PART : PHYSICS

1. Two masses each of mass 1 kg are separated by a distance 2R, rotating under their mutual gravitation force. Find their angular velocity :

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

Ans. **(1)**

Sol. $\frac{Gm^2}{4R^2} = m\omega^2 R$

$\omega = \sqrt{\frac{Gm}{4R^3}}$

$\omega = \frac{1}{2}\sqrt{\frac{G}{R^3}}$

2. A conducting wire has resistance 16Ω at 15ºC and 20Ω at 100ºC. Find temperature coefficient of resistance

(1) $\frac{1}{340}$ ºC^{-1} (2) $\frac{1}{200}$ ºC^{-1} (3) $\frac{1}{470}$ ºC^{-1} (4) $\frac{1}{300}$ ºC^{-1}

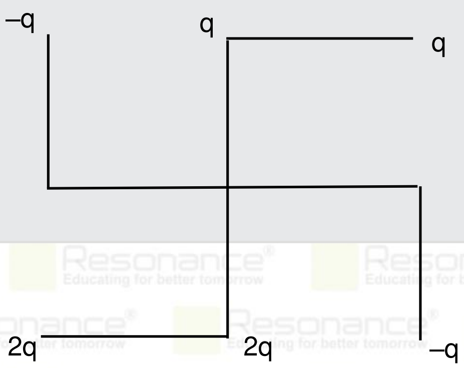
Ans. **(1)**

Sol. $R' = R(1 + \alpha\Delta t)$

$20 = 16(1 + \alpha . 85)$

$\alpha = \frac{\frac{20}{16}-1}{85} = \frac{1}{4\times 85} = \frac{1}{340}\,°C^{-1}$

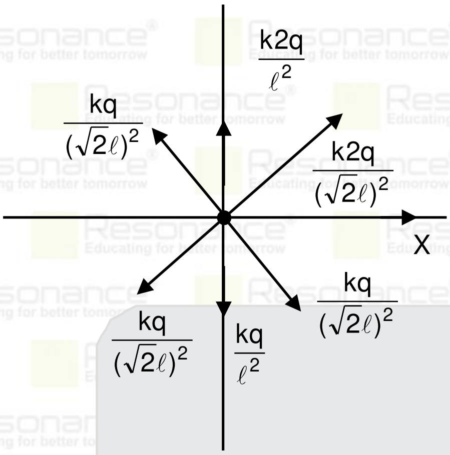
3. In the figure each side has length ℓ. Find electric field at centre :



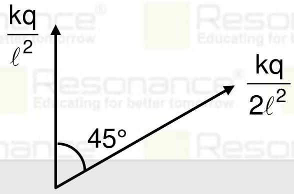
(1) $\frac{kq}{2\ell^2}(\sqrt{2}-1)$ (2) $\frac{kq\sqrt{2}}{2\ell^2}$ (3) $\frac{kq}{\ell^2}\sqrt{\left(\frac{5}{4}+\frac{1}{\sqrt{2}}\right)}$ (4) $\frac{kq}{\ell^2}(\sqrt{2}+1)$

Ans. **(3)**

Sol.



$\Rightarrow$



$$E = \frac{kq}{\ell^2}\left(\sqrt{1+\frac{1}{4}+2\times\frac{1}{2}\times\frac{1}{\sqrt{2}}}\right)$$

$$= \frac{kq}{\ell^2}\sqrt{\left(\frac{5}{4}+\frac{1}{\sqrt{2}}\right)}$$

4. A force $F = F_0\left[1-\left(\frac{T-t}{T}\right)^2\right]$ start to act on a ball of mass m at t = 0. Initially ball was at rest. Find velocity of the ball at t = 2T :

(1) $\frac{F_0}{m}\left[\frac{4T}{3}\right]$ (2) $\frac{F_0}{m}\left[\frac{3T}{2}\right]$ (3) $\frac{F_0}{m}\left[\frac{T}{3}\right]$ (4) $\frac{F_0}{m}\left[\frac{T}{2}\right]$

