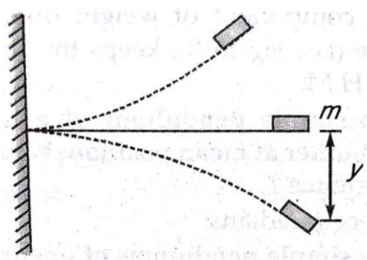
## Short Answer Type Questions – I

**Q.1. What is cantilever?**

**Ans.** Cantilever is a horizontal beam fixed at one end only and load at the other end as shown in the figure below,




The load on the beam tends to displace it, say through a distance y. Restoring force will bring the beam to mean position and the beam starts vibrating.

Time period of vibration is given by,

$$T = 2\pi\sqrt{\frac{\text{Inertia factor}}{\text{Spring factor}}}$$

$$= 2\pi\sqrt{\frac{\text{m}}{k}}$$

**Q.2. Why the amplitude of the vibrating pendulum should be small?**

**Ans.** When amplitude of the vibrating pendulum is small then θ is small. Here the restoring force F $= -mg\sin\theta = -mg\theta = -mgx/l,$ where $x$ is the displacement of bob and $l$ is the length of pendulum. Hence F $\propto -x$. Since F is directed towards mean position. Therefore, the motion of the bob of simple pendulum will be SHM, if θ is small.

**Q.3. When a pendulum clock gain time, what adjustments should be made?**

**Ans.** When a pendulum clock gains time, it means it has gone fast, i.e., it makes more vibration per day than required.

This shows that the time period of oscillations has decreased. Therefore, to correct it, the length of pendulum should be properly increased.

**Q.4. What will be the effect on the time period, if the amplitude of a simple pendulum increases?**

**Ans.** We know that time period of a simple pendulum is independent of amplitude of vibration so as long as θ is not large enough for sin θ ≠ θ, the motion is S.H.M. if the amplitude of a simple pendulum increase, the angle θ increases.

Now, sin θ ≠ θ. In this situation the motion of simple pendulum will be oscillatory but not simple harmonic.

**Q.5. What would happen to the motion of an oscillating system if the sign of the force term in equation F = -kx is changed?**

**Ans.** When the sign in the force equation is changed from '– ve' to '+ ve', the force and hence acceleration will not be opposite to displacement. Due to which the particle will not oscillate but will be accelerated in the direction of displacement. As a result of it, the motion will become a linearly accelerated motion.

**Q.6. What will be the time period of seconds pendulum if its length is doubled?**

**Ans.** For second pendulum T = 2.

So, T = $2\pi\sqrt{\frac{l}{g}} = 2$

when length is doubled (i.e. $l'$ = 2l) then new time period,

T = $2\pi\sqrt{\frac{2l}{g}}$

or T = $\sqrt{2} \times 2\pi\sqrt{\frac{l}{g}}$

or T' = $\sqrt{2}$ T = $\sqrt{2} \times 2 = 2.83\ s$

Hence new time period will be $\sqrt{2}$ time of original time period which will be 2.83 s.

**Q.7. Show that in S.H.M., the acceleration is directly proportional to its displacement at the given instant.**

**Ans.** In S.H.M., the displacement of the particle at an instant is given by:

$$y = r sin\ \omega t.$$

Velocity, $v = \frac{dy}{dt} = r\omega \cos \omega t$

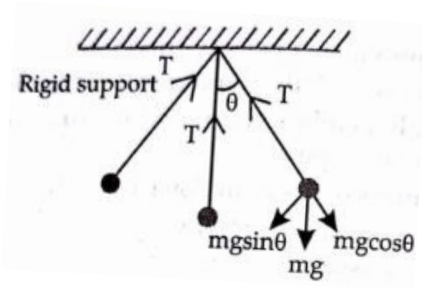
Acceleration, $a = \frac{dy}{dt} = -\omega^2 r sin\ \omega t$

$$= -\omega^2 y.$$

From the above equation, we note that $a \propto y$, i.e., acceleration in S.H.M. at an instant is directly proportional to the displacement of the particle from the mean position at that instant.

**Q.8. Consider a simple pendulum, having a bob attached to a string, that oscillated under the action of the force of gravity. Suppose that the period of oscillation of the simple pendulum depends on its length ($L$), mass of the bob ($m$) and acceleration due to gravity ($g$). Derive the expression for its time period using method of dimension.**

**Ans.** Let θ be the angle made by the string with vertical when the bob is at exteme position.




There are two forces acting on the bob; the tension T along the vertical force due to gravity (=$mg$). The force can be resolved into $mg\cos\theta$ along a circle of length L and centre at this support point. Its radial acceleration ($\omega^2$L) and also tangential acceleration. So net radial force = T – $mg\ cos\ \theta$, while the tangential acceleration provided by $mg\sin\theta$. Since the radial force gives zero torque. So torque provided by the tangential component.

$$\tau = L\ mg\sin\theta \qquad \ldots(i)$$

$\tau = I\alpha$ (by Newton's law of rotational motion) …(ii)

∴ $I\alpha = mg\sin\theta L$

$$\alpha = \frac{mgL}{I}\sin\theta$$

where, I is the moment of inertia, α is angular acceleration.

