PHYSICS

SECTION-A

1. 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) 200%

(3) 300% (4) 400%

Official Ans. by NTA (1)

Sol. $K_2 = 4K_1$

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

$v_2 = 2v_1$

$P = mv$

$P_2 = mv_2 = 2mv_1$

$P_1 = mv_1$

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

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

Official Ans. by NTA (3)

Sol. L = Length of escalator

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

When only escalator is moving.

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

when both are moving

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

$V_{b/g} = \frac{L}{t_1} + \frac{L}{t_2} \Rightarrow \left[t = \frac{L}{V_{b/g}} = \frac{t_1t_2}{t_1 + t_2}\right]$

3. 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 1.02 R. The percentage difference in the time periods of the two satellites is :

(1) 1.5 (2) 2.0

(3) 0.7 (4) 3.0

Official Ans. by NTA (4)

Sol. $T^2 \propto R^3$

$T = kR^{3/2}$

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

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

% Change = 3%

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

(1) 306 km/sec (2) 322 km/sec

(3) 296 km/sec (4) 336 km/sec

Official Ans. by NTA (1)

Sol. $f = f_0\sqrt{\frac{1+\beta}{1-\beta}}$ $\beta = \frac{v}{c}$

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

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

β is small compared to 1

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

$\beta = \frac{\Delta f}{f_0} = \frac{v}{c}$

$v = 6\times\frac{c}{5890} = 305.6\text{ km/s}$

5. 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) $\sqrt{\ell_1 \ell_2}$ (2) $\frac{\ell_1 T_2 - \ell_2 T_1}{T_2 - T_1}$

(3) $\frac{\ell_1 T_2 + \ell_2 T_1}{T_2 + T_1}$ (4) $\frac{\ell_1 + \ell_2}{2}$

Official Ans. by NTA (2)

Sol. $T_1 = k(\ell_1 - \ell_0)$

$T_2 = k(\ell_2 - \ell_0)$

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

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

6. 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) $(\hat{k})$ (2) $\hat{j}$

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

Official Ans. by NTA (4)

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

7. 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) 0°, resistive circuit

(2) ≈ 90°, predominantly inductive circuit

(3) 0°, resonance circuit

(4) ≈ 90°, predominantly capacitive circuit

Official Ans. by NTA (4)

Sol. $R = 100\Omega$

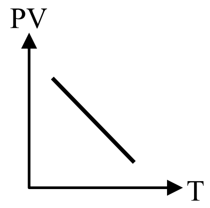
$X_L = \omega L = 50\pi \times 10^{-3}$

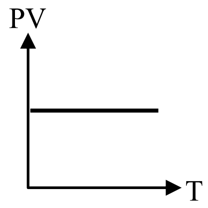
$X_C = \frac{1}{\omega C} = \frac{10^{11}}{100\pi}$

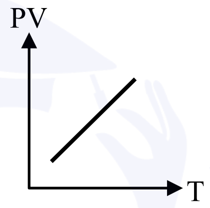
$X_C >> X_L$

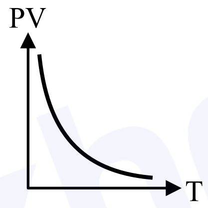
$\& \ |X_C - X_L| >> R$

8. Which of the following graphs represent the behavior of an ideal gas ? Symbols have their usual meaning.

(1) 

(2) 

(3) 

(4) 

Official Ans. by NTA (3)

Sol. PV = nRT

$PV \propto T$

Straight line with positive slope (nR)

9. A particle is making simple harmonic motion along the X-axis. If at a distances 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) $T = 2\pi\sqrt{\frac{x_2^2 - x_1^2}{v_1^2 - v_2^2}}$

Official Ans. by NTA (4)

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

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

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

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

10. 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) $\frac{2m^2c^2\lambda^2}{h^2}$

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

Official Ans. by NTA (3)

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

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

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

11. 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

Official Ans. by NTA (2)

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

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

Body is solid cylinder

12. If time (t), velocity (v), and angular momentum (l) are taken as the fundamental units. Then the dimension of mass (m) in terms of t, v and l is :