Ans. **(1)**

Sol. acceleration of ball

$$\mathbf{a} = \frac{F}{m}$$

$$\mathbf{a} = \frac{F_0}{m}\left[1-\left(\frac{T-t}{T}\right)^2\right]$$

$$\frac{dv}{dt} = \frac{F_0}{m}\left[1-\left(\frac{T-t}{T}\right)^2\right]$$

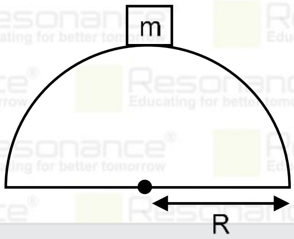
$$\int_0^v dv = \frac{F_0}{m}\int_0^{2T}\left[1-\left(\frac{T-t}{T}\right)^2\right]dt$$

$$V = \frac{F_0}{m}\left[t+\frac{1}{3T^2}(T-t)^3\right]_0^{2T}$$

$$V = \frac{F_0}{m}\left\{\left[2T+\frac{1}{3T^2}(T-2T)^3\right]-\left[0+\frac{T^3}{3T^2}\right]\right\}$$

$$V = \frac{F_0}{m}\left[\frac{4T}{3}\right]$$

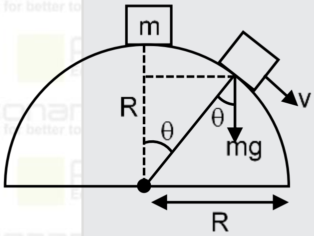
5. A block of mass m as shown in figure is released from rest from the top of a fixed smooth hemisphere. Find the angle made by this particle with vertical at the instant when it looses contact with the hemisphere:



(1) $\cos^{-1}(2/3)$ (2) $\cos^{-1}(1/3)$ (3) $\cos^{-1}(1/2)$ (4) $\cos^{-1}(1/4)$

Ans. **(1)**

Sol.



From work energy theorem $W = \Delta K$

$Mg(R - R\cos\theta) = 1/2\ mv^2$

$v = \sqrt{2gR(1-\cos\theta)}$

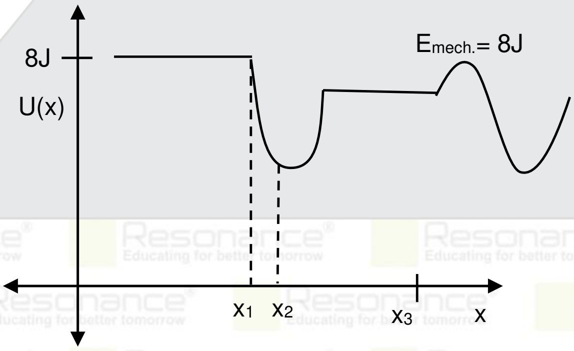
To loose contact $\frac{mv^2}{R} = mg\cos\theta$

$M2g(1 - \cos\theta) = mg\cos\theta$

$2 - 2\cos\theta = \cos\theta$

$\cos\theta = 2/3$; $\theta = \cos^{-1}(2/3)$

6. Figure shows variation of potential energy (U) verses displacement (x) graph :



Find the correct statement :

(1) $x < x_1$, KE is least and body has constant speed.

(2) $x = x_2$, K.E is minimum

(3) $x > x_2$ K.E. is maximum and velocity is maximum

(4) $x > x_2$ K.E. is minimum so velocity is minimum

Ans. **(1)**

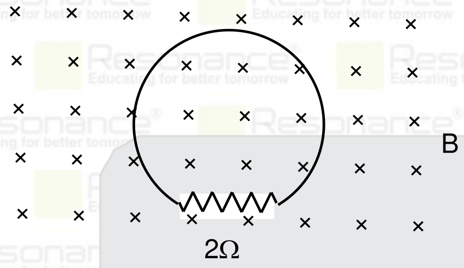
Sol. K + U = E mechanical energy = constant

7. Magnetic flux in a circular loop having resistance of 2Ω is varying with time as $\phi = 10t^2 + 20t$. What will be the current in circuit at t = 5sec. (in Ampere)

(1) 20 (2) 40 (3) 60 (4) 80

Ans. **(3)**

Sol.