If θ is too small

∴ $\sin\theta = \theta$

$$\alpha = -\frac{mgL}{I}\theta$$ [for simple harmonic $\alpha = -\omega^2\theta$] [θ is expressed in radian]

$$\omega = \sqrt{\frac{mgL}{I}}$$

and $T = 2\pi\sqrt{\frac{1}{mgL}}$ $\left[\because = \frac{2\pi}{T}\right]$

**Q.9. The angular velocity and amplitude of simple pendulum is θ and $r$ respectively. At a displacement $x$ from the mean position, if its kinetic energy is T and potential energy is V, find the ratio of T to V.**

**Ans.** Kinetic energy, $T = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2\ (r^2 - x^2)$;

Potential energy, $V = \frac{1}{2}m\omega^2x^2$

So $\frac{T}{V} = \frac{r^2-x^2}{x^2}$

**Q.10. What is the length of a simple pendulum which ticks seconds?**

**Ans.** A simple pendulum which ticks seconds is a second pendulum. Its time period T = 2 $s$. If $l$ is the length of this pendulum, then

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Or $$l = \frac{gT^2}{4\pi^2}$$

$$= \frac{9.8\times 2^2}{4\times(22/7)^2} = 0.99 \text{ m}$$

**Q.11. The displacement of a harmonic oscillator is given by $x = \alpha\sin\omega t + \beta\cos\omega t$. What is the amplitude of the oscillation?**

**Ans.** Given: $x = \alpha\sin\omega t + \beta\cos\omega t$

Let $\alpha = r\cos\theta \text{ and } \beta = r\sin\theta$

Then $x = r\cos\theta\sin\omega t + r\sin\theta\cos\omega t$

$= r\sin(\omega t + \theta)$

∴ The amplitude of oscillations is $r$

$\alpha^2 = rcos^2\theta$ (1)

$\beta^2 = rsin^2\theta$ (2)

From (1) and (2)

$$r = \sqrt{\alpha^2 + \beta^2}$$

**Q.12. Define force constant of a spring. Give its S.I. unit and dimensional formula.**

**Ans.** Force constant of a spring is defined as the force required to produce unit extension or compression in the spring i.e., $k = F/y$.

The S.I. unit of $k$ is $Nm^{-1}$.

Dimensional formula = $MLT^{-2}/L = [MT^2]$.

**Q.13. The length of a seconds pendulum on the surface of earth is 100 cm. what will be the length of a seconds pendulum on the surface of moon?**

**Ans.** For a simple pendulum, time period (T) is given by; $T = 2\pi\sqrt{\frac{l}{g}}$.

At Earth, $T = 2\pi\sqrt{\frac{l}{g}}$ (i)

At Moon, $T' = v2\pi\sqrt{\frac{l'}{g'}}$ (ii)

Here, T = T' and $g' = \frac{1}{6}g$

So, from equation (i) & (ii)

$$\frac{l}{g} = \frac{l'}{g'}$$

or, $l' = \frac{g'}{g} \times l$

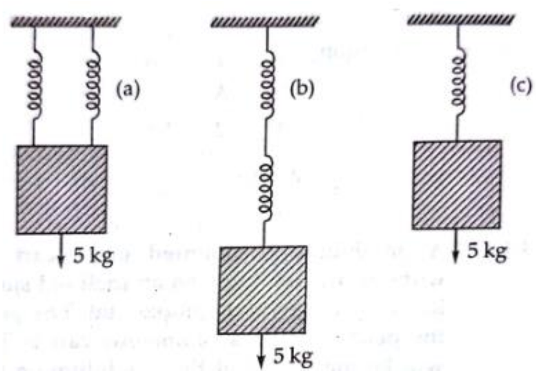
$= \frac{1}{6} g \times \frac{1}{g} \times l$

$= \frac{1}{6} \times l$

$= \frac{1}{6} \times 100$ cm

= 16.7 cm

**Q.14. Two identical springs have the same force constant of 147 Nm$^{-1}$. What elongation will be produced in each case shown in figure?**




**Ans.** Here $k = 147$ Nm$^{-1}$

In figure (a), the effective spring constant,

$k_1 = k + k = 2k = 2 \times 147$

$= 294$ Nm$^{-1}$

∴ Elongation in the spring,

$y_1 = \frac{mg}{k} = \frac{5 \times 9.8}{294} = \frac{1}{6}$ m

In figure (b), the effective spring constant,

$k_2 = \frac{k \times k}{k + k} = \frac{k}{2}$

$= \frac{147}{2}$ m$^{-1}$

∴ Total elongation in the spring

$y_2 = \frac{5 \times 9.8 \times 2}{147} = \frac{2}{3}$ m

In figure ©, the effective constant,

$k = 147$ Nm$^{-1}$

∴ Elongation in the spring,

$y_3 = \frac{5\times9.8}{147} = \frac{1}{3}$ m.

**Q.15. Which of the following functions of time represent (a) S.H.M., and (b) periodic but not simple harmonic motion? Give the period for each case:**
**(i) sin $\omega t - \cos\omega t$**
**(ii) $\sin^2$ ωt.**

**Ans.** (i) sin $\omega t - \cos\omega t$

= $\sqrt{2}\left[\sin\omega t\cos\frac{\pi}{4} - \cos\omega t\sin\frac{\pi}{4}\right]$

= $\sqrt{2}\sin\left(\omega t - \frac{\pi}{4}\right)$

This function represents S.H.M., having period

T = $2\pi/\omega$ and initial phase = $-\frac{\pi}{4}$rad.

(ii) $\sin^2\omega t = (1 - \cos^2\omega t)$

The function is periodic, having a period

T = $\frac{2\pi}{2\omega} = \frac{\pi}{\omega}$

But does not represent S.H.M.

