Q-1 - 10964560

$x-t$ equation of a particle in SHM is

$x=(4cm)\cos\left(\frac{\pi}{2}t\right)$

Here ,t is in seconds. Find the distance travelled by the particle in first three seconds.

CORRECT ANSWER: A::B::C

SOLUTION:

$A=4cm$

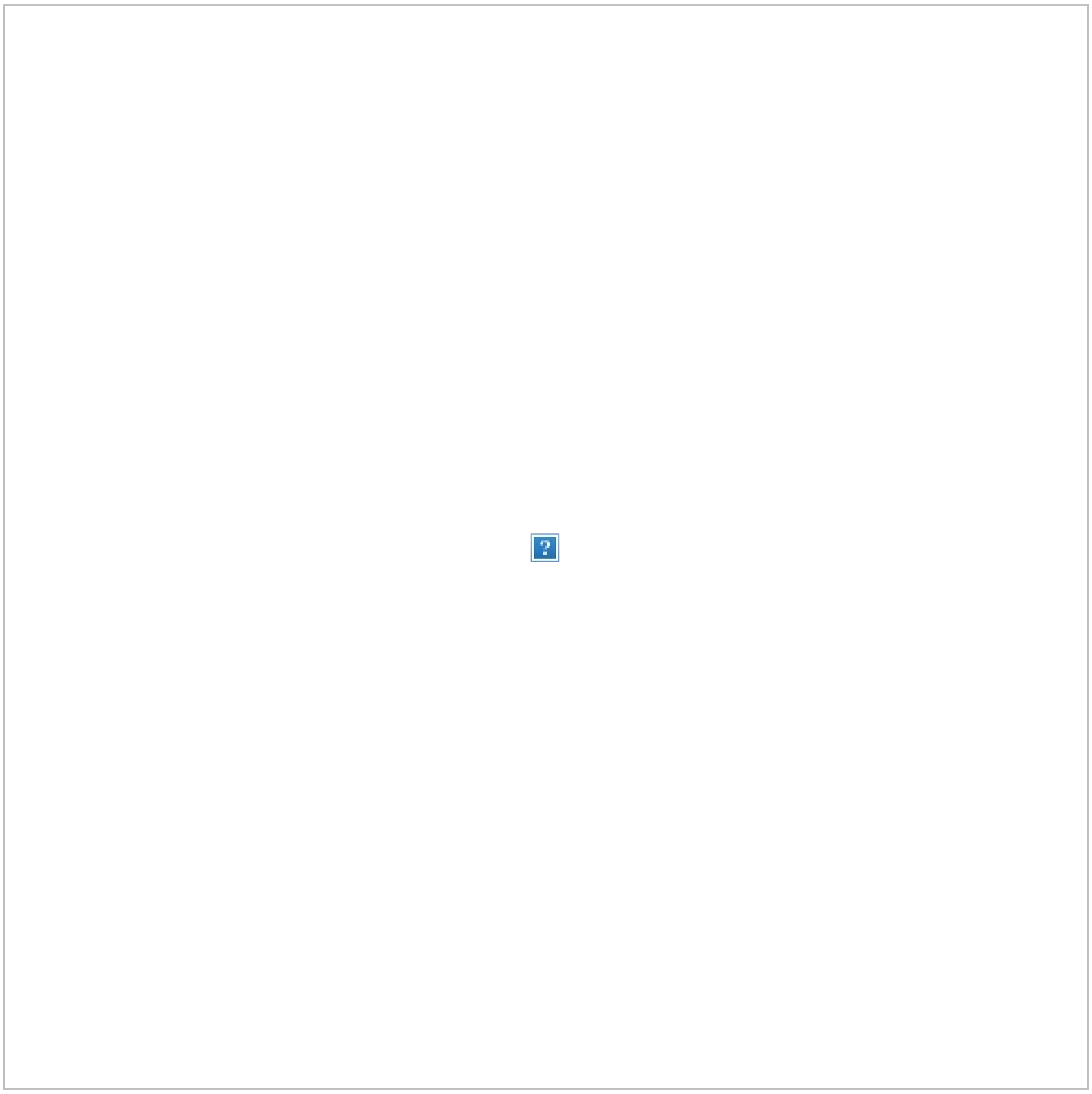
$\omega=\left(\frac{\pi}{2}\right)rad/s$

$\therefore T=\frac{2\pi}{T}=4\sec$

The given equation is $x=A\cos\omega t$

Therefore, the particle starts from $x = +A$

The given time $t = 3 \sec$ is $\frac{3T}{4}$. So, the particle moves from $+A$ to $-A$ and then from $-A$ to O.



So, distance travelled in the given time interval is $3A$ or $12cm$.

Q-2 - 11446994

A wave travelling along X-axis is given by

$y = 2(mm)\sin(3t - 6x + \pi$
$/4)$

where x is in centimetres and t in second. Write the phases and,

hence, the find the phase difference between them at t=0 for two

points on X-axis, $x = x_1 = \pi/3$ cm and $x = x_2 = \pi/2$ cm.

SOLUTION:

At $t = 0$

$y = \sin(-6x + \pi/4)$

phase at

$x_1, \phi = \left(-6 \times \frac{\pi}{3}\right.$

$\left. + \frac{\pi}{4}\right) = \frac{7}{4}\pi$

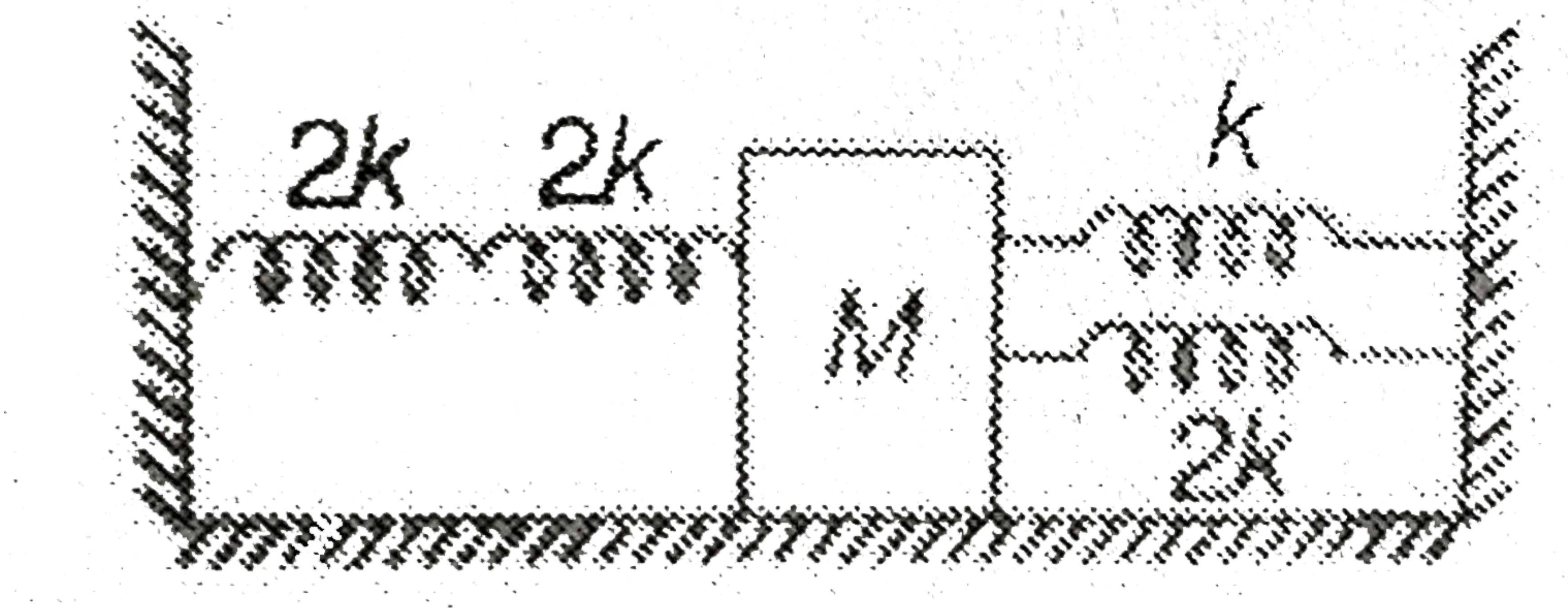
and that at

$$x_2 is\left(-6\times\frac{\pi}{2}+\frac{\pi}{4}\right)$$
$$=\frac{11}{4}\pi$$

the phase difference is $\left|\frac{7}{4}\pi-\frac{11}{4}\pi\right|=\pi$, the dusturbation at the two point are out of phase.

Q-3 - 17936984

Four massless springs whose force constants are 2k, 2k, k and 2k respectively are attached to a mass M kept on a frictionless plane (as shown in figure). If the mass M is displaced in the horizontal direction.



(A) $\dfrac{\frac{1}{2\pi}}{\sqrt{\frac{k}{4M}}}$

(B) $\dfrac{1}{2\pi}\sqrt{\dfrac{4k}{M}}$

(C) $\dfrac{1}{2\pi}\sqrt{\dfrac{k}{7M}}$

(D) $\dfrac{1}{2\pi}\sqrt{\dfrac{7k}{M}}$

CORRECT ANSWER: B

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Q-4 - 12230032

A particle is subjected to two mutually perpendicular simple harmonic motions such that its X and y coordinates are given by

$X = 2\sin\omega t$, $y = 2\sin\left(\omega + \frac{\pi}{4}\right)$

The path of the particle will be:

(A) an ellipse

(B) a straight line

(C) a parabola

(D) a circle

CORRECT ANSWER: A

Q-5 - 14927923

The time period of a mass suspended from a spring is T. If the spring is cut into four equal parts and the same mass is suspended from one of the parts, then the new time period will be

(A) 2T

(B) $\frac{T}{4}$

(C) 2

(D) $\frac{T}{2}$

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Q-6 - 17937028

A cylinderical block of wood of mass m and area cross-section A is floating in water (density = ρ) when its axis vertical. When dressed a little and the released the block starts oscillating. The period oscillations is

(A) $\left(2\pi\sqrt{\frac{m}{\rho bid \wedge g}}\right.$

(B) $2\pi\sqrt{\frac{mg}{\rho A}}$

(C) $2\pi\sqrt{\frac{\rho A g}{m}}$

(D) $2\pi\frac{\sqrt{\rho A}}{mg}\Bigg)$

CORRECT ANSWER: A

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Q-7 - 11446813

Frequency of a particle executing SHM is 10 Hz. The particle is suspended from a vertical spring. At the highest point of its oscillation the spring is unstretched. Maximum speed of the particle is $\left(g = 10\frac{m}{s}\right)$

(A) $2\pi\frac{m}{s}$

(B) $\pi\frac{m}{s}$

(C) $\frac{1}{\pi}\frac{m}{s}$

(D) $\frac{1}{2\pi} / \frac{m}{s}$

CORRECT ANSWER: D

SOLUTION:

Mean position of the particle is $\frac{mg}{k}$ distance below the unstretched position of spring. Therefore aplitude of oscillation $A = \frac{mg}{k}$

$\omega = \sqrt{\frac{k}{m}} = 2\pi f$

$= 20\pi (f = 10Hz)$

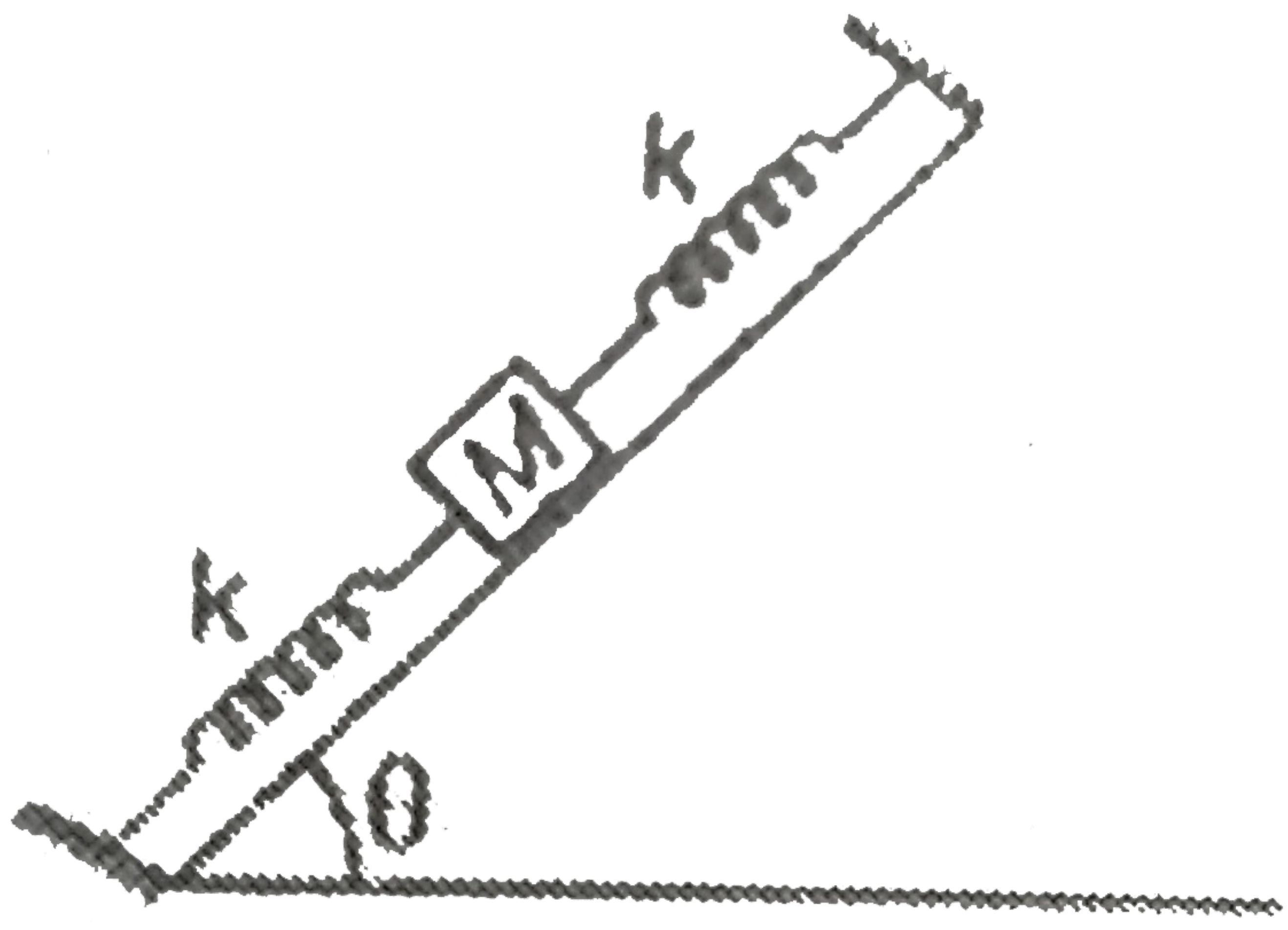
$\frac{m}{k} = \frac{1}{400\pi^2}$

$v_{\max} = A\omega = \frac{g}{400\pi^2}$

$\times 20\pi = \frac{1}{2\pi} \frac{m}{s}$

Q-8 - 17937004

On a smooth inclined plane a body of mass M is attached between two springs. The other ends of the springs are fixed to firm supports. If each spring has a force constant k, the period of oscilation of the body is (assuming the spring as massless)



(A) $2\pi\sqrt{\frac{M}{2k}}$

(B) $2\pi\frac{\sqrt{2M}}{k})$

(C) $2\pi\frac{\sqrt{M\sin\theta}}{2k}$

(D) $2\pi\frac{\sqrt{2M\sin\theta}}{k})$

CORRECT ANSWER: A

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Q-9 - 14799457

Displacement-time equation of a particle executing SHM is

$x = A\sin\left(\omega t + \frac{\pi}{6}\right)$ Time taken by the particle to go directly from $x = -\frac{A}{2}$ to $x = +\frac{A}{2}$

(A) $\frac{\pi}{3\omega}$

(B) $\frac{\pi}{2\omega}$

(C) $\frac{\pi}{\omega}$

(D) $\frac{\pi}{\omega}$

CORRECT ANSWER: A

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Q-10 - 17936990

A cuboidal piece of wood has dimensions a, b and c. its relatively density is d. it is floating in a large body of water such that side a is vertical. It is pushed down a bit and released. The time period of SHM executed by it is

(A) $2\pi\frac{\sqrt{abc}}{g}$

(B) $2\pi\sqrt{\frac{g}{da}}$

(C) $2\pi\sqrt{\frac{bc}{dg}}$

(D) $2\pi\sqrt{\frac{da}{g}}$

CORRECT ANSWER: D

Q-11 - 15085600

A wire having mass per unit length m and length L is fixed between two fixed vertical walls at a separation L. Due to its own weight the wire sags. The sag in the middle is $d(< \; < L)$. Assume that tension is practically constant along the wire, owing to its small mass. Calculate the speed of the transverse wave on the wire.