(1) $[t^{-1} v^1 l^{-2}]$ (2) $[t^1 v^2 l^{-1}]$

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

Official Ans. by NTA (4)

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

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

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

comparing powers

c = 1, b = –2, a = –1

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

13. The correct relation between the degrees of freedom f and the ratio of specific heat γ is :

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

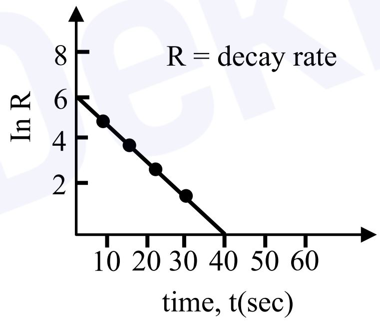
(3) $f = \frac{\gamma + 1}{2}$ (4) $f = \frac{1}{\gamma + 1}$

Official Ans. by NTA (1)

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

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

14. For a certain radioactive process the graph between In 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) 9.15 sec (2) 6.93 sec

(3) 2.62 sec (4) 4.62 sec

Official Ans. by NTA (4)

Sol.

0

$\ell nR = \ell nR_0 - \lambda t$

$-\lambda$ is slope of straight line

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

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

15. 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) $\frac{T_A}{T_B} = \left(\frac{r_A}{r_B}\right)^{\frac{3}{2}}$

(2) $T_A = T_B$

(3) $T_A > T_B$ (if $m_A > m_B$)

(4) $T_A > T_B$ (if $r_A > r_B$)

Official Ans. by NTA (2)

Sol. $T_A = T_B$ (since $\omega_A = \omega_B$)

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

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

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

Official Ans. by NTA (4)

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

$= \tan 45°\cos 30°$

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

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

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

Official Ans. by NTA (1)

Sol. P = constant

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

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

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

by integration.

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

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

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

Official Ans. by NTA (4)

Sol. $|\vec{P}| = |\vec{Q}| = x$ …(i)

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

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

Using (i) in above equation

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

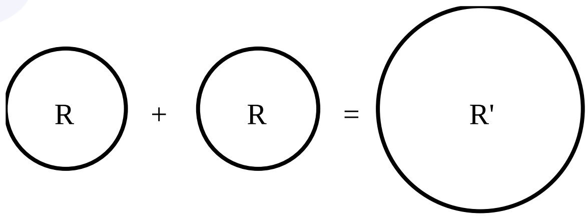
$\theta = \cos^{-1}\left(\frac{n^2-1}{n^2+1}\right)$

19. 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) $2^{\frac{1}{3}}:1$ (2) $1:2^{\frac{1}{3}}$ (3) 2 : 1 (4) 1 : 2

Official Ans. by NTA (1)

Sol.



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

$R' = 2^{\frac{1}{3}}R$ ….(i)

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

$A_f = 4\pi R'^2$

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

20. The magnetic susceptibility of a material of a rod is 499. Permeability in vacuum 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) $2\pi \times 10^{-4}$ H/m

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

Official Ans. by NTA (2)

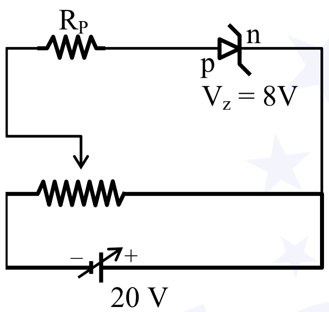
Sol. $\mu = \mu_0 (1 + x_m)$

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

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

SECTION-B

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



Official Ans. by NTA (192)

Sol. P = Vi

0.5 = 8i

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

$E = 20 = 8 + i R_P$

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

2. A body of mass '*m*' is launched up on a rough inclined plane making an angle of 30° with the horizontal. The coefficient 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 ______.

