medium is stationary $v_m = 0$ then $n' = \left(\frac{v - v_L}{v - v_s}\right)n.$

(1) No Doppler effect takes place ($n' = n$) when relative motion between source and listener is zero.

(2) Source and listener moves at right angle to the direction of wave propagation. ($n' = n$)

(i) If the velocity of source and listener is equal to or greater than the sound velocity then Doppler effect is not observed.

(ii) Doppler effect does not say about intensity of sound.

(iii) Doppler effect in sound is asymmetric but in light it is symmetric.

QUESTIONS

ONE MARK QUESTIONS

1. How is the time period effected, if the amplitude of a simple pendulum is increased?

2. Define force constant of a spring.

3. At what distance from the mean position, is the kinetic energy in simple harmonic oscillator equal to potential energy ?

4. How is the frequency of oscillation related with the frequency of change in the K.E. and P.E. of the body in S.H.M.?

5. What is the frequency of total energy of a particle in S.H.M. ?

6. How is the length of seconds pendulum related with acceleration due to gravity of any planet ?

7. If the bob of a simple pendulum is made to oscillate in some fluid of density greater than the density of air (density of the bob > density of the fluid), then time period of the pendulum increased or decrease.

8. How is the time period of the pendulum effected when pendulum is taken to hills or in mines ?

9. A transverse wave travels along x-axis. The particles of the medium must move in which direction ?

10. Define angular frequency. Give its S.I. unit.

11. Sound waves from a point source are propagating in all directions. What will be the ratio of amplitudes at distances of x meter and y meter from the source ?

12. Does the direction of acceleration at various points during the oscillation of a simple pendulum remain towards mean position ?

13. What is the time period for the function $f(t) = \sin \omega t + \cos \omega t$ may represent the simple harmonic motion ?

14. When is the swinging of simple pendulum considered approximately SHM ?

15. Can the motion of an artificial satellite around the earth be taken as SHM?

16. What is the phase relationship between displacement, velocity and acceleration in SHM ?

17. What forces keep the simple pendulum in motion ?

18. How will the time period of a simple pendulum change when its length is doubled ?

19. What is a harmonic wave function ?

20. If the motion of revolving particle is periodic in nature, give the nature of motion or projection of the revolving particle along the diameter.

21. In a forced oscillation of a particle, the amplitude is maximum for a frequency w_1 of the force, while the energy is maximum for a frequency w_2 of the force. What is the relation between w_1 and w_2 ?

22. Which property of the medium are responsible for propagation of waves through it ?

23. What is the nature of the thermal change in air, when a sound wave propagates through it ?

24. Why does sound travel faster in iron than in water or air ?

25. When will the motion of a simple pendulum be simple harmonic ?

26. A simple harmonic motion of acceleration 'a' and displacement 'x' is represented by $a + 4\pi^2 x = 0$. What is the time period of S.H.M ?

27. What is the main difference between forced oscillations and resonance ?

28. Define amplitude of S.H.M.

29. What is the condition to be satisfied by a mathematical relation between time and displacement to describe a periodic motion ?

30. Why the pitch of an organ pipe on a hot summer day is higher ?

31. Under what conditions does a sudden phase reversal of waves on reflection takes place ?

32. The speed of sound does not depend upon its frequency. Give an example in support of this statement.

33. If an explosion takes place at the bottom of lake or sea, will the shock waves in water be longitudinal or transverse ?

34. Frequency is the most fundamental property of wave, why ?

35. How do wave velocity and particle velocity differ from each other ?

36. If any liquid of density higher than the density of water is used in a resonance tube, how will the frequency change ?

37. Under what condition, the Doppler effect will not be observed, if the source of sound moves towards the listener ?

38. What physical change occurs when a source of sound moves and the listener is stationary ?

39. What physical change occurs when a source of sound is stationary and the listener moves ?

40. If two sound waves of frequencies 480 Hz and 536 Hz superpose, will they produce beats? Would you hear the beats ?

41. Define non dissipative medium.

2 MARKS QUESTIONS

42. Which of the following condition is not sufficient for simple harmonic motion and why ?

(i) acceleration and displacement

(ii) restoring force and displacement

43. The formula for time period T for a loaded spring, $T = 2\pi\sqrt{\frac{\text{displacement}}{\text{acceleration}}}$

Does the time period depend on length of the spring ?

44. Water in a U-tube executes S.H.M. Will the time period for mercury filled up to the same height in the tube be lesser of greater than that in case of water ?

45. There are two springs, one delicate and another hard or stout one. For which spring, the frequency of the oscillator will be more ?

46. Time period of a particle in S.H.M. depends on the force constant K and mass m of the particle $T = 2\pi\sqrt{\frac{m}{k}}\cdot$ A simple pendulum for small angular displacement executes S.H.M. approximately. Why then is the time period of a pendulum independent of the mass of the pendulum ?

47. What is the frequency of oscillation of a simple pendulum mounted in a cabin that is falling freely ?

48. The maximum acceleration of simple harmonic oscillator is A_0. While the maximum velocity is v_0, calculate amplitude of motion.

49. The velocity of sound in a tube containing air at 27°C and pressure of 76 cm of Hg is 330 ms^{-1}. What will be its velocity, when pressure is increased to 152 cm of mercury and temperature is kept constant ?

50. Even after the breakup of one prong of tunning fork it produces a round of same frequency, then what is the use of having a tunning fork with two prongs ?

51. Why is the sonometer box hollow and provided with holes ?

52. The displacement of particle in S.H.M. may be given by $y = a \sin(\omega t + \phi)$ show that if the time t is increased by $2\pi/\omega$, the value of y remains the same.

53. The length of simple pendulum executing SHM is increased by 21%. By what % time period of pendulum increase ?

54. Define wave number and angular wave number and give their S.l. units.

55. Why does the sound travel faster in humid air ?

56. Use the formula $v = \sqrt{\frac{\gamma p}{\rho}}$ to explain, why the speed of sound in air

(a) is independent of pressure

(b) increase with temperature

57. Differentiate between closed pipe and open pipe at both ends of same length for frequency of fundamental note and harmonics.

58. Bats can ascertain distances, directions; nature and size of the obstacle without any eyes, explain how ?

59. In a sound wave, a displacement node is a pressure antinode and vice- versa. Explain, why ?

60. How does the frequency of a tuning fork change, when the temperature is increased ?

61. Explain, why can we not hear an echo in a small room ?

62. What do you mean by reverberation? What is reverberation time ?

3 MARKS QUESTIONS

63. Show that for a particle in linear simple harmonic motion, the acceleration is directly proportional to its displacement of the given instant.

64. Show that for a particle in linear simple harmonic motion, the average kinetic energy over a period of oscillation, equals the average potential energy over the same period.

65. Deduce an expression for the velocity of a particle executing S.H.M. when is the particle velocity (i) Maximum (ii) minimum?

66. Draw (a) displacement time graph of a particle executing SHM with phase angle ϕ equal to zero (b) velocity time graph and (c) acceleration time graph of the particle.

67. Show that a linear combination of sine and cosine function like $x(t) = a \sin \omega t + b \cos \omega t$ represents a simple harmonic. Also, determine its amplitude and phase constant.

68. Show that in a S.H.M. the phase difference between displacement and velocity is $\pi/2$, and between displacement and acceleration is π.

69. Derive an expression for the time period of the horizontal oscillations of a massless loaded spring.

70. Show that for small oscillations the motion of a simple pendulum is simple harmonic. Derive an expression for its time period.

71. Distinguish with an illustration among free, forced and resonant oscillations.

72. In reference to a wave motion, define the terms

(i) amplitude

(ii) time period

(iii) frequency

(iv) angular frequency

(v) wave length and wave number.

73. What do you understand by phase of a wave? How does the phase change with time and position.

74. At what time from mean position of a body executive S.H.M. kinetic energy and potential energy will be equal?

LONG ANSWER QUESTIONS

75. Derive expressions for the kinetic and potential energies of a simple harmonic oscillator. Hence show that the total energy is conserved in S.H.M. in which positions of the oscillator, is the energy wholly kinetic or wholly potential ?

