UNIT 8

Wave Motion and Sound

INTRODUCTION

Simple pendulum

A small, heavy metallic bob suspended from a rigid support by a light inextensible string, is called a simple pendulum.

Oscillation

The motion of the pendulum bob from one extreme position to the other extreme position and then back to the first extreme position, constitutes one complete oscillation.

Time period

The time taken to complete one oscillation is called time period. It is denoted by T.

Length of a pendulum

The length from the point of suspension upto the centre of the bob is called the length of the pendulum. It is denoted by L.

Time period of a simple pendulum: The time period of a simple pendulum depends upon its length and the value of 'g' at the place of the experiment. The graph of T Vs. L is a parabola whereas that of T^2 Vs. L is a straight line.

Also, $$T = 2\pi\sqrt{\frac{L}{g}}$$

Restoring force

A force which is always directed towards the mean position (or equilibrium position) during the oscillatory motion of a body is called the restoring force.

Second's pendulum

A second's pendulum has a time period of 2 seconds.

Periodic motion

A motion which repeats itself regularly after equal intervals of time is called periodic motion.

S.H.M.

In case of S.H.M., the body moves to and fro about its mean position. A restoring force also acts on the body executing S.H.M.

Wave

A wave is a kind of disturbance which propagates through a medium due to the repeated oscillatory motion of the particles of the medium about their mean positions, the motion being handed-over from one particle of the medium to the next particle progressively.

Pulse

A disturbance which is sudden and lasts for a short duration of time is called pulse.

Mechanical wave

A mechanical wave is the disturbance which takes place in a material medium for its propagation. Sound waves are mechanical waves but light waves are electromagnetic waves and do not need any medium for their propagation. Thus, light waves can pass through vacuum but sound waves cannot pass through vacuum.

Transverse wave

A wave in which particles of the medium move up and down perpendicular to the direction of the wave

propagation in the medium, is known as transverse wave. Such a wave travels in the form of crests and troughs

Longitudinal wave

A wave in which particles of the medium move to and fro about their mean position along the direction of propagation of the wave, is called the longitudinal wave. Such a wave travels in the form of compressions and rarefactions.

Sound waves

Sound waves through air are longitudinal waves. Light waves are transverse waves.

Wavelength

The distance after which the pattern of wave motion repeats itself is called the wavelength of the wave. It is denoted by λ. It may also be defined as the distance between two consecutive crests or two consecutive troughs (in case of transverse wave) or two consecutive compressions or two consecutive rarefactions (in case of longitudinal wave).

Time period of a wave

The time taken by a wave to travel a distance 'λ' in the medium is called its time period (T).

Frequency of a wave

The number of oscillations made per second by the vibrating particle of the medium during the course of wave propagation is called frequency (f or ν).

$$\therefore \qquad f = \frac{1}{T}$$

Velocity of a wave

The velocity 'V with which a wave propagates through a medium is given by the relation,

$$V = f\lambda$$

Audible range

Sound waves of frequency below 20 Hz are called infrasonics and the sound waves of frequency higher than 20,000 Hz are called ultrasonics. The range of human hearing is from 20 Hz to 20,000 Hz.

Supersonic velocities

The velocities greater than the velocity of sound are called supersonic velocities.

Echo

An echo is a reflection of sound. Depth of a sea can be found by an echo. An echo is produced by the reflection of sound by a smooth and hard surface.

Speed of sound

The speed of sound is much less than the speed of light. Sound travels in dry air at a speed of about 340 ms^{-1} but the speed of light is 3×10^8 ms^{-1}.

Reverberation

Reverberation is the continuous occurrence of echoes.

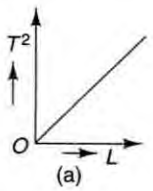
SONAR

SONAR stands for sound navigation and ranging. It is used to detect underwater objects by reflected, or emitted sound.

