PART : PHYSICS

1. A deuteron & α-particle both enters in a region of magnetic field perpendicular to it with same kinetic energy find the ratio of their radii ?

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

Ans. (3)

Sol. $r = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}$

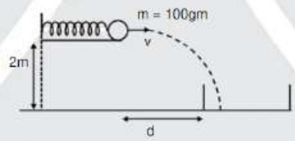
$r \propto \frac{\sqrt{m}}{q}$

$m_\alpha = 2m_d$

$q_\alpha = 2q_d$

$\frac{r_d}{r_\alpha} = \frac{\sqrt{m_d}}{q_d} \times \frac{2q_d}{\sqrt{2m_d}} = \sqrt{2}$

2. In the given arrangement, spring of spring constant 100 N/m is compressed by 0.5m. The height of the arrangement is 2m. A basket is placed at distance d such that after projection, ball will fall in the basket. If the mass of the ball is 100 gm, find maximum value of d ?



(1) 5 m (2) 10 m (3) 15 m (4) 20 m

Ans. (2)

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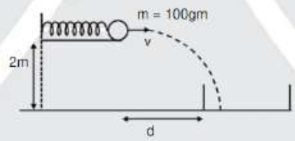

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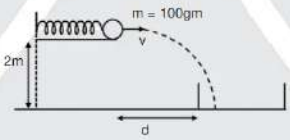


(1) 5 m (2) 10 m (3) 15 m (4) 20 m

Ans. (2)

Sol. By energy conservation

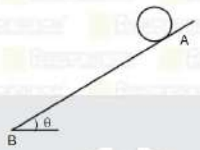
$\frac{1}{2}kx^2 = \frac{1}{2}mv^2 \Rightarrow v = x\sqrt{\frac{k}{m}}$ $\quad v = 0.5 \times \sqrt{\frac{100}{0.1}} = 5\sqrt{10}\,m/s$

Time of flight of ball $T = \sqrt{\frac{2H}{g}} = \sqrt{\frac{2 \times 2}{10}} = \frac{2}{\sqrt{10}}$ sec

Range of ball s = ut

$d = 5\sqrt{10} \times \left(\frac{2}{\sqrt{10}}\right) = 10m$

3. When a disc slides on smooth inclined surface from rest, the time taken to move from A to B if t_1. When disc performs pure rolling from rest then time taken to move from A to B is t_2. If $\frac{t_2}{t_1} = \sqrt{\frac{3}{x}}$ find x.



Ans. 2

Sol. When disc slides $a_1 = g\sin\theta$ So $S = ut_1 + \frac{1}{2}a_1t_1^2 = \frac{1}{2}g\sin\theta.t_1^2$ ...(1)

When disc do pure rolling $a_2 = \frac{g\sin\theta}{1+k^2/R^2} = \frac{g\sin\theta}{1+1/2} = \frac{2}{3}g\sin\theta$

So $S = ut_2 + \frac{1}{2}a_2t_2^2 = \frac{1}{2}.\frac{2}{3}g\sin\theta.t_2^2$ ...(2)

From (1) & (2)

$\frac{t_2}{t_1} = \sqrt{\frac{3}{2}}$

4. We have a charge of magnitude Q. If we divide charge in two parts, what should be their ratio so that there will be max repulsion force between them ?

(1) 1 : 1 (2) 2 : 1 (3) 1 : 2 (4) 3 : 2

Ans. (1)

Sol.