76. One end of a U-tube containing mercury is connected to a suction pump and the other end is connected to the atmosphere. A small pressure difference is maintained between the two columns. Show that when the suction pump is removed, the liquid in the U-tube executes S.H.M.

77. Discuss the Newton's formula for velocity of sound in air. What correction was applied to it by Laplace and why ?

78. What are standing waves? Desire and expression for the standing waves. Also define the terms node and antinode and obtain their positions.

79. Discuss the formation of harmonics in a stretched string. Show that in case of a stretched string the first four harmonics are in the ratio 1:2:3:4.

80. Give the differences between progressive and stationary waves.

81. If the pitch of the sound of a source appears to drop by 10% to a moving person, then determine the velocity of motion of the person. Velocity of sound = 30 ms^{-1}.

82. Give a qualitative discussion of the different modes of vibration of an open organ pipe.

83. Describe the various modes of vibrations of a closed organ pipe.

84. What are beats? How are they produced? Briefly discuss one application for this phenomenon.

85. Show that the speed of sound in air increases by 61 cms^{-1} for every 1°C rise of temperature.

NUMERICALS

86. The time period of a body executing S.H.M is 1s. After how much time will its displacement be $\frac{1}{\sqrt{2}}$ of its amplitude.

87. A particle is moving with SHM in a straight line. When the distance of the particle from the equilibrium position has values x_1 and x_2, the corresponding value of velocities are u_1 and u_2. Show that the time period of oscillation is given by

$$t = 2\pi\left[\frac{x_2^2 - x_1^2}{u_1^2 - u_2^2}\right]^{1/2}$$

88. Find the period of vibrating particle (SHM), which has acceleration of 45 cm s^{-2}, when displacement from mean position is 5 cm.

89. A 40 gm mass produces on extension of 4 cm in a vertical spring. A mass of 200 gm is suspended at its bottom and left pulling down. Calculate the frequency of its vibration.

90. The acceleration due to gravity on the surface of the moon is 1.7 ms^{-2}. What is the time period of a simple pendulum on the moon, if its time period on the earth is 3.5 s? [g = 9.8 ms^{-2}]

91. A particle executes simple harmonic motion of amplitude A.

(i) At what distance from the mean position is its kinetic energy equal to its potential energy?

(ii) At what points is its speed half the maximum speed ?

92. A set of 24 tunning forks is arranged so that each gives 4 beats per second with the previous one and the last sounds the octave of first. Find frequency of I[st] and last tunning forks.

93. The vertical motion of a huge piston in a machine is approximately S.H.M. with a frequency of 0.5 s^{-1}. A block of 10kg is placed on the piston. What is the maximum amplitude of the piston's S.H.M. for the block and piston to remain together ?

94. At what temperature will the speed of sound be double its value at 273°K?

95. A spring balance has a scale that reads from 0 to 50 kg. The length of the scale is 20 cm. A body suspended from this spring, when displaced and released, oscillates with a period of 0.60 s. What is the weight of the body ?

96. If the pitch of the sound of a source appears to drop by 10% to a moving person, then determine the velocity of motion of the person. Velocity of sound = 330 ms^{-1}.

97. A body of mass *m* suspended from a spring executes SHM. Calculate ratio of K.E. and P.E. of body when it is at a displacement half of its amplitude from mean position.

98. A string of mass 2.5 kg is under a tension of 200N. The length of the stretched string is 20m. If a transverse jerk is struck at one end of the string, how long does the disturbance take to reach the other end ?

99. Which of the following function of time represent (a) periodic and (b) non-periodic motion? Give the period for each case of periodic motion. [*w* is any positive constant].

(i) $\sin \omega t + \cos \omega t$

(ii) $\sin \omega t + \sin 2\omega t + \sin 4\omega t$

(iii) $e^{-\omega t}$

(iv) $\log (\omega t)$

100. The equation of a plane progressive wave is given by the equation $y = 10 \sin 2\pi (t - 0.005x)$ where y and x are in cm and t in seconds. Calculate the amplitude, frequency, wave length and velocity of the wave.

101. A tuning fork arrangement (pair) produces 4 beats s^{-1} with one fork of frequency 288 cps. A little wax is placed on the unknown fork and it then produces 2 beats s^{-1}. What is the frequency of the unknown fork ?

102. A pipe 20 cm long is closed at one end, which harmonic mode of the pipe is resonantly excited by a 430 Hz source? Will this same source can be in resonance with the pipe, if both ends are open? Speed of sound = 340 ms^{-1}.

103. The length of a wire between the two ends of a sonometer is 105 cm. Where should the two bridges be placed so that the fundamental frequencies of the three segments are in the ratio of 1 : 3 : 15 ?

104. The transverse displacement of a string (clamped at its two ends) is given by

$$y(x,t) = 0.06 \sin \frac{2\pi}{3} \cos 120 \omega t.$$

where x, y are in m and t is in s. The length of the string is 1.5 m and its mass is 3.0×10^{-2} kg. Answer the following.

(a) Does the function represent a travelling or a stationary wave?

(b) Interpret the wave as a superposition of two waves travelling in opposite directions. What are the wavelength frequency and speed of propagation of each wave ?

(c) Determine the tension in the string.

105. A wire stretched between two rigid supports vibrates in its fundamental mode with a frequency 45 Hz. The mass of the wire is 3.5×10^{-2} kg and its linear density is 4.0×10^{-2} kg m^{-1}. What is (a) the speed of transverse wave on the string and (b) the tension in the string ?

106. A steel rod 100 cm long is clamped at its middle. The fundamental frequency of longitudinal vibrations of the rod as given to be 2.53 kHz. What is the speed of sound in steel ?

107. A progressive wave of frequency 500 Hz is travelling with velocity 360 m/s. How far apart are two points 60° out of phase ?

108. An observer moves towards a stationary source of sound with a velocity one fifth of velocity of sound. What is the % increase in apparent frequency ?

ASSERTION - REASON BASED QUESTIONS

Direction:- Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false.

(e) If assertion is false but reason is true.

1. Assertion : All oscillatory motions are necessarily periodic motion but all periodic motions are not oscillatory.

Reason: Simple pendulum is an example of oscillatory motion.

2. Assertion: Simple harmonic motion is a uniform motion.

   Reason: Simple harmonic motion is the projection of uniform circular motion.

3. Assertion: Acceleration is proportional to the displacement. This condition is not sufficient for motion in simple harmonic.

   Reason: In simple harmonic motion direction of displacement is also considered.

4. Assertion: Sine and cosine functions are periodic functions.

   Reason: Sinusoidal functions repeats it values after a definite interval of time.

5. Assertion: The graph between velocity and displacement for a harmonic oscillator is a parabola.

   Reason: Velocity does not change uniformly with displacement in harmonic motion.

6. Assertion: When a simple pendulum is made to oscillate on the surface of moon, its time period Increases.

   Reason: Moon is much smaller as compared to earth.

7. Assertion: Resonance is special case of forced vibration in which the natural frequency of vibration of the body is the same as the impressed frequency of external periodic force and the amplitude of forced vibration is maximum.

   Reason: The amplitude of forced vibrations of a bod increases with an increase in the frequency of the externally impressed periodic force.

8. Assertion: The graph of total energy of a particle in SHM w.r.t. position is a straight line with zero slope.

   Reason: Total energy of particle in SHM remains constant throughout its motion.

9. Assertion: The percentage change in time period is 1.5%, if the length of simple pendulum increases by 3%.

   Reason: Time period is directly proportional to length of pendulum.

10. Assertion: The frequency of a second pendulum in an elevator moving up with an acceleration half the acceleration due to gravity is 0.612 Hz .

    Reason: The frequency of a second pendulum does not depend upon acceleration due to gravity.

11. Assertion: Damped oscillation indicates loss of energy.

    Reason: The energy loss in damped oscillation may be due to friction, air resistance etc.