$\varepsilon = \left|-\frac{d\phi}{dt}\right| = 20t + 20$

at t = 5sec, ε = 120 V

thus, $i = \frac{\varepsilon}{R} = \frac{120}{2}$ = 60 Amp.

8. Match list-I with list-II and select the correct option from below the list

List -I	**List-II (Dimension)**
1. Electric field intensity (E)	(i) $M^{-1}L^{-2}I^2T^{+4}$
2. Magnetic permeability (μ_0)	(ii) $M^{-1}L^{-3}T^4I^2$
3. Electrical permittivity ($\in_0$)	(iii) $MLI^{-1}T^{-3}$
4. Capacitance (C)	(iv) $ML^2T^{-4}I^{-2}$

(1) 1→ (ii), 2 → (iii), 3 → (iv), 4 → (i)
(2) 1→ (iii), 2 → (i), 3 → (iii), 4 → (ii)
(3) 1→ (iii), 2 → (iv), 3 → (ii), 4 → (i)
(4) 1→ (ii), 2 → (iv), 3 → (i), 4 → (iii)

Ans. **(3)**

9. A block of mass 1kg connected to a massless spring fixed from one end executing SHM. Initially at mean position. Its amplitude is 5 cm and time period is 0.2 sec. Find potential energy after 0.05 sec.

(1) $\frac{1}{2}$J (2) $\frac{3}{4}$J (3) $\frac{5}{6}$J (4) $\frac{5}{4}$J

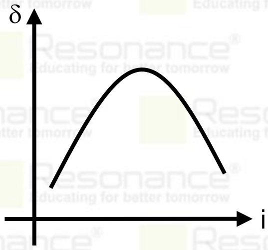
Ans. **(4)**

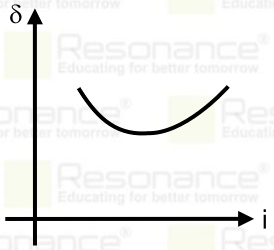
Sol. A $t = \frac{T}{4}$ particle is at extreme. $\upsilon = K.E_{max} = \frac{1}{2} m\omega^2A^2$, $T = 2\pi\sqrt{\frac{m}{K}}$

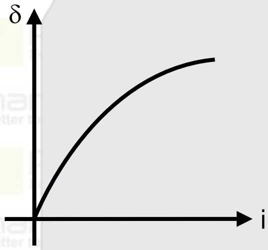
$= \frac{1}{2}m\left(\frac{2\pi}{0.2}\right)^2 A^2$

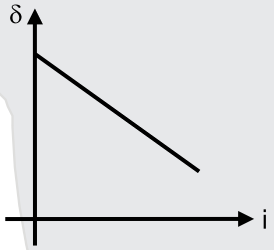
$= \frac{1}{2}\times 100\pi^2 \times \frac{25}{10000} = \frac{5}{4}$J

10. Which of the following is correct graph between deviation (δ) and angle of incident 'i', if a ray of light passes through a prism :

(1)


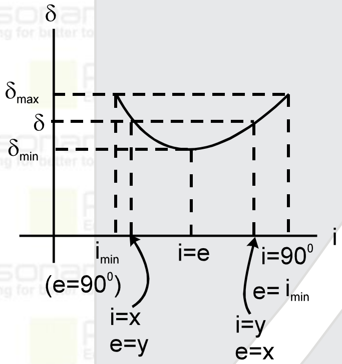
(2)


(3)


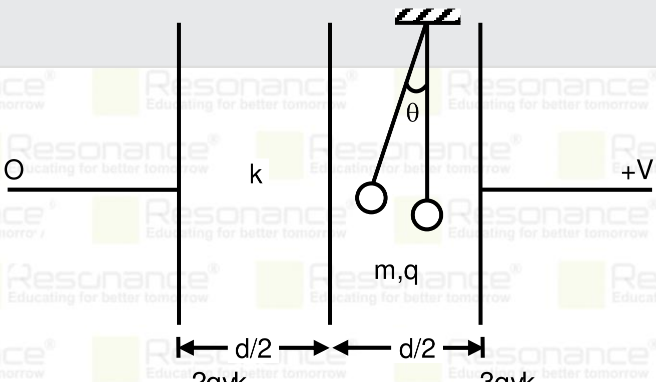
(4)


Ans. **(2)**

Sol. $\therefore\ \delta = i + e - A.$



11. Pendulum bob of mass m and charge q is hinge between the plates of a parallel plate capacitor. The first half of space between the plates is filled with dielectric of dielectric constant K and another half is vacuum, where bob is hinged. What will be the angular deflection in string of pendulum with vertical if bob is in equilibrium. The voltage across capacitor is V.