CORRECT ANSWER: $V = LSQRT\left(\frac{G}{8D}\right)$

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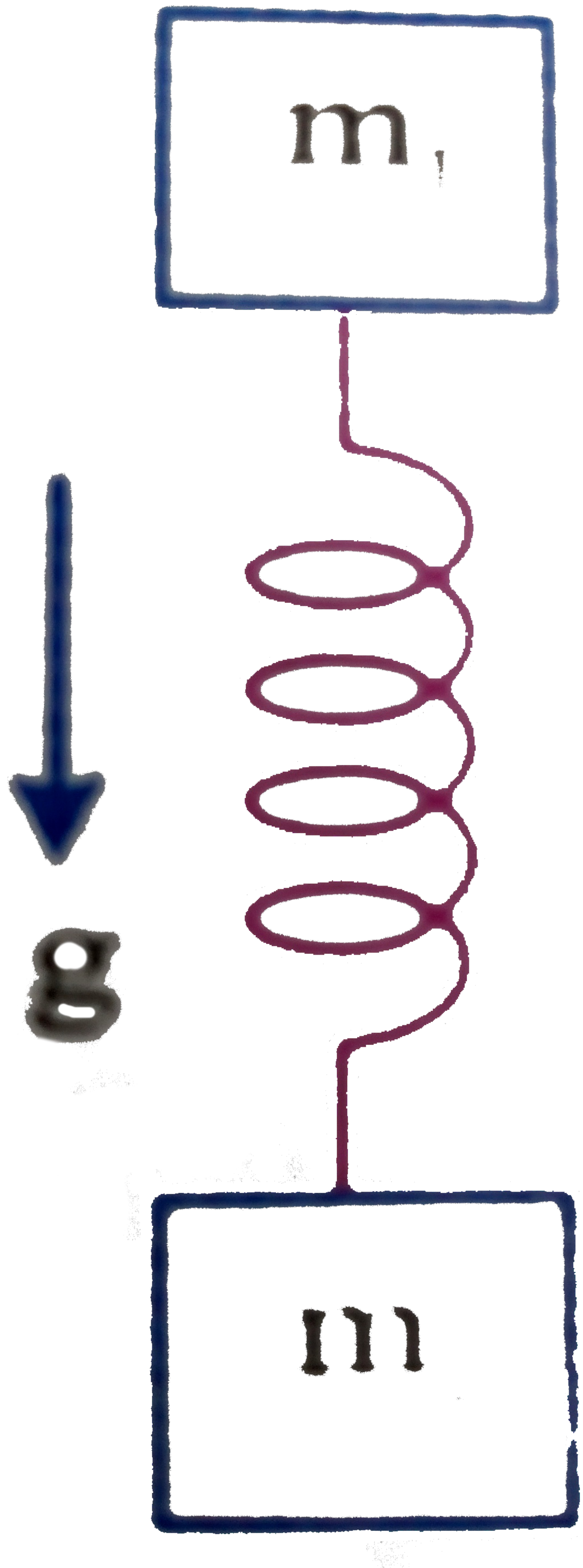
Q-12 - 13163435

There is a spring with netural length L_0. Two masses m_1 and m_2 are connected to both of its ends as shown in figure. The whole system is held at rest. At any time $t = 0$, m_2 is released and system starts free fall. Initial stretched length of spring before fall is L. what is the displacement of centre of mass as function of time?



(A) gt^2

(B) $\frac{1}{2}gt^2$

(C) $\frac{g}{K}t^2$

(D) $\frac{m_1 + m_2}{m_1 m_2} \times t$

CORRECT ANSWER: B

SOLUTION:

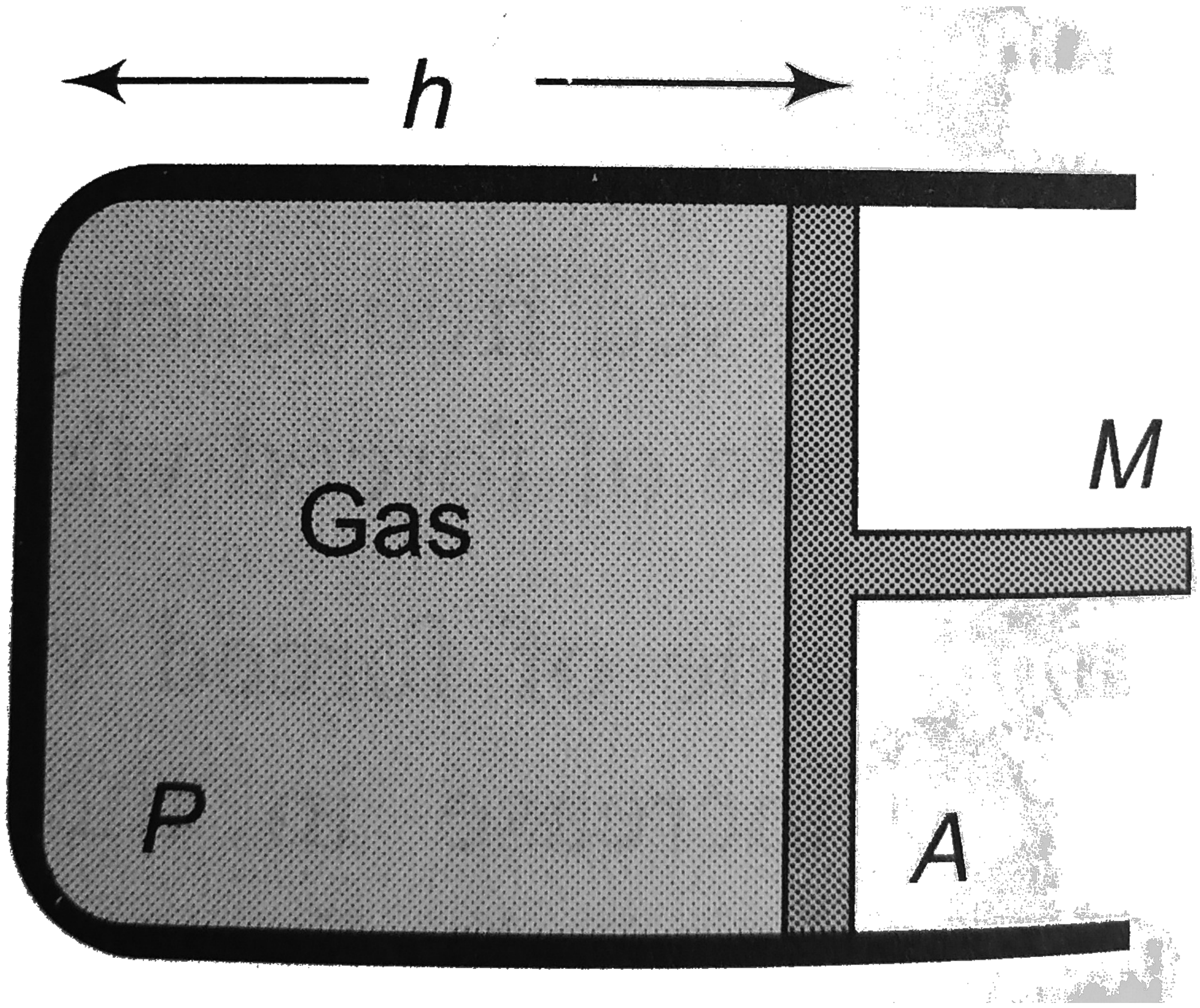
$$a_{cm} = \frac{m_1 a_1 + m_2 a_2}{m_1 + m_2},$$
$$a_1 = a_2 = g$$

$$\therefore S = \frac{1}{2} a_{cm} t^2$$
$$= \frac{1}{2} g t^2$$

Q-13 - 11750099

A cylinder piston of mass M sides smoothlly inside a long cylinder closed at and enclesing a cartin mass of gas The cylinder is kept with its axis horizantal if the pistan is distanced from its equations positions it oscillation simple harmoniically .THe period of

oscillation will be



(A) $T = 2\pi\sqrt{\left(\frac{Mh}{PA}\right)}$

(B) $T = 2\pi\sqrt{\left(\frac{MA}{Pb}\right)}$

(C) $T = 2\pi\sqrt{\left(\frac{M}{PAh}\right)}$

(D) $T = 2\pi\sqrt{MPhA}$

CORRECT ANSWER: A

SOLUTION:

Let the piston be displace through distance x toward left

then velocity drcrease pressed increase if pressure and

ΔV is decrerase in volume then considring the pracess

as take place gravity (i.e.sothermal)

$$P_1 V_1 = P_2 V_2 \Rightarrow PV(P + \Delta p)(V - \Delta V)$$

$$\Rightarrow PV = PV + \Delta PV - \Delta P \Delta V$$

$$\Rightarrow \Delta P. V - P(Ah) = P(Ax) \Rightarrow \Delta P(Ax)$$
$$\Rightarrow \Delta P = \frac{P. x}{h}$$