**Q.16. A simple harmonic motion of amplitudes A, has a time period T. What will be the acceleration of the oscillator, when its displacement is half of the amplitude?**

**Ans.** Acceleration,

α = $-\omega^2 y = -\frac{4\pi^2}{T^2}\times\frac{A}{2}$

$= -\frac{2\pi^2 A}{T^2}$

**Q.17. A pendulum is mounted on a cart rolling without friction down on an inclined surface of inclination θ with the horizontal. The period of the pendulum on an immobile cart is T. what will be the period of the pendulum on the cart when the cart rolls down the surface?**

**Ans.** When the cart is at rest, the effective acceleration due to gravity is g and when the cart is rolling down the inclined surface, the effective acceleration due to gravity involved perpendicular to plane is g cos θ. Time period of pendulum when art is immobile,

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Time period of cart when it moving down the plane,

$$T' = 2\pi\sqrt{\frac{l}{g\cos\theta}}$$

Or T'= $\frac{T}{\sqrt{\cos\theta}}$

**Q.18. A ball of radius $r$ is made to oscillate in a bowl of radius R, find its time period of oscillation.**

**Ans.** Here, equivalent length of simple pendulum = distance between centre of ball to centre of bowl.

i.e., $l = (R - r)$

∴ Time period of Oscillation of ball

$$= 2\pi\sqrt{\frac{(R-r)}{g}}$$

**Q.19. A simple pendulum performs S.H.M. about $x = 0$ with an amplitude $a$ and time period T. What is the speed of the pendulum at $x = a/2$?**

**Ans.** Speed of pendulum, $v = \omega\sqrt{a^2 - x^2}$

$$v = \frac{2\pi}{T}\sqrt{a^2 - \frac{a^2}{4}}$$

$$= \frac{\sqrt{3}a\pi}{T}$$

**Q.20. A block rests on a horizontal table which is executing S.H.M. in the horizontal plane with an amplitude A. What will be the frequency of oscillation, the block will just start to slip? (Coefficient of friction = μ.)**

**Ans.** Restoring force on the block

= $m\omega^2 A = \mu mg$

∴ Acceleration in the block = $\mu g$

Frequency of oscillation,

$$f = \frac{1}{2\pi}\sqrt{\frac{\text{Acceleration}}{\text{Displacement}}}$$

$$= \frac{1}{2\pi}\sqrt{\frac{\mu g}{y}}$$

**Q.21. The periodic time of a body executing S.H.M. is 2 sec. after how much interval from$t = 0$., will its displacement be half of its amplitude?**

**Ans.** Here, T = 2s; $t$ = ?, $y$ = $a/2$

Now, $y = a\sin\omega t = a\sin\frac{2\pi}{T}t$ (∵ T = 2s)

∴ $\frac{a}{2} = a\sin\frac{2\pi}{T}t = a\sin\pi t$

Or $\sin \pi t = \frac{1}{2}$

∴ $\sin 30^\circ = \sin\frac{\pi}{6}$

Or $\pi t = \frac{\pi}{6}$ $or\ t = \frac{1}{6}$ sec.

**Q.22. Will a pendulum gain or lose time when taken to the top of a hill?**

**Ans.** Value of acceleration due to gravity decreases at the top of the hill. Time period of a simple pendulum is given by:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Decrease in $g$ means, increase in T, i.e., the pendulum takes more time to complete vibration, it implies that it will lose time.

**Q.23. The acceleration due to gravity on the surface of moon is 1.7 ms$^{-2}$. What is the time period of a simple pendulum on the surface of moon if its time period on the surface of earth is 3.5 s? ($g$ = 9.8 ms$^{-2}$)**

**Ans.** On earth time period,

$$T = 2\pi\sqrt{\frac{l}{g}}$$

i.e., $$3.5 = 2\pi\sqrt{\frac{l}{9.8}}$$

Moon g = 1.7 ms$^{-1}$

$$T' = \sqrt{\frac{l}{1.7}}$$

Dividing $$\frac{T'}{3.5} = \frac{2\pi\sqrt{\frac{l}{1.7}}}{2\pi\sqrt{\frac{l}{9.8}}}$$

or $$T' = \sqrt{\frac{9.8}{1.7}} \times 3.5 = 8.4 \text{ s.}$$

**Q.24. At what displacement, (i) the P.E. of a simple harmonic oscillator is maximum, (ii) the K.E. is maximum?**

**Ans.** The P.E. of a particle executing S.H.M. is given by:

$$E_P = \frac{1}{2}m\omega^2y^2.$$

$E_p$ is maximum when $y = r =$ amplitude of vibration, i.e., the particle is passing from the extreme position and is minimum when $y = 0$, i.e., the particle is passing from the mean position.

The K.E. of a particle executing S.H.M. is given by;

$$E_K = \frac{1}{2}m\omega^2(r^2 - y^2)$$

$E_K$ is maximum when $y = 0$, i.e., the particle is passing from the mean position and $E_K$ is minimum when $y = r$, i.e., the particle is passing from the extreme position.

