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JEE (Main)

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

2021

COMPUTER BASED TEST (CBT)
Memory Based Questions & Solutions

Date: 20 July, 2021 (SHIFT-2) | TIME : (3.00 p.m. to 6.00 p.m)

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SUBJECT: PHYSICS

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PART : PHYSICS

1. If kinetic energy of particle becomes four times, then % change in momentum will be :

(1) 200 (2) 100 (3) 150 (4) 50

Ans. **(2)**

Sol. K.E. $\Rightarrow K = \frac{P^2}{2m}$

$P \propto \sqrt{K}$

P_2 $\sqrt{K_2}$ P_2 $\sqrt{4K}$

$\frac{P_2}{P_1} = \sqrt{\frac{K_2}{K_1}} \Rightarrow \frac{P_2}{P_1} = \sqrt{\frac{4K}{K}}$

$\Rightarrow \quad \frac{P_2}{P_1} = 2$

$\Rightarrow \quad \frac{P_2 - P_1}{P_1}\% = \left(\frac{P_2}{P_1} - 1\right) \times 100 = (2-1) \times 100 = 100$

$\Delta P\% = 100\%$

2. A RLC circuit is in its resonance condition. Its circuit components have value

R = 5Ω

L = 2H

C = 0.5 mF, V = 250V

Then find power in circuit ?

(1) 6kW (2) 10kW (3) 12kW (4) 12.5kW

Ans. (4)

Sol. As circuit is in resonance. Thus

$X_L = X_C$

$\therefore \quad Z = R$ so $i_{rms} = V/Z = V/R$

$P = i_{rms}^2 R$

$P = \frac{V^2}{R} = \frac{250 \times 250}{5} = 12500$ J/s = 12.5 kW

3. A wheel rotating with an angular speed of 600 rpm is given an constant angular acceleration of

Ans. (1)

Sol. $\omega_0 = 600$ rpm

$\alpha = 1800$ rpm^2

t = 10 sec = 1/6 minute

$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$= 600 \times \frac{10}{60} + \frac{1}{2} \times 1800 \times \frac{1}{36}$

= 100 + 25 = 125 revolution.

4. $|\vec{P}| = |\vec{Q}|$, $|\vec{P} + \vec{Q}| = |\vec{P} - \vec{Q}|$. Find angle between $\vec{P}$ & $\vec{Q}$

(1) 45° (2) 90° (3) 135° (4) 150°

Ans. (2)

Sol. $|\vec{P} + \vec{Q}| = |\vec{P} - \vec{Q}|$

$|\vec{P}|^2 + |\vec{Q}|^2 + 2|\vec{P}||\vec{Q}|\cos\theta = |\vec{P}|^2 + |\vec{Q}|^2 - 2|\vec{P}||\vec{Q}|\cos\theta$

Thus, $\theta = 90°$

5. A body is moved from rest along straight line by a machine delivering a constant power. Time taken by body to travel a distance "S" is proportional to

(1) $S^{1/3}$ (2) $S^{2/3}$ (3) $S^{1/2}$ (4) $S^{1/4}$

Ans. (2)

Sol. Energy supply = Pt

in t sec

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

$V \propto \sqrt{t}$

$\frac{dS}{dt} = C\sqrt{t}$

$\int_0^S dS = C\int_0^t t^{1/2}dt$

$t^{3/2} = \frac{3S}{2C}$

$t = S^{2/3}\left(\frac{3}{2C}\right)^{2/3}$

$T \propto S^{2/3}$

6. A uniform rod of young's modulus Y is stretched by two tension T_1 and T_2 such that rods get expanded to length L_1 and L_2 respectively. Find initial length of rod ?

(1) $\frac{L_1T_1 - L_2T_2}{T_1 - T_2}$ (2) $\frac{L_2T_1 - L_1T_2}{T_2 - T_1}$ (3) $\frac{L_1T_2 - L_2T_1}{T_2 - T_1}$ (4) $\frac{L_1}{T_1} \times \frac{T_2}{L_2}$

Ans. (3)

Sol. Let initial length of rod be L_0 and Area A.