$F = \frac{Kq_1q_2}{r^2} = \frac{K(q)(Q-q)}{r^2}$

$\frac{dF}{dq} = 0$

$Q - 2q = 0$

$q = Q/2$

ratio = 1 : 1

5. Four planks are arranged in a lift going upwards with an acceleration of 0.2 m/s² as shown in figure. Find

$$F = \frac{Kq_1q_2}{r^2} = \frac{K(q)(Q-q)}{r^2}$$

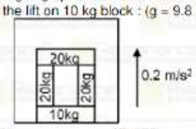
$$\frac{dF}{dq} = 0$$

$Q - 2q = 0$

$q = Q/2$

ratio = 1 : 1

5. Four planks are arranged in a lift going upwards with an acceleration of 0.2 m/s^2 as shown in figure. Find the normal reaction applied by the lift on 10 kg block : ($g = 9.8$ m/s^2)

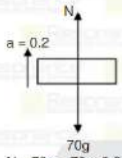


(1) 500 (2) 700 (3) 672 (4) 800

Ans. (2)

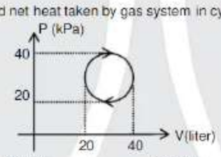
Sol.

Sol.



$N - 70g = 70 \times 0.2$
$N = 70(g + 0.2)$
$N = 700$

6. For given PV curve. Find net heat taken by gas system in cyclic process.



(1) 25π (2) 50π (3) 75π (4) 100π

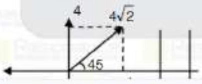
Ans. (4)

Sol. $\Delta Q = W + \Delta U = W$ = area enclosed by the curve
$\Delta Q = \pi ab$
$= \left[\frac{40-20}{2} \times 10^3\right] \times \left[\frac{40-20}{2} \times 10^{-3}\right]$
$= 100\pi$ Joule

7. A butterfly is flying in North–East with $4\sqrt{2}$ m/s w.r.t. wind. Wind is blowing at 1 m/s southwards. Displacement of butterfly in 3s is
(1) 10 meter (2) 15 meter (3) 20 meter (4) 5m

Ans. (2)

Sol.



$= \left[\frac{\quad}{2} \times 10\right] \times \left[\frac{\quad}{2} \times 10\right]$

$= 100\,\pi$ Joule

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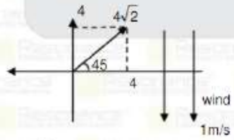


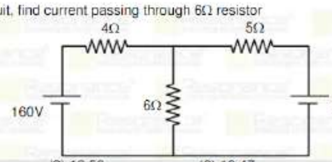
$\vec{D} = v_{F,G} \times T$

$= \{4\hat{i} + 4\hat{j} + (-\hat{j})\} \times 3s$

$= (4\hat{i} + 3\hat{j}) \times 3s$

$|\vec{D}| = 15m$

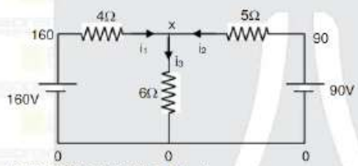
8. In the given circuit, find current passing through 6Ω resistor



(1) 15.67 (2) 16.50 (3) 18.47 (4) 10.46

Ans. (1)

Sol.



Let potential at junction point = x

By KCL $\sum i_{in} = 0$

$$\Rightarrow \frac{160-x}{4}+\frac{90-x}{5}+\frac{0-x}{6}=0$$

$$\Rightarrow \frac{160\times15-15x+90\times12-12x+0-10x}{60}=0$$

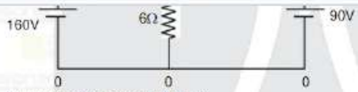
$$\Rightarrow 37x = 2400+1080$$

$$x = 94.05$$

So current $i_3 = \frac{x}{6}$

$$= \frac{94.05}{6} = 15.67$$

9. In the given system, uniform magnetic field exists from x = 0 to x = b. A rod is first moved from x = 0 to x = 2b uniformly and then moved reverse uniformly from x = 2b to x = 0. Match the quantities with proper curves



Let potential at junction point = x

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$\Rightarrow \frac{160 - x}{4} + \frac{90 - x}{5} + \frac{0 - x}{6} = 0$