**Q.25. The maximum acceleration of a simple harmonic oscillator is $a_0$, while the maximum velocity is $v_0$, what is the displacement amplitude?**

**Ans.** Here, $v_0 = \omega A, a_0 = \omega^2 A = (\omega A)\omega = v_0 \omega$

or $v_0 \omega = a_0$

$$\omega = \frac{a_0}{v_0}$$

Thus $A = \frac{v_0}{\omega} = \frac{v_0}{\left(\frac{a_0}{v_0}\right)} = \frac{v_0^2}{a_0}$

**Q.26. At what distance from the mean position is the K.E. in simple harmonic oscillator equal to P.E.?**

**Ans.** When the displacement of a particle executing S.H.M. is y, then its

K.E. $= \frac{1}{2} m\omega^2 (A^2 - y^2)$

And P.E. $= \frac{1}{2} m\omega^2 y^2$

If K.E. = P.E.

then, $\frac{1}{2} m\omega^2 (A^2 - y^2) = \frac{1}{2} m\omega^2 y^2$

Or $2y^2 = A^2$

Or $y = \frac{A}{\sqrt{2}}$

**Q.27. Two exactly identical pendulums are oscillating with amplitude 2 cm and 6 cm. Calculate the ratio of their energies of oscillations.**

**Ans.** Total energy of the bob of simple pendulum is given by E = $m\omega^2 r^2$, i.e., E $\propto r^2$,

So $\frac{E_1}{E_2} = \frac{r_1^2}{r_2^2} = \left(\frac{2}{6}\right)^2 = \frac{1}{9}$

**Q.28. Explain why waves on strings are always transverse?**

**Ans.** A string is non-stretchable, i.e., compressions and rarefactions cannot be produced in strings. Therefore, longitudinal waves in strings are not possible, strings do have elasticity of shape. Therefore, waves on strings are transverse.

**Q.29. Liquids and gases cannot propagate transverse waves. Why?**

**Ans.** Liquids and gases cannot sustain shearing stress. Therefore transverse waves in the form of crests and troughs (involving change of shape) are not possible in fluids. Rather, the fluid posses volume elasticity. Therefore, compressions and rarefactions (involving changes in volume) can be propagated through fluids.

**Q.30. What is periodic wave function?**

**Ans.** A wave function $(x, t)$ which satisfies the periodicity conditions of position and time is called a periodic wave function, i.e.,

(i) $y(x + m\lambda t) = y(x, t)$

(ii) $y(x, t + n\mathrm{T}) = y(x, t)$

where λ = wavelength of wave, T = period of the wave, $n$ and $m$ are integers.

**Q.31. Write down the expression for speed of transverse waves in solids and in a stretched string.**

**Ans.** In a solid:

Speed of transverse wave, $v = \sqrt{\frac{\eta}{\rho}}$

Where η is modulus of rigidity and ρ is density of material of solid.

In a stretched string:

Here $v = \sqrt{\frac{\mathrm{T}}{m}}$

Where T is tension in the string and $m$ is mass per unit length of the string.

**Q.32. What is phase in wave equation $\boldsymbol{y = r}\textbf{sin}\left(\boldsymbol{2\pi\frac{t}{\mathrm{T}} + 2\pi\frac{x}{\lambda}}\right)$**

**Ans.** Rewriting $y = r\sin 2\pi\left(\frac{t}{\mathrm{T}} + \frac{x}{\lambda}\right)$

Here $2\pi\left(\frac{t}{\mathrm{T}} + \frac{x}{\lambda}\right)$ is phase of the wave.

**Q.33. What are fundamental note and overtones?**

**Ans.** When a source is sounded, it generally vibrates in more than one mode and therefore, emits tones of different frequencies. The tone of lowest frequency is called the fundamental note and the tones of higher frequencies are called overtones.

**Q.34. What are the conditions for resonance of air column with a tuning fork?**

**Ans.** The resonance will take place in air column if the compression or rarefaction produced by the vibration of the tuning fork travels from open end of the air column to lower closed end (water level in the resonance apparatus) and back to the upper open end in the same time in which the prong goes from one extreme to other.

**Q.35. Why is the sonometer box hollow and provided with holes?**

**Ans.** When the strings of a vibrating turning fork is gently pressed against the top face of sonometer box, the air enclosed in the box also vibrates. This increase the intensity of sound. The holes bring the inside air in contact with the outside air and check the effect of elastic fatigue.

**Q.36. Draperies and furniture often improve the acoustics of a room. Why?**

**Ans.** According to Sabine, acoustic of a room depends upon its time of reverberation which can be adjusted by placing such things in the room which may absorb the sound falling on them. As dampers and furniture in the room absorb the sound produced in the room, they help to control the time of reverberation of the room. Therefore the presence of draperies and furniture often improve the acoustics of the room.

**Q.37. A bugle has no valves. How then can we sound different notes on it?**

**Ans.** We know that the frequency of a note produced by an organ pipe (bugle) depends upon the pressure with which air is forced into it. Therefore, sound of different notes can be produced by forcing air through the mouth piece at different pressures in the bugle. That is why a buglarexpands his mouth unequally, while playing upon the bugle.

**Q.38. What would a person hear, if he moves away from a source of sound with the speed of sound?**

**Ans.** The person would be hearing nothing if he is moving away from the source with the speed of sound. It is so, because the relative velocity of sound waves with respect to person is zero. Therefore, the sound waves cannot strike the drum of the person's ears and hence, no sensation of hearing is produced.

**Q.39. Match the following correctly :**

| Column A | Column B |
|---|---|
| Pitch | Waveform |
| Quality | Frequency |
| Loudness | Intensity |

**Ans.** The correct matching is: Pitch → Frequency, Quality → Waveform, Loudness → Intensity.

**Q.40. Distinguish between sound waves and radio waves of same frequency, say 15 kHz.**

**Ans.** Some of the points of distinction between sound waves and radio waves of same frequency are:

(i) Sound waves cannot travel through free space (vacuum), but radio waves can.
(ii) Velocity of sound waves in air = 332 m/s. velocity of radio waves in free space = $3 \times 10^8$ m/s.
(iii) Velocity of sound increases with rise in temperature while velocity of radio waves is not affected by temperature.
(iv) Sound waves of frequencies ranging from 20 Hz to 20 kHz can be detected by the ear. Radio waves cannot be detected by the ear.