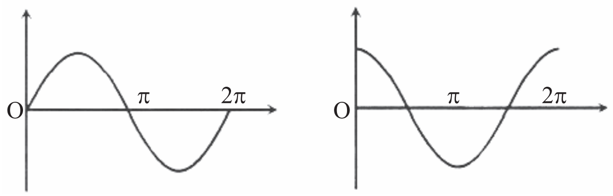
HINTS AND ANSWERS

1. (b) Both assertion and reason are correct but reason is not the correct explanation of assertion.

2. (e) simple harmonic motion, $v = \omega\sqrt{a^2 - y^2}$ as y changes,velocity v will also change. So simple hanllonic motion is not uniform motion. But simple harmonic motion may be dehned as the projection of uni fonll circular motion along one of the diameter of the circle.

3. (a) In SHM, the acceleratio n is always in a direction opposite to that of the displacement i.e., proportional to (–y).

4. (a) A periodic function is one whose value repeats after a dehnite interval of time. sinθ and cosθ are periodic functions because they repeat itself after 2π interval of time.



sin curve cos curve

It is also true that moon is smaller than the earth, but this statement is not explaining the assertion.

5. (e) In SHM, $v = \omega\sqrt{a^2 - y^2}$ or $v^2 = \omega^2 y^2$.

Dividing both sides by $\omega^2 a^2$, $\frac{v^2}{\omega^2 a^2} + \frac{y^2}{a^2} = 1$. This is the equation of an ellipse. Hence the graph between v and y is an ellipse not a parabola.

6. (b) $T = 2\pi\sqrt{\frac{1}{g}}$. On moon, g is much smaller compared to g on earth.

Therefore, T increases.

7. (c) Amplitude of oscillation for a forced, damped oscillator is

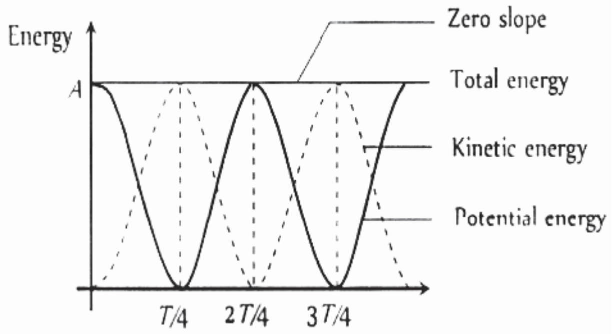
$A = \frac{F_0 / m}{\sqrt{\left(\omega^2 - \omega_0^2\right) + \left(b\omega / m\right)^2}}$, where b is constant related to the strength of the resistive force, $\omega_0 = \sqrt{k/m}$ is natural frequency of undamped oscillator (b = 0).

When the Frequency of driving force $\omega \approx \omega_0$, then amplitude A is very larger.

For ω < ω or ω > ω, the amplitude decrease.

8. (a) The total energy of S.H.M. = Kinetic energy of particle + potential energy of particle.

The variation of total energy of the particle in SHM with time is shown in a graph.



9. (c) Time period of simple pendulum of length is,

$$T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow T \propto \sqrt{l} \Rightarrow \sqrt{\frac{\Delta T}{T}} = \frac{1}{2}\frac{\Delta l}{l}$$

$$\therefore \quad \frac{\Delta T}{T} = \frac{1}{2} \times 3 \; = \; 1.5\%$$

10. (c) Frequency of second pendulum n = (1 / 2)s^{-1}. When elevator is movmg upwards with acceleration g/2, the effective acceleration due to gravity is

$$g = g + a = g + g/2 = 3g/2.$$

$$\text{As} \;\; n = \frac{1}{2\pi}\sqrt{\frac{g}{l}} \quad \text{so} \;\; n^2 \propto g.$$

$$\therefore \quad \frac{n_1^2}{n_2^2} = \frac{g_1}{g} = \frac{3g/2}{g} = \frac{3}{2} \quad \text{or} \quad \frac{n_1}{n} = \sqrt{\frac{3}{2}} = 1.225$$

or, $n_1 = 1.225n = 1.225 \times (1/2) = 0.612 s^{-1}$.

11. (b) Energy of damped oscillator at an any instant t is given by $E = E_0 e^{-bt/m}$ [where $E_0 = \frac{1}{2}kx^2$ = maximum energy]

Due to damping forces the amplitude of oscillator will go on decreasing with time whose energy is expressed by above equation.

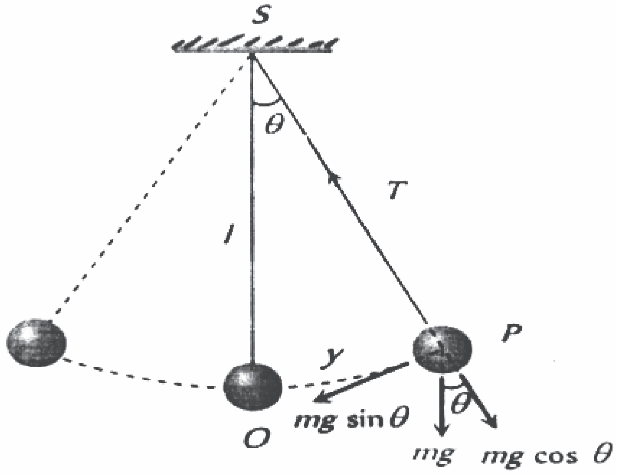
CASE STUDY BASED QUESTIONS

Simple Pendulum

An ideal simple pendulum consists of a heavy point mass body (bob) suspend d by a weightless, inextensible and perfectly flexible string from a rigid support about which it is free to oscillate.

But in reality neither point mass nor weightless string exist, so we can never construct a simple pendulum strictly according to the definition.

Suppose simple pendulum of length l is displaced through a small angle θ from it's mean (vertical) position. Consider m as of the bob is m and linear displacement from mean position is x.



Answer the following questions :-

1. The period of a simple pendulum is doubled, when
   (a) Its length is doubled
   (b) The mass of the bob is doubled
   (c) Its length is made four times
   (d) The mass of the bob and the length of the pendulum are doubled

2. The period of oscillation of a simple pendulum of constant length at earth surface is T. Its period inside a mine is
   (a) Greater than T
   (b) Less than T
   (c) Equal to T
   (d) Cannot be compared

3. A pendulum suspended from the ceiling of a train has a period T, when the train is at rest. When the train is accelerating with a uniform acceleration a, the period of oscillation will

(a) Increase (b) Decrease

(c) Remain unaffected (d) Become infinite

4. Which of the following statements is not true? In the case of a simple pendulum for small amplitudes the period of oscillation is

(a) Directly proportional to square root of the length of the pendulum

(b) Inversely proportional to the square root of the acceleration due to gravity

(c) Dependent on the mass, size and material of the bob

(d) Independent of the amplitude

5. The time period of a second's pendulum is 2 sec. The spherical bob which is empty from inside has a mass of 50 gm. This is now replaced by another solid bob of same radius but having different mass of 100 gm. The new time period will be

(a) 4 sec (b) 1 sec (c) 2sec (d) 8sec

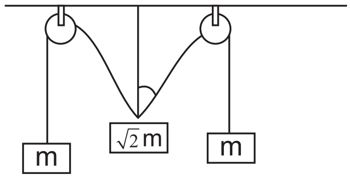
HINTS AND ANSWERS

1. (c) $T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow T \propto \sqrt{l}$

2. (a) Inside the mine g decreases

Hence from $T = 2\pi\sqrt{\frac{l}{g}}$; T increases

3. (b) Initially time period was $T = 2\pi\sqrt{\frac{l}{g}}$.



When train acceleration, the effective value of g becomes $\sqrt{(g^2 + a^2)}$ which is greater than g.

Hence, new time period, becomes less than the initial time period.

4. (c)

5. (c) $T = 2\pi\sqrt{\frac{l}{g}}$ (independent of mass)

WAVES

ASSERTION - REASON BASED QUESTIONS

Direction:- Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) If the assertion and reason both are false.
(e) If assertion is false but reason is true.

1. Assertion : Two persons on the surface of moon cannot talk to each other.

Reason: There is no atmosphere on moon.

2. Assertion: Transverse waves are not produced in liquids and gases.

Reason: Light waves are transverse waves.

