# JEE MAIN July 2021

**PHYSICS**

**20th July 2021 [SHIFT – 2]**

**QUESTION WITH SOLUTION**

# JEE I NEET I Foundation

## SECTION - A

**1.** A body at rest is moved along a horizontal straight line by a machine delivering a constant power. The distance moved by the body in time 't' is proportional to :

(1) $t^{\frac{1}{4}}$ (2) $t^{\frac{3}{4}}$ (3) $t^{\frac{3}{2}}$ (4) $t^{\frac{1}{2}}$

**Sol.** **3**

P = constant

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

$$\Rightarrow v \propto \sqrt{t}$$

$$\frac{dx}{dt} = C\sqrt{t}$$ C = constant

by integration.

$$x = C\frac{t^{\frac{1}{2}+1}}{\frac{1}{2}+1}$$

$$x \propto t^{3/2}$$

**2.** An electron having de-Broglie wavelength λ is incident on a target in a X-ray tube. Cut-off wavelength of emitted X-ray is :

(1) 0 (2) $\frac{hc}{mc}$ (3) $\frac{2m^2c^2\lambda^2}{h^2}$ (4) $\frac{2mc\lambda^2}{h}$

**Sol.** **4**

$$\lambda = \frac{h}{mv}$$

Kinetic energy, $\frac{P^2}{2m} = \frac{h^2}{2m\lambda^2} = \frac{hc}{\lambda_c}$

$$\lambda_c = \frac{2m\lambda^2 c}{h}$$

**3.** For a series LCR circuit with R = 100 Ω, L = 0.5 mH and C = 0.1 pF connected across 220 V–50 Hz AC supply, the phase angle between current and supplied voltage and the nature of the circuit is :

(1) ≈ 90°, predominantly inductive circuit
(2) 0°, resistive circuit
(3) 0°, resonance circuit
(4) ≈ 90°, predominantly capacitive circuit

**Sol.** **4**

$$R = 100\Omega$$

$$X_L = \omega L = 50\pi \times 10^{-3}$$

$$X_c = \frac{1}{\omega C} = \frac{10^{11}}{100\pi}$$

$$X_C >> X_L$$

$$\& |X_C - X_L| >> R$$

**4.** At an angle of 30° to the magnetic meridian, the apparent dip is 45°. Find the true dip :

(1) $\tan^{-1}\frac{1}{\sqrt{3}}$ (2) $\tan^{-1}\frac{\sqrt{3}}{2}$ (3) $\tan^{-1}\sqrt{3}$ (d) $\tan^{-1}\frac{2}{\sqrt{3}}$

**Sol.** **2**

$A\tan\delta = \tan\delta'\cos\theta$

$= \tan 45^o \cos 30^o$

$\tan\delta = 1 \times \frac{\sqrt{3}}{2}$

$\delta = \tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$

**5.** A body rolls down an inclined plane without slipping. The kinetic energy of rotation is 50% of its translational kinetic energy. The body is :

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

**Sol.** **2**

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

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

Body is solid cylinder

**6.** Consider a binary star system of star A and star B with masses $m_A$ and $m_B$ revolving in a circular orbit of radii $r_A$ and $r_B$, respectively. If $T_A$ and $T_B$ are the time period of star A and star B, respectively, then –

(1) $T_A = T_B$ (2) $T_A > T_B$ (if $m_A > m_B$)

(3) $T_A > T_B$ (if $r_A > r_B$) (4) $\frac{T_A}{T_B} = \left(\frac{r_A}{r_B}\right)^{3/2}$

**Sol.** **1**

$T_A = T_B (\text{Since } \omega_A = \omega_B)$

**7.** A satellite is launched into a circular orbit of radius R around earth, while a second satellite is launched into a circular orbit of radius 1.02R. The percentage difference in the time periods of the two satellites is -

(1) 1.5 (2) 2.0 (3) 3.0 (4) 0.7

**Sol.** **3**

$T^2 \propto R^3$

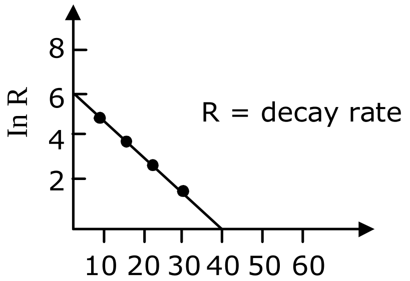
$T = kR^{3/2}$

$\frac{dT}{T} = \frac{3}{2}\frac{dR}{R}$

$= \frac{3}{2}\times 0.02 = 0.03$

% Change = 3%

**8.** For a certain radioactive process the graph between ln R and t(sec) is obtained as shown in the figure. Then the value of half life for the unknown radioactive material is approximately -