**Q.41. Set up a relation between speed of sound in a gas and root mean square velocity of the molecules of that gas.**

**Ans.** Speed of sound in a gas is $v = \sqrt{\frac{\gamma P}{\rho}}$ …(i)

According to kinetic theory of gases, root mean square velocity (c) of molecules of gas is obtained from the relation

$$P = \frac{1}{3}\rho c^2,\ c = \sqrt{\frac{3P}{\rho}} \quad \ldots(ii)$$

Dividing (i) by (ii),

$$\frac{v}{c} = \sqrt{\frac{\gamma}{3}}$$

Or $$v = c\sqrt{\frac{\gamma}{3}}$$

This is the required solution.

**Q.42. Air gets thinner as we go up in the atmosphere. Will the velocity of sound change?**

**Ans.** As we move up, the pressure (P) of air and density of air (ρ), both decreases. As $v = \sqrt{\frac{\gamma RT}{M}}$, therefore, velocity of sound will not change.

**Q.43. A vessel is placed below a water tap. We can estimate the height of the water level reached in the vessel from a distance simply by listening to the sound. Why?**

**Ans.** The frequency of sound produced in an air column is inversely proportional to the length of the air column. As level of water in the vessel increases, length of air column above it decreases. Hence the frequency of sound produced goes on increasing. The sound becomes shriller.

**Q.44. If a balloon if filled with $CO_2$ gas, then how will it behave as a lens for sound waves? If it were filled with hydrogen gas, then what will happen?**

**Ans.** Velocity of sound in $CO_2$ is less than that in air. Therefore balloon will behave as a convex lens for sound waves. In hydrogen, velocity of sound is greater than that in air. Therefore, balloon filled with hydrogen will behave as a concave lens.

**Q.45. Giving reason for you selection, select pairs out of the following four waves in a medium which will give rise to (i) beats, (ii) destructive interference, (iii) stationary waves.**

(i) $\xi_1 = \mathrm{A}\cos 2\pi\left(v_1 t + \frac{x}{\lambda_1}\right)$

(ii) $\xi_2 = \mathrm{A}\cos 2\pi\left(v_1 t + \frac{x}{\lambda_1} + \pi\right)$

(iii) $\xi_3 = \mathrm{A}\cos 2\pi\left(v_1 t + \frac{x}{\lambda_2}\right)$

(iv) $\xi_4 = \mathrm{A}\cos 2\pi\left(v_1 t - \frac{x}{\lambda_2}\right)$

**Ans.** (i) The pairs (1) and (3) will give rise to beats as they represent two simple harmonic waves of slightly different frequency. Travelling in the same direction.

(ii) The pairs (1) and (2) will produce destructive interference as they represent two identical waves with a phase difference of $\pi$, travelling in the same direction.

(iii) The pairs (3) and (4) represent identical waves travelling in opposite directions. They will give rise to stationary waves.

**Q.46. Can beats be observed in two light sources of nearly equal frequencies?**

**Ans.** No, the emission of light from atom is a random and rapid phenomena. The phase at a point due to two independent light sources will change rapidly and rapidly and randomly. Therefore, instead of beats, we shall get uniform intensity.

However, if light sources are laser beams of nearly equal frequencies, we may be able to observe the phenomenon of beats in light.

**Q.47. Why all the stringed instruments are provided with hollow boxes?**

**Ans.** The stringed instrument are provided with hollow boxed in order to increase the surface area of vibration, which increases the loudness/ intensity ($\mathrm{I}$) of the sound produces [As $\mathrm{I} \propto a^2$]. Moreover, the air inside the hollow box is set into forces vibration which also increases the loudness of sound produced.

**Q.48. The reverberation time of an empty hall is larger than that of a crowded hall. Why?**

**Ans.** The audience is also absorber of sound. The total absorption in case of crowded hall is more, therefore, as per Sabine formula, reverberation time of a crowded hall is smaller than that of an empty hall.

**Q.49. How roar of a lion can be differentiated from buzzing of a mosquito?**

**Ans.** Roaring of a lion produces a sound of low pitch and high intensity/loudness, whereas the buzzing of mosquito produces a sound of high pitch and low intensity/loudness. That is how roar of a lion can be differentiated from buzzing of mosquito.

**Q.50. A source of sound moves towards a stationary observer. Is the increase in pitch due to :**

**(i) Increase in the velocity of sound?**
**(ii) Actual or apparent change in wavelength?**
**(iii) Both?**

**Ans.** When a source of sound moves towards a stationary observer the increase in pitch is due to actual or apparent change in wavelength. It is so because, due to motion of the source of sound towards observer at rest, waves get compressed as the effective velocity of sound waves relative to source becomes less than the actual. As a result of it, the wavelength of sound waves decreases and hence the observed pitch increases.

**Q.51. When we start filling an empty bucket with water, the pitch of sound produced goes on changing. Why?**

**Ans.** A bucket can be treated as a pipe closed at one end. The frequency of the note produced = $v/4$L, where $v$ is velocity of sound in air and L is length of air column, which is equal to depth of water level from the open end. As the bucket is filled with water, L decrease. Therefore, frequency of sound produced goes on increasing.