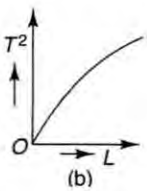
MULTIPLE CHOICE QUESTIONS

Tick (✓) the correct choice amongst the following:

1. The period of pendulum depends upon
   (a) mass (b) length
   (c) amplitude (d) energy
2. A pendulum suspended from the ceiling of a train has a time period T when the train is at rest. When the train is accelerating with a uniform acceleration, the time period will
   (a) increase (b) decrease
   (c) become infinite (d) remain unaffected
3. The time period T is found to depend upon L as
   (a) $T \propto L$ (b) $T \propto L^2$
   (c) $T^2 \propto L$ (d) $T \propto \sqrt{\frac{1}{L}}$
4. The relation between T and g is given by
   (a) $T \propto g$ (b) $T \propto g^2$
   (c) $T^2 \propto g$ (d) $T \propto \sqrt{\frac{1}{g}}$
5. The graph between L and T^2 is



(a)



(b)

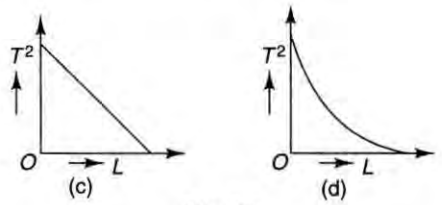


Fig. 8.1

6. The oscillations of a pendulum slow down due to
   (a) the force exerted by air and friction at the support
   (b) the force exerted by air only
   (c) the forces exerted by friction at the support only
   (d) none of these
7. If a pendulum is allowed to oscillate into a jar containing water, its time period will
   (a) increase (b) decrease
   (c) remain same (d) none of these
8. If a pendulum is allowed to oscillate in vacuum, its time period will
   (a) decrease (b) increase
   (c) remain same (d) none of these
9. Kinetic energy of the bob of a simple pendulum is maximum
   (a) at the mean position
   (b) at the extreme left position
   (c) at the extreme right position
   (d) none of these
10. If the string of a pendulum were cut when the bob is at its central position, the bob would fall to the earth due to the absence of the
    (a) force of buoyancy
    (b) force of deformation
    (c) force exerted by the string in the downward direction
    (d) force exerted by the string in the upward direction
11. Though the forces are balanced at the mean position, even then the bob crosses over to the other extreme position after being released. This is due to
    (a) inertia of the bob
    (b) potential energy of the bob
    (c) velocity of the bob
    (d) none of these
12. If the mass of a pendulum is doubled, the time period
    (a) becomes double (b) becomes half
    (c) becomes 4 times (d) remains the same
13. When the bob is in the central position, the forces are
    (a) balanced
    (b) unbalanced
    (c) sometimes balanced and sometimes unbalanced
    (d) none of these
14. The phenomenon in which the amplitude of oscillation of a pendulum decreases gradually is called
    (a) decay period of oscillation
    (b) damping
    (c) building up of oscillation
    (d) maintained oscillation
15. The graph between L and T is correctly shown by (Fig. 8.2)

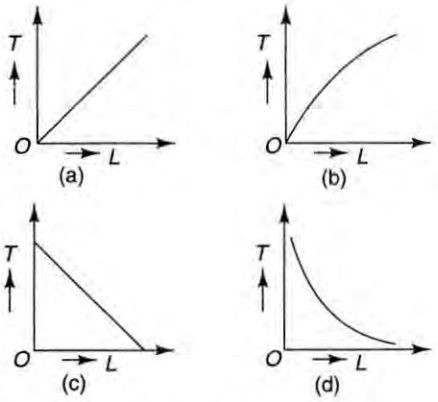


Fig. 8.2

16. The length of a pendulum is doubled and the mass of its bob is halved. Its time period would
    (a) become double (b) become half
    (c) become $\sqrt{2}$ times (d) remain the same
17. A pendulum having a period of oscillation of 2 seconds is taken on a planet where g is four times that on the earth. The period of the pendulum would be
    (a) 2 s (b) 1 s
    (c) 4 s (d) $2\sqrt{2}$ s