This execute pressed is responsible the reastroing force

(F) to the pistom of mass M

Hence $F = \Delta pA = \frac{pks}{h}$

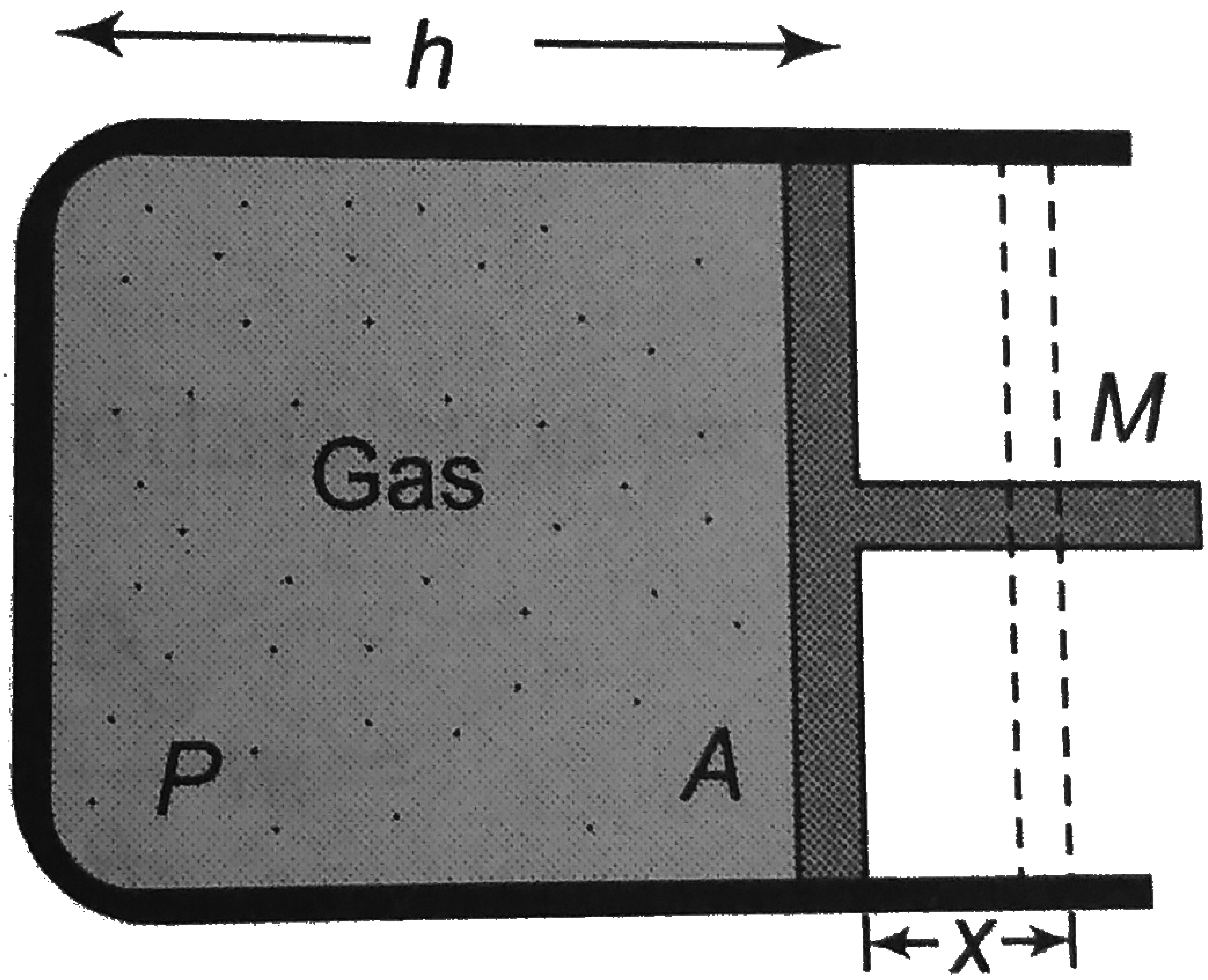
comparing a with

$(F) = kx \Rightarrow k = M\omega^2$

$= \frac{pA}{h}$

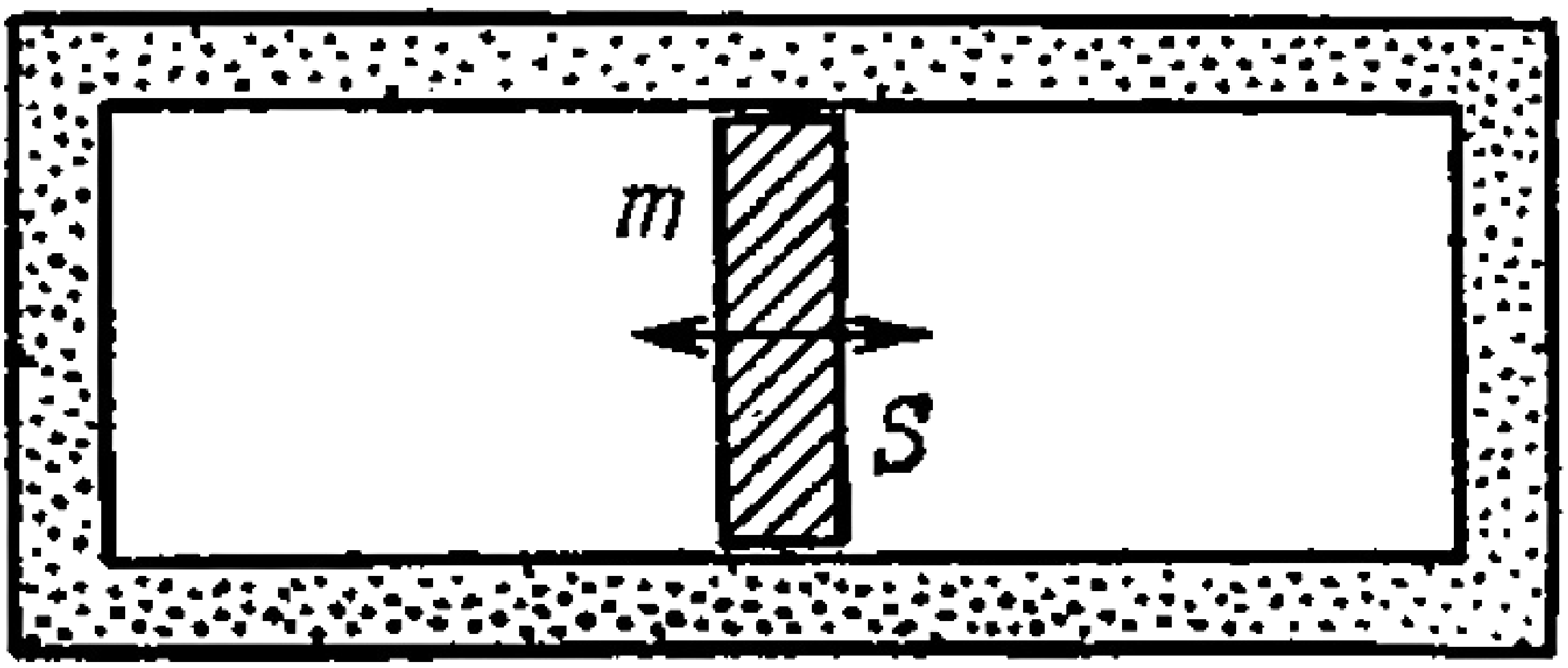
$\Rightarrow \omega = \sqrt{\frac{pA}{Mh}} \Rightarrow T$

$= 2\pi\sqrt{\frac{Mh}{pA}}$



Q-14 - 12307103

In a cylinder filled up with ideal gas end gas and closed from both ends there is a piston of mass m and cross $-$ sectional area S (figure).In equilibrium the piston divides the cylinder into two equal parts, each with volime V_0 . The gas ppressure is p_0. The piston was slightly displaced from the equlibrium position and released.Find the oscillation frequency, assuming the prosecces in the gas to be adiabatic and the friction negligible.



SOLUTION:

Let, us displace the pistone through small distance x,

towards right , then from $F_x = mw_x$

or,

$(p_1 - p_2)S = -m\ddot{x}$

...(1)

But, the process is adiabatic, so from $PV^\gamma =$ const.

$p_2 = \frac{p_0 V_0^\gamma}{(V_0 - Sx)^\gamma}$ and $p_1 = \frac{p_0 V_0^\gamma}{(V_0 + Sx)^\gamma}$

as the new volumes of the left and the right parts are

now $(V_0 + Sx)$ and$(V_0 - Sx)$ respectively.

So, the Eqn (1) becomes.

$$\frac{p_0 V_0^\gamma S}{m}\left\{\frac{1}{(V_0 - Sx)^\gamma} - \frac{1}{(V_0 + S_x)^\gamma}\right\} = -\ddot{x}$$

or,

$$\frac{p_0 V_0^{\gamma} S}{m}$$

$$\left\{ \left(\frac{(V_0 + Sx)^{\gamma} - (V_0 - Sx)^{\gamma}}{\left(V_0^2 - S^2 x^2\right)^{\gamma}} \right\} \right.$$

$$= -\ddot{x}$$

$$\frac{p_0 V_0^{\gamma} S}{m} \left\{ \frac{\left(1 + \frac{\gamma S x}{V_0}\right) - \left(1 - \frac{\gamma S x}{V_0}\right)}{V_0^{\gamma}\left(- \frac{\gamma S^2 x^2}{V_0^2}\right)} \right\}$$

$$= -\ddot{x}$$

Neglecting the term $\frac{\gamma S^2 x^2}{V_0^2}$ in the denominator, as it is very small, we get,

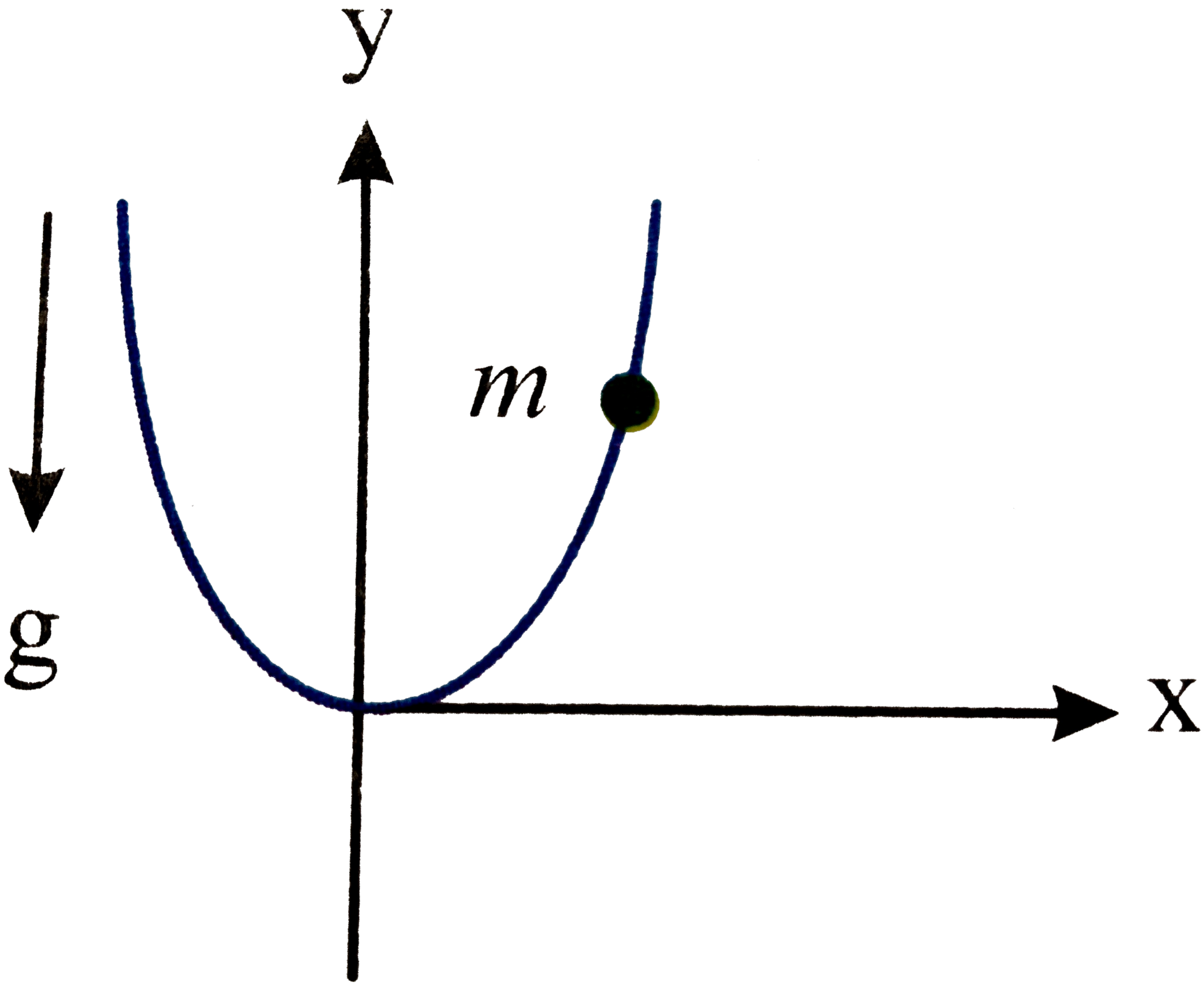
$$\ddot{x} = \frac{2 p_0 S^2 \gamma x}{m V_0}$$

which is the equation for $S.H.M.$ and hence the oscillating frequency.

$$\omega_0 = S\sqrt{\frac{2p_0\gamma}{mV_0}}$$

Q-15 - 13163445

A particle of mass m is allowed to oscillate near the minimum of a vertical parabolic path having the equaiton $x^2 = 4ay$. The angular frequency of small oscillation is given by



(A) $\sqrt{gh}$

(B) $\sqrt{2gh}$

(C) $\sqrt{\left(\frac{g}{2a}\right)}$

(D) $\sqrt{\left(\frac{g}{a}\right)}$

CORRECT ANSWER: C

SOLUTION:

$f = -mg\sin\theta$ for small $'\theta'\sin\theta = \tan\theta$

$f = -mg\tan\theta$ here

$$\tan\theta = \frac{dy}{dx} = \frac{2x}{4a}$$

$$= \frac{x}{2a}$$

$$f = -\frac{mgx}{2a} =$$

$$-m\omega^2 x$$

Q-16 - 18246607

A particle of mass m is executing oscillation about the origin on X-axis Its potential energy is V(x)=kIxI Where K is a positive constant If the amplitude oscillation is a, then its time period T is proportional

(A) $\sqrt{a}$

(B) a

(C) $\sqrt{a}$

(D) $a^{3/2}$

CORRECT ANSWER: A

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Q-17 - 10059206

A particle free to move along the (x - axis) hsd potential energy given by

$$U(x) = k\left[1 - \exp\left(-x^2\right)\right] f$$

$$\text{or } \; -oo \leq x \leq +oo$$

, where (k) is a positive constant of appropriate dimensions. Then.

(A) at points away from the origin, the particle is in unstable equilibrium.

(B) For any finite nonzero value of (x), there is a force directed away from the origin.

(C) if its total mechanical energy is $k/2$, it has its minimum kinetic energy at the origin.

(D) for small displacements from (x = 0), the motion is simple harmonic.

CORRECT ANSWER: D

SOLUTION:

Let us plot the graph of the mathematical equation

$U(x) = K\left[1 - e^{-x2}\right]$,

$$F = -\frac{dU}{dx}$$

$$= 2kxe^{-x^2}$$

(##JMA_CHMO_C10_003_S01##).

From the graph it is clear that the potential energy is minimum at (x = 0). Therefore, (x = 0) is the state of stable equilibrium. Now if we displace from (x = 0) then for displacements the particle tends to regain the position (x = 0) with a force $F = \frac{2kx}{e^{x2}}$. Therefore for small values of (x) we have $F \propto x$.

Q-18 - 13163386

A particle executes SHM with an amplitude of $10cm$ and frequency $2Hz$. At $t = 0$, the particle is at a point where potential energy and kinetic energy are same. The equation for its displacement is

(A)
$$x = 0.1 \sin\left(4\pi t + \frac{\pi}{4}\right)m$$

(B) $x = 0.1(\sin 4\pi t)m$

(C) $x = 0.1 \cos\left(4\pi t + \frac{\pi}{3}\right)$

(D)

$x = 0.1\left(\sin 4\pi t - \frac{\pi}{3}\right)m$

CORRECT ANSWER: A

SOLUTION:

$x = A \sin(\omega t + \phi), \phi = \frac{\pi}{4}$

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Q-19 - 15085533

A man is swimming at a depth d in a sea at a distance $L(>>d)$ from a ship (S). An explosion occurs in the ship and after hearing the sound the man immediately moves to the surface. It takes 0.8 s for the man to rise to the surface after he hears the sound of explosion. 0.2 s after reaching the surface he once again hears a sound of explosion. Calculate L.

Give: speed of sound in air $= 340 ms^{-1}$, Bulk modulus of water $= 2 \times 10^9 Pa$

CORRECT ANSWER: 447.6 M

Q-20 - 17937204

A solid cube floats in water half immersed and h small vertical oscillations of time period $\frac{\pi}{5}$ s. Find the mass (in kg) (Take g=10m/ s^2.

CORRECT ANSWER: 4

Q-21 - 13026206

A weakly damped harmonic oscillator of frequency n_1 is driven by an external periodic force of frequency n_2. When the steady state is reached, the frequency of the oscillator will be

(A) n_1

(B) n_2

(C) $\frac{n_1 + n_2}{2}$

(D) $(n_1 + n_2)$

CORRECT ANSWER: A

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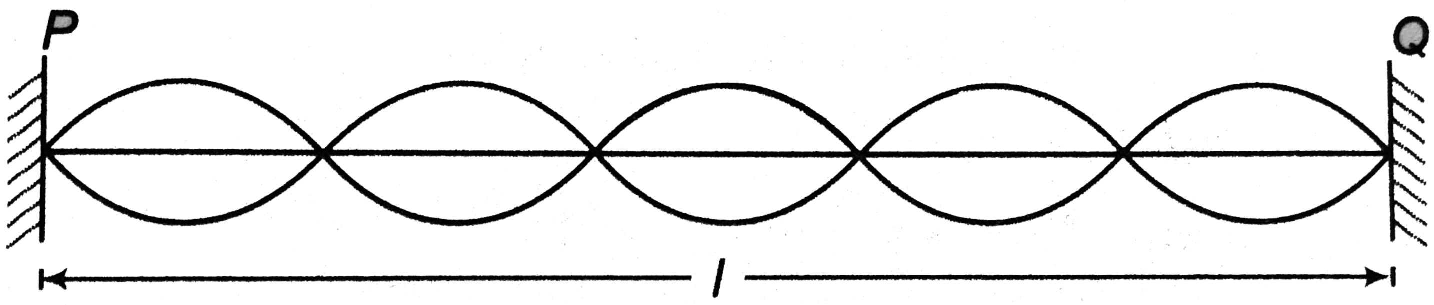
Q-22 - 10965541

Length of a stretched wire is 2m. It is oscillating in its fourth overtone mode. Maximum amplitude of oscillations is 2mm. Find amplitude of oscillation at a distance of 0.2m from one fixed end.