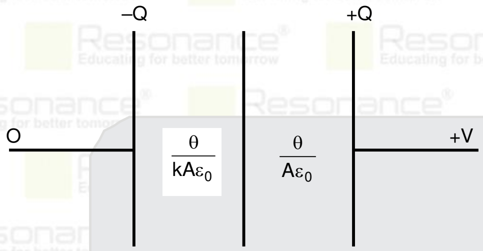
(1) $\tan^{-1}\dfrac{qvk}{(k+1)mgd}$ (2) $\tan^{-1}\dfrac{2qvk}{(k+1)mgd}$ (3) $\tan^{-1}\dfrac{3qvk}{(k+1)mgd}$ (4) $\tan^{-1}\dfrac{4qv(k+1)}{(k)mgd}$

Ans. **(2)**

Sol. (C_{eq}) Equivalent capacitance = $\dfrac{\varepsilon_0 A}{\dfrac{d}{2k}+\dfrac{d}{2}} = \dfrac{2\varepsilon_0 Ak}{d(k+1)}$

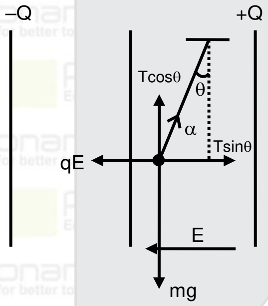
potential difference = V

charge on capacitor = v × C_{eq} = $\dfrac{2\varepsilon_0 AVk}{d(k+1)}$



$\Rightarrow$ Electric field in vacuum = $\dfrac{Q}{A\varepsilon_0} \Rightarrow \dfrac{2Vk\varepsilon_0 A}{d(k+1)A\varepsilon_0}$

$E = \dfrac{2Vk}{d(k+1)}$



As bob is in equilibrium

$T\cos\theta = mg$

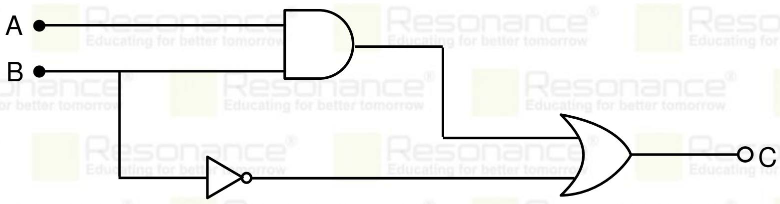
$T\sin\theta = qE$

$\tan\theta = \dfrac{qE}{mg}$

$\tan\theta = \dfrac{q2Vk}{mgd(k+1)}$

$\theta = \tan^{-1}\left(\dfrac{2qVk}{mgd(k+1)}\right)$

12. For the given gate circuit, choose the correct truth table ?



(1)

A	B	C
0	0	0
0	1	0
1	0	1
1	1	1

(2)

A	B	C
0	0	1
0	1	0
1	0	1
1	1	1

(3)

A	B	C
0	0	1
0	1	1
1	0	1
1	1	1

(4)

A	B	C
0	0	1
0	1	0
1	0	0
1	1	0

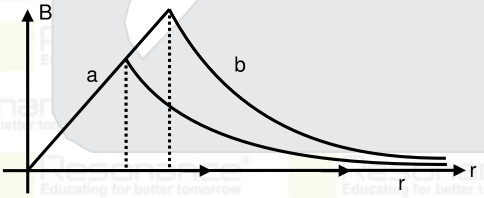
Ans. (3)