$\Rightarrow \frac{160 \times 15 - 15x + 90 \times 12 - 12x + 0 - 10x}{60} = 0$

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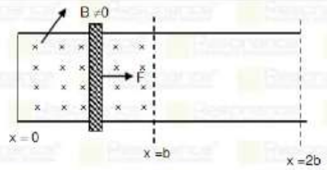
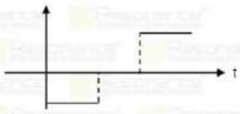
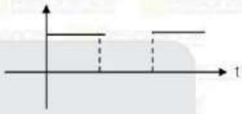
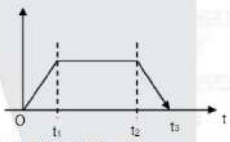


Column-I		Column-II	
(a)	Flux (ϕ)	(i)	
(b)	EMF (e)	(ii)	
(c)	Power (P)	(iii)	

(1) (a) – (iii), (b) – (i), (c) – (ii)
(2) (a) – (ii), (b) – (iii), (c) – (i)
(3) (a) – (iii), (b) – (ii), (c) – (i)
(4) (a) – (i), (b) – (iii), (c) – (ii)

Ans. (1)

Sol. Flux = ϕ = B.A

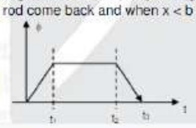
$\Rightarrow$ B × A cos0

Where A = ℓvt

ϕ = Bℓvt

One rod go at x > b then ϕ stop changing this constant flux = Bℓb.

When rod come back and when x < b flux start decreasing so graph ϕv/st



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Ans. (1)

Sol. Flux = ϕ = B.A

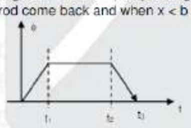
$\Rightarrow$ $B \times A \cos 0$

Where $A = \ell vt$

$\phi = B\ell vt$

One rod go at x > b then ϕ stop changing this constant flux = $B\ell b$.

When rod come back and when x < b flux start decreasing so graph ϕ v/s t



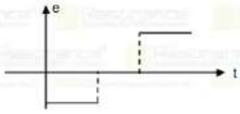
b → (ii)

$$e = \frac{-d\phi}{dt}$$

e = – slope of ϕ – t graph

In 0 – t_1 graph slope +ve and constant so e = negative and zero.

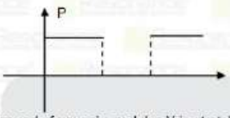
in t_2–t_3 slope of ϕ–t is negative and constant so e = positive and zero



Power = $\frac{e^2}{R}$

Resistance is only of rod so R of the circuit is constant

$$P = \frac{B^2\ell^2v^2}{R} = \text{constant}$$



10. 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

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

11. If $\vec{A}\cdot\vec{B} = |\vec{A}\times\vec{B}|$; Find $|\vec{A} - \vec{B}|$

(1) $\sqrt{A^2 + B^2 - \sqrt{2}AB}$

(2) $\sqrt{A^2 + B^2 + \sqrt{2}AB}$

(3) A – B

(4) A + B

Ans. (1)

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

Dividing

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

11. If $\vec{A}\cdot\vec{B} = |\vec{A}\times\vec{B}|$; Find $|\vec{A}-\vec{B}|$

(1) $\sqrt{A^2 + B^2 - \sqrt{2}AB}$

(2) $\sqrt{A^2 + B^2 + \sqrt{2}AB}$

(3) $A - B$

(4) $A + B$

Ans. (1)

Sol. $\vec{A}\cdot\vec{B} = |\vec{A}\times\vec{B}|$

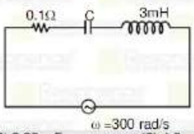
$\Rightarrow$ $AB\cos\theta = AB\sin\theta$

$\therefore$ $\theta = 45^\circ$

$\therefore$ $|\vec{A}-\vec{B}| = \sqrt{A^2 + B^2 - 2AB\cos 45^\circ}$

$= \sqrt{A^2 + B^2 - \sqrt{2}AB}$

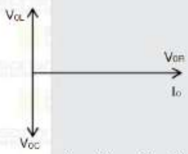
12. In the L-C-R series A.C. circuit shown fellow, current leads source voltage by 45°. Find capacitance of the capacitor.