CORRECT ANSWER: B

SOLUTION:

Fourth overtone mode means five loops.



$$\therefore l = 5\left(\frac{\lambda}{2}\right)$$

or $\lambda = \frac{2l}{5}$

$$= \frac{2 \times 2}{5} = 0.8m$$

$k = \frac{2\pi}{\lambda} = \frac{2\pi}{0.8}$=(2.5 pi) m^(-1) Now, P is a node. So, take x = 0 at P.

$Then,$

$atadis\tan cex\mathfrak{o}mP,$

A_x = A_(max) sin kx = (2mm) sin (2.5 pi) (0.2)= (2mm) sin (pi/2)=2mm` .

Q-23 - 15511391

A string of length 3L is fixed at both ends it resonates with a tunning fork in third harmonic with amplitude at antinode equal to A_0 at time t=0 a string element at position of antinode is at half its positive amplitude and moving towards mean position displacement of a string element at $L/2$ is given by

(A) $\frac{A_0}{2}\sin\left(\omega t+\frac{11\pi}{6}\right)$

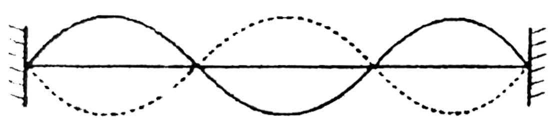
(B) $\frac{\sqrt{3A_0}}{2}\sin\left(\omega t+\frac{5\pi}{6}\right)$

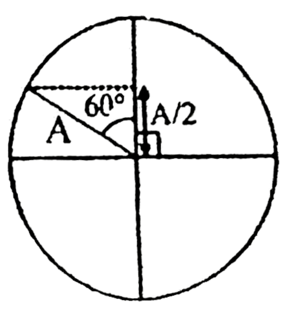
(C) $A_0\sin\left(\omega t+\frac{5\pi}{6}\right)$

(D) $\frac{A_0}{2}\sin\left(\omega t+\frac{5\pi}{6}\right)$

CORRECT ANSWER: C

SOLUTION:





$$3\frac{\lambda}{2} = 3L \Rightarrow \lambda = 2L$$

$$y = A_0 \sin kx \sin\left(\omega t + \frac{\pi}{2} + \frac{\pi}{3}\right)$$

$$= A_0 \sin\left(\frac{2\pi}{2L}\right) \times \left(\frac{L}{2}\right) \sin\left(\omega t + \frac{5\pi}{6}\right)$$

$$A_0 \sin\left(\omega t + \frac{5\pi}{6}\right)$$

Q-24 - 11446994

A wave travelling along X-axis is given by $y = 2(mm)\sin(3t - 6x + \pi / 4)$

where x is in centimetres and t in second. Write the phases and, hence, the find the phase difference between them at t=0 for two points on X-axis, $x = x_1 = \pi/3$ cm and $x = x_2 = \pi/2$ cm.

SOLUTION:

At $t = 0$

$y = \sin(-6x + \pi/4)$

phase at

$$x_1, \phi = \left(-6 \times \frac{\pi}{3} + \frac{\pi}{4}\right) = \frac{7}{4}\pi$$

and that at

$$x_2 is \left(-6 \times \frac{\pi}{2} + \frac{\pi}{4}\right) = \frac{11}{4}\pi$$

the phase difference is $\left|\frac{7}{4}\pi - \frac{11}{4}\pi\right| = \pi$, the dusturbation at the two point are out of phase.

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Q-25 - 18254118

A transverse wave along a string is given by

$$y = 2\sin\left(2\pi(3t - x) + \frac{\pi}{4}\right)$$

where x and y are in cm and t in second. Find acceleration of a particle located at x = 4 cm at t = 1s.

(A) $36\sqrt{2}\pi^2 cm / s^2$

(B) $36\pi^2 cm / s^2$

(C) $-36\sqrt{2}\pi^2 cm / s^2$

(D) $-36\pi^2 cm / s^2$

CORRECT ANSWER: C

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Q-26 - 18254137

A sonometer wire of length 114 cm is fixed at both the ends. Where should the two bridges be placed so as to divide the wire into three segments whose fundamental frequencies are in the ratio $1:3:4$?

(A) At 36 cm and 84 cm from one end

(B) At 24 cm and 72 cm from one end

(C) At 48 cm and 96 cm from one end

(D) At 72 cm and 96 cm from one end

CORRECT ANSWER: C

Q-27 - 10965510

If at $t = 0$, a travelling wave pulse on a string is described by the function.

$$y=\frac{6}{x^2+3}$$

What will be the waves function representing the pulse at time t, if

the pulse is propagating along positive x-axis with speed $4m/s$?

(A) $y=\frac{6}{(x+4t)^2}+3$

(B) $y=\frac{6}{(x-4t)^2}+3$

(C) $y=\frac{6}{(x-t)^2}$

(D) $y=\frac{6}{(x-t)^2}+12$

CORRECT ANSWER: B

SOLUTION:

The wave pulse is travelling along positive x-axis.

Hence, at and bx should have opposite signs. Further,

wave speed

$$v = \frac{\text{Coefficient of t}}{\text{Coefficient of x}}$$

$\therefore 4$

$$= \frac{\text{Coefficient of t}}{1}$$

$\therefore$Coefficient of t = 4 s^(-1)`

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Q-28 - 11447134

At t=0, a transverse wave pulse in a wire is described by the function $y = 6/(x^2 - 3)$ where x and y are in metres. The function y(x,t) that describes this wave equation if it is travelling in the positive x direction with a speed of $4.5m/s$ is

(A) $y = \dfrac{6}{(x + 4.5t)^2 - 3}$

(B) $y = \dfrac{6}{(x - 4.5t)^2 + 3}$

(C) $y = \dfrac{6}{(x + 4.5t)^2 + 3}$

(D) $y = \dfrac{6}{(x - 4.5t)^2 - 3}$

CORRECT ANSWER: D

SOLUTION:

$$y(x, t) = \frac{a}{(x \pm vt)^2 + b}$$

is another form of progressive wave equation propagating with a sppeed v.

Negative sign to be taken for pprogation along +x-axis and positive sign to be taken to propagation along -x-axis.

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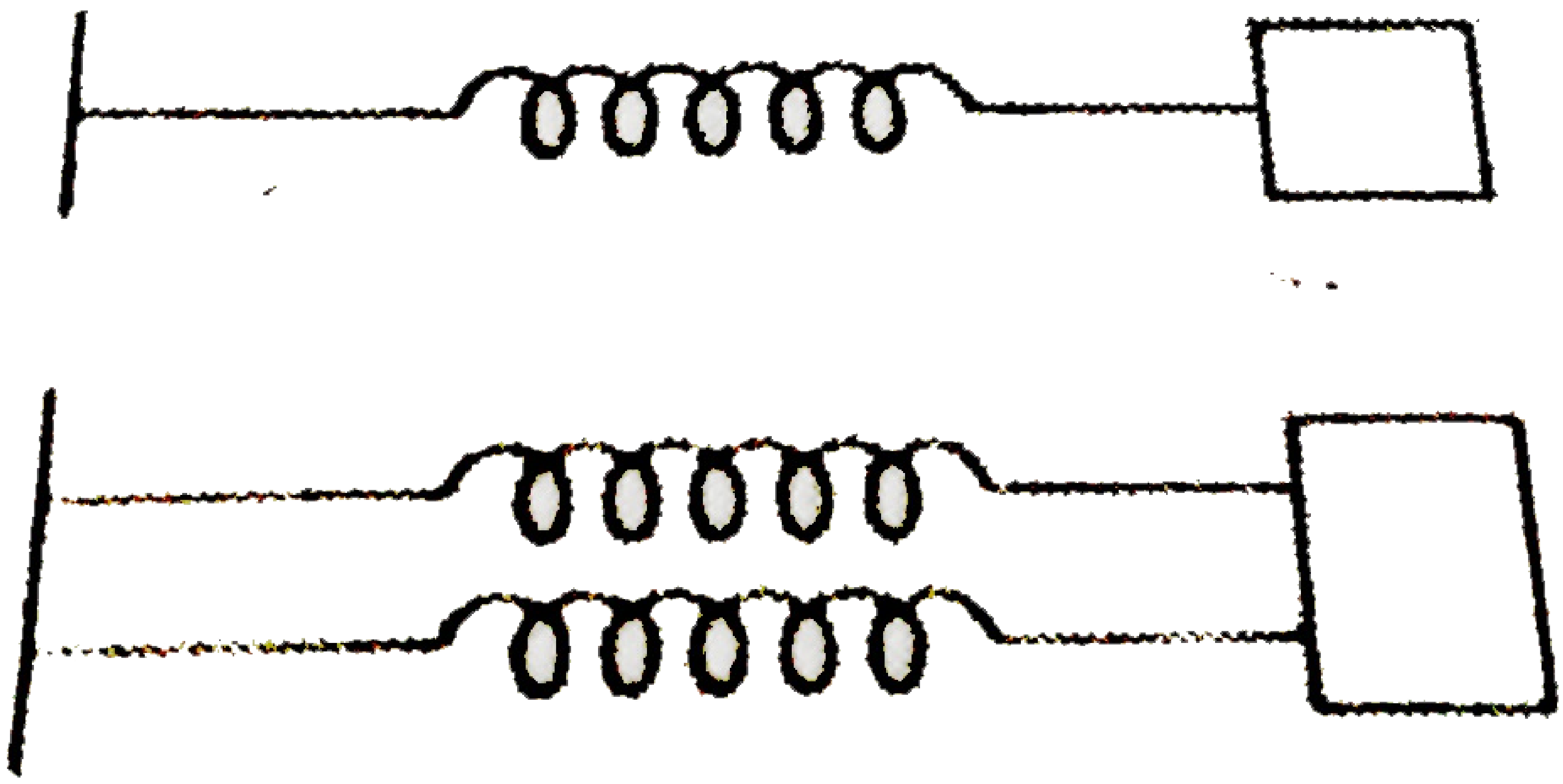
Q-29 - 15085510

A transverse harmonic wave of amplitude 4 mm and wavelength 1.5 m is travelling in positive x direction on a stretched string. At an instant, the particle at $x = 1.0$ m is at $y = +2$ mm and is travelling in positive y direction. Find the co- ordinate of the nearest particle $(x > 1.0m)$ which is at its positive extreme at this instant.

CORRECT ANSWER: 2.25 M

Q-30 - 18254096

If k_s and k_p respectively are effective spring constant in series and parallel combination of springs as shown in figure, find $\frac{k_s}{k_p}$.



(A) $\frac{9}{2}$

(B) $\frac{3}{7}$

(C) $\frac{2}{9}$

(D) $\frac{7}{3}$

CORRECT ANSWER: C

SOLUTION:

The effective spring constant k_s of this arrangement is

$$\frac{1}{k_s} = \frac{1}{k} + \frac{1}{2k}$$

$$\Rightarrow \frac{1}{2k_s} = \frac{2+1}{2k}$$

$$= \frac{3}{2k}$$

$$\therefore \quad k_s = \frac{2k}{3}$$

The effective spring costant k_p of this arrangement is

$$k_p = k_1 + k_2 = k + 2k$$

$$= 3k$$

$$\therefore \quad \frac{k_s}{k_p} = \frac{2k/3}{3k}$$

$$= \frac{2}{9}$$

Q-31 - 18254128

A string of length l is fixed at both ends and is vibrating in second harmonic. The amplitude at anti-node is 2 mm. The amplitude of a particle at distance $l/8$ from the fixed end is

(A) $5\sqrt{2}mm$

(B) $\frac{5}{\sqrt{2}}mm$

(C) $5mm$

(D) $\frac{10}{\sqrt{2}}mm$

CORRECT ANSWER: B

SOLUTION:

The equation of stationary wave on a string fixed at both ends is

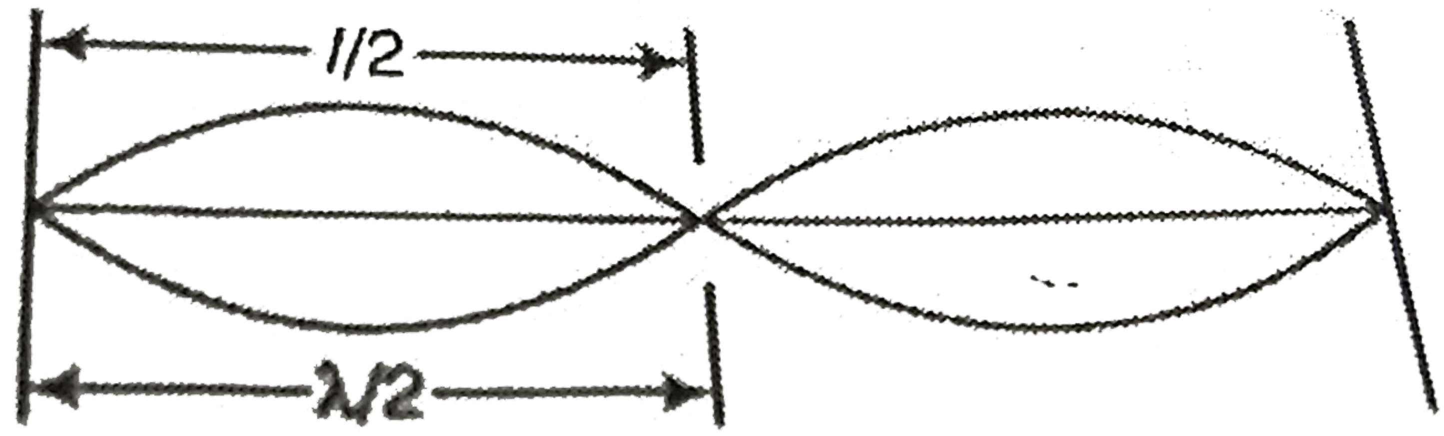
y = 2a sin kx $\cos\omega t$

The amplitude of a particle at distance x from fixed end is

A = 2a sin kx.