3. Assertion: Sound waves cannot propagate through vacuum but light waves can.

Reason: Sound waves cannot be polarised but light waves can be polarised.

4. Assertion: The velocity of sound increases with increase in humidity.

Reason: Velocity of sound does not depend upon the medium.

5. Assertion: Ocean waves hitting a beach are always found to be nearly normal to the shore.

Reason: Ocean waves are longitudinal waves.

6. Assertion: Compression and rarefaction involve changes in density and pressure.

Reason: When particles are compressed, density of medium increases and when they are rarefied, density of medium decreases.

7. Assertion: Transverse waves travel through air in an organ pipe.

Reason: Air possesses only volume elasticity.

8. Assertion: Sound would travel faster on a hot summer day than on a cold winter day.

Reason: Velocity of sound is directly proportional to the square of its absolute temperature.

9. Assertion: The basic of Laplace correction was that, exchange of heat between the region of compression and rarefaction in air is not possible.

   Reason: Air is a bad conductor of heat and velocity of sound in air is large.

10. Assertion: Particle velocity and wave velocity both are independent of time.

    Reason: For the propagation of wave motion, the medium must have the properties of elasticity and inertia.

11. Assertion: When we start filling an empty bucket with water, the pitch of sound produced goes on decreasing.

    Reason: The frequency of man voice is usually higher than that of woman.

12. Assertion: A tuning fork is made of an alloy of steel, nickel and chromium.

    Reason: The alloy of steel, nickel and chromium is called elinvar.

HINTS AND ANSWERS

1. (a) Sound waves require material medium to travel. As there is no atmosphere (vacuum) on the surface of moon, therefore the sound waves cannot reach from one person to another.

2. (b) Transverse waves travel in the form of crests and troughs involving change in shape of the medium. As liquids and gases do not possess the elasticity of shape, therefore, transverse waves cannot be produced in liquid and gases. Also, light wave is one example of transverse wave.

3. (b) Sound waves cannot propagate through vacuum because sound waves are mechanical waves. Light waves can propagate through vacuum because light waves are electromagnetic waves. Since sound waves are longitudinal waves, the particles move in the direction of propagation, therefore these waves cannot be polarised.

4. (c) Velocity of sound in gas medium is $v = \sqrt{\frac{K}{\rho}} = \sqrt{\frac{\gamma p}{\rho}}$ is ratio of its principal heat capacities $\left(C_p / C_v\right)$. For moist air ρ is less than that for dry air and γ is slightly greater.

   $\therefore$ velocity of sound increases with increase in humidity.

5. (c) Ocean waves are transverse waves travelling in concentric circles of ever-increasing radius. When they hit the shore, their radius of curvature is so large that they can be treated as plane waves. Hence, they hit the shore nearly normal to the shore.

6. (a) A compression is a region of medium in which particles come closer i.e., distance between the particles becomes less than the normal distance between them. Thus, there is a temporary decrease in volume and a consequent increase in density of medium. Similarly in rarefaction, particle get farther apart and a consequent decrease in density.

7. (e) Since transverse wave can propagate through medium which possess elasticity of shape. Air posses only volume elasticity therefore transverse wave cannot propagate through air.

8. (c) The velocity of sound in a gas is directly proportional to the square root of its absolute temperature $\left(\text{as } v = \sqrt{\frac{\gamma RT}{M}}\right)$. Since temperature of a hot day is more than cold winter day, therefore sound would travel faster on a hot summer day than on a cold winter day.

9. (c) According to Laplace, the changes in pressure and volume of a gas, when sound waves propagated through it, are not isothermal, but adiabatic. A gas is a bad conductor of heat. It does not allow the free exchange of heat between compressed layer, rarefied layer and surrounding.

10. (e) The velocity of every oscillating particle of the medium is different of its different positions in one oscillation but the velocity of wave motion is always constant i.e., particle velocity vary with respect to time, while the wave velocity is independent of time.

Also for wave propagation medium must have the properties of elasticity and inertia.

11. (d) A bucket can be treated as a pipe closed at one end. The frequency of the note produced $l = \frac{v}{4L}$, here L equal to depth of water level from the open end. As the bucket is filled with water L decreases, hence frequency increases. Therefore, frequency or pitch of sound produced goes on increasing. Also, the frequency of woman voice is usually higher than that of man.

12. (b) A tuning fork is made of a material for which elasticity does not change. Since the alloy of nickel, steel and chromium (elinvar) has constant elasticity, therefore it is used for the preparation of tuning fork.

CASE STUDY BASED QUESTIONS

I. **Doppler's Effect or Doppler Shift** is the change in frequency of a wave in relation to an observer who is moving relative to the wave source. It is named after the Austrian physicist Christian Doppler, who described the phenomenon in 1842.

Whenever there is a relative motion between a source of sound and the observer (listener), the frequency of sound heard by the observer is different from the actual frequency of sound emitted by the source. The frequency observed by the observer is called the apparent frequency. It may be less than or greater than the actual frequency emitted by the sound source. The difference depends on the relative motion between the source and observer.

A common example of Doppler shift is the change of pitch heard when a vehicle sounding a horn approaches and recedes from an observer. Compared to the emitted frequency, the received frequency is higher during the approach, identical at the instant of passing by, and lower during the recession.

Answer the following questions :-

1. Doppler shift in frequency does not depend upon
   (a) The frequency of the wave produced
   (b) The velocity of the source
   (c) The velocity of the observer
   (d) Distance from the source to the listener

2. A source of sound of frequency 450 cycles/sec is moving towards a stationary observer with 34 m/sec speed. If the speed of sound is 340 m/sec, then the apparent frequency will be
   (a) 410 cycles/sec (b) 500 cycles/sec
   (c) 550 cycles/sec (d) 450 cycles/sec

3. The wavelength is 120 cm when the source is stationary. If the source is moving with relative velocity of 60 m/sec towards the observer, then the wavelength of the sound wave reaching to the observer will be (velocity of sound = 330 m/s)
   (a) 98 cm (b) 140 cm (c) 120 cm (d) 144 cm

4. The frequency of a whistle of an engine is 600 cycles/sec is moving with the speed of 30 m/sec towards an observer. The apparent frequency will be (velocity of sound = 330 m/s)
   (a) 600 cps (b) 660 cps (c) 990 cps (d) 330 cps

5. A source of sound emits waves with frequency f Hz and speed V m/sec. Two observers move away from this source in opposite directions each with a speed 0.2 V relative to the source. The ratio of frequencies heard by the two observers will be

(a) 3 : 2 (b) 2 : 3 (c) 1 : 1 (d) 4 : 10

II. Standing Wave in a Organ Pipe

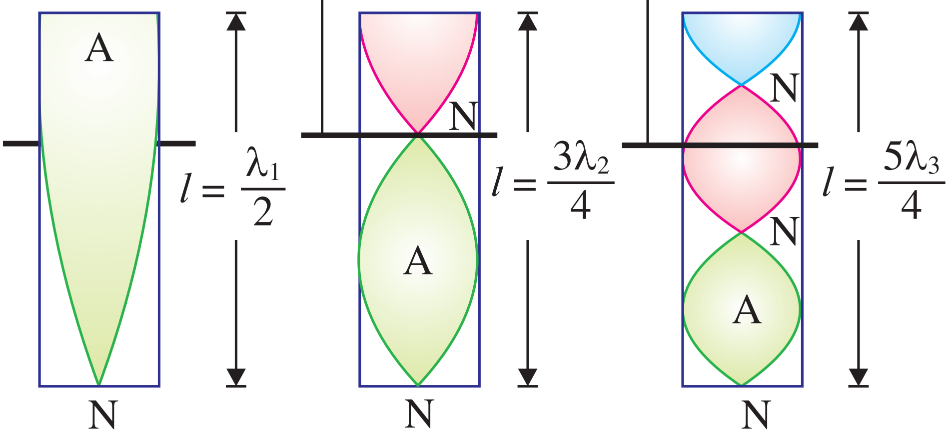
Organ pipes are the musical instrument which are used for producing musical sound by blowing air into the pipe. Longitudinal stationary waves are Formed on account of superimposition of incident and reflected longitudinal waves.