(1) 6.93 sec (2) 4.62 sec (3) 2.62 sec (4) 9.15 sec

**Sol. 2**

$R = R_o e^{-\lambda t}$

$\ell nR = \ell nR_o - \lambda t$

$-\lambda$ is slope of straight line

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

$t_{1/2} = \frac{\ell n2}{\lambda} = 4.62$

**9.** A boy reaches the airport and finds that the escalator is not working. He walks up the stationary escalator in time $t_1$. If he remains stationary on a moving escalator then the escalator takes him up in time $t_2$. The time taken by him to walk up on the moving escalator will be -

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

**Sol. 4**

L = length of escalator

$V_{esc} = \frac{L}{t_1}$

When only escalator is moving

$V_{b/esc} = \frac{L}{t_2}$

When both are moving

$V_{b/g} = V_{b/esc} + V_{esc}$

$V_{b/g} = \frac{L}{t_1} + \frac{L}{t_2} \Rightarrow \left[ t = \frac{L}{V_{b/g}} = \frac{t_1 t_2}{t_1 + t_2} \right]$

**10.** A particle is making simple harmonic motion along the x-axis. If at a distance $x_1$ and $x_2$ from the mean position the velocities of the particle are $v_1$ and $v_2$ respectively. The time period of its oscillation is given as -

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

**Sol.** **2**

$$v^2 = \omega^2(A^2 - x^2)$$

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

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

$$T = 2\pi\sqrt{\frac{{x_2}^2 - {x_1}^1}{v_1^2 - v_2^2}}$$

**11.** The magnetic susceptibility of a material of a rod is 499. Permeability in vaccum is $4\pi \times 10^{-7}$ H/m. Absolute permeability of the material of the rod is -

(1) $4\pi \times 10^{-4}$ H/m (2) $\pi \times 10^{-4}$ H/m (3) $2\pi \times 10^{-4}$ H/m (4) $3\pi \times 10^{-4}$ H/m

**Sol.** **3**

$$\mu = \mu_o(1 + x_m)$$

$$= 4\pi \times 10^{-7} \times 500$$

$$= 2\pi \times 10^{-4} H/m$$

**12.** With what speed should a galaxy move outward with respect to earth so that the sodium-D line at wavelength 5890Å is observed at 5896 Å ?

(1) 336 km/sec (2) 296 km/sec (3) 306 km/sec (4) 322 km/sec

**Sol.** **3**

$$f = f_0\sqrt{\frac{1+\alpha}{1-\alpha}} \qquad \beta = \frac{v}{c}$$

$$\frac{f}{f_0} = \sqrt{\frac{1+\alpha}{1-\beta}}$$

$$\frac{f_0 + \Delta f}{f_0} =$$

$$\left(1 + \frac{\Delta f}{f_0}\right)^2 = (1+\beta)(1-\beta)^{-1}$$

$\beta$ is small compared to 1

$$\left(1 + \frac{2\Delta f}{f_0}\right) = (1 + 2\beta)$$

$$\beta = \frac{\Delta F}{F_0} = \frac{v}{c}$$

$$v = 6 \times \frac{c}{5890} = 305.06\,\text{km/s}$$

**13.** If time (t), velocity (u), and angular momentum (I) are taken as the fundamental units. Then the dimension of mass (m) in terms of t, u and I is :

(1) $[t^{-1} u^{-2} I^{1}]$ (2) $[t^{1} v^{2} I^{-1}]$ (3) $[t^{-2} v^{-1} I^{1}]$ (4) $[t^{-1} v^{1} I^{-2}]$

**Sol.** **1**

$$m \propto t^a v^b \ell^c$$

$$m \propto [T]^a[LT^{-1}]^b[ML^2T^{-1}]^c$$

$$M^1L^0T^0 = M^cL^{b+2c}T^{a-b-c}$$

comparing powers

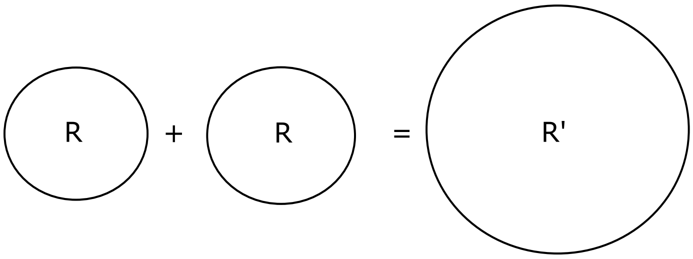
v = 1, b = −2, a = −1

$$m \propto t^{-1}v^{-2}\ell^1$$

**14.** Two small drops of mercury each of radius R coalesce to form a single large drop. The ratio of total surface energy before and after the change is -