For second harmonic, string vibrates in two loops (shown in figure).

$$\therefore \quad \frac{\lambda}{2} = \frac{l}{2}$$



$$\therefore \quad \lambda = l$$

$$\therefore \quad k = \frac{2\pi}{\lambda} = \frac{2\pi}{l}$$

$$\therefore A = 2a \sin kx$$

$$= 2a \sin . \frac{2\pi}{l} \times \frac{l}{8}$$

$$= 2a \sin . \frac{\pi}{4}$$

The amplitude at antinode is 2a = 5 mm

$$\therefore \quad A = 5 \sin . \frac{\pi}{4}$$

$$= \frac{5}{\sqrt{2}} mm$$

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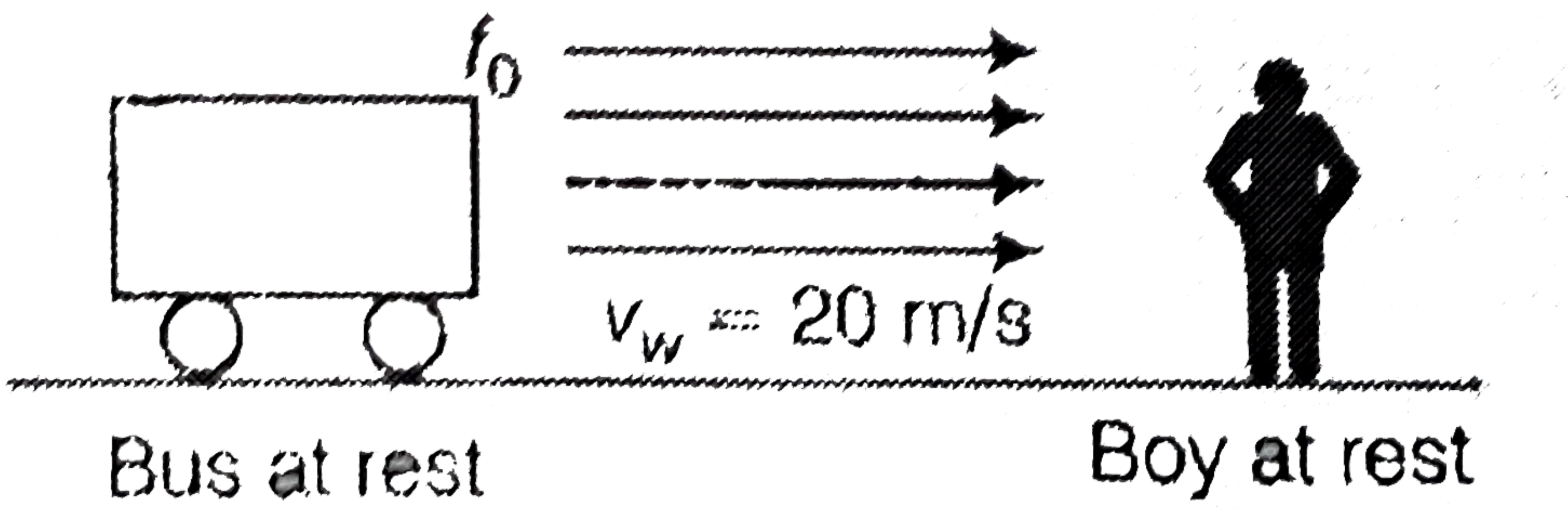
Q-32 - 19037808

In the above siltuation, bus is at rest blowing horm of frequency f_0. A boy is at rest at some distance. What will be apparent frwuecy of sound, if the air star moving with the speed of 20 m/s from bus towards boy?



(A) $< f_0$

(B) $> f_0$

(C) $= f_0$

(D) None of these

CORRECT ANSWER: C

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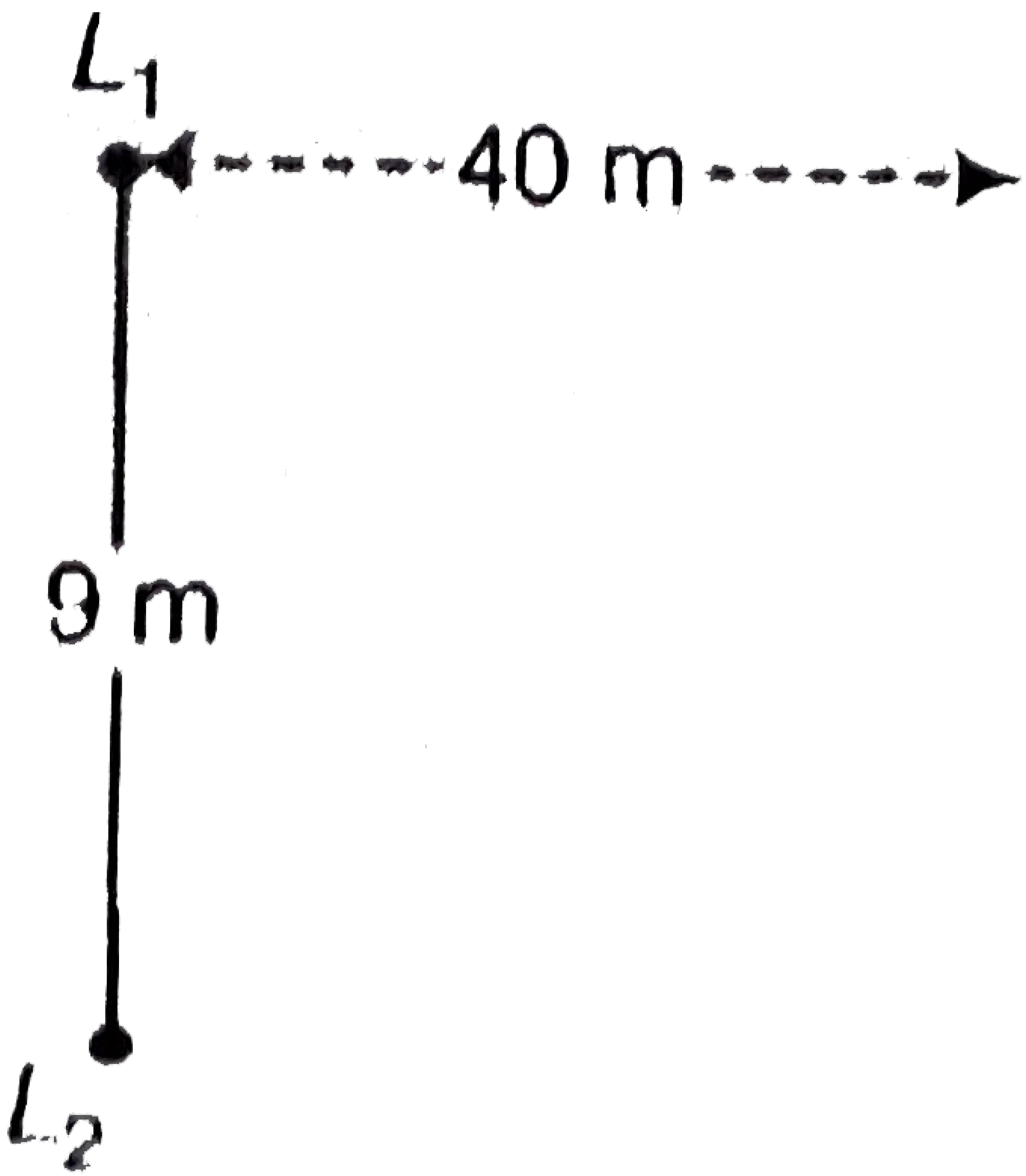
Q-33 - 19037824

Two loudspeakers L_1 and L_2 driven by a common oscillator and smplifier, are arranged as shown. The frequency of the oscillator is gradually increased from zero and the detector at D records a series of maxima and minima. If the speed of sound is 330 ms^{-1} then the frequency at which the first maximum is observed is



(A) 165 Hz

(B) 330 Hz

(C) 495 Hz

(D) 660 Hz

CORRECT ANSWER: B

SOLUTION:

Let Δx = path difference

$$\Rightarrow \quad \Delta x = L_2 D$$
$$- L_1 D \Rightarrow \Delta x$$
$$= \sqrt{40^2 + 9^2} - 40$$

$$\Rightarrow \quad \Delta x = 41 - 41$$
$$\Rightarrow \Delta x = 1m$$

For first maximum ,

$$\Delta x = (2n)\frac{\lambda}{2}$$

$$(where\,'n = 1)$$

$$\Rightarrow 1 = 2(1)\frac{\lambda}{2} \Rightarrow \lambda$$

$$= 1m \Rightarrow f = \frac{v}{\lambda}$$

$$= 330Hz$$

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Q-34 - 10965802

A car travelling towards a hill at $10m/s$ sound its horn which a frequency $500H_Z$. This is heard in a second car travelling behind the first car in the same direction with speed $20m/s$. The sound can also be heard in the second car by reflections of sound the hill. The beat frequency heard by the driver of the sound car will be (speed of sound in air $= 340m/s$)

(A) $31H_Z$

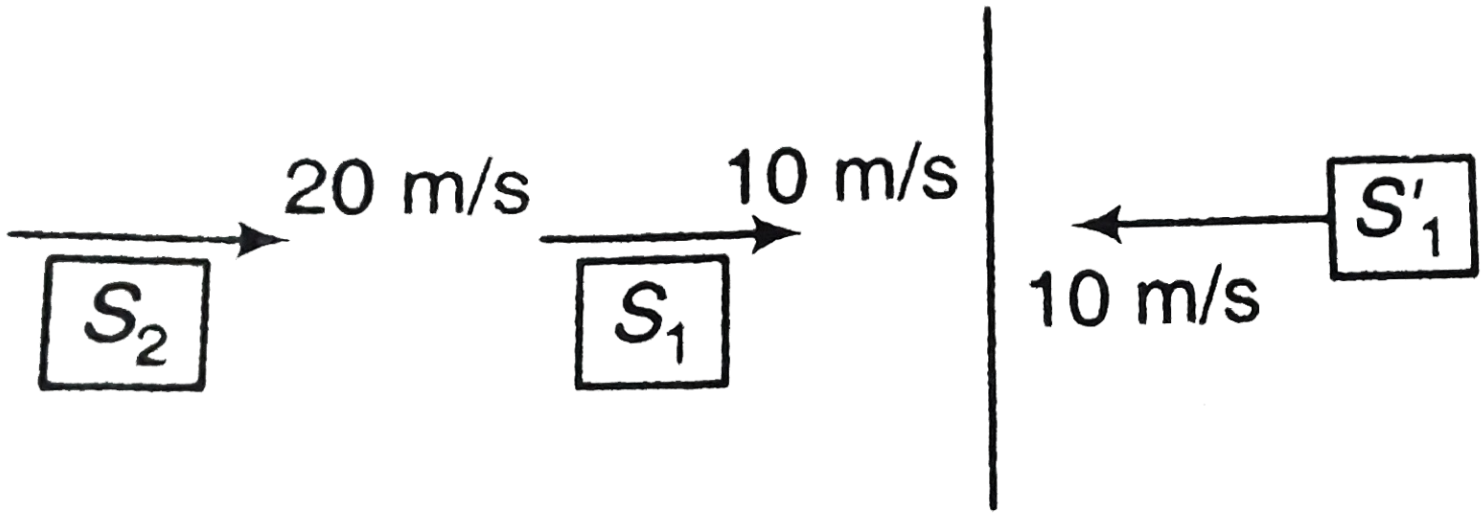
(B) $24H_Z$

(C) $21H_Z$

(D) $34H_Z$

CORRECT ANSWER: A

SOLUTION:



$$f_b = f_{S'} - f_{S_1}$$

$$= 500\left[\frac{340+20}{340-10}\right]$$

$$-500\left[\frac{340+20}{340+10}\right]$$

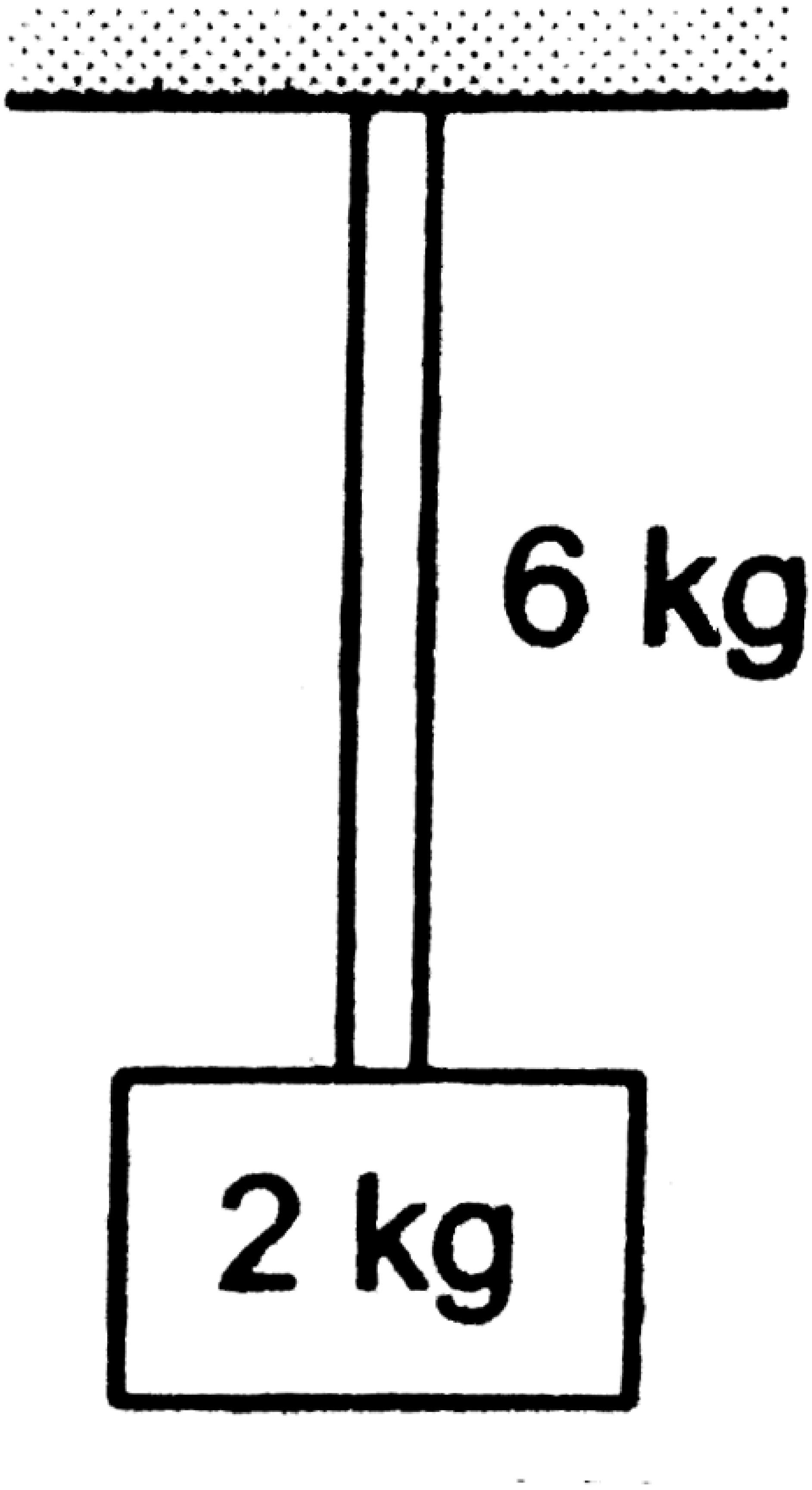
$$\approx 31H_Z$$

Q-35 - 9527821

A uniform rope of length 12 mm and mass 6 kg hangs vertically from a rigid support. A block of mass 2 kg is attached to the free end of the rope. A transverse pulse of wavelength 0.06 m is produced at the lower end of the rope. What is the wavelength of the pulse when it reaches the top of the rope?

SOLUTION:

As the rope is heavy its tension will be different at different point. The tensinN/At the free end will be 92kg)g and that at the upper end it will be (8kg)g.