Equation of standing wave $y = 2a\cos\frac{2\pi vt}{\lambda}\sin\frac{2\pi x}{\lambda}$

Frequency or vibration $n = \frac{v}{\lambda}$

Different mode of vibration in organ pipe

Closed organ pipe		
Fundamental mode	Third harmonic First over tone	Fifth harmonic Second over tone



Answer the following questions :-

1. A tube closed at one end and containing air is excited. It produces the fundamental note of frequency 512 Hz. If the same tube is open at both the ends the fundamental frequency that can be produced is

(a) 1024 Hz (b) 512 Hz (c) 256 Hz (d) 128 Hz

2. A closed pipe and an open pipe have their first overtones identical in frequency. Their lengths are in the ratio

   (a) 1 : 2 (b) 2 : 3 (c) 3 : 4 (d) 4 : 5

3. The first overtone in a closed pipe has a frequency

   (a) Same as the fundamental frequency of an open tube of same length
   (b) Twice the fundamental frequency of an open tube of same length
   (c) Same as that of the first overtone of an open tube of same length
   (d) None of the above

4. An empty vessel is partially filled with water, then the frequency of vibration of air column in the vessel

   (a) Remains same (b) Decreases
   (c) Increases (d) First increases then decreases

5. It is desired to increase the fundamental resonance frequency in a tube which is closed at one end. This can be achieved by

   (a) Replacing the air in the tube by hydrogen gas
   (b) Increasing the length of the tube
   (c) Decreasing the length of the tube

HINTS AND ANSWERS

I. 1. (d)

2. (b) $n' = n\left(\frac{v}{v - v_O}\right) = 450\left(\frac{340}{340 - 34}\right) = 500$ cycles / sec.

3. (a) $n' = n\left(\frac{v}{v - v_s}\right) \Rightarrow \lambda' = \lambda\left(\frac{v - v_s}{v}\right)$

   $\Rightarrow \lambda' = 120\left(\frac{330 - 60}{330}\right) = 98$ cm.

4. (b) $n' = n\left(\frac{v}{v - v_S}\right) = 600\left(\frac{330}{300}\right) = 660$ cps.

5. (c) Both listeners, hears the same frequencies.

II. 1. (a) Fundamental frequency of open pipe is double that of the closed pipe.

2. (c) If is given that

First over tone of closed pipe = First over tone of open pipe

$$\Rightarrow 3\left(\frac{v}{4l_1}\right) = 2\left(\frac{v}{2l_2}\right);$$

where l and l are the lengths of closed and open organ pipes hence

$$\frac{l_1}{l_2} = \frac{3}{4}$$

3. (d) First overtone for closed pipe $= \frac{3v}{4l}$

Fundamental frequency for open pipe $= \frac{v}{2l}$

First overtone for open pipe $= \frac{2v}{2l}$.

4. (c) For closed pipe in general $n = \frac{v}{4l}(2N-1) \Rightarrow n \propto \frac{1}{l}$

i.e. if length of air column decreases frequency increases.

5.

(a,c,d) Fundamental frequency for closed pipe $n = \frac{v}{4l}$

where $v = \sqrt{\frac{\gamma RT}{M}} \Rightarrow v \propto \frac{1}{\sqrt{M}}$

$\because \; M_{H_2} < M_{air} \Rightarrow v_{H_2} > v_{air}$

Hence, fundamental frequency with H will be more as compared to air. So option (a) is correct.

Aslo $n \propto \frac{1}{l}$, hence if l decrease n increases so option (c) is correct.

It is well known that (n) = 2(n) hence option (d) is correct.

SOLUTIONS

ANSWERS OF ONE MARK QUESTIONS

1. No effect on time period when amplitude of pendulum is increased or decreased.

2. The spring constant of a spring is the change in the force it exerts, divided by the change in deflection of the spring. ($K = f/x$)

3. At $x = a/\sqrt{2}$., KE = PE = $\frac{1}{4}m\omega^2 a^2$

4. P.E. or K.E. completes two vibrations in a time during which S.H.M. completes one vibration or the frequency of R.E. or K.E is double than that of S.H.M.

5. The frequency of total energy of particle is S.H.M. is zero because it remains constant.

6. Length of the seconds pendulum proportional to (acceleration due to gravity)

7. Increased

8. As $T \alpha \frac{1}{\sqrt{g}}$, T will increase.

9. In the y-z plane or in plane perpendicular to x-axis.

10. It is the angle covered per unit time or it is the quantity obtained by multiplying frequency by a factor of 2π.

    $\omega = 2\pi n$, S.I. unit is rad s^{-1}.

11. Intensity = amplitude$^2 \propto \frac{1}{(\text{distance})^2}$

    ∴ Required ratio = y/x

12. No, the resultant of Tension in the string and weight of bob is not always towards the mean position.

13. $T = 2\pi/\omega$

14. Swinging through small angles.

15. No, it is a circular and periodic motion but not SHM.

16. In SHM, The velocity leads the displacement by a phase $\pi/2$ radians and acceleration leads the velocity by a phase $\pi/2$ radians.

17. The component of weight ($mg \sin \theta$).

18. $\sqrt{2}$ times, as $T \alpha \sqrt{l}$

19. A harmonic wave function is a periodic function whose functional form is sine or cosine.

20. S.H.M.

21. Both amplitude and energy of the particle can be maximum only in the case of resonance, for resonance to occur $\omega_1 = \omega_2$.

22. Properties of elasticity and inertia.

23. When the sound wave travel through air adiabatic changes take place in the medium.

24. Sound travel faster in iron or solids because iron or solid is highly elastic as compared to water (liquids) or air (gases).

25. When the displacement of bob from the mean position is so small that $\sin \theta \approx \theta$.

26. $a = -4\pi^2 x = -\omega^2 x \Rightarrow \omega = 2\pi$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{2\pi} = 1s$$

27. The frequency of external periodic force is different from the natural frequency of the oscillator in case of forced oscillation but in resonance two frequencies are equal.

28. The maximum displacement of oscillating particle on either side of its mean position is called its amplitude.

29. A periodic motion repeats after a definite time interval T.

So, $y(t) = y(t + T) = y(t + 2T)$ etc.

30. On a hot day, the velocity of sound will be more since (frequency proportional to velocity) the frequency of sound increases and hence its pitch increases.

31. On reflection from a denser medium, a wave suffers a sudden phase reversal.

32. If sounds are produced by different musical instruments simultaneously, then all these sounds are heard at the same time.

33. Explosion at the bottom of lake or sea create enormous increase in pressure of medium (water). A shock wave is thus a longitudinal wave travelling at a speed which is greater than that of ordinary wave.

34. When a wave passes through different media, velocity and wavelength change but frequency does not change.

35. Wave velocity is constant for a given medium and is given by $V = n\lambda$. But particle velocity changes harmonically with time and it is maximum at mean position and zero at extreme position.

36. The frequency of vibration depends on the length of the air column and not on reflecting media, hence frequency does not change.

37. Doppler effect will not be observed, if the source of sound moves towards the listener with a velocity greater than the velocity of sound. Same is also true if listener moves with velocity greater than the velocity of sound towards the source of sound.

38. Wave length of sound changes.

39. The number of sound waves received by the listener changes.

40. Yes, the sound waves will produce 56 beats every second. But due to persistence of hearing, we would not be able to hear these beats.

41. A medium in which speed of wave motion is independent of frequency of wave is called non-dispersive medium. For sound, air is non dispersive medium.

ANSWERS OF TWO MARKS QUESTIONS

42. Condition (i) is not sufficient, because direction of acceleration is not mentioned. In SHM, the acceleration is always in a direction opposite to that of the displacement.

43. Although length of the spring does not appear in the expression for the time period, yet the time period depends on the length of the spring. It is because, force constant of the spring depends on the length of the spring.

44. The time period of the liquid in a U-tube executing S.H.M. does not depend upon density of the liquid, therefore time period will be same, when the mercury is filled up to the same height in place of water in the U-tube.