18. Potential energy of the bob is maximum
    (a) at the mean position
    (b) at the extreme positions
    (c) between the mean position and extreme positions
    (d) none of these
19. The force which tries to bring the body back to its mean position is called
    (a) deforming force
    (b) restoring force
    (c) gravitational force
    (d) buoyant force
20. For a given length of a pendulum, the time period is maximum
    (a) on the surface of the earth
    (b) on the surface of the moon
    (c) at the centre of the earth
    (d) none of these
21. In which of the following media will sound travel the fastest?
    (a) solid
    (b) both solid and liquid
    (c) liquid
    (d) gas
22. Sound waves in air are _____ waves.
    (a) longitudinal (b) radio
    (c) transverse (d) electromagnetic
23. Sound waves cannot pass through
    (a) a solid-liquid mixture
    (b) an ideal gas
    (c) a liquid-gas mixture
    (d) a perfect vacuum
24. Out of the following, which frequency is not clearly audible to the human ear?
    (a) 30 Hz (b) 30,000 Hz
    (c) 300 Hz (d) 3000 Hz
25. The frequency of sound waves can be expressed in
    (a) Hz only (b) cycles/second only
    (c) s^{-1} only (d) all the above
26. The distance between two consecutive crests is L, then the wavelength is given by
    (a) $L/2$ (b) $2L$
    (c) $4L$ (d) L
27. If the distance between a crest and its consecutive trough is L, then the wavelength is given by
    (a) $L/2$ (b) L
    (c) $4L$ (d) $2L$
28. The product of the time period of a wave and its frequency is
    (a) infinite
    (b) zero
    (c) more than unity but less than infinity
    (d) unity
29. A wave completes 20 vibrations in 2.5 s. Its frequency is
    (a) 20 Hz (b) 8 Hz
    (c) 200 Hz (d) 50 Hz
30. Imagine a cannon being fired on the surface of the moon. Then
    (a) the sound will be heard at the surface of the earth during all seasons
    (b) the sound will not be heard at the surface of the earth
    (c) the sound will be heard at the surface of the earth during the rainy season
    (d) no sound will be heard on the earth or on the moon
31. Sound waves are
    (a) transverse mechanical waves
    (b) longitudinal mechanical waves
    (c) neither (a) nor (b)
    (d) none of these
32. The speed of sound wave in a given medium is
    (a) directly proportional to its frequency
    (b) inversely proportional to its frequency
    (c) directly proportional to the square of its frequency
    (d) independent of its frequency
33. *Supersonic* means
    (a) frequencies less than 20 Hz
    (b) same as ultrasonic
    (c) frequencies much more than that of ultrasonics
    (d) same as infrasonics
34. The frequency of a wave is 5 Hz. It refers to (type of wave)
    (a) ultrasonics (b) microwaves
    (c) infrasonics (d) radio waves
35. When a vibrating tuning fork is placed on a table, a large sound is heard. This is due to

(a) forced vibrations (b) resonance
(c) beats (d) reflection

36. A wave completes 24 cycles in 0.8 s. The frequency of the wave is
(a) 30 Hz (b) 8 Hz
(c) 24 Hz (d) 12 Hz

37. The time period of the above wave would be
(a) 1/30 s (b) 30 s
(c) 1/24 s (d) none of these

38. The relation between frequency (n) and wavelength (λ) is given by (v is velocity, n is frequency and T is time-period)
(a) $v = n\lambda$ (b) $n = -$
(c) $v = \frac{n}{2}$ (d) $n = \frac{T}{-}$

39. Frequency (v) and time period (T) are related as
(a) $v \times T = 1$ (b) $\frac{v}{T} = 1$
(c) $v \times T^2$ (d) $v = T^{-2}$

40. A body produces sound only if it is
(a) made of steel (b) made of glass
(c) plucked (d) vibrating

41. If the time period of a wave increases, its frequency will
(a) increase
(b) decrease
(c) remain the same
(d) first increases then decreases

42. A pulse is a wave
(a) of high duration
(b) of short duration
(c) which travels in vacuum only
(d) which travels in solids only