We have $v = v\lambda$

$$\text{or} \quad \sqrt{\frac{F}{\mu}} = v\lambda$$

$$\text{or} \quad \frac{\sqrt{F}}{l}mda = v\sqrt{\mu}$$

The frequency of the wave pulse will be same

everywhere on the rope as it depends only onthe frequency of the source The mass per unit length is also

the same throughout the rope as ilt is uniform. thus, by

$i. \frac{\sqrt{F}}{\lambda}$ is constant

Hence

$$\frac{\sqrt{((2kg)g)}}{0.06m} = \frac{\sqrt{((8kg)g)}}{\lambda_1}$$

λ_1 is the wavelength at the top of the rope. This gives

`lamda_1=0.12m.

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Q-36 - 19037817

There is road between two parallel rows of building and distance between the rows of building is 106 m. Find the velocity of car if a car blows a horm shose echo is heard by the drive agfter 1 s.

(Given, speed of sound = 340 m/s)

(A) 180 m/s

(B) 165 m/s

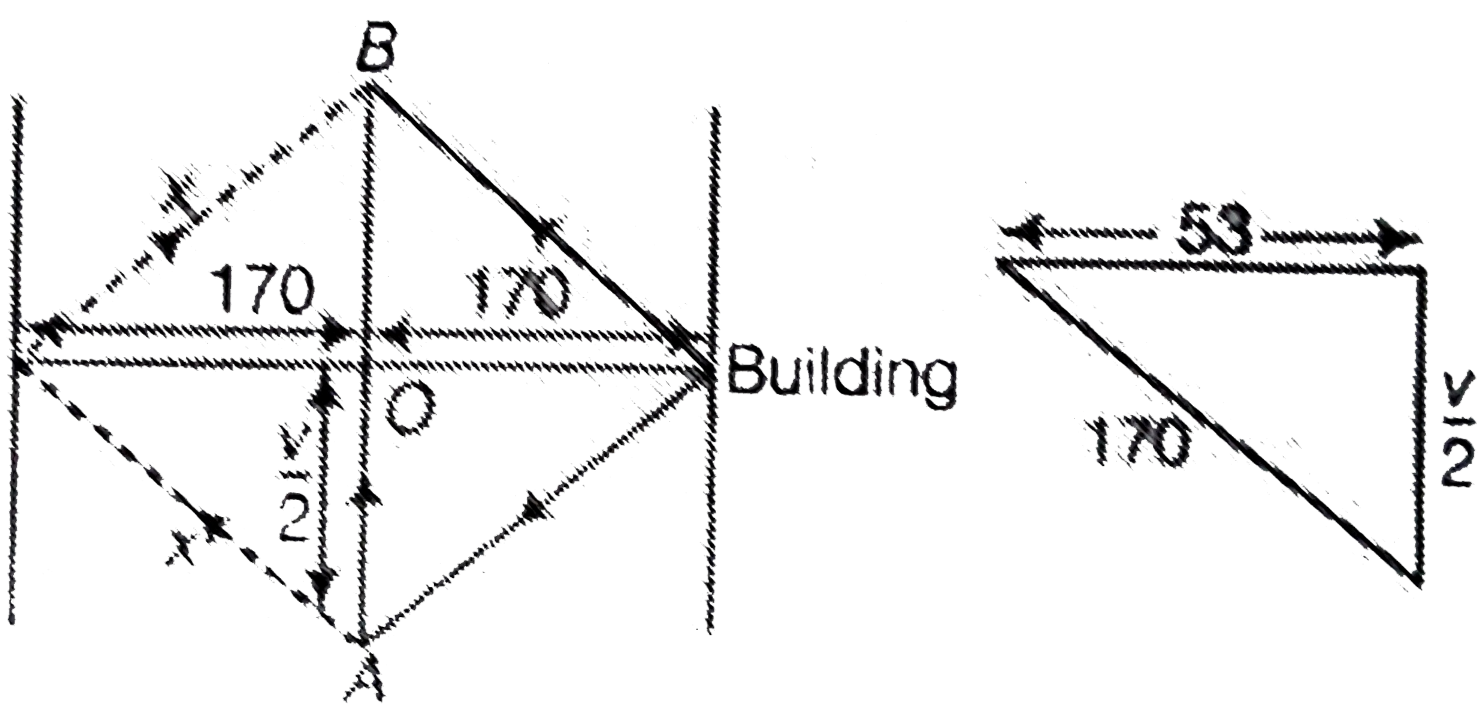
(C) 323 m/s

(D) 150 m/s

CORRECT ANSWER: C

SOLUTION:

Signal goes from A to B. Let the velocity of car=v.



Distance travelled AB=v,oA=$\frac{v}{2}$

$$\frac{2\times}{1} = 340 \Rightarrow \times$$
$$= 170m$$

$$(170)^2 = (53)^2 + \frac{v^2}{4}$$
$$\sqrt{4(28900 - 2809)}$$
$$= v \quad \Rightarrow v = 323m$$
$$/s$$

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Q-37 - 14801008

A particle performs simple harmonic motion with amplitude A. its speed is double at the instant when it is at distance $\frac{A}{3}$ from equilibrium position. The new amplitude of the motion is $\frac{\sqrt{33}A}{\beta}$. Find β

CORRECT ANSWER: 3

SOLUTION:

$$V=\omega\sqrt{A^2-\left(\frac{A}{3}\right)^2}$$

$$V=\sqrt{\frac{8A^2\omega}{9}}$$

$$=\frac{2\sqrt{2}}{3}A\omega$$

.

$$V_{\neq w}=2V=\frac{4\sqrt{2}}{3}A\omega$$

So the new amplitude is given by

$$V_{\neq w}$$

$$=\omega\sqrt{\left(A_{\neq w}\right)^2-\left(\frac{A}{3}\right)^2}$$

$$\frac{32}{9}A^2=\left(A_{\neq w}\right)^2$$

$$-\frac{A^2}{9}$$

$$A_{\neq w}2=\frac{33A^2}{9}$$

$$A_{\neq w}=\frac{\sqrt{33}A}{3}$$

Q-38 - 16176891

A particle is vibrating in a simple harmonic motion with an amplitude of 4 cm . At what displacement from the equilibrium position, is its energy half potential and half kinetic

(A) 1 cm

(B) $\sqrt{2}cm$

(C) 3 cm

(D) $2\sqrt{2}cm$

CORRECT ANSWER: D

Q-39 - 13163275

The angular velocities of three bodies in SHM are $\omega_1, \omega_2, \omega_3$ with their respective amplitudes as A_1, A_2, A_3. If all three bodies have same mass and maximum velocity then

(A) $A_1\omega_1 = A_2\omega_2 = A_3\omega_3$

(B) $A_1\omega_1^2 = A_2\omega_2^2 = A_3\omega_3^2$

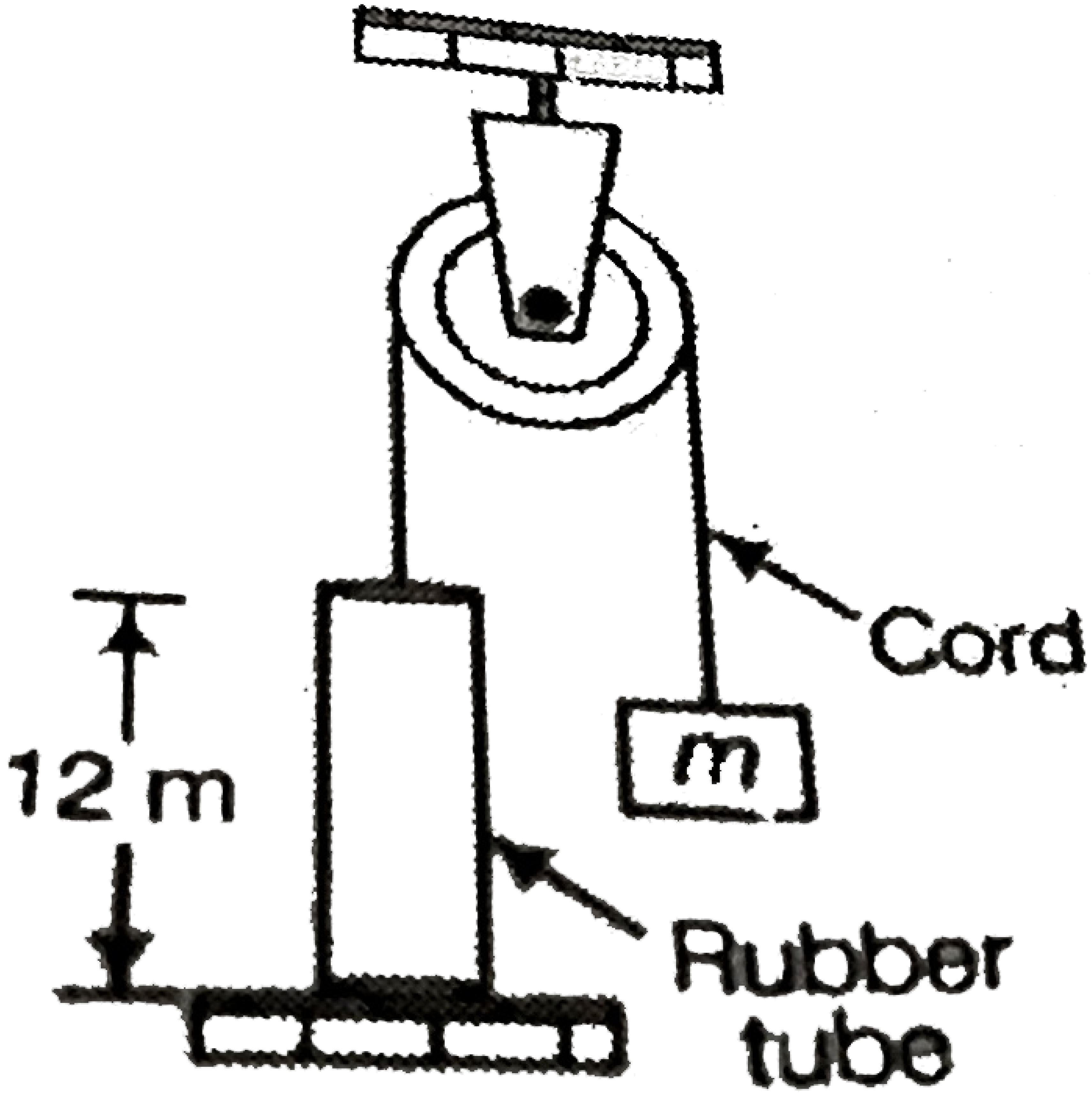
(C) $A_1^2\omega_1 = A_2^2\omega_2 = A_2^2\omega_2$

(D) $A_1^2\omega_1^2 = A_2^2\omega_2^2 = A_3^2\omega_3^2$

CORRECT ANSWER: A

Q-40 - 18254121

A long rubber tube having mass 0.9 kg is fastened to a fixed support and the free end of the tube is attached to a cord which passes over a pulley and supports an object, with a mass of 5 kg as shown in figure. If the tube is struck by a transverse blow at one end, find the time required for the pulse to reach the other end.



(A) 5 s

(B) 0.47 s

(C) 4.7 s

(D) 3.2 s

CORRECT ANSWER: B

SOLUTION:

Let μ = mass per unit length of rubber tube

$$\mu = \frac{0.9}{12} = 0.075kg$$

$/m$

Tension in tube, T = mg $= 5 \times 9.8 = 49N$

Speed of wave on the tube

$$v = \sqrt{\left(\frac{T}{\mu}\right)}$$

$$= \sqrt{\frac{49}{0.075}} = 25.56m$$

$/s$

Time required = t= $\frac{AB}{v} = \frac{12}{25.56} = 0.47s$

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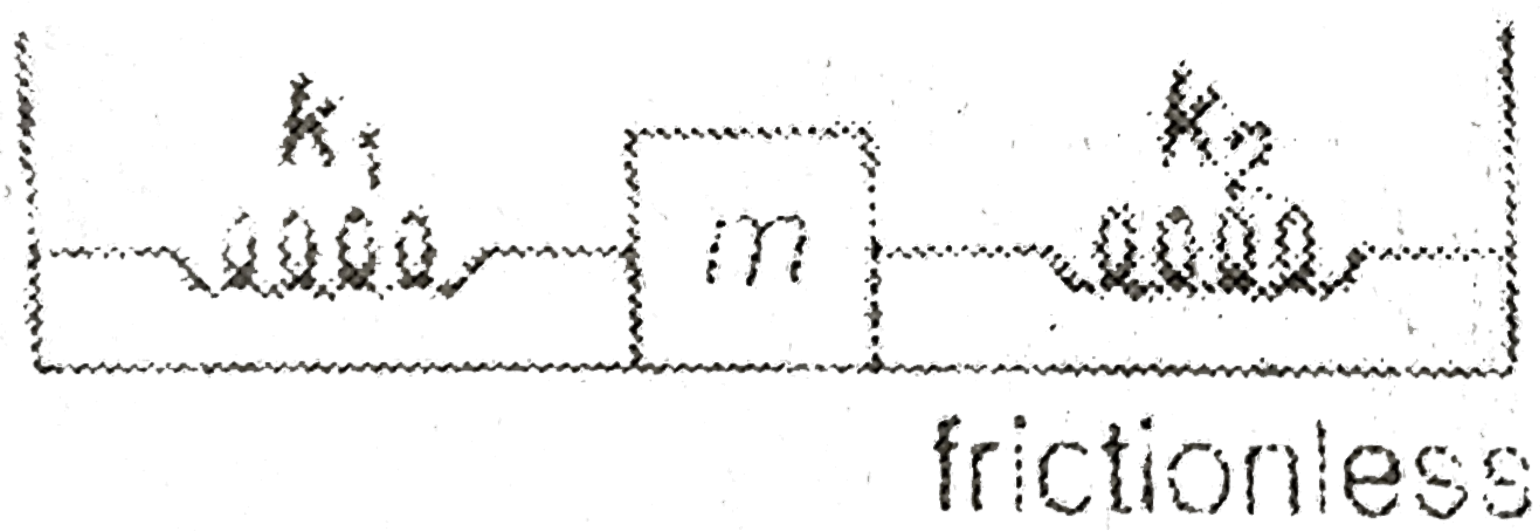
Q-41 - 17937039

Two springs with negligible massess and force constant of $k_1 = 200Nm^{-1}$ and $k_2 = 160Nm^{-1}$ are attached to the block of mass m = 10kg as shown in the figure. Initially the block is at rest at the equilibrium position the block is at rest at the equilibrium position ir. Which both springs are neither stretched nor compressed. At time t = 0, sharp impulse of 50 N-s is given to the block in horizontal direction.



(A) period of oscialltions for the mass m is $\left(\frac{\pi}{6}\right)$ s

(B) maximum velocity of the mass m during its oscillation is $10ms^{-1}$.

(C) maximum velocity is 6m/s

(D) amplitude of oscillations is $\frac{5}{6}$m.