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

**Sol.** **1**




$$\frac{4}{3}\pi R^3 + \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R'^3$$

$$R' = 2^{\frac{1}{3}} R \qquad ...(i)$$

$$A_i = 2[4\pi R^2]$$

$$A_f = 4\pi R'^2$$

$$\frac{U_i}{U_f} = \frac{A_i}{A_f} = \frac{2R^2}{2^{2/3}R^2} = 2^{1/3}$$

**15.** Two vectors $\vec{P}$ and $\vec{Q}$ have equal magnitudes. If the magnitude of $\vec{P}+\vec{Q}$ is n times the magnitude of $\vec{P}-\vec{Q}$, then angle between $\vec{P}$ and $\vec{Q}$ is -

(1) $\sin^{-1}\left(\frac{n-1}{n+1}\right)$  (2) $\cos^{-1}\left(\frac{n-1}{n+1}\right)$  (3) $\cos^{-1}\left(\frac{n^2-1}{n^2+1}\right)$  (4) $\sin^{-1}\left(\frac{n^2-1}{n^2+1}\right)$

**Sol.** **3**

$$|\vec{P}+\vec{Q}| = n|\vec{P}-\vec{Q}|$$

$$P^2 + Q^2 + 2PQ\cos\theta = n^2(P^2 + Q^2 - 2PQ\cos\theta)$$

Using (i) in above equation

$$\cos\theta = \frac{n^2-1}{1+n^2}$$

$$\theta = \cos^{-1}\left(\frac{n^2-1}{n^2+1}\right)$$

**16.** The correct relation between the degree of freedom f and the ratio of specific heat $\gamma$ is -

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

**Sol.** **4**

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

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

**17.** The length of a metal wire is $l_1$, when the tension in it is $T_1$ and is $l_2$ when the tension is $T_2$. The natural length of the wire is -

(1) $\sqrt{l_1 l_2}$  (2) $\frac{l_1+l_2}{2}$  (3) $\frac{l_1T_2 - l_2T_1}{T_2 - T_1}$  (4) $\frac{l_1T_2 + l_2T_1}{T_2 + T_1}$

**Sol.** **3**

Let natural length of wire = $\ell_0$

$T_1 = k(\ell_1 - \ell_o)$

$T_2 = k(\ell_2 - \ell_o)$

$\frac{T_1}{T_2} = \frac{(\ell_1 - \ell_o)}{(\ell_2 - \ell_o)}$

$\frac{T_1\ell_2 - T_2\ell_1}{T_1 - T_2} = \ell_o$

$\ell_0 = \frac{\ell_1 T_2 - \ell_2 T_1}{T_2 - T_1}$

**18.** If the kinetic energy of a moving body becomes four times its initial kinetic energy, then the percentage change in its momentum will be -

(1) 100% (2) 300% (3) 400% (4) 200%

**Sol.** **1**

$K_2 = 4K_1$

$\frac{1}{2}mv_2^2 = 4\frac{1}{2}mv_1^2$

$v_2 = 2v_1$

$P = mv$

$P_2 = mv_2 = 2mv_1$

$P_1 = mv_1$

$\% \, change = \frac{\Delta P}{P_1} \times 100 = \frac{2mv_1 - mv_1}{mv_1} \times 100 = 100\%$

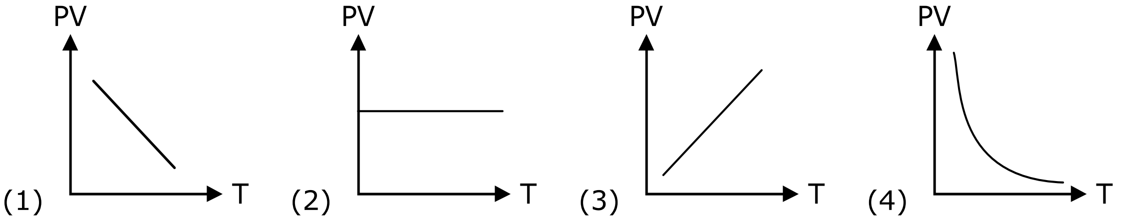
**19.** In an electromagnetic wave the electric field vector and magnetic field vector are given as $\vec{E} = E_0\hat{i}$ and $\vec{B} = B_0\hat{k}$ respectively. The direction of propagation of electromagnetic wave is along.