**Q.52. What are the essential points of difference between sound and light waves?**

**Ans.** (i) Sound waves are mechanical waves which are longitudinal in nature. Light waves which are longitudinal in nature. Light waves are electromagnetic waves which are transverse in character.

(ii) Sound waves need a material medium for propagation, whereas light waves do not need any medium.

(iii) Velocity of sound waves in air at $0^oC \approx 332$ m/s, whereas velocity of light waves in air/vacuum = $3 \times 10^8$ m/s.

**Q.53. A person deep inside water cannot hear sound produced in air. Why?**

**Ans.** As speed of sound in water is roughly four times the speed of sound in air, therefore

$\mu = \frac{\sin i}{\sin r} = \frac{v_a}{v_w}$

$= \frac{1}{4} = 0.25$

For refraction,

$r_{max} = 90^o$

$\therefore \ (\sin i)_{max} = 0.25$

$\therefore i_{max} \approx 14^o$. That is why most of sound produced in air and falling at $\angle i > 14^o$ gets reflected in air and person deep inside water cannot hear the sound.

**Q.54. The velocity of sound air N.T.P. is 331 $ms^{-1}$. Find its velocity when the temperature rises to $91^oC$ and its pressure is doubled.**

**Ans.** Here, $v_0 = 331$ $ms^{-1}$

Rise in temperature, $t = 91^oC$

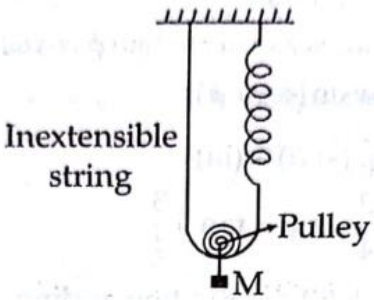
Since velocity of sound is not affected by the change in pressure, therefore we have to see the effect of temperature alone.

As $v_1 = v_0\sqrt{\frac{273+t}{273}} = 331\sqrt{\frac{273+91}{273}}$

$= 331\sqrt{1 + \frac{91}{273}} = 331\sqrt{1 + \frac{1}{3}}$

$= 331 \times \frac{2}{\sqrt{3}} = 382.2$ $ms^{-1}$

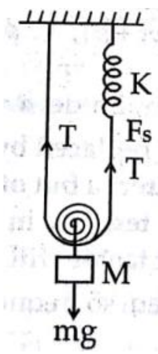
**Q.55. Find the time period of mass M when displaced from its equilibrium position and then released for the system show in Fig.**




**Ans.** Mg = T + T {system is in equilibrium}

∴ Mg = 2T

Because of mass hanging spring elongated by $2l$. Where $l$ is the distance moved by hanging mass




T = $F_s$ (In the spring)

T = 2 kl

∴ Mg = 2($2kl$) = $2k(2l)$

Displacing mass through $y$ distance towards

Restoring force

F = Mg − $2k(2l + 2y)$

= Mg – $(2k)(2l) - 4ky$

Or F = Mg – Mg − $4ky = -4ky$

$M\frac{d^2y}{dt^2} = -4ky$

$\frac{d^2y}{dt^2} = -\frac{4k}{M}y$ {Comparing with $\frac{d^2y}{dt^2} = -w^2y$}

$\therefore w = \sqrt{\frac{4k}{M}}$ or $T = \frac{2\pi}{w} = 2\pi\sqrt{\frac{M}{4k}}$

**Q.56. Show that the motion of a particle represented by y = sin ωt – cos ωt is simple harmonic with a period of 2π/ω.**

**Ans.** $y = \sin \omega t - \cos \omega t$

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

$= \sqrt{2}\left(\cos\frac{\pi}{4} \sin \omega t - \sin\frac{\pi}{4} \cos \omega t\right)$

$\therefore \quad y \quad = \sqrt{2} \sin\left(wt - \frac{\pi}{4}\right)$

∴ (sin ωt – cos ωt) represents SHM.

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

$= \sqrt{2}\sin\left(\omega\left(t + \frac{2\pi}{\omega}\right) - \frac{\pi}{4}\right)$

∴ Time period = $\frac{2\pi}{\omega}$

**Q.57. Find the displacement of a simple harmonic oscillator at which its P.E. is half of the maximum energy of the oscillator.**

**Ans.** PE of oscillator, U = $\frac{1}{2} mw^2 y^2$ {y = displacement Maximum – energy of oscillator, E = $\frac{1}{2} mw^2 A^2$}

U = $\frac{1}{2}$E

or $\frac{1}{2} mw^2 y^2 = \frac{1}{4}\ mw^2 A^2$

or $y^2 = \frac{A^2}{2}$

or $y = \pm \frac{A}{\sqrt{2}}$

**Q.58. A body of mass $m$ is situated in a potential field U(x) = $U_o$(1 – cos α x) when $U_o$ and α are constants. Find the time period of small oscillations.**

**Ans.** U(x) = $U_o(1 - \cos \alpha x)$

Differentiating both sides with respect to x

$\frac{dU(x)}{dx} = U_o[0 + \alpha \sin \alpha x] = U_o \alpha \sin \alpha x$

∴ F = $-\frac{dU(x)}{dx} = -U_o \alpha \sin \alpha\ x$

When oscillations are small, sin θ ≈ θ

or sin α$x$ = α$x$

∴ F = $-U_o \alpha(\alpha x) = -U_o \alpha^2 x$

∴ F = $-(U_0 \alpha^2)x$ (i)

We know that F = $-kx$ (ii)