43. When we pluck the wire of a sitar, the waves produced in the wire are
(a) longitudinal
(b) transverse
(c) sometimes longitudinal and sometimes transverse
(d) electromagnetic

44. When we pluck the wire of a sitar, the waves produced in the air are
(a) longitudinal
(b) transverse
(c) sometimes longitudinal and sometimes transverse
(d) electromagnetic

45. A crest is the point of
(a) zero displacement
(b) maximum displacement
(c) minimum displacement
(d) none of these

46. Sound travels fastest in
(a) water (b) steel
(c) air (d) kerosene oil

47. Two particles having the same phase must be at
(a) one crest and one trough
(b) one crest and the mean position
(c) one trough and the mean position
(d) two consecutive crests

48. If the frequency of a wave is doubled, its wavelength
(a) becomes doubled
(b) remains same
(c) becomes half of the original
(d) none of these

49. An anchored boat is rocked by waves whose crests are 100 m apart and whose velocity is 25 m/s. How often do the crests reach the boat?
(a) 0.35 s (b) 4 s
(c) 75 s (d) 2500 s

50. Figure 8.3 shows that the shape of a part of a long string in which transverse waves are produced. Which pair of particles are in phase?
(a) A and G (b) D and G
(c) B and E (d) C and K

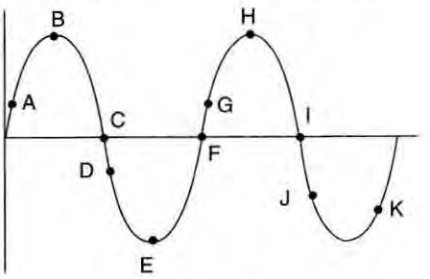


Fig. 8.3

51. The waves in which the particles of the medium travel in the same direction as the waves are
(a) linear waves
(b) longitudinal waves
(c) transverse waves
(d) electromagnetic waves

52. Velocity of sound is maximum in
(a) iron (b) mercury
(c) water (d) air

53. The vibrating body while playing a violin is
(a) wire
(b) the box of the violin
(c) both wire and box
(d) only air

54. The waves which propagate in metals are
(a) longitudinal
(b) transverse
(c) both (a) and (b)
(d) neither (a) nor (b)

55. Velocity of sound is minimum in
(a) nitrogen (b) hydrogen
(c) air (d) carbon dioxide

56. The distance between two consecutive points in the same phase is called
(a) pitch (b) velocity
(c) wavelength (d) period

57. Sound takes some time to travel from one place to another. It will be maximum
(a) at night
(b) during summer
(c) during winter
(d) all the time same

58. The periodic time of a vibrating body is 0.01 sec. Its frequency will be
(a) 1.0 c/s (b) 10.0 c/s
(c) 100.0 c/s (d) 1000.0 c/s

59. The sound propagates in a gaseous medium by
(a) transverse waves
(b) longitudinal waves
(c) both (a) and (b)
(d) neither (a) nor (b)

60. If a wave of wavelength λ is travelling in a medium with velocity V, then its frequency is
(a) $\frac{V}{\lambda}$ (b) $V\lambda$
(c) $\frac{\lambda}{V}$ (d) $\frac{1}{V}$

61. If a wave of time period T travels with a velocity V, then the wavelength is given by
(a) $\frac{V}{T}$ (b) VT
(c) $\frac{1}{VT}$ (d) $\frac{T}{V}$

62. The motion of a simple pendulum is
(a) exactly simple harmonic
(b) exactly rectilinear
(c) approximately simple harmonic
(d) none of these

63. A particle is moving on a circular track with uniform speed. Its motion is
(a) periodic and simple harmonic
(b) periodic but not simple harmonic
(c) damped
(d) none of the above

64. The persistence of hearing for human beings is not more than
(a) 1 s (b) $\frac{1}{5}$ s
(c) $\frac{1}{10}$ s (d) $\frac{1}{2}$ s

65. Vibrations, whose amplitudes of oscillations decrease with time, are called
(a) free vibrations
(b) forced vibrations
(c) damped vibrations
(d) none of these