(1) $\hat{j}$ (2) $(\hat{k})$ (3) $(-\hat{k})$ (4) $(-\hat{j})$

**Sol.** **4**

Direct of propagation = $\vec{E} \times \vec{B} = \hat{i} \times \hat{k} = -\hat{j}$

**20.** Which of the following graphs represent the behavior of an ideal gas ? SYmbols have their usual meaning.




**Sol.** **3**

$PV = nRT$

$PV \propto T$

**Section - B**

**1.** A radioactive substance decays to $\left(\frac{1}{16}\right)^{th}$ of its initial activity in 80 days. The half life of the radioactive substance expressed in days is_____.

**Sol.** **20**

$$N_o \xrightarrow{t_{\frac{1}{2}}} \frac{N_o}{2} \xrightarrow{t_{\frac{1}{2}}} \frac{N_o}{4} \xrightarrow{t_{\frac{1}{2}}} \frac{N_o}{8} \xrightarrow{t_{\frac{1}{2}}} \frac{N_o}{16}$$

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

$$t_{1/2} = 20\, days$$

**2.** A series LCR circuit of R = 5Ω, L = 20 mH and C = 0.5μF is connected across an AC supply of 250 V, having variable frequency. The power dissipated at resonance condition is ______ × $10^2$ W.

**Sol.** **125**

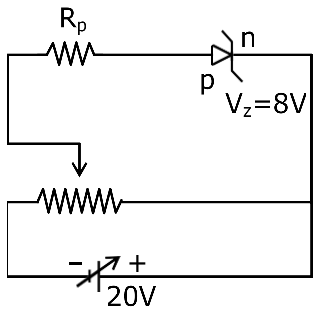
$X_L = X_C$ (due to resonance)

$$Z = R \quad So\, i_{rms} = \frac{V}{Z} = \frac{V}{R}$$

$$\frac{V^2}{R} = \frac{250 \times 250}{5} = 125 \times 10^2 W$$

**3.** A zener diode having zener voltage 8V and power dissipation rating of 0.5W is connected across a potential divide arranged with maximum potential drop across zener diode is as shown in the diagram. The value of protective resistance $R_p$ is _______ Ω.

**Sol.** **192**




**Sol.** **192**

$$P = Vi$$

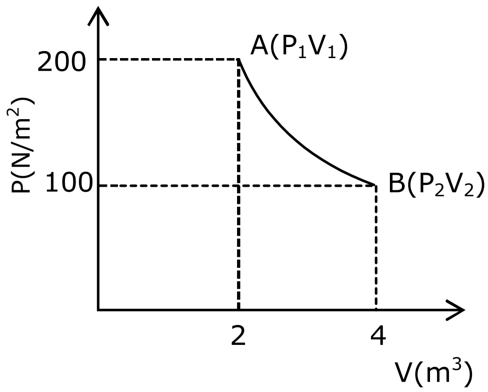
$$0.5 = 8i$$

$$i = \frac{1}{16} A$$

$$E = 20 = 8 + i\ R_p$$

$$R_p = 12 \times 16 = 192\Omega$$

**4.** One mole of an ideal gas at 27°C is taken from A to B as shown in the given PV indicator diagram. The work done by the system will be _________ $\times 10^{-1}$ J.
[Given : R = 8.3 J/mole K, ln2 = 0.6931] (Round off to the nearest integer)




**Sol. 17258**

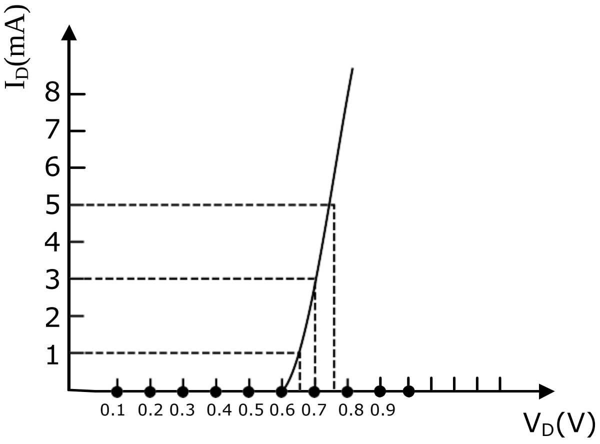
Process of isothermal

$$W = nRT\,ln\left(\frac{V_2}{V_1}\right)$$

$$1 \times 8.3 \times 300 \times \ln 2$$

$$= 17258 \times 10^{-1} J$$

**5.** For the forward biased diode characteristics shown in the figure, the dynamic resistance at $I_D$ = 3mA will be ______ Ω.