$k = U_o\alpha^2$ {From (i) & (ii)}

∴ T = $2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{m}{U_o\alpha^2}}$

**Q.59. A mass of 2 kg is attached to the spring constant 50 Nm$^{-1}$. The block is pulled to a distance of 5 cm from its equilibrium position at $x$ = 0 on a horizontal frictionless surface from rest at $t$ = 0. Write the expression for its displacement at anytime $t$.**

**Ans.** Given : m = 2 kg, k = 50 Nm$^{-1}$, A = 5 cm

$w = \sqrt{\frac{k}{m}} = \sqrt{\frac{50}{2}} = \sqrt{25} = 5\text{s}^{-1}$

At t = 0, x = 0

∴ Displacement at any time t

$x$ = A sin $wt$ or $x = 5$ sin 5$t$

**Q.60. Consider a pair of identical pendulums, which oscillate with equal amplitude independently such that when on pendulum is at its extreme position making an angle of 2° to the right with the vertical. The other pendulum makes an angle of 1° to the left of the vertical. What is the phase difference between the pendulums?**

**Ans.** suppose $\theta_0$ is Angular amplitude of each of the pendulums.

$\theta_1 = \theta_0 \sin(wt + \delta_1)$

$\theta_2 = \theta_0 \sin(wt + \delta_2)$ {SHM of pendulums}

One pendulum is making 2° angle with vertical, $\theta_0 = 2°$. For I *pendulum*$\theta_1 = 2°$

∴ 2° = 2° sin $(wt + \delta_1)$

sin $(wt + \delta_1)$ = 1

$wt + \delta_1 = 90°$

For other pendulum, $\theta_2 = -1°$

∴ $-1°$ = 2° sin $(wt + \delta_2)$

or sin $(wt + \delta_2) = -\frac{1}{2}$

$wt + \delta_2 = -30°$

∴ $(wt + \delta_1) - (wt + \delta_2) = 90° - (-30°)$

$\delta_1 - \delta_2 = 120°$

**Q.61. A steel wire has a length of 12 m and a mass of 2.10 kg. What will be the speed of a transverse wave on this wire when a tension of 2.06 × 10$^4$ N is applied?**

**Ans.** Given: $l = 12$ m, mass = 2.10 kg

Tension, T = 2.06 × $10^4$ N,

$m = \frac{M}{l} = \frac{2.10}{12}$

∴ $v = \sqrt{\frac{T}{m}} = \sqrt{\frac{2.06 \times 10^4 \times 12}{2.10}}$

$= \sqrt{11.77 \times 10^4}$

$v = 3.43 \times 10^2$ m/s

$v = 343$ m/s

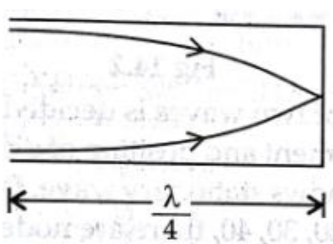
**Q.62. A pipe 20 cm long is closed at one end. Which harmonic mode of the pipe is resonantly excited by a source of 1237.5 Hz? (Sound velocity in air = 330 m $s^{-1}$)**

**Ans.** Given: $l = 20$ cm = 0.2 m

$\text{v} = 1237.5$ Hz

$v = 330$ m/s

$l = \frac{\lambda}{4}$ or λ = 4$l$




$\text{v}_{\text{fundamental}} = \frac{\text{v}}{4l}$

$\text{v}_{\text{fundamental}} = \frac{330}{4 \times 0.2} = 412.5$ Hz

$\text{v}_{\text{given}} = 1237.5$ Hz

$\frac{\text{v}_{\text{given}}}{\text{v}_{\text{fundamental}}} = \frac{1237.5}{412.5} = \frac{3}{1}$

So, 3rd harmonic node of pipe is excited by 1237.5 Hz frequency.

**Q.62. A train standing at the outer signal of a railway station blows a whistle of frequency 400 Hz still air. the train begins to move with a speed of 10 $ms^{-1}$ towards the platform. What is the frequency of the sound for an observer standing on the platform?(sound velocity in air = 330 m $s^{-1}$)**

**Ans.** Given: $\text{v}_0 = 400$ Hz

Velocity of train, $v_1 = 10$ m/s

Velocity of sound in air, $v_a = 330$ m/s

Apparent frequency when source is moving

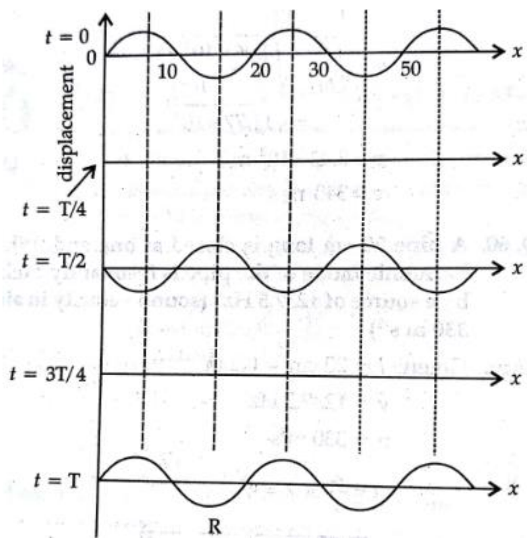
$v_{app} = \frac{v_a}{(v_a - v_t)} v_0$

$= \frac{330 \times 400}{(330-10)}$

$v_{app} = \frac{825}{2} = 412.5$ Hz

$v_{app} = 412.5$ Hz

**Q.64. The wave pattern on a stretched string is shown in Fig. Interpret what kind of wave this is and find its wavelength.**




**Ans.** Nature of two waves is decided by observing the displacement and position points. the graphs shows stationary wave. Points on positions $x$ = 10, 20, 30, 40, there are nodes.