45. We have, $v = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$

So, when a hard spring is loaded with a mass *m*. The extension I will be lesser w.r.t. delicate one. So frequency of the oscillation of the hard spring will be more and if time period is asked it will be lesser.

46. Restoring force in case of simple pendulum is given by

$$F = \frac{mg}{l}y \Rightarrow K = mg/l$$

So force constant itself proportional to *m* as the value of *k* is substituted in the formula, *m* is cancelled out.

47. The pendulum is in a state of weightlessness *i.e.* $g = 0$. The frequency of pendulum

$$v = \frac{1}{2\pi}\sqrt{\frac{g}{l}} = 0$$

48. $A_{max} = \omega^2 a = A_0$, $U_{max} = \omega a = v_0$

$$\Rightarrow \omega = \frac{v_0}{a}$$

$$\therefore \quad a = \frac{A_0}{\omega^2} \quad \Rightarrow a = \frac{A_0}{v_0^2}a^2$$

$$\Rightarrow a = \frac{v_0^2}{A_0}.$$

49. At a given temperature, the velocity of sound is independent of pressure, so velocity of sound in tube will remain 330 ms^{-1}.

50. Two prongs of a tunning fork set each other in resonant vitorations and help to maintain the vibrations for a longer time.

51. When the stem of the a tunning fork gently pressed against the top of sonometer box, the air enclosed in box also vibrates and increases the intensity of sound. The holes bring the inside air incontact with the outside air and check the effect of elastic fatigue.

52. The displacement at any time t is

$$y = a \sin (\omega t + \phi)$$

$\therefore$ displacement at any time $(t + 2\pi/\omega)$ will be

$$y = a \sin [\omega (t + 2\pi/\omega) + \phi] = [\sin \{\omega t + \phi) + 2\pi\}]$$

$$y = a \sin (\omega t + \phi) \qquad [\because \sin (2\pi + \phi) = \sin \phi]$$

Hence, the displacement at time t and $(t + 2\pi/\omega)$ are same.

53. When a number of waves travel through the same region at the same time, each wave travels independently as if all other waves were absent.

This characteristic of wave is known as independent behaviour of waves. For example we can distinguish different sounds in a full orchestra.

54. Wave number is the number of waves present in a unit distance of medium. $(\bar{v} = 1/\lambda)$ S.I. unit of k is rad m^{-1}.

Angular wave number or propagation constant is $2\pi/\lambda$. It represents phase change per unit path difference and denoted by $k = 2\pi/\lambda$. S.I. unit of k is rad m^{-1}.

55. Because the density of water vapour is less than that of the dry air hence density of air decreases with the increase of water vapours or humidity and velocity of sound inversely proportional to square root of density.

56. Given, $v = \sqrt{\dfrac{\gamma P}{\rho}}$

(a) Let V be the volume of 1 mole of air, then

$$\rho = \frac{M}{V} \quad \text{or} \quad V = \frac{M}{\rho}$$

for 1 mole of air PV = RT

$$\therefore \quad \frac{PM}{\rho} = RT \quad \text{or} \quad \frac{P}{\rho} = \frac{RT}{M}$$

$$\Rightarrow \quad v = \sqrt{\frac{\gamma RT}{M}} \qquad ....(i)$$

So at constant temperature v is constant as γ, R and M are constant.

(b) From equation (i) we know that $V \alpha \sqrt{T}$, so with the increase in temperature velocity of sound increases.

57. (i) In a pipe open at both ends, the frequency of fundamental note produced is twice as that produced by a closed pipe of same length.

(ii) An open pipe produces all the harmonics, while in a closed pipe, the even harmonics are absent,

58. Bats emit ultrasonic waves of very small wavelength (high frequencies) and so high speed. The reflected waves from an obstacle in their path give them idea about the distance, direction, nature and size of the obstacle.

59. At the point, where a compression and a rarefaction meet, the displacement is minimum and it is called displacement node. At this point, pressure difference is maximum *i.e.* at the same point it is a pressure antinode. On the other hand, at the mid point of compression or a rarefaction, the displacement variation is maximum i.e. such a point is pressure node, as pressure variation is minimum at such point.

60. As the temperature increases, the length of the prong of the tunning fork increases. This increases the wavelength of the stationary waves set up in the tunning fork. As frequency, $v \,\alpha \sqrt{\frac{1}{\lambda}}$, so frequency of the tunning fork decreases.

61. For an echo of a simple sound to be heard, the minimum distance between the speaker and the walls should be 17 m, so in any room having length less than 17 m, our ears can not distinguish between sound received directly and sound received after reflection.

62. The phenomenon of persistence or prolongation of sound after the source has stopped emitting sound is called reverberation. The time for which the sound persists until it becomes inaudible is called the reverberation time.

SOLUTION / HINTS OF NUMERICALS

86. $$y = r \sin \omega t = r \sin \frac{2\pi}{T} t$$

Here $y = \frac{1}{3} r$ and $T = 1s$

$$\therefore \frac{1}{\sqrt{2}} r = r \sin \frac{2\pi}{T} t \Rightarrow 2\pi t = \frac{\pi}{4} \quad \Rightarrow \quad t = \frac{1}{8} s.$$

87. When $x = x_1, v = u_1$

When $x = x_2, v = u_2$

As $v = \omega\sqrt{A^2 - x^2}$

$\therefore$ $u_1 = \omega\sqrt{A^2 - x_1^2}$ or $u_1^2 = \omega^2(A^2 - x_1^2)$ ....(i)

and $u_2 = \omega\sqrt{A^2 - x_2^2}$ or $u_2^2 = \omega^2(A^2 - x_2^2)$ ....(ii)

Subtracting (ii) from (i), we get

$$u_1^2 - u_2^2 = (A^2 - x_1^2) - \omega^2(A^2 - x_2^2) = \omega^2(x_2^2 - x_1^2)$$

or $$\omega = \left[\frac{u_1^2 - u_2^2}{x_2^2 - x_1^2}\right]^{1/2}$$

$$T = \frac{2\pi}{\omega} = 2\pi\left[\frac{x_2^2 - x_1^2}{u_1^2 - u_2^2}\right]^{1/2}$$

88. Here $y = 5$ cm and acceleration $a = 45$ cm s^{-2}

We know $a = \omega^2 y$

$\therefore$ $45 = \omega^2 \times 5$ or $\omega = 3$ rad s^{-1}

and $T = \frac{2\pi}{\omega} = \frac{2\pi}{3} = 2.095 s.$

89. Here $mg = 40\ g = 40 \times 980$ dyne ; $l = 4$ cm.

say k is the force constant of spring, then

$mg = kl$ or $k = mg/l$

$$k = \frac{40 \times 980}{4} = 9800 \text{ dyne cm}^{-1}$$

when the spring is loaded with mass $m = 200$ g

$$v = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\sqrt{\frac{9800}{200}}$$

$= 1.113\ s^{-1}$.

90. Here on earth, $T = 3.5\ s;\ g = 9.8\ ms^{-2}$

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

$$3.5 = 2\pi\sqrt{\frac{l}{9.8}} \quad \text{....(i)}$$

on moon, $g' = 1.7\ ms^{-2}$ and if T' is time period

then $T' = 2\pi\sqrt{\frac{l}{1.7}}$ ....(ii)

Dividing eqn. (ii) by eqn. (i), we get

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

91. (i) $\frac{1}{2}m\omega^2(a^2 - y^2) = \frac{1}{2}m\omega^2 y^2 \Rightarrow y = \frac{a}{\sqrt{2}}$

(ii) $v = \omega\sqrt{a^2 - y^2} \Rightarrow a\omega = \omega\sqrt{a^2 - y^2} \Rightarrow y = \pm\frac{a\sqrt{3}}{2}$.

92. Let frequency of I^{st} tunning fork $= x$

frequency of II^{nd} tunning fork $= x + 4$

frequency of III^{rd} tunning fork $= x + 2\ (4)$

frequency of IV^{th} tunning fork $= x + 3\ (4)$

$\therefore$ Let frequency of 24^{th} tunning fork $= x + 23\ (4)$

octave means, (twice in freq.)

