} = \sqrt{\frac{(3H-4h)g}{2}}$$

t: time to fall of liquid $= \sqrt{\frac{2h}{g}} \Rightarrow x = V_{eff} \times t = \sqrt{(3H-4h)h}$

$\Rightarrow$ **Ans: (B)**.