**Sol. 25**

$$R_d = \frac{dV}{di} = \frac{1}{\frac{di}{dv}} = \frac{1}{\frac{(5-1)\times 10^{-3}}{0.75-0.65}}$$

$$\frac{100}{4} = 25\Omega$$

**6.** Two bodies, a ring and a solid cylinder of same material are rolling down without slipping an inclined plane. The radii of the bodies are same. The ratio of velocity of the centre of mass at the bottom of the inclined plane of the ring to that of the cylinder is $\frac{\sqrt{x}}{2}$. Then, the value of x is _______

**Sol. 3**

I in both cases is about point of contact IAOR,

Ring,

$$mgh = \frac{1}{2} I\omega^2$$

$$mgh = \frac{1}{2}(2\text{mR}^2)\frac{v_R^2}{R^2}$$

$$V_R = \sqrt{gh}$$

Solid, cylinder

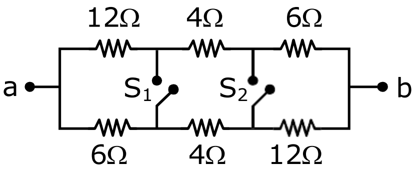
$$mgh = \frac{1}{2} I\omega^2$$

$$mgh = \frac{1}{2}(\frac{3}{2}\text{mR}^2)\frac{v_C^2}{R^2}$$

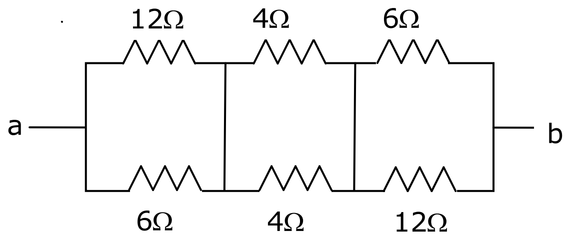
$$V_R = \sqrt{\frac{4gh}{3}}$$

$$\frac{v_R}{v_C} = \frac{\sqrt{3}}{2}$$

**7.** In the given figure switches $S_1$ and $S_2$ are in open condition. The resistance across ab when the switches $S_1$ and $S_2$ are closed is ______ Ω.




**Sol. 10**




$$\frac{12 \times 6}{12+6} + 2 + \frac{6 \times 12}{6+12}$$

$$\frac{72}{18} + 2 + \frac{72}{18} = 4 + 2 + 4 = 10\Omega$$

**8.** A body of mass 'm' is launched up on a rough inclined plane making an angle of 30° with the horizontal. The coeffcient of friction between the body and plane is $\frac{\sqrt{x}}{5}$ if the time of ascent is half of the time of descent. The value of x is ______.

**Sol.** **3**

$t_a = \frac{1}{2} t_d$

$\sqrt{\frac{2s}{a_a}} = \frac{1}{2}\sqrt{\frac{2s}{a_d}}$

$a_a = g\sin\theta + \mu g\cos\theta$

$= \frac{g}{2} + \frac{\sqrt{3}}{2}\mu g$

$a_d = g\sin\theta - \mu g\cos\theta$

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

Using the above values of $a_a$ and $a_d$ and putting in equation (i) we will gate $\mu = \frac{\sqrt{3}}{5}$

**9.** A body rotating with an angular speed of 600 rpm is uniformly accelerated to 1800 rpm in 10 sec. The number of rotations made in the process is _______.

**Sol.** **200**

$\omega_f = \omega_0 + \alpha t$

$\alpha = \frac{1200}{10} \times 60\, rev/\min^2 = 1200 \times 6$

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

$= 600 \times \frac{10}{60} + \frac{1}{2} \times 1200 \times 6 \times \frac{1}{36}(rev)$

$\theta = 200$

**10.** A certain metallic surface is illuminated by monochromatic radiation of wavelength λ. The stopping potential for photoelectric current for this radiation is $3V_0$. If the same surface is illuminated with a radiation of wavelength 2λ, the stopping potential is $V_0$. The threshold wavelength of this surface for photoelectric effect is ______ λ.

**Sol.** **4**

$KE = \frac{hc}{\lambda} - \phi$

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

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

using (i) & (ii)

$\phi = \frac{hc}{4\lambda_0} = \frac{hc}{\lambda_t}$

$\lambda_t = 4\lambda_0$

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