$\therefore$ freq. of 24th $= 2 \times$ freq. of $I^{st} = 2x$

$\therefore\ 2x = x + 23\ (4) \Rightarrow x = 92$

freq. of $24^{th} = 2 \times 92 = 184\ H_3$.

93. Given, $v = 0.5\ s^{-1},\ g = 9.8\ ms^{-1}$

$$a = \omega^2 y = (2\pi v)^2 y = 4\pi^2 v^2 y$$

a_{max} at the extreme position *i.e.*, $r = y$

$a_{max} = 4\pi^2 v^2 r$ and $a_{max} = g$ to remain in contact.

or $r = \frac{g}{4\pi^2 v^2} = \frac{9.8}{4\pi^2 \times (0.5)^2} = 0.993\text{m}.$

94. Say v_1 in the velocity of sound at $T_1 = 273°K$ and $v_2 = 2v_1$ at temperature T_2

Now $\frac{V_2}{V_1} = \sqrt{\frac{T_2}{T_1}}$, $\therefore \frac{2v_1}{v_1} = \sqrt{\frac{T_2}{273}}$

or $T_2 = 4 \times 273 = 1092°K$.

95. Here $m = 50$ kg, $l = 0.2\ m$

we know $mg = kl$ or $k = \frac{mg}{l} = \frac{50 \times 9.8}{0.2} = 2450\ \text{Nm}^{-1}$

$T = 0.60\ s$ and M is the mass of the body, then using

$$T = 2\pi\sqrt{\frac{M}{k}} \Rightarrow M = \frac{2450 \times (0.60)^2}{4\pi^2} = 22.34\ \text{kg}$$

Weight of body Mg = 22.34 × 9.8 = 218.93 N.

96. Apparent freq.

$$v' = \left(\frac{v - v_0}{v}\right)v \quad \text{or} \quad \frac{v'}{v} = \frac{v - v_0}{v}$$

$$\frac{v'}{v} = \frac{900}{1000} = \frac{9}{10}, \quad v = 330\ \text{ms}^{-1}$$

$$\therefore \quad \frac{9}{10} = \frac{330 - v_0}{330}$$

$$330 - v_0 = \frac{9}{10} \times 330 = 297$$

$$v_0 = 330 - 297 = 33\ \text{m/s}.$$

97. $$\text{KE} = \frac{1}{2}m\omega^2(a^2 - y^2)$$

at $y = \frac{a}{2}$

$$\text{KE} = \frac{1}{2}m\omega^2\left[a^2 - \left(\frac{a}{2}\right)^2\right] = \frac{1}{2}m\omega^2 . \frac{3a^2}{4}$$

$$PE = \frac{1}{2}m\omega^2 y^2 = \frac{1}{2}m\omega^2 \frac{a^2}{4}$$

$$\frac{KE}{PE} = \frac{3}{1}.$$

98. Given $T = 200$ N, length of string $l = 20$ m

total mass of the string = 2.5 kg

$\therefore$ mass per unit length of the string

$$m = \frac{2.5}{20} = 0.125 \text{ kg } m^{-1}$$

Now $v = \sqrt{\frac{T}{m}} = \sqrt{\frac{200}{0.125}} = 40 \text{ ms}^{-1}$

Hence time taken by the transverse wave to reach other end

$$t = \frac{l}{v} = \frac{20}{40} = 0.5s.$$

99. (i) $\sin \omega t + \cos \omega t = \sqrt{2}\left[\frac{1}{\sqrt{2}}\sin \omega t + \frac{1}{\sqrt{2}}\cos \omega t\right]$

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

It is simple harmonic function with period $= \frac{2\pi}{\omega}$

(ii) $\sin \omega t + \sin 2\omega t + \sin 4\omega t$ is a periodic but not simple harmonic function. Its time period is $\frac{2\pi}{\omega}$.

(iii) $e^{-\omega t}$ is exponential function, which never repeat itself. Hence it is non-periodic function.

(iv) $\log \omega t$ is also non-periodic function.

100. Here $y = 10 \sin 2\varpi(t - 0.005x)$

$$y = 10 \sin \frac{2\pi}{200}(200t - x) \quad \text{....(i)}$$

The equation of a travelling wave is given by

$$y = a\sin\frac{2\pi}{\lambda}(vt - x) \qquad ....(ii)$$

Comparing the equation (i) and (ii), we have

$$\alpha = 10 \text{ cm}, \lambda = 200 \text{ cm and } v = 200 \text{ ms}^{-1}$$

Now $\quad v = \frac{v}{\lambda} = \frac{200}{200} = 1\,\text{Hz}$

101. Unknown freq. = Known freq. I Beat freq.

$$= 288 \pm 4 = 292 \text{ or } 284 \text{ Hz}$$

On putting wax, freq. decreases, beat freq. is also descrease to 2

∴ unknown freq. = 292 Hz (higher one)

102. The frequency of n^{th} mode of vibration of a pipe closed at one end is given by

$$v_n = \frac{(2n-1)v}{4L}$$

river $v = 340 \text{ ms}^{-1}$, $L = 20$ cm = 0.2 m; $v_n = 430$ Hz

$$\therefore \quad 430 = \frac{(2n-1)\times 340}{4\times 0.2} \Rightarrow n = 1$$

Therefore, first mode of vibration of the pipe is excited, for open pipe since n must be an integer, the same source can not be in resonance with the pipe with both ends open.

103. Total length of the wire, $L = 105$ cm

$$v_1 : v_2 : v_3 = 1 : 3 : 15$$

Let L_1, L_2 and L_3 be the length of the three parts. As $v \propto \frac{1}{L}$

$$\therefore \; L_1 : L_2 : L_3 = 1 : \frac{1}{3} : \frac{1}{15} = 15 : 5 : 1$$

Sum of the ratios = 15 + 5 + 1 = 21

$$\therefore \quad L_1 = \frac{15}{21}\times 105 = 75 \text{ cm}; \; L_2 = \frac{5}{21}\times 105 = 25 \text{ cm};$$

$$L_3 = \frac{1}{21} \times 105 = 5 \text{ cm}$$

Hence the bridges should be placed at 75 cm and (75 + 25) = 100 cm from one end.

104. $y(x,t) = 0.06 \sin \frac{2\pi}{3} \times \cos 120\pi t$ ....(i)

(a) The displacement which involves harmonic functions of x and t separately represents a stationary wave and the displacement, which is harmonic function of the form $(vt \pm x)$, represents a travelling wave. Hence, the equation given above represents a stationary wave.

(b) When a wave pulse $y_1 = a \sin \frac{2\pi}{\lambda}(vt - x)$ travelling along x-axis is superimposed by the reflected pulse.

$y_2 = -a \sin \frac{2\pi}{\lambda}(vt + x)$ from the other end, a stationary wave is formed and is given by

$$y = y_1 + y_2 = -2a \sin \frac{2\pi}{\lambda} \times \cos \frac{2\pi}{\lambda} vt \qquad \text{....(ii)}$$

Comparing the eqs. (i) and (ii), we have

$$\frac{2\pi}{\lambda} = \frac{2\pi}{3} \quad \text{or} \quad \lambda = 3\text{m}$$

$$\frac{2\pi}{\lambda} v = 120\pi \quad \text{or} \quad v = 60\lambda = 60 \times 3 = 180 \text{ ms}^{-1}$$

Now frequency $\gamma = \frac{v}{\lambda} = \frac{180}{3} = 60$ Hz

(c) Velocity of transverse wave in a string is given by

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

Here $m = \frac{3 \times 10^{-2}}{1.5} = 2 \times 10^{-2}$ kgm^{-1}

Also $v = 180$ ms^{-1}

$\therefore$ $T = v^2 m = (180)^2 \times 2 \times 10^{-2} = 648$N.