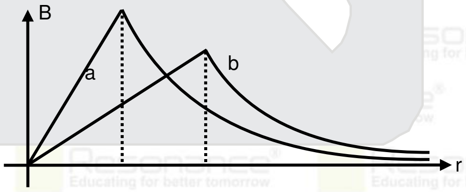
13. Write the approx. Value of plank's constant & permittivity constant :

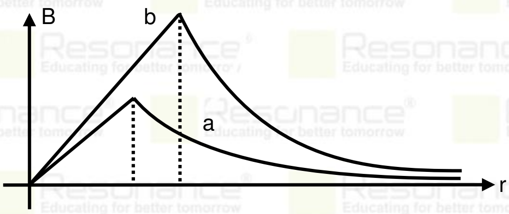
(1) 6.6×10^{-34} J-s, 8.85×10^{-12} F/m
(2) 6.6×10^{-19} J-s, 8.85×10^{-12} F/m
(3) 6.6×10^{-34} J-s, 9×10^{9} m/F
(4) None

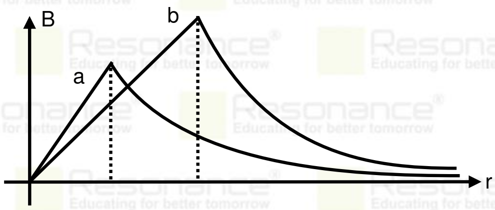
Ans. (1)

14. Two long wires having same current having radius a & b (a < b) what will be the correct representation of magnetic field intensity v/s r :

(1)


(2)


(3)


(4)


Ans. (2)

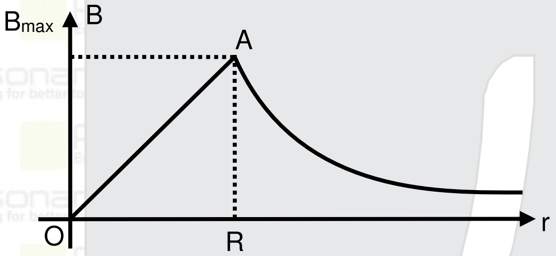
Sol. B due to wire :

$r < R \quad B = \frac{\mu_0 J r}{2}$

where $J = \frac{i}{\pi R^2}$

for wire of radius a $J_1 = \frac{i}{\pi a^2}$

for wire of radius b $J_2 = \frac{i}{\pi b^2}$



slope of OA = J

$B_{max} = \frac{\mu_0 J R}{2} = \frac{\mu_0 i R}{2\pi R^2} = \frac{\mu_0 i}{2\pi R}$

we can see slope of wire of radius a (J_1) > slope of wire of radius b (J_2)

as b > a then B_{max} for a > B_{max} for b.

So Ans (B)

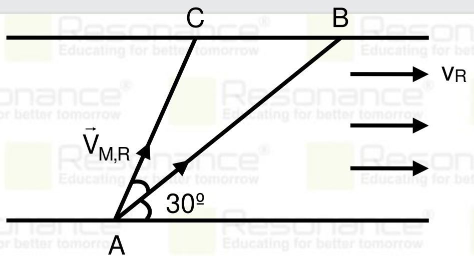
15. If Thomson model is considered and α rays are bombard on this model then, α rays will :

(1) deflected at wide angle
(2) reflected all at
(3) will pass undeviated
(4) all deflected at same angle

Ans. (3)

Sol. Theory based

16. A man crosses a river flowing with speed same as speed of man with respect to river. If man cross the river along path AB making an angle of 30º with the direction of river flow. Man starts swimming along line Ac, making an angle θ with path AB. then value of θ was ?



(1) 60º
(2) 30º
(3) 45º
(4) 75º

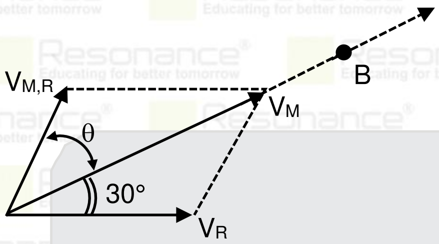
Ans. (2)