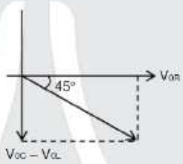


(1) 2.1 mF (2) 3.33 mF (3) 4.3 mF (4) 5.1 mF

Ans. (2)

Sol.





$\tan 45^\circ = \frac{V_{0C} - V_{0L}}{V_{0R}} = \frac{X_C - X_L}{R}$

$R = \frac{1}{\omega C} - \omega L$

$0.1\Omega = \frac{1}{300C} - 3 \times 10^{-3} \times 300$

$\Rightarrow C = 3.33$ mF (approx)

13. A radioactive material having number of active nuclei N is decaying by two processes, one with half-life of 1400 yr and other with half-life of 700 yr. After how much time number of active nuclei will be N/3?

(1) 520 yr (2) 740 yr (3) 470 yr (4) 640 yr

Ans. (2)

Sol.

V_{0C} $\qquad$ $V_{0C} - V_{0L}$

$$\tan 45^\circ = \frac{V_{0C} - V_{0L}}{V_{0R}} = \frac{X_C - X_L}{R}$$

$$R = \frac{1}{\omega C} - \omega L$$

$$0.1\Omega = \frac{1}{300C} - 3 \times 10^{-3} \times 300$$

$$\Rightarrow C = 3.33 \text{ mF (approx)}$$

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(1) 520 yr (2) 740 yr (3) 470 yr (4) 640 yr

Ans. (2)

Sol. X → A (1400 year); X → B (700 year)

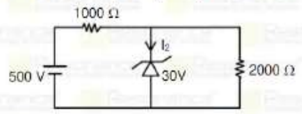
$$-\frac{dN_x}{dt} = \lambda_1 N_x + \lambda_2 N_x$$

$$\int_N^{N/3} \frac{dN_x}{N_x} = \int_0^t (\lambda_1 + \lambda_2)dt$$

$$\ln 3 = \left(\frac{\ln 2}{1400} + \frac{\ln 2}{700}\right)t$$

$$t = \frac{\ln 3}{\ln 2} \times \frac{1400}{3} = 740 \text{ year}$$

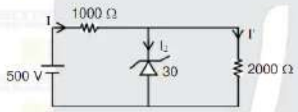
14. In the given circuit find current 'I' passing through Zener diode?



(1) 0.445 A (2) 0.345 A (3) 0.245 A (4) 0.145 A

Ans. (1)

Sol.



$I = \frac{500 - 30}{1000} = 0.47 \text{ A}$

$I' = \frac{30}{2000} = 0.015$

$I = I_z + I'$

$I_z = I - I = 0.47 - 0.015 = 0.445 \text{ A}$

15. The wave number of the spectral line in the emission spectrum of hydrogen will be equal to 8/9 times of the Rydberg's constant. Then the electron jumps from

(1) $5 \to 2$ (2) $5 \to 3$ (3) $3 \to 1$ (4) $4 \to 2$

Ans. (3)

Sol. $\bar{v} = Rz^2\left(\frac{1}{n_L^2} - \frac{1}{n_H^2}\right)$

If $n_L = 1$, $n_H = 3$; $\bar{v} = R.1\left[\frac{1}{1} - \frac{1}{(3)^2}\right]$; $\bar{v} = \frac{8}{9}R$

16. A vehicle moving with velocity v and releasing sound of frequency 400 Hz. Listening the reflected sound

$I = I_2 + I'$

$I_2 = I - I' = 0.47 - 0.015 = 0.445$ A

15. The wave number of the spectral line in the emission spectrum of hydrogen will be equal to 8/9 times of the Rydberg's constant. Then the electron jumps from

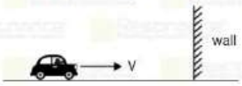
(1) $5 \rightarrow 2$ (2) $5 \rightarrow 3$ (3) $3 \rightarrow 1$ (4) $4 \rightarrow 2$

Ans. (3)

Sol. $\bar{v} = Rz^2\left(\frac{1}{n_L^2} - \frac{1}{n_H^2}\right)$

If $n_L = 1$, $n_H = 3$; $\bar{v} = R.1\left[\frac{1}{1} - \frac{1}{(3)^2}\right]$; $\bar{v} = \frac{8}{9}R$

16. A vehicle moving with velocity v and releasing sound of frequency 400 Hz. Listening the reflected sound from a wall of frequency 500 Hz. Find the velocity of vehicle v.