As $\frac{T}{A} = Y\frac{\Delta \ell}{\ell}$

So, $\frac{T_1}{A} = \frac{Y(L_1 - L_0)}{L_0}$

$\frac{T_2}{A} = \frac{Y(L_2 - L_0)}{L_0}$

Dividing

$\frac{T_1}{T_2} = \frac{L_1 - L_0}{L_2 - L_0}$; $T_1L_2 - T_1L_0 = T_2L_1 - T_2L_0$; $L_0 = \frac{L_1T_2 - L_2T_1}{T_2 - T_1}$

7. Time (T), velocity (C) and angular momentum (h) are choosen as fundamental quantities instead of mass, length and time. In term of these, dimension of mass would be :

(1) $[M] = [T^{-1}C^{-2}h]$ (2) $[M] = [T^{-1}C^{2}h]$

(3) $[M] = [T^{-1}C^{-2}h^{-1}]$ (4) $[M] = [T^{-1}C^{-2}h]$

Ans. (1)

Sol. $M \propto T^xC^yh^z$

$M^0L^0T^0 = T^x [LT^{-1}]^y [ML^2T^{-1}]^z$

$M^1L^0T^0 = T^{x-y-z} L^{y+2z} M^z$

On comparing powers

$z = 1$ ...(1)

$x - y - z = 0$ ...(2)

$y + 2 \times 1 = 0$

$y = -2$

$x - (-2) - 1 = 0$

$x = -1$

$M = T^{-1}C^{-2}h^{1}$

$M \propto T^{-1}C^{-2}h^{1}$

$[M] \propto [T^{-1}C^{-2}h]$

8. Find relation between γ (adiabatic constant) and degree of freedom (f)

(1) $f = \frac{2}{\gamma - 1}$ (2) $f = \frac{\gamma}{\gamma - 1}$ (3) $f = \frac{\gamma - 1}{2}$ (4) $f = \frac{\gamma - 1}{\gamma}$

Ans. (1)

Sol. $C_V = \frac{fR}{2}$

$\Rightarrow \quad C_P = \left(\frac{f}{2} + 1\right)R$

$\Rightarrow \quad \gamma = \frac{C_P}{C_V} = 1 + \frac{2}{f}$

$f = \frac{2}{\gamma - 1}$

9. Two identical drops of Hg coalesce to form a bigger drop. Find ratio of surface energy of bigger drop to smaller drop.

(1) $2^{3/2}$ (2) $3^{2/5}$ (3) $2^{2/3}$ (4) $5^{2/3}$

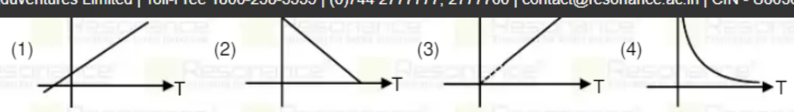
Ans. (3)

Sol. $2 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$

$\frac{R}{r} = 2^{1/3}$ ...(1)

Now $\frac{U_{bigger}}{U_{smaller}} = \frac{S \times 4\pi R^2}{S \times 4\pi r^2} = \left(\frac{R}{r}\right)^2 = 2^{2/3}$

10. Identify correct graph between PV and T for an ideal gas.



Ans. (3)

Sol. PV = nRT

$\Rightarrow \quad PV = CT$

Therefore, PV v/s T graph is straight line.

11. For a body in pure rolling, its rotational kinetic energy is 1/2 times of its translation kinetic energy. They body should be ?

(1) solid cylinder (2) Ring (3) solid sphere (4) Hollow sphere

Ans. (1)

Sol. Given

$$\frac{1}{2}I\omega^2 = \frac{1}{2}\times\frac{1}{2}mv^2$$

as $v = R\omega$ (pure rolling

$$I = \frac{1}{2}mR^2$$

Thus, solid cylinder.

12. Magnetic susceptibility of material is 499 & $\mu_0 = 4\pi \times 10^{-7}$. SI unit then find μ_r

(1) 500 (2) 400 (3) 300 (4) 200

Ans. (1)

Sol. $\mu_r = 1 + \chi$

$= 1 + 499 = 500$

13. A plane electromagnetic wave travels in free space. Electric field is $\vec{E} = E_0\hat{i}$ and magnetic field is represented by $\vec{B} = B_0\hat{k}$. What is the unit vector along the direction of propagation of electromagnetic wave?

Sol. Direction of EM wave in given by direction of $\vec{E}\times\vec{B}$.