Sol. $\vec{V}_M = \vec{V}_{M,R} + \vec{V}_R$

V_M should be along line AB

$\Rightarrow \quad |\vec{V}_{M,R}| = |\vec{V}_R|$

As $|\vec{V}_{M,R}| = |\vec{V}_R|$



$\therefore$ V_M should be along angle bisector of angle between $\vec{V}_{M,R}$ and $\vec{V}_R$

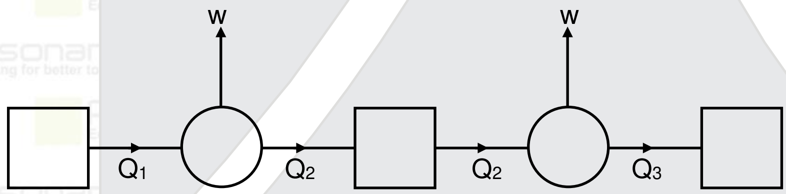
$\therefore \quad \theta = 30°$

17. Two Carnot engines A and B are operated in series. The first one, A receives heat at T_1 (=600 K) and rejects to a reservoir at temperature T_2. The second engine B receives heat rejected by the first engine and, in turn, rejects to a heat reservoir at T_3 (=400K). Calculate the temperature T_2 if the work outputs of the two engines are equal :

(1) 500 k (2) 300 K (3) 600 K (4) 400 K

Ans. **(1)**

Sol.



$W = Q_1 - Q_2$

$W = Q_2 - Q_3$

$Q_1 - Q_2 = Q_2 - Q_3$

$Q_1 + Q_3 = 2Q_2$

$$\frac{Q_1}{Q_2} + \frac{Q_3}{Q_2} = 2$$

$$\frac{T_1}{T_2} + \frac{T_3}{T_2} = 2 \Rightarrow T_2 = \frac{T_1 + T_3}{2} = 500\text{ K.}$$

18. An electron and a proton combined to form a H-atom in which electron is in 2nd excited state. From this excited state it releases a photon that strike a metal and emits an electron. The threshold wavelength for metal is 4000 Å , then find maximum possible kinetic energy for emitted electron.

(1) 9.0 eV (2) 3.1 eV (3) 7.1 eV (4) 13.6 eV

Ans. **(1)**

Sol. $E = 13.6\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]ev$

$E = 13.6\left[\frac{1}{1} - \frac{1}{(3)^2}\right]$

$E = 13.6\left[\frac{8}{9}\right] = 12.1\ eV$

$KE_{max} = E - \frac{hc}{\lambda_0} = 12.1 - \frac{12400}{4000}\ eV$

$= 12.1 - 3.1\ eV = 9.0\ eV$

19. Rain drops are falling vertically on earth with speed of 20m/s. Now wind start blowing horizontally with speed of 5m/s and a cyclist is moving with speed of 35 m/s opposite to the wind. Then find the velocity of rain with which rain hitting the cyclist.

(1) $10\sqrt{5}$ (2) $22\sqrt{5}$ (3) $20\sqrt{5}$ m/s (4) $\frac{22}{\sqrt{5}}$

Ans. **(3)**

Sol. $V_{rg} = V_{rw} + {}^{V}w_g$

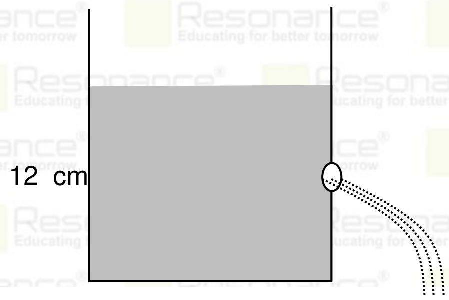
$= -20\hat{J} + 5\hat{I}$

$V_{rain,cy} = V_{raing} - V_{cy.g}$

$= -20\hat{J} + 5\hat{I} - 35(-\hat{I}) = -20\hat{J} + 40(\hat{I})$

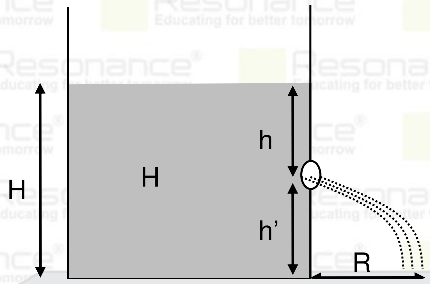
$V_{rain,\ cy} = \sqrt{20^2 + 40^2} = 20\sqrt{5}$ m/s