They are stationary waves:

Distance between successive nodes = $\frac{\lambda}{2}$

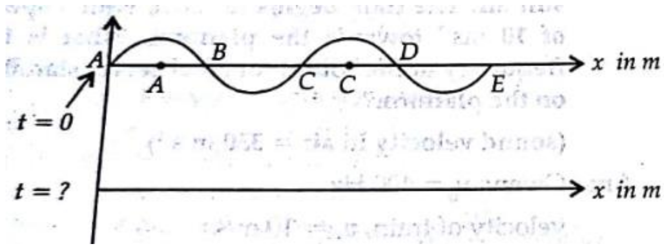
λ = 2 × (node-to-node distance)

= 2 × (20 – 10)

= 2 × 10

λ = 20 cm

**Q.65. The pattern of standing waves formed on a stretched string at two instants of time are shown in Fig. The velocity of two waves superimposing to form stationary waves is 360 ms$^{-1}$ and their frequencies are 256 Hz.**




**(a) Calculate the time at which the second curve is plotted.**
**(b) Mark nodes and antinodes on the curve.**
**(c) Calculate the distance between A' and C'.**

**Ans.** Given: frequency of wave, v = 256 Hz

Time period, T = $\frac{1}{v} = \frac{1}{256}$

$= 3.9 \times 10^{-3}$ s

(a) Time taken to pass through mean position

$t = \frac{T}{4}$

$= \frac{3.9 \times 10^{3}}{4} s$

$= 9.8 \times 10^{-4}$ s

(b) Nodes- A, B, C, D, E (zero displacement)

Antinodes- A', C' (maximum displacement)

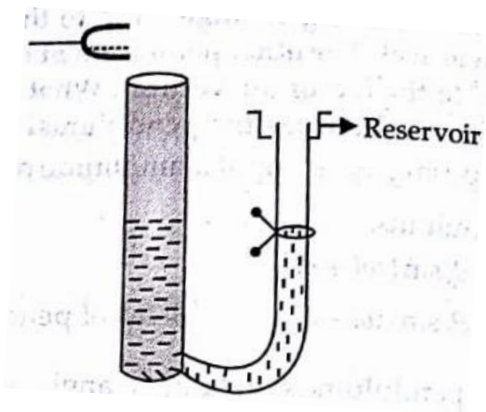
(c) At A', C', there are consecutive anti-nodes, so distance between A' and C',

$\lambda = \frac{u}{v} = \frac{360}{256}$

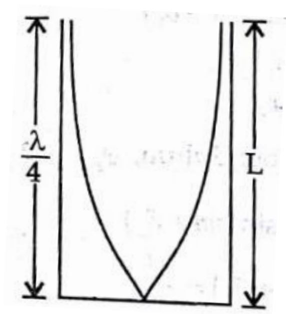
λ = 1.41 m

**Q.66. A tuning fork vibrating with a frequency of 512 Hz is kept close to the open end of a tube filled with water (Fig.). The water level in the tube is gradually lowered. When the water level is 17 cm below the open end, maximum intensity of sound is heard. If the room temperature is 20$^{o}$C, calculate**

**(a) Speed of sound in air at room temperature**
**(b) Speed of sound in air at 0$^{o}$C**
**(c) If the water in the tube is replaced with mercury, will there be any difference in your observations?**




**Ans.** Let us consider the following diagram




For maximum intensity –

(a) L = $\frac{\lambda}{4}$

Or λ = 4L

$v = \nu\lambda = \nu \times 4L$

= 512 × 4 × 17 × $10^{-2}$

= 348.16 m/s

(b) As, $v \propto \sqrt{T}$ (T = Temperature)

$\frac{v_{20}}{v_0} = \sqrt{\frac{273+20}{273+0}} = \sqrt{\frac{293}{273}}$

$$\frac{v_{20}}{v_0} = 1.04$$

Or $v_0 = \frac{v_{20}}{1.04} = \frac{348.16}{1.04} = 334.8$ m/s

(c) Water and mercury in tube reflects the sound into air column to form stationary wave and reflection is more in mercury than water as mercury is more denser than water. So, intensity of sound heard will be longer but reading does not change as medium in tube (air) and running fork are same.

**Q.67. Show that when a string fixed at its two ends vibrates in 1 loop, 2 loops, 3 loops, and 4 loops, the frequency are in the ratio 1:2:3:4.**

**Ans.** Length for each loop = $\frac{\lambda}{2}$

Now,

L = $\frac{n\lambda}{2}$

λ = $\frac{2L}{n}$ (1)

But $v = v\lambda$ or λ = $\frac{v}{u}$

Putting in eqn, (1)

$\frac{v}{u} = \frac{2L}{n}$

$v = \frac{n}{2L}u$

$v = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$ $[\because u = \sqrt{\frac{T}{\mu}}]$

For n = 1, $v_1 = \frac{1}{2L}\sqrt{\frac{T}{m}} = \mathrm{v}_0$

For n = 2, $v_2 = \frac{1}{2L}\sqrt{\frac{T}{m}} = 2\mathrm{v}_0$

Therefore, $u_1 : u_2 : u_3 : u_4 = n_1 : n_2 : n_3 : n_4$

$u_1 : u_2 : u_3 : u_4 = 1 : 2 : 3 : 4$