Unit vector in direction $\vec{E}\times\vec{B} \Rightarrow \dfrac{\vec{E}\times\vec{B}}{|\vec{E}\times\vec{B}|}$

$$\Rightarrow \frac{E_0\hat{i}\times B_0\hat{k}}{E_0B_0\sin 90}$$

$$\Rightarrow \hat{i}\times\hat{k}$$

$$\Rightarrow -\hat{j}$$

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14. Two satellites of mass M_A and M_B are revolving around a planet of mass M in radius R_A and R_B respectively. Then ?

(1) $T_A > T_B$ if $R_A > R_B$ (2) $T_A > T_B$ if $M_A > M_B$

(3) $T_A = T_B$ if $M_A > M_B$ (4) $T_A > T_B$ if $R_A < R_B$

Ans. **(1)**

Sol. $T \propto r^{3/2}$

15. If N_0 active nuclei becomes $\frac{N_0}{16}$ in 80 days. Find half life of nuclei ?

(1) 40 days (2) 20 days (3) 60 days (4) 30 days

Ans. **(2)**

Sol. $N_0 \xrightarrow{t_{1/2}} \frac{N_0}{2} \xrightarrow{t_{1/2}} \frac{N}{4} \xrightarrow{t_{1/2}} \frac{N}{8} \xrightarrow{t_{1/2}} \frac{N}{16}$

$4 \times t_{1/2} = 80$ days

$t_{1/2} = 20$ days

16. A satellite is revolving around a planet in an orbit of radius R. Suddenly radius of orbit becomes 1.02 R then what will be percentage change in its time period of revolution ?

Ans. **3**

Sol. As $T \propto R^{3/2}$

$T_1 = kR^{3/2}$

17. A person walks up a stationary escalator in the time t_1. If he remains stationary on the escalator, then it can take him up in time t_2. Determine the time it would take to walk up on the moving escalator ?

(1) $\frac{t_1t_2}{t_1+t_2}$ (2) $\frac{t_1t_2}{t_1-t_2}$ (3) $\frac{2t_1t_2}{t_1+t_2}$ (4) $\frac{2t_1t_2}{t_1-t_2}$

Ans. (1)

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Sol. Suppose length of escalator = L

Speed of man wrt escalator = $\frac{L}{t_1}$

Speed of escalator = $\frac{L}{t_2}$

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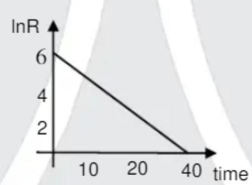
Time taken by the man to walk on the moving escalator $= \frac{L}{\frac{L}{t_1}+\frac{L}{t_2}} = \frac{t_1t_2}{t_1+t_2}$

18. For given graph between decay rate & time. Find half life (where R = decay rate)



(1) $\frac{10}{3}\ln 2$ (2) $\frac{20}{3}\ln 2$ (3) $\frac{3}{20}\ln 2$ (4) $\frac{20}{3}\ln 2$

Ans. (2)

slope = $-\lambda = \frac{-6}{40}$

$\lambda = \frac{3}{20}$

$t_{1/2} = \frac{\ln 2}{\lambda} = \frac{\ln 2}{3} \times 20 = \frac{20}{3} \ln 2$

19. The velocities of particle performing SHM at a distance of x_1 & x_2 from mean position are v_1 & v_2 find the time period of oscillation ?

(1) $2\pi\sqrt{\frac{x_2^2 + x_1^2}{v_1^2 - v_2^2}}$ (2) $2\pi\sqrt{\frac{x_2^2 - x_1^2}{v_1^2 + v_2^2}}$ (3) $2\pi\sqrt{\frac{x_2^2 - x_1^2}{v_1^2 - v_2^2}}$ (4) $2\pi\sqrt{\frac{x_2^2 + x_1^2}{v_1^2 + v_2^2}}$

Ans. (3)

Sol. $v = \omega\sqrt{A^2 - x^2}$

$v_1 = \omega\sqrt{A^2 - x_1^2}$

$v_2 = \omega\sqrt{A^2 - x_2^2}$

$\omega^2 = \frac{v_1^2 - v_2^2}{x_2^2 - x_1^2}$

$\omega = \sqrt{\frac{v_1^2 - v_2^2}{x_2^2 - x_1^2}}$

$T = 2\pi\sqrt{\frac{x_2^2 - x_1^2}{v_1^2 - v_2^2}}$

20. In photoelectric effect stopping potential is $3V_0$ for incident wave length λ_0 and stopping potential V_0 for incident wavelength $2\lambda_0$. Find threshold wavelength.