20. A beaker filled to the height of 12 cm was given, find the location where a hole should be made for max range.



Ans. 6

Sol. $R = 2\sqrt{hh'}$



R is maximum when h'= h

$\therefore$ h' = h = H/2

= 12/2 = 6

21. A particle performing SHM is given by x = A sin(ωT + Φ). At t = 0, particle is at x = 2 and its velocity is 2ω then find amplitude :

(1) $2\sqrt{2}$ (2) $5\sqrt{2}$ (3) $4\sqrt{2}$ (6) $6\sqrt{2}$

Ans. **(1)**

Sol. $2 = A\sin(0 + \phi)$

$\Rightarrow \sin\phi = \frac{2}{A}$

$\Rightarrow \cos\phi \sqrt{1-\frac{4}{A^2}} = \sqrt{\frac{A^2-4}{A^2}}$

$V = \frac{dx}{dt}$

$V = A\omega\cos(\omega t + \phi)$

$\Rightarrow 2\omega = A\omega\cos(0 + \phi)$

$\Rightarrow 2 = A\cos\phi$

$\Rightarrow A = \frac{2}{\cos\phi}$ .... (i)

$\Rightarrow A = \frac{2}{\sqrt{\frac{A^2-4}{A^2}}}$

$\Rightarrow A = \frac{2A}{\sqrt{A^2-4}}$

$\Rightarrow \sqrt{A^2-4} = 2$

$\Rightarrow A = \pm\sqrt{8}$

22. A body of mass m at rest starts moving along straight line by a machine delivering a constant power. Distance travelled by body in time t is :

(1) $\frac{4\sqrt{\frac{2p}{m}}}{3}\times t^{3/2}$ (2) $\frac{2\sqrt{\frac{2p}{m}}}{3}\times t^{3/2}$ (3) $\frac{\sqrt{\frac{2p}{m}}}{3}\times t^{3/2}$ (4) $2\sqrt{3\frac{2p}{m}}\times t^{3/2}$

Ans. **(2)**

Sol. Energy supply = Pt

in t sec

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

$V = \sqrt{\frac{2pt}{m}}$

$\frac{dS}{dt} = \sqrt{\frac{2p}{m}}\sqrt{t}$

$\int_0^S dS = \sqrt{\frac{2p}{m}}\int_0^t t^{1/2}dt$

$S = \frac{2\sqrt{\frac{2p}{m}}t^{3/2}}{3}$

$t^{3/2} = \frac{3S}{2\sqrt{\frac{2p}{m}}}$

$S = \frac{2\sqrt{\frac{2p}{m}}}{3}\times t^{3/2}$

23. In a communication, a message signal of amplitude 4 V is modulated with carrier signal of amplitude 12V, then find modulation index.

(1) $\frac{1}{2}$ (2) $\frac{1}{3}$ (3) $\frac{1}{4}$ (4) $\frac{1}{6}$

Ans. **(2)**

Sol. $A_{max} = 12 + 4 = 16$ V

$A_{min} = 12 - 4 = 8$V

$\therefore\ m = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} = \frac{16-8}{16+8} = \frac{8}{24} = \frac{1}{3}$

24. 1 moles of an ideal gas undergoes adiabatic process, which increases the temperature form 27°C to 37°C. Gas is polyatomic has 4 vibrational modes of freedom. Find net work :

(1) Work done by the gas 528 J
(2) Work done on the gas 582 J
(3) Work done on the gas 382 J
(4) Work done by the gas 382 J

Ans. **(2)**

Sol. $f = 3 + 3 + (4 \times 2)$

$f = 14$

$$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1} = \frac{nR(T_1 - T_2)}{\gamma - 1}$$

$$= \frac{1 \times 8.314 \times (-10)}{\left(\frac{8}{7} - 1\right)} \quad \left(\because \gamma = 1 + \frac{2}{f} = \frac{8}{7}\right)$$

$= -\ 582$ J