CORRECT ANSWER: D

Q-42 - 11749969

A particle of mass m is executing oscillations about origin on the x axis amplitude A its potential energy is given as$U(x) = \beta x^4$ where β is constant x cooridirate of the particle where the potential energy is one third of the kinetic energy is

(A) $\pm \frac{A}{2}$

(B) $\pm \frac{A}{\sqrt{2}}$

(C) $\pm \frac{A}{3}$

(D) $\pm \frac{A}{\sqrt{3}}$

CORRECT ANSWER: B

SOLUTION:

$U = \beta x^4$ (given)

$\therefore U_{\max} = \beta . A^4$
$k(x) = U_{\max} - U(x)$
$= \beta A^4 - \beta x^4$
$= \beta\left(A^4 - x^4\right)$

$U(x) = \frac{1}{3} K(k)$ (Given)
$\therefore \beta x^4 = \frac{1}{3} \beta\left(A^4 - x^4\right)$

$\Rightarrow 3\beta x^4 = \beta A^4 - \beta x^4$
$4\beta x^4 = \beta A^4 \Rightarrow x^4 = \frac{A^4}{4}$

$$\Rightarrow x = \pm \frac{A}{\sqrt{2}}$$

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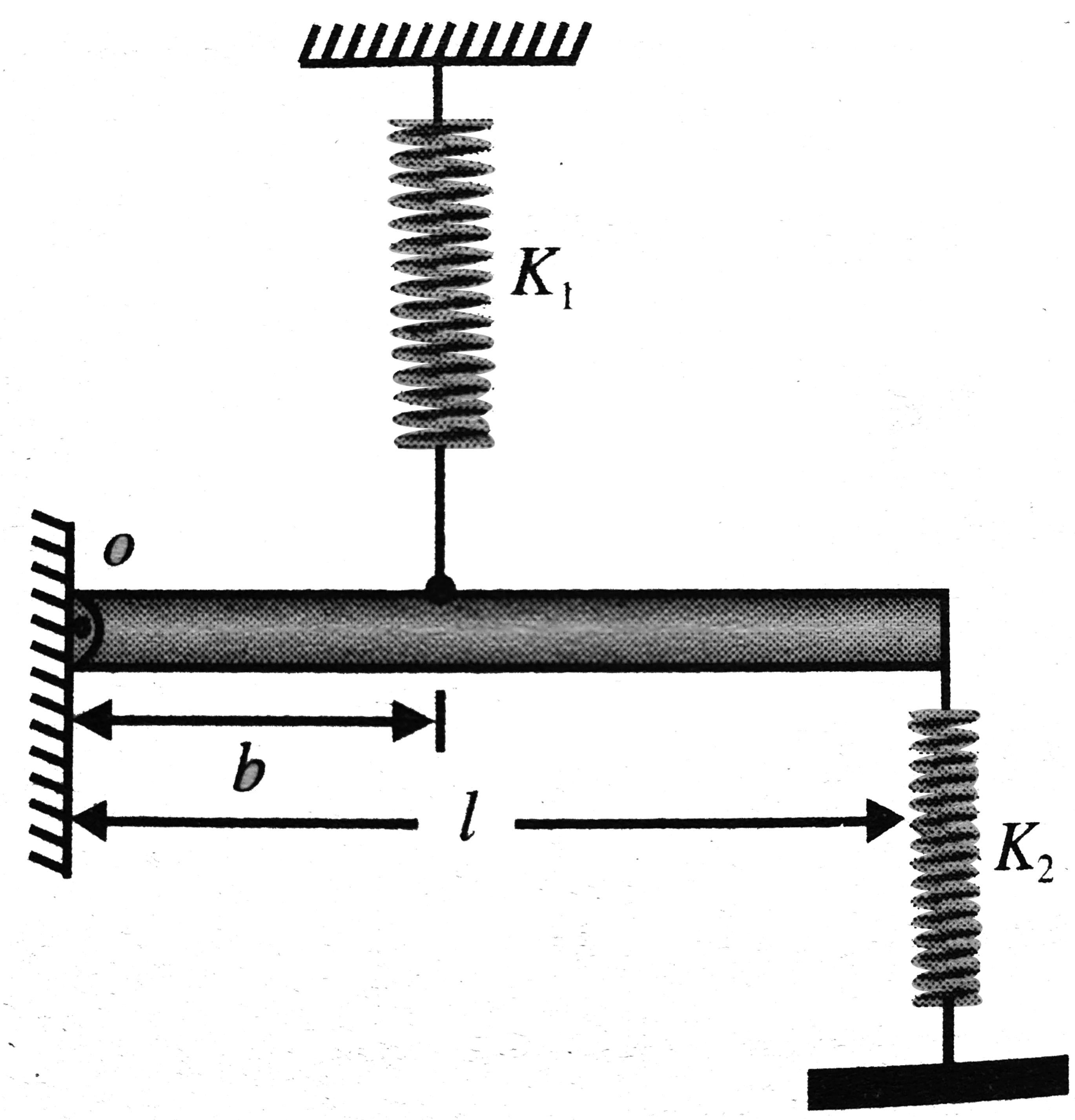
Q-43 - 11446982



A rod of mass m and length l hinged at one end is connected by two springs of spring constant k_1 and k_2 so that it is horizontal at equilibrium What is the angular frequency of the system? (in $\frac{rad}{s}$)

(Take $l = 1m$,$b = \frac{1}{4}m$,$K_1 = 16\frac{N}{m}$,$K_2 = 61\frac{N}{m}$.

SOLUTION:

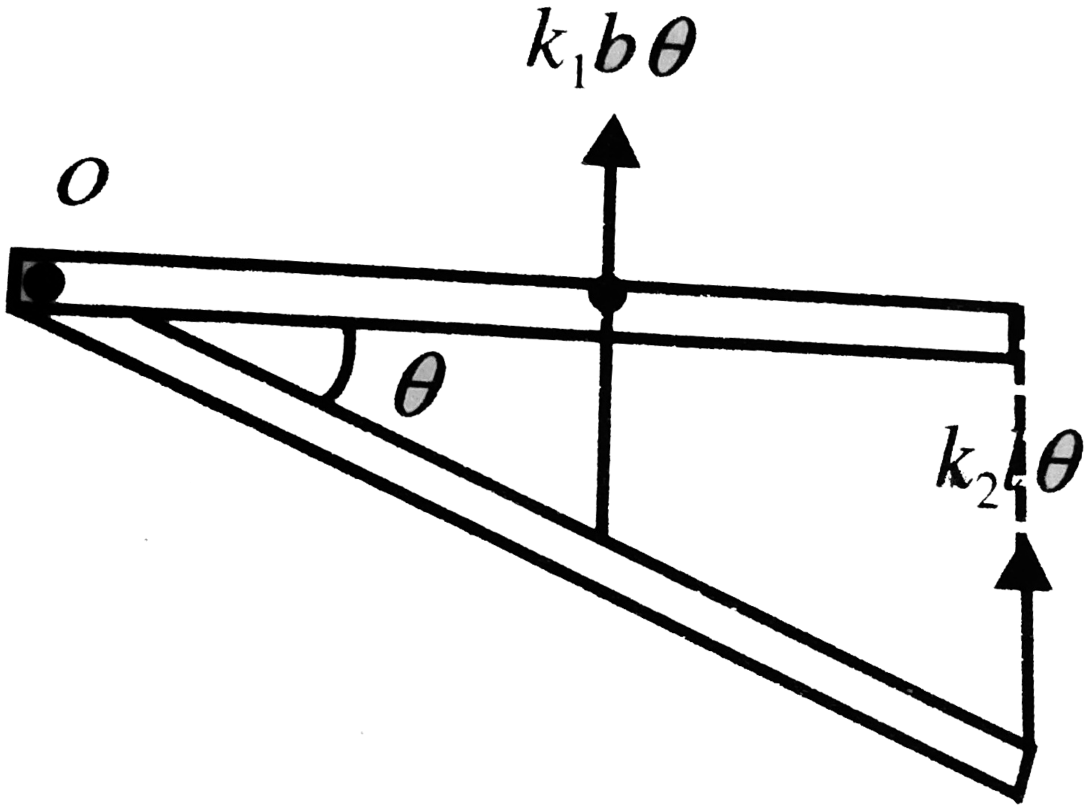


Fig. S4.75

Applying torque equation about

$\tau_0 = l_0 \alpha$

$k_1 b\theta \times \cos\theta + \frac{k_2 l_\theta}{\theta}$

$\times\ l\cos\theta = \ - \frac{Id^2\theta}{dt^2}$

Here $I = \frac{ml^2}{3}$, and as θ is small $\cos\theta = 1$

$$\frac{ml^2 d^2\theta}{3dt^2} + \left(k_1 b^2 + k_2 l^2\right)\theta = 0$$

Hence, $\omega = \sqrt{\frac{3k_1 b^2 + k_2 l^2}{ml}}$

On substituting the values we get $\omega = 8\frac{rad}{s}$

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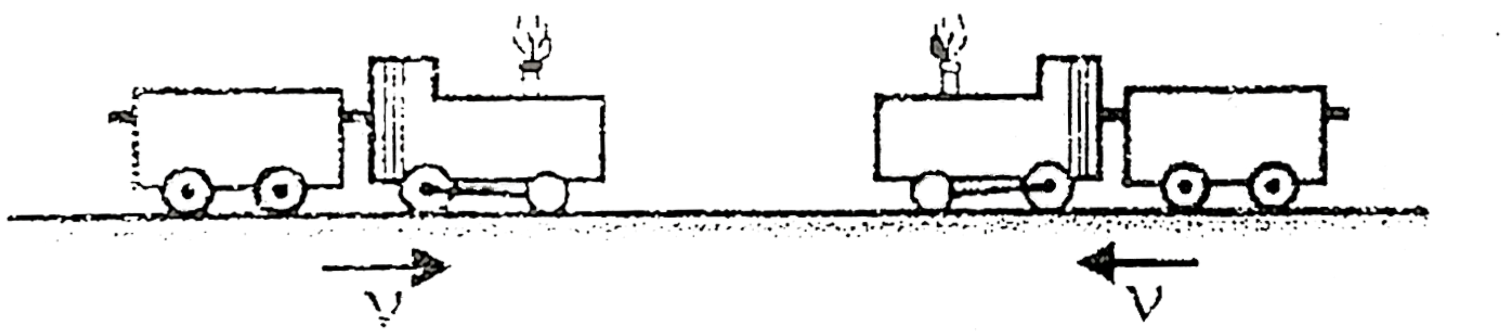
Q-44 - 15602206

Two trains moves towards each other with the same speed. Speed of sound is $340m/s^{-1}$. If the pitch of the tone of the whistle of one when heard on the end other changes to $9/8$ times, then the speed of each train is :



CORRECT ANSWER: $20M / S$

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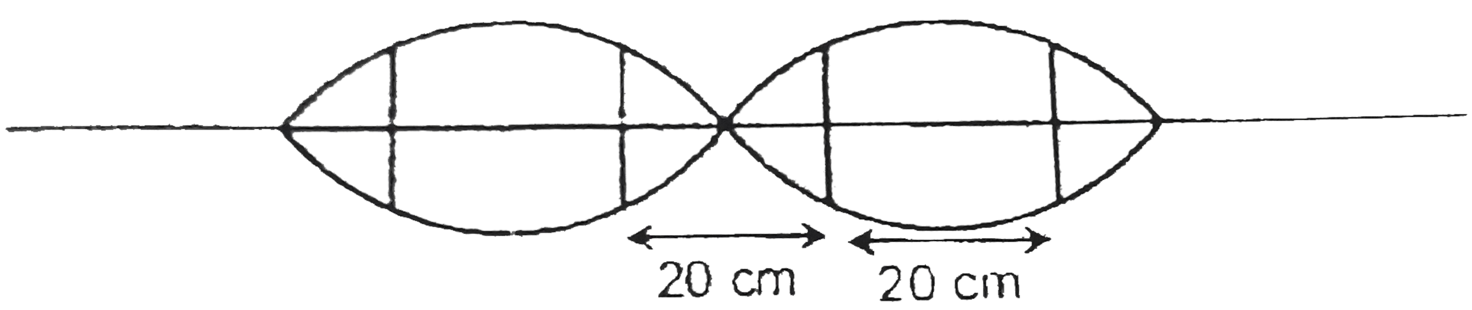
Q-45 - 14801204

An open organ pipe in vibrating in its fifth overtone. The distance between two consecutive points where pressure amplitude is $\frac{1}{\sqrt{2}}$ time the pressure amplitude at pressure antinodes is 20 cm. if the length of the pipe is $\frac{12}{n}$ m the value of n is?

CORRECT ANSWER: 5

SOLUTION:



$$\frac{\lambda}{2} = 40cm \Rightarrow \lambda$$
$$= 0.8cm$$

$$l = \frac{6\lambda}{2} = 2.4mt$$

$$= \frac{12}{5}m$$

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Q-46 - 14533395

One end of a string of length L is tied to the celling of lift accelerating upwards with an accelerating 2g The other end of the string is free. The linear mass density of the string varies linearly from 0 of λ from bottom to top :-

(A) The velocity of the wave in the string will be 0

(B) The acceleration of the wave in the string will be $3g/4$ every where

(C) The time taken by a pulse to reach from bottom to top will be $\sqrt{8L/3g}$

(D) The time taken by a pulse to reach from bottom to top will be $\sqrt{4L/3g}$

CORRECT ANSWER: B::C

SOLUTION:

$$\mu = \frac{\lambda}{L}x$$

(at a distance 'x' from free end)

$$\therefore T = \int_0^x \mu dx(g + 2g)$$

$$= \frac{3\lambda g x^2}{2L}$$

$$\therefore v_{\text{wave}} = \sqrt{\frac{T}{\mu}}$$

$$= \sqrt{\frac{3\lambda g x^2}{2L\left(\frac{\lambda x}{L}\right)}}$$

$$= \sqrt{\frac{3xg}{2}}$$

$$\Rightarrow v^2 = \frac{3xg}{2}$$

$$\Rightarrow 2v\frac{dv}{dx} = \frac{3g}{2} \Rightarrow a$$

$$= 3g/4$$

Now

$$S = ut + \frac{1}{2}at^2 \Rightarrow L$$

$$= 0 + \frac{3g}{8}t^2$$

$$\Rightarrow t = \sqrt{8L/3g}$$

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Q-47 - 11393518

The frequency changes by 10 % as the source approaches a stationary observer with constant speed v_S, What sould be the percentage change in ferquency as the source recedes from the observer with the same speed? Given that $v_S < < v$ (v speed of sound in air).

(A) $14.3\ \%$

(B) $20\ \%$

(C) $16.7\ \%$

(D) $10\ \%$

CORRECT ANSWER: D

SOLUTION:

When the source approaches the observer

$$f_1 = f\left(\frac{v}{v - v_s}\right)$$

$$= f\left(1 - \frac{v_s}{v}\right)^{-}$$

$$= f\left(1 + \frac{v_s}{v}\right)$$

or

$$\left(\frac{f_1 - f}{f}\right) \times 100$$

$$= \frac{v_s}{v} \times 100 = 10$$

In the second case, when the source recedes from the observer

$$f_2 = f\left(\frac{v}{v + v_s}\right)$$

$$= f\left(1 + \frac{v_s}{v}\right)^{-}$$

$$= f\left(1 - \frac{v_s}{v}\right)$$

$$\left(\frac{f_2 - f}{f}\right) \times 100 =$$

$$-\frac{v_s}{v} \times 100 = -10$$

In the first case, observed frequency increases by $10\,\%$ while in the second case, observed frequency decreases by 10% .