(1) $3\lambda_0$ (2) $2\lambda_0$ (3) $4\lambda_0$ (4) $8\lambda_0$

Ans. **(3)**

Sol. KE = $h\nu - W$

For first case

$e(3V_0) = \frac{hc}{\lambda_0} - W$ ...(i)

For second case

$eV_0 = \frac{hc}{2\lambda_0} - W$ ...(ii)

From equation (i) and (ii)

$W = \frac{hc}{4\lambda_0}$

For λ_{th}

$W = \frac{hc}{\lambda_{th}}$

$\Rightarrow \quad \frac{hc}{4\lambda_0} = \frac{hc}{\lambda_{th}} \quad \Rightarrow \quad \lambda_{th} = 4\lambda_0$

21. At 45° of magnetic meridian angle of dip is 30° then find the angle of dip in vertical plane at 45° ?

(1) $\tan^{-1}\left(\frac{1}{\ }\right)$ (2) $\tan^{-1}\left(\frac{1}{\ }\right)$ (3) $\tan^{-1}\left(\frac{1}{\ }\right)$ (4) $\tan^{-1}\left(\frac{1}{\ }\right)$

Sol. Let vertical and horizontal component of earth's magnetic field at meridian will be V and H.

Angle of dip, $\tan\theta = \frac{V}{H}$ ...(i)

at angle of 45° from magnetic meridian, angle of dip = 30°

$$\tan 30° = \frac{V}{H\cos 45°} \quad \Rightarrow \quad \frac{1}{\sqrt{3}} = \frac{V}{H\cos 45°}$$

$$\frac{V}{H} = \frac{1}{\sqrt{6}}$$

$$\tan\theta = \frac{V}{H} \Rightarrow \frac{1}{\sqrt{6}}$$

$$\theta = \tan^{-1}\left(\frac{1}{\sqrt{6}}\right)$$

22. A sodium lamp in space was emitting waves of wavelength 2880Å. When observed from a planet, its

(1) 4.25×10^5 m/s (2) 6.25×10^5 m/s (3) 2.75×10^5 m/s (4) 3.75×10^5 m/s

Ans. (2)

Sol. $\frac{v_{rel}}{C} = \frac{\Delta\lambda}{\lambda}$

$V_{rel} = \frac{6}{2880} \times 3 \times 10^8$

$= 6.25 \times 10^5$ m/s

23. An electron having debroglie wavelength is falls on an X-ray tube. The cut off wave length of emitted X-Ray is

(1) $\frac{2mc\lambda^2}{h}$ (2) $\frac{2h}{mc}$ (3) $\frac{h}{mc}$ (4) $\frac{2}{3}\frac{mc\lambda^2}{h}$

Ans. (1)

Sol. De-broglie wavelength

$\lambda_B = h$

$\Rightarrow P = \frac{h}{\lambda_B}$

$\therefore$ Kinetic energy of electron $\Rightarrow E = \frac{P^2}{2m_e} = \frac{h^2}{2m_e\lambda_B^2}$

For cut-off wavelength of emitted X-Ray

$E = \frac{hc}{\lambda}$

$\Rightarrow \frac{h^2}{2m_e\lambda_B^2} = \frac{hc}{\lambda}$

$\Rightarrow \lambda = \frac{2m_e c\lambda_B^2}{h} = \frac{2mc\lambda^2}{h}$ where $\lambda_B = \lambda$ & $m_e = m$.

24. A gas is undergoing change in state by an isothermal process AB as follows. Work done by gas in process AB is

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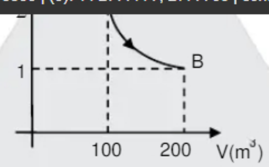

(1) 100 ln2 Joule (2) – 100 ln2 Joule (3) 200 ln2 Joule (4) – 200 ln2 Joule

Ans. (3)

Sol. $W_{isothermal} = P_1V_1 \ln\frac{V_2}{V_1}$

$V_1 = 100m^3$

$V_2 = 200m^3$

$P_1 = 2\ N/m^2$

$W = 2 \times 100 \ln\frac{200}{100}$

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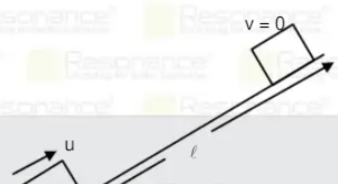
descending and the coefficient of friction is $\mu = \frac{3}{5\sqrt{n}}$. Then n =......