105. Frequency of fundamental mode, $v = 45\text{Hz}$

Mass of wire $M = 3.5 \times 10^{-2}$ kg; mass per unit length, $m = 4.0 \times 10^{-2}$ kgm^{1}

$$\therefore \quad \text{Length of wire } L = \frac{M}{m} = \frac{3.5\times10^{-2}}{4.0\times10^{-2}} = 0.875\,m$$

(a) For fundamental mode $L = \frac{\lambda}{2}$ or $\lambda = 2L = 0.875 \times 2 = 1.75$ m

$\therefore$ velocity $v = v\lambda = 45 \times 1.75 = 78.75$ ms^{-1}

(b) The velocity of transverse wave

$$v = \sqrt{\frac{T}{m}} \Rightarrow T = v^2 m = (78.75)^2 \times 4.0\times10^2 = 248.6\,N$$

106. Given : $u = 2.53$ kHz $= 2.53 \times 10^3$ Hz

(L) Length of steel rod = 100 cm = 1 m.

when the steel rod clamped at its middle executes longitudinal vibrations of its fundamental frequency, then

$$L = \frac{\lambda}{2} \text{ or } \lambda = 2L = 2 \times 1 = 2 \text{ m}$$

The speed of sound in steel

$$v = n\lambda = 2.53 \times 10^3 \times 2 = 5.06 \times 10^3 \text{ ms}^{-1}.$$

107.

$$\Delta\phi = 60° = 60 \times \frac{\pi}{180} = \frac{\pi}{3} \text{ rad.}$$

$$v = v\lambda \Rightarrow \lambda = \frac{v}{v} = \frac{360}{500} = 0.72 \text{ m}$$

As $\quad \Delta\phi = \frac{2\pi}{\lambda}.\Delta x$

$$\Delta x = \frac{\lambda}{2\pi} \times \Delta\phi = \frac{\pi}{3} \times \frac{0.72}{2\pi}$$

$$= 0.12 \text{ m.}$$

108. $v_0 = -\frac{v}{5}, v_s = 0$

Apparent freq. $v' = \left(\frac{v - v_0}{v - v_s}\right) v$

$$= \left(\frac{v + \frac{v}{5}}{v - 0} \right) v = \frac{6}{5} v = 1.2v$$

$$\% \text{ change} = \frac{\Delta v}{v} \times 100 = \frac{1.2v - v}{v} \times 100 = 20\%$$

OBJECTIVE QUESTIONS

109. The periodic time of a body executing simple harmonic motion is 3s. After how much interval from t = 0, its displacement will be half of its amplitude?

(a) $\frac{1}{8}$s (b) $\frac{1}{6}$s

(c) $\frac{1}{4}$s (d) $\frac{1}{3}$s

110. Two equations of two SHM y = a Sin (ωt–α) and y = a Cos (ωt–α). The phase difference between the two is

(a) 0° (b) α°

(c) 90° (d) 180°

111. If a simple pendulum oscillates with an amplitude of 50 mm and time period of 2s, its maximum velocity is

(a) 0.10 m/s (b) 0.15 m/s

(c) 0.8 m/s (d) 0.26 m/s

112. The equation of simple harmonic motion y = a sin (2π t + α) then its phase at time t is

(a) 2πn t (b) α

(c) 2π t + α (d) 2π t

113. The equation of simple harmonic motion y = a sin (2π t + α) then its phase at time t = 0s is

(a) 2πn t (b) α

(c) 2π t + α (d) 2π t

114. A particle is oscillating according to the equation x = 7 cos (0.5π t), where t is in second. The point moves from the position of equilibrium to maximum displacement in time

(a) 4s (b) 2s

(c) 1s (d) 0.5s

115. The instantaneous displacement of a simple pendulum oscillator is given by $x = A\cos\left(\omega t + \frac{\pi}{4}\right)$. If speed will be maximum at time

(a) $\frac{\pi}{4\omega}$ (b) $\frac{\pi}{2\omega}$

(c) $\frac{\pi}{\omega}$ (d) $\frac{2\pi}{\omega}$

116. The velocity of particle in SHM at displacement y from mean position is

(a) $w\sqrt{(a^2+y^2)}$ (b) $w\sqrt{(a^2-y^2)}$

(c) wy (d) $w^2\sqrt{a^2+y^2}$

117. A particle is executing SHM with a period of T seconds and amplitude a meter. The shortest time it takes to reach a point $\frac{a}{\sqrt{2}}$ m from its mean position in seconds is

(a) T (b) $\frac{T}{8}$

(c) $\frac{T}{4}$ (d) $\frac{T}{16}$

118. Displacement between maximum potential energy position and maximum kinetic energy position for a particle executing SHM is

(a) –a (b) +a

(c) $\pm$ a (d) $\pm\frac{a}{4}$

119. If tension in the string is increased from 1 KN to 4 KN, other factors remaining unchanged, the frequency of the second harmonic will

(a) be halved (b) main changed

(c) be doubled (d) becomes four times

120. An open organ pipe and a closed organ pipe have the frequency of their first overtone identical. What is the ratio of their lengths?

(a) $\frac{1}{2}$ (b) $\frac{4}{3}$

(c) $\frac{3}{4}$ (d) 1

121. The fundamental frequency of a stretched string is V_0. If the length is reduced by 35% and tension increased by 69% the fundamental frequency will be

(a) 0.2 V_0 (b) 0.5 V_0

(c) 2.0 V_0 (d) 1.6 V_0

122. Two waves of same frequency traveling in the same medium in opposite direction when super imposed give rise to

(a) beats (b) harmonics

(c) standing waves (d) resonance

123. Equation of a progressive wave is given by $y = 0.2 \cos \pi\left\{(0.04\,t + 0.02\,x) - \frac{\pi}{6}\right\}$ The distance is expressed in cm and time in second. What will be the minimum distance between two particles having the phase difference of $^{\pi}/_{2}$?

(a) 4 cm (b) 8 cm

(c) 25 cm (d) 12.5 cm

124. For two systems to be in resonance, which of the following properties should be equal?

(a) Wavelength (b) Frequency

(c) Amplitude (d) Wave velocity

125. Fundamental frequency of a sonometer wire is n. If the length, diameter and tension are doubled, the new fundamental frequency will be

(a) n (b) $\sqrt{2}\,n$

(c) $\frac{n}{\sqrt{2}}$ (d) $\frac{n}{2\sqrt{2}}$

126. The frequency of an open organ pipe is ν. If half part of organ pipe is dipped in water then its frequency is

(a) ν (b) $\frac{\nu}{2}$

(c) $\frac{\nu}{4}$ (d) O

127. Two tuning forks when sounded together given one beat every 0.2 s. What is the difference of frequencies?

(a) 0.2 (b) 2

(c) 5 (d) 10

128. Angle between wave velocity and particle velocity of a longitudinal wave is

(a) 90° (b) 60°

(c) 0° (d) 120°

Answer : (Objective Type Questions)

109. (c)	110. (c)	111. (b)	112. (c)	113. (b)	114. (c)
115. (a)	116. (b)	117. (c)	118. (c)	119. (c)	120. (c)
121. (c)	122. (c)	123. (c)	124. (b)	125. (d)	126. (a)
127. (c)	128. (c)				

HINTS :

109. $y = a \sin wt$ as $y = \frac{a}{2}$ we get $t = \frac{1}{4} s$ (Given $T = 3s$)

111. $V_{max} = a\,w = \frac{5}{100} \times \frac{2\pi}{2}$ m/s

114. $wt = 0.5\,\pi\,t \Rightarrow w = 0.5\,\pi \Rightarrow T = 4s$ req. time $= \frac{T}{4} = 1\,s$

117. $y = a \sin wt$ $\quad y = \frac{1}{\sqrt{2}}$

119. $\nu \,\alpha\, \sqrt{T}$

120. For open pipe, frequency of I overtone, $\nu_1 = \frac{1}{L_1}\sqrt{\frac{\gamma P}{P}}$

For closed organ pipe, frequency of I overtone, $\nu_2 = \frac{3}{4L_2}\sqrt{\frac{\gamma P}{P}}$

121. $\nu_0 = \frac{1}{2L}\sqrt{\frac{T}{M}}$ Frequency in new cond. $\nu = \frac{1}{2(65\% \text{ of } L)}\sqrt{\frac{T + 69\% \text{ of } T}{M}}$

123. Req. distance $= \frac{\lambda}{4}$

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