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Q-48 - 11750195

A source of sound gives five beats per second when sounded with another source of frequency $100s^{-1}$. The second harmonic of the source together with a source of frequency $205s^{-1}$ gives five beats per second. What is the ferquency of the source?

(A) $105s^{-1}$

(B) $205s^{-1}$

(C) $95s^{-1}$

(D) $100s^{-1}$

CORRECT ANSWER: A

SOLUTION:

Frequency of the source $= 100 \pm 5 = 105 Hz$ or $95 Hz$.

Second harmonic of the source $= 210 Hz$ or $190 Hz$.

As the second harmonic gives 5 beats/sec with sound of frequency 205 Hz, the sound harmonic should be 210 Hz.

$\Rightarrow$ frequency of the source $= 105 Hz$

Q-49 - 11447211

A sinusoidal wave is propagating in negative x-direction in a string stretched along x-axis. A particle of string at $x = 2$ cm is found at its mean position and it is moving in positive y-direction at $t = 1$ s. the amplitude of the wave, the wavelength and the angular frequency of the wave are $0.1 m$, $\pi / 4 m$ and $4\pi rad / s$, respectively.

The speed of particle at $x = 2m$ and $t = 1s$ is

(A) $0.2\pi m / s$

(B) $0.6\pi m / s$

(C) $0.4\pi m / s$

(D) 0

CORRECT ANSWER: C

SOLUTION:

As given the particle at $x - 2$is at mean position at

$t = 1s$. :. Its velocity

$v = \omega A = 4\pi \times 0.1$

$= 0.4\pi m / s$

.

Two simple pendulum of length l and 16l are released from the same phase together. They will be at the same time phase after a minimum time.

(A) $\frac{8\pi}{3}\sqrt{\frac{l}{g}}$

(B) $\frac{\pi}{3}\sqrt{\frac{l}{g}}$

(C) 2s

(D) None of these

CORRECT ANSWER: A

Q-51 - 17937054

Vertical displacement of a plank with a body of mass m on it is varying according to the law $y = \sin \omega t + \sqrt{3} \cos \omega t$. The minimum value of ω for which the mass just breaks off the plank and the moment it occurs first time after t=0, are given by (y is positive towards vertically upwards).

(A) $\sqrt{\frac{g}{2}}, \sqrt{\frac{2}{6}}, \frac{\pi}{\sqrt{g}}$

(B) $\frac{g}{\sqrt{2}}, \frac{2}{3}\frac{\sqrt{\pi}}{g}\Big)$

(C) $\sqrt{\frac{g}{2}}, \frac{\pi}{3}\Big)\sqrt{\frac{2}{g}}$

(D) $\sqrt{2g}, \sqrt{\frac{2\pi}{3g}}$

CORRECT ANSWER: A

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Q-52 - 11750275

The second overtone of an open pipe A and closed pipe B have the same frequencies at a given temperature. Both pipes contain air.

The ratio of fundamental frequency of a to the fundamental

frequency of B is

(A) $3:5$

(B) $5:3$

(C) $5:6$

(D) $6:5$

CORRECT ANSWER: B

SOLUTION:

Second overtone of open pipe $= \frac{3V}{2l_1}$

Second overtone of closed pipe $= \frac{5V}{4l_2}$

Since, ratio of frequency are same

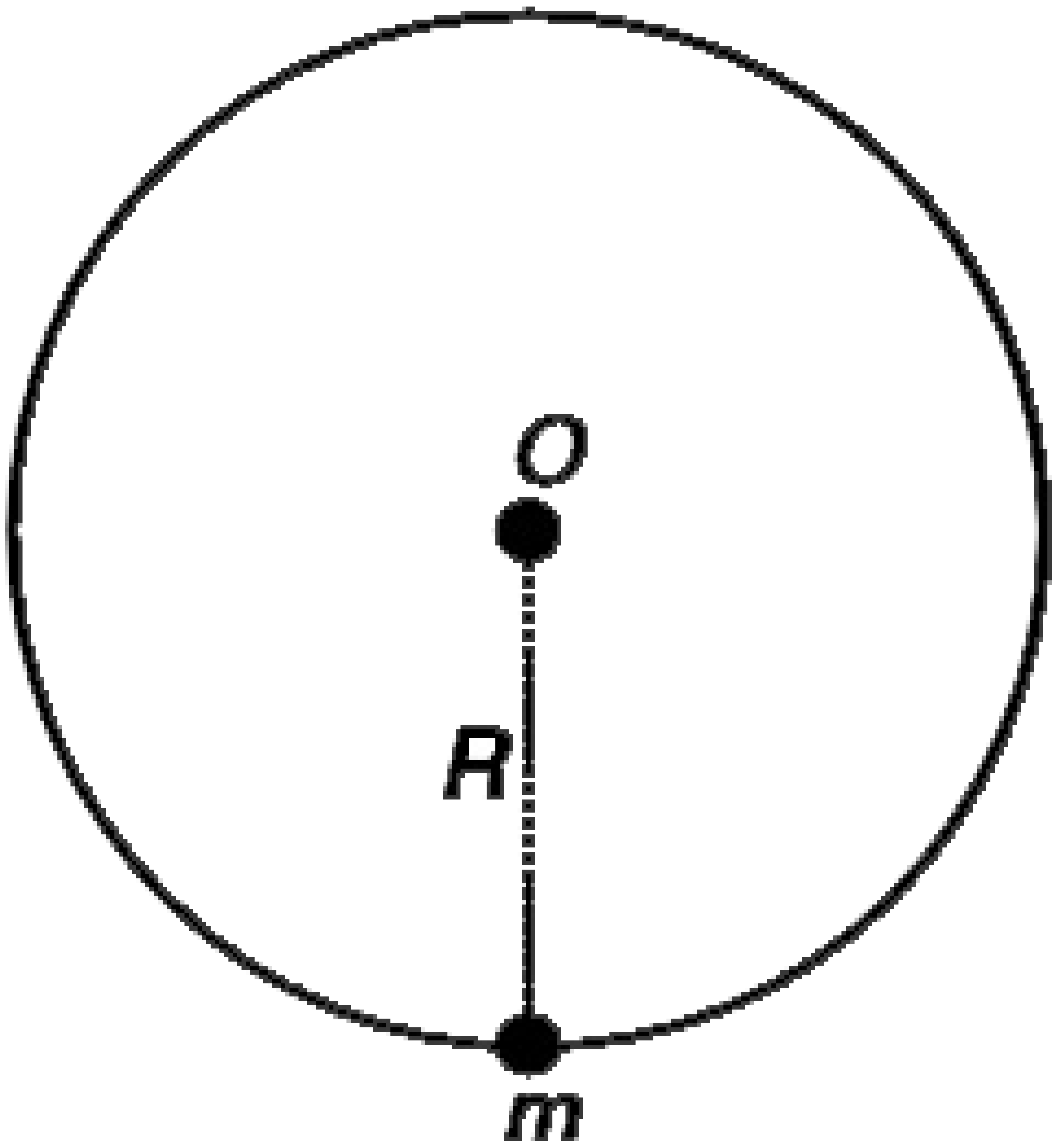
$$\frac{3V}{2l_1} = \frac{5V}{4l_2} \Rightarrow \frac{l_1}{l_2}$$
$$= \frac{4 \times 3}{2 \times 5} = \frac{6}{5}$$

Now, the ratio of fundamental frequencies:

$$\frac{f_1}{f_2} = \frac{\frac{V}{2l_1}}{\frac{V}{4l_2}} \Rightarrow \frac{2l_2}{l_1}$$
$$= 10 : 6 = 5 : 3$$

Q-53 - 15159348

A disc of mass M = 2m and radius R is pivoted at its centre. The disc is free to rotate in the vertical plane about its horizontal axis through its centre O. A particle of mass m is stuck on the periphery of the disc. Find the frequency of small oscillations of the system about its equilibrium position.



CORRECT ANSWER:

$$F = \frac{1}{2PI} SQRT\left(\frac{G}{2R}\right)$$

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Two strings of same material are joined to form a large string and is stretched between rigid supports. The diameter of the second string is twice that of the first. It was observed in an experiment that the whole string was oscillating in 4 loops with a node at the joint. Find the possible lengths of the second string if the length of first string is 90 cm.

CORRECT ANSWER: $15CM, 4CM, 135CM$

Q-55 - 14796992

A particle is executing simple harmonic motion with frequency f . The frequency at which its kinetic energy changes into potential energy is

(A) $f/2$

(B) f

(C) $2f$

(D) $4f$

Q-56 - 18254067

A particle executes simple harmonic motion with a frequency f. The frequency with which the potential. Energy oscillates is

(A) f

(B) f/2

(C) 2f

(D) zero

CORRECT ANSWER: C

SOLUTION:

If $x = A \sin \omega t$

Then, $PE = \frac{1}{2} m A^2 \omega^2 \sin^2 \omega t$

$\therefore \quad PE$

$= \frac{1}{2} m A^2 \omega^2$

$\left(\frac{1 - \cos 2\omega t}{2} \right)$

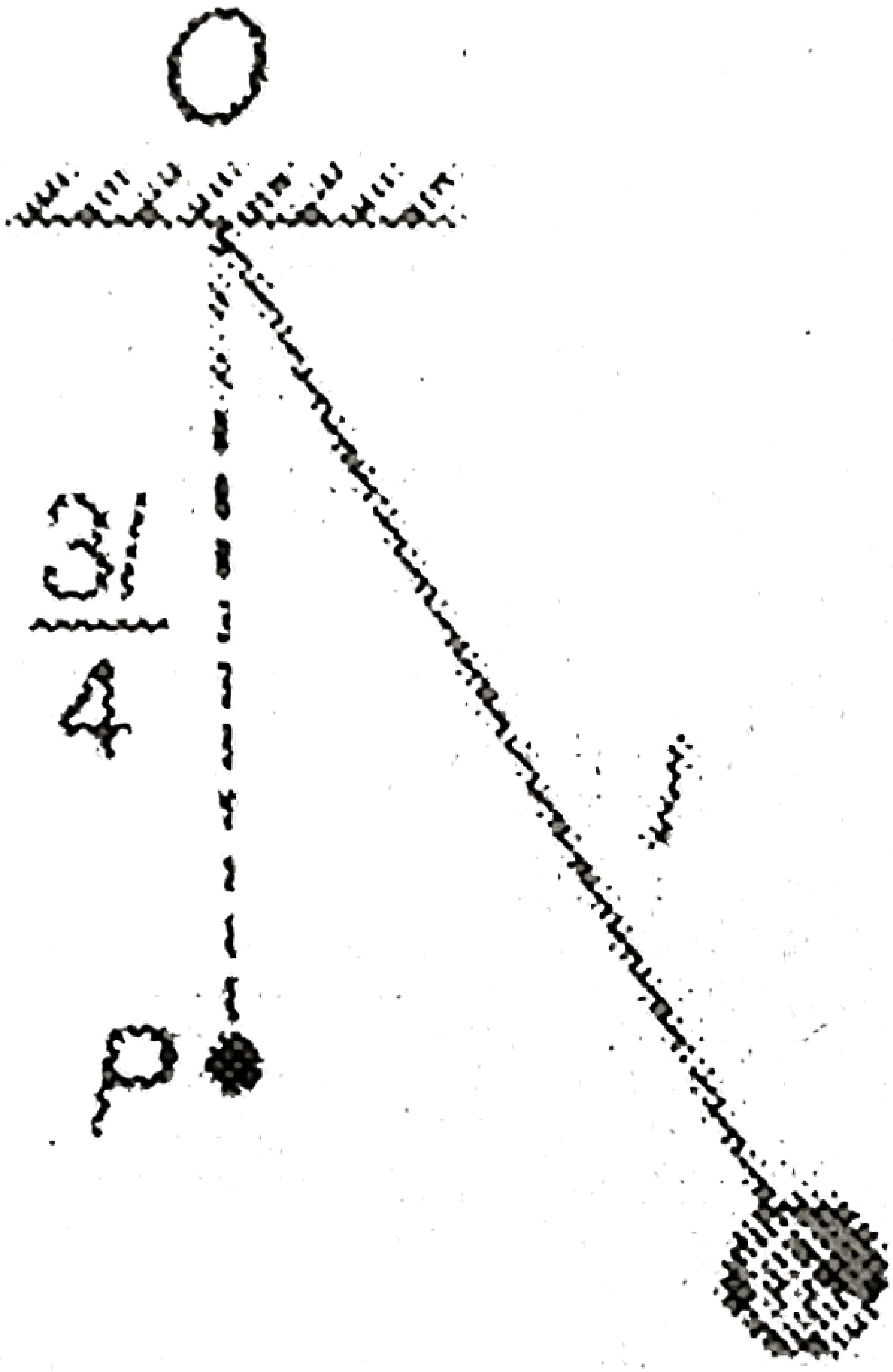
$\therefore \quad \omega' = 2\omega$

or $2\pi f' = 2 \times 2\pi f$

$\therefore \quad f' = 2f$

Q-57 - 17937021

A pendulum has time period T for small oscillations. An obstacle P is situated below the point of suspension O at a distance $\frac{3l}{4}$. The pendulum is released from rest. Throughout the motion, the moving string makes small angle with vertical. Time after which the pendulum returns back to its initial position is



(A) T

(B) $\frac{3T}{4}$

(C) $\frac{3T}{5}$

(D) $\frac{4T}{5}$

CORRECT ANSWER: B

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Q-58 - 15159346

A simple pendulum oscillating with a small amplitude has a time period of $T = 1.0s$. A horizontal thin rod is now placed beneath the point of suspension at a distance equal to half the length of the pendulum. The string collides with the rod once in each oscillation and there is no loss of energy in such collisions. Find the new time period T of the pendulum

---

CORRECT ANSWER: $\left(\frac{SQRT(2)+1}{2SQRT(2)}\right)T$

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Q-59 - 17937203

Force constant of a weightless spring is 16 N/m. A body of mass 1.0 kg suspended from it is pulled down through 5 cm from its mean position and the released. The maximum kinetic energy of the system (spring+body) will be (0.0x) J. Find value of x.

CORRECT ANSWER: 2

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Q-60 - 17937090

A particle is placed at the lowest point of a smooth wire frame in the shape of a parabola, lying in the vertical xy-plane having equatioin x^2=5y(x,y are in meter). After slight displacement, the particle is set free. Find angular frequency of osciallation (in rad/sec) (Take g=10 m/s^2)

(A) 2 rad/s

(B) 4 rad/s

(C) 6 rad/s

(D) 8 rad/s

CORRECT ANSWER: A