(1) 36.67 m/s (2) 30.12 m/s (3) 22.37 m/s (4) 20.25 m/s

Ans. (1)

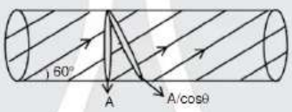
Sol. Frequency received by wall $f' = \left(\frac{v_s}{v_s - v}\right) f_0$

Reflected frequency received by man is $f'' = \left(\frac{v_s + v}{v_s}\right) f'$

$\Rightarrow \quad f'' = \left(\frac{v_s + v}{v_s}\right)\left(\frac{v_s}{v_s - v}\right) f_0 \Rightarrow \quad f'' = \left(\frac{v_s + v}{v_s - v}\right) f_0 \Rightarrow \quad 500 = \left(\frac{330 + v}{330 - v}\right) 400$

$\Rightarrow \quad v = \frac{330}{9} = 36.67 \text{ m/s}$

17 In a magnesium rod of area $3m^2$, current $I = 5A$ is flowing at angle of $60°$ from axis of rod. Resistivity of material is 44×10^{-2} ohm × m. Find electric field inside the rod?



(1) 0.567 (2) 0.367 (3) 0.667 (4) 0.767

Ans. (2)

Sol. $J = \sigma E$

$\frac{I}{A_{effective}} = \frac{E}{\rho}$

$E = \frac{\rho I}{A} \cos 60° = \frac{44 \times 10^{-2} \times 5}{3 \times 2}$; $E = 0.367$

18. Four moles of a diatomic gas is heated from 0°C to 50°C. Find the heat supplied to the gas if work done by it is zero.

(1) 700 R (2) 600 R (3) 500 R (4) 100 R

Ans. (3)

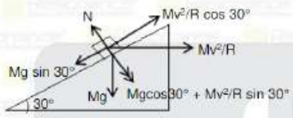
Sol. $n = 4$

19. A car is moving on a Banked rough road, the mass of car is 800 kg. The angle of Banking is 30°, car is moving with maximum speed given that $\mu_s = 0.2$. find the Normal Reaction (in Newton)?

(1) 24000 (2) 5000 (3) 10000 (4) 9000

Ans. (3)

Sol.



Perpendicular to inclined plane

$$N = mgcos30^\circ + \frac{mv^2}{R}\sin30^\circ$$

$$N - mgcos30^\circ = \frac{mv^2}{R}\sin30^\circ \quad ...(1)$$

along inclined plane

$$mgsin30^\circ + \mu_s N = \frac{mv^2}{R}\cos30^\circ \quad ...(2)$$

Dividing (1) by (2)

$$\frac{N - mgcos30^\circ}{mgsin30^\circ + \mu_s N} = \tan30^\circ$$

Solving N = 10000 (Approx)

20. A particle of mass m moving with speed v collide elastically with the end of a uniform rod of mass M and length L perpendicularly as shown in figure. If the particle comes to rest after collision find the value of $\frac{m}{M}$.

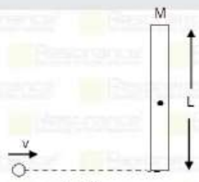
M

Dividing (1) by (2)

$$\frac{N - mg\cos 30^\circ}{mg\sin 30^\circ + \mu_s N} = \tan 30^\circ$$

Solving N = 10000 (Approx)

20. A particle of mass m moving with speed v collide elastically with the end of a uniform rod of mass M and length L perpendicularly as shown in figure. If the particle comes to rest after collision find the value of $\frac{m}{M}$.



(1) 1/3 (2) 1/2 (3) 1/4 (4) 1/5

Ans. (3)