66. Waves produced due to the earthquake are known as
(a) seismic waves (b) shock waves
(c) infrasonic waves (d) none of these

67. The speed of electromagnetic waves in air is
(a) 3×10^5 km/s (b) 3×10^6 km/s
(c) 3×10^7 km/s (d) 3×10^8 km/s

68. Which of the following types of waves is different from others?
(a) Light waves (b) X-rays
(c) Radio waves (d) Sound waves

69. Waves produced by supersonic jet planes are
(a) shock waves (b) seismic waves
(c) infrasonics (d) none of these
70. On the surface of the moon, a clock will
(a) run slow
(b) run fast
(c) remain stationary
(d) nothing can be decided
71. The frequency of a second's pendulum is
(a) 0.5 Hz (b) 1.0 Hz
(c) 2.0 Hz (d) none of these
72. Water waves are
(a) longitudinal
(b) transverse
(c) neither longitudinal nor transverse
(d) both longitudinal and transverse
73. The speed of a wave is 340 ms^{-1}. What is the wavelength of the wave if its frequency is 500 Hz?
(a) 0.68 m (b) 6.8 m
(c) 68 m (d) 0.068 m
74. The SI unit of amplitude of oscillation is
(a) cm (b) m
(c) km (d) none of these
75. Echo is produced due to
(a) reflection of sound
(b) refraction of sound
(c) resonance
(d) none of these
76. The echo will be heard if the original sound reflected by an obstacle reaches our ears after
(a) 10 s (b) 5 s
(c) 1 s (d) 0.1 s
77. An echo will be heard if the minimum distance between the source of sound and the obstacle is
(a) 1 m (b) 10 m
(c) 15 m (d) 17 m
78. SONAR is based on the principle of
(a) echo
(b) resonance
(c) reverberation
(d) any one of the above
79. The audible range of frequency is
(a) 20 Hz to 20,000 Hz
(b) 40 Hz to 40,000 Hz
(c) 60 Hz to 60,000 Hz
(d) 10 Hz to 20,000 Hz
80. Which of the following frequencies of sound cannot be heard by human beings?
(a) 5 Hz (b) 20 Hz
(c) 400 Hz (d) 1000 Hz
81. Which of the following frequencies of sound can't be heard by human beings?
(a) 40 Hz (b) 400 Hz
(c) 4000 Hz (d) 40,000 Hz
82. Velocity of sound in air is about
(a) 330 m/s (b) 360 m/s
(c) 380 m/s (d) 400 m/s
83. The depth of the troughs of a wave is called its
(a) amplitude (b) displacement
(c) frequency (d) none of these
84. The height of the crests of a wave is called its
(a) amplitude (b) displacement
(c) frequency (d) none of these

ANSWERS

1. (b)	2. (b)	3. (c)	4. (d)	5. (a)
6. (a)	7. (a)	8. (a)	9. (a)	10. (c)
11. (a)	12. (d)	13. (a)	14. (b)	15. (b)
16. (c)	17. (b)	18. (b)	19. (b)	20. (b)
21. (a)	22. (a)	23. (d)	24. (b)	25. (d)
26. (d)	27. (d)	28. (d)	29. (b)	30. (b)
31. (b)	32. (a)	33. (b)	34. (c)	35. (a)
36. (a)	37. (a)	38. (a)	39. (a)	40. (d)
41. (b)	42. (b)	43. (b)	44. (a)	45. (b)
46. (b)	47. (d)	48. (c)	49. (b)	50. (a)
51. (b)	52. (a)	53. (c)	54. (c)	55. (d)
56. (c)	57. (c)	58. (c)	59. (b)	60. (a)
61. (b)	62. (c)	63. (b)	64. (c)	65. (c)
66. (a)	67. (a)	68. (d)	69. (a)	70. (a)
71. (a)	72. (d)	73. (a)	74. (b)	75. (a)
76. (d)	77. (d)	78. (a)	79. (a)	80. (a)
81. (d)	82. (a)	83. (a)	84. (a)	