Official Ans. by NTA (3)

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

$$\sqrt{\frac{2s}{a_a}} = \frac{1}{2}\sqrt{\frac{2s}{a_d}} \quad \text{....(i)}$$

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

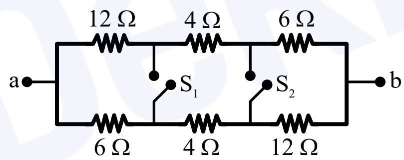
$$= \frac{g}{2} + \frac{\sqrt{3}}{2}\mu g$$

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

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

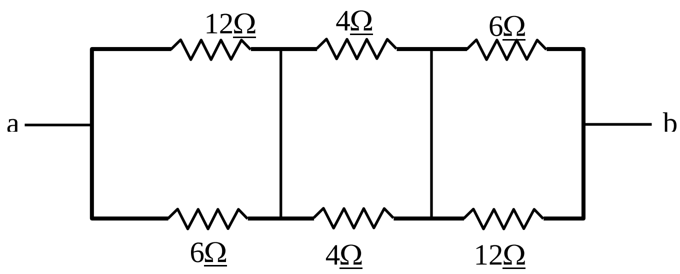
using the above values of a_a and a_d and putting in equtión (i) we will gate $\mu = \frac{\sqrt{3}}{5}$

3. 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.



Official Ans. by NTA (10)

Sol. when switch S_1 and S_2 are closed



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

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

4. 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 _____.

Official Ans. by NTA (3)

Sol. I in both cases is about point of contact

Ring

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

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

$$v_R = \sqrt{gh}$$

Solid cylinder

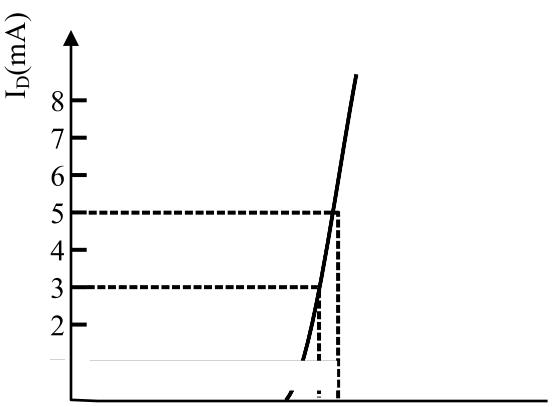
$$mgh = \frac{1}{2}I\omega^2$$

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

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

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

5. For the forward biased diode characteristics shown in the figure, the dynamic resistance at I_D = 3 mA will be_______Ω.



Official Ans. by NTA (25)

Sol. $R_d = \frac{dV}{di} = \frac{1}{\frac{di}{dv}} = \frac{1}{\frac{5-1\times10^{-3}}{0.75-0.65}}$

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

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

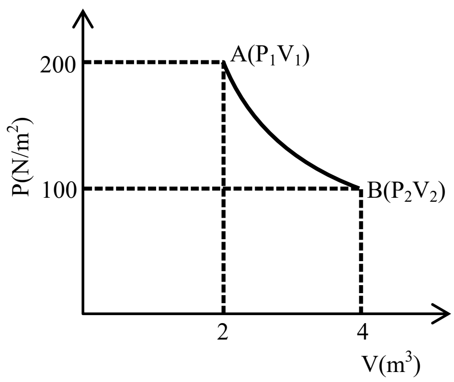
Official Ans. by NTA (125)

Sol. $X_L = X_C$ (due to resonance)

$$Z = R \text{ so } i_{rms} = \frac{V}{Z} = \frac{V}{R}$$

$$\frac{V^2}{R} = \frac{250\times250}{5} = 125\times10^2\text{ W}$$

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



Official Ans. by NTA (17258)

Sol. Process of isothermal

$$W = nRT\ell n\left(\frac{V_2}{V_1}\right)$$

= 1 × 8.3 × 300 × ln2

= 17258 ×10^{-1} J

8. 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.

Official Ans. by NTA (4)

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

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

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

Using (i) & (ii)

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

$\lambda_t = 4\lambda_0$

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___.

Official Ans. by NTA (200)

Sol. $\omega_f = \omega_0 + \alpha t$

$\alpha = 1200 \times 6$

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

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

$\theta = 200$

10. 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____.

Official Ans. by NTA (20)

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

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

$t_{1/2} = 20$ days