Ans. 3

Sol. $S=\frac{1}{2}a_At_A^2$ .....(1)

$S=\frac{1}{2}a_Dt_D^2$ .....(2)

From Equation (1) & (2)

$\frac{t_A^2}{t_D^2}=\frac{a_D}{a_A}$

$\Rightarrow \frac{t_A^2}{t_D^2}=\frac{g\sin\theta-\mu g\cos\theta}{g\sin\theta+\mu g\cos\theta}$

$\Rightarrow \frac{t_A}{t_D}=\sqrt{\frac{g\sin\theta-\mu g\cos\theta}{g\sin\theta+\mu g\cos\theta}}$

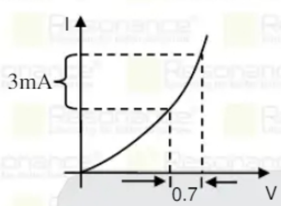
$\Rightarrow \frac{1}{2}=\sqrt{\frac{1-\sqrt{3}\mu}{1+\sqrt{3}\mu}}$

$\Rightarrow 1+\sqrt{3}\mu=4-4\sqrt{3}\mu$

$\Rightarrow 5\sqrt{3}\mu=3$

$\Rightarrow \mu=\frac{3}{5\sqrt{3}}$

26. I – V characteristic curve of a diode in forward bias is given in fig. find out dynamic resistance -



(1) 212.3Ω (2) 205.3Ω (3) 245.3Ω (4) 233.3Ω

Ans. (4)

Sol. Dynamic resistance = $\frac{\Delta V}{\Delta I}$

$=\frac{0.7}{3mA}=233.3\Omega$

27. An electron is accelerated through a voltage of 40 kV. What will be its wavelength ?

(1) 0.061Å (2) 0.011Å (3) 0.021Å (4) 0.161Å

Ans. (1)

Sol. $\lambda_B=\frac{h}{P}$

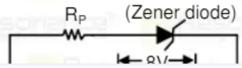
$\frac{h}{}$

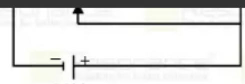
$= \frac{}{\sqrt{2meV}}$

$= \frac{12.27}{\sqrt{V}}$ Å

$= \frac{12.27}{\sqrt{40 \times 10^3}}$ Å $= 0.061$Å

28. Find value of R_P in given ckt ? (V_Z = 8V)





(1) 4Ω (2) 6Ω (3) 3Ω (4) 5Ω

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Ans. (2)

Sol. Applying KVL

$20 - 8 - 2R_P = 0$

$R_P = 6\Omega$

29. Two stars of masses m_1 and m_2 are in mutual interaction and revolving in orbits of radii r_1 and r_2 respectively. Time period of revolution for this system will be ?

(1) $2\pi\sqrt{\frac{(r_1 - r_2)^3}{G(m_1 + m_2)}}$ (2) $2\pi\sqrt{\frac{(r_1 + r_2)^3}{G(m_1 + m_2)}}$ (3) $2\pi\sqrt{\frac{(r_1 - r_2)^3}{G(m_1 - m_2)}}$ (4) $2\pi\sqrt{\frac{(r_1 + r_2)^3}{G(m_1 - m_2)}}$

Ans. (2)

Sol.

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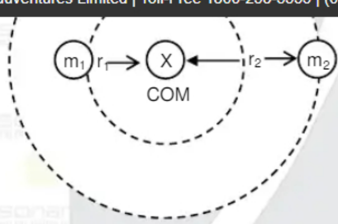

Let angular velocity will be ω

For mass m_1

$$\frac{Gm_1m_2}{(r_1 + r_2)^2} = m_1 r_1 \omega^2 = m_1 \times \frac{m_2(r_1 + r_2)}{m_1 + m_2}\omega^2$$

$$\omega = \frac{\sqrt{G(m_1 + m_2)}}{(r_1 + r_2)^{3/2}}$$

$$T = \frac{2\pi}{\omega}$$

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$= 2\pi\sqrt{} \; G(m_1 + m_2)$

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