CHAPTER 15

WAVES

FACT/DEFINITION TYPE QUESTIONS

1. Water waves produced by a motor boat sailing in water are
(a) only longitudinal
(b) only transverse
(c) both longitudinal and transverse
(d) neither longitudinal nor transverse

2. For which of the following do the longitudinal waves exist?
(a) Vacuum (b) Air
(c) Water (d) Both (b) and (c)

3. Which of the following is a transverse wave ?
(a) Wave produced in a cylinder containing a liquid by moving its position back and forth.
(b) Ultrasonic wave in air produced by a vibrating quartz crystal.
(c) Both (a) and (b)
(d) None of these

4. There is no transmission of energy in
(a) electromagnetic waves
(b) transverse progressive waves
(c) longitudinal progressive waves
(d) stationary waves

5. What type of vibrations are produced in a sitar wire ?
(a) Progressive transverse
(b) Progressive longitudinal
(c) Stationary transverse
(d) Stationary longitudinal

6. The waves associated with the moving particles are called
(a) mechanical waves (b) ultrasonic waves
(c) matter waves (d) shock waves

7. The property of a medium necessary for wave propagation is
(a) inertia (b) elasticity
(c) low resistance (d) All of the above

8. Which of the following phenomenon cannot be observed for sound waves?
(a) Refraction (b) interference
(c) diffraction (d) polarisation

9. Which one of the following statements is true?
(a) Both light and sound waves in air are transverse
(b) The sound waves in air are longitudinal while the light waves are transverse
(c) Both light and sound waves in air are longitudinal
(d) Both light and sound waves can travel in vacuum

10. With the propagation of a longitudinal wave through a material medium, the quantities transmitted in the propagation direction are
(a) energy, momentum and mass
(b) energy
(c) energy and mass
(d) energy and linear momentum

11. When a sound wave goes from one medium to another, the quantity that remains unchanged is
(a) frequency (b) amplitude
(c) wavelength (d) speed

12. Speed of a progressive wave is given by
(a) $v = n\lambda$ (b) $v = n/\lambda$
(c) $v = \lambda/n$ (d) T/λ

13. Sound travels in rocks in the form of
(a) longitudinal elastic waves only
(b) transverse elastic waves only
(c) both longitudinal and transverse elastic waves
(d) non-elastic waves

14. Sound waves are not transmitted to long distances because,
(a) they are absorbed by the atmosphere
(b) they have constant frequency
(c) the height of antenna required, should be very high
(d) velocity of sound waves is very less

15. For a sinusoidal wave represented by $y(x, t) = a \sin (kx - \omega t + \phi)$, for a given a, the factor determines the displacement of the wave of any position and at any instant is
(a) constant k (b) angular velocity ω
(c) time interval t (d) phase $(kx - \omega t + \phi)$

16. Speed of mechanical wave is determined by
(a) inertial properties of the medium
(b) elastic properties of the medium
(c) Both (a) and (b)
(d) None of these

17. Speed of sound is maximum in
(a) solids
(b) liquids
(c) gases
(d) depends on the temperature of the medium

18. Where will a person hear the maximum sound ?
(a) At nodes
(b) At antinodes
(c) At harmonics
(d) Same at nodes and antinodes

19. Which of the following is true about the velocity of sound V in a gaseous medium ?
(a) $V \propto \sqrt{\text{density of gas}}$ (b) $V \propto \frac{1}{\text{density of gas}}$
(c) $V \propto$ density of gas (d) $V \propto \frac{1}{\sqrt{\text{density of gas}}}$

20. For which of the following waves, the speed depends on temperature ?
(a) Light (b) Sound
(c) Both (a) and (b) (d) None of these

21. The velocity of sound in a gas
(a) increases by 0.61 m/s when the temperature rises by 1° C
(b) decreases by 0.61 m/s when the temperature rises by 1° C
(c) depends upon the pressure of the gas
(d) depends upon the coefficient of the shearing of the gas

22. Ultrasonic, infrasonic and audible waves travel through a medium with speeds v_u, v_i, v_a respectively, then
(a) v_u, v_i, v_a are nearly equal
(b) $v_u \geq v_a \geq v_i$
(c) $v_u \leq v_a \leq v_i$
(d) $v_a \leq v_u$ and $v_u \approx v_i$

23. The differential equation of a wave is
(a) $d^2y/dt^2 = v^2 d^2y/dx^2$
(b) $d^2y/dx^2 = v^2 d^2y/dt^2$
(c) $d^2y/dx^2 = \frac{1}{v} d^2y/dt^2$
(d) $d^2y/dx^2 = -v\, d^2y/dt^2$

24. Sound waves are travelling in a medium whose adiabatic elasticity is E and isothermal elasticity E'. The velocity of sound waves is proportional to
(a) E (b) $\sqrt{E}$
(c) $\sqrt{E'}$ (d) $\frac{E}{E'}$

25. The speed of sound in a perfectly rigid rod is
(a) infinite (b) zero
(c) 332 m/s (d) 3×10^8 m/s

26. The ratio of the speed of a body to the speed of sound is called
(a) Mach number (b) Doppler ratio
(c) sonic index (d) refractive index

27. In the experiment to determine the speed of sound using a resonance column,
(a) prongs of the tuning fork are kept in a vertical plane
(b) prongs of the tuning fork are kept in a horizontal plane
(c) in one of the two resonances observed, the length of the resonating air column is close to the wavelength of sound in air
(d) in one of the two resonances observed, the length of the resonating air column is close to half of the wavelength of sound in air

28. The relation between velocity of sound in a gas (v) and r.m.s. velocity of molecules of gas ($v_{r.m.s.}$) is
(a) $v = v_{r.m.s.}(\gamma/3)^{1/2}$ (b) $v_{r.m.s.} = v(2/3)^{1/2}$
(c) $v = v_{r.m.s.}$ (d) $v = v_{r.m.s.}(3/\gamma)^{1/2}$

29. What is the effect of humidity on sound waves when humidity increases?
(a) Speed of sound waves is more
(b) Speed of sound waves is less
(c) Speed of sound waves remains same
(d) Speed of sound waves becomes zero

30. The bulk modulus of a liquid of density 8000 kg m^{-3} is 2×10^9 N m^{-2}. The speed of sound in that liquid is (in m s^{-1})
(a) 200 (b) 250 (c) 100 (d) 500

31. A wave travelling on a string is described by
$y(x, t) = 0.005 \sin(80.0x - 3.0t)$
The period of the wave is
(a) 3.00 s (b) 2.09 s
(c) 0.48 s (d) 0.05 s

32. The frequency of fundamental note is given by
(a) $\nu = \frac{1}{L}\sqrt{\frac{T}{m}}$ (b) $\nu = \frac{1}{L}\sqrt{\frac{2T}{m}}$
(c) $\nu = \frac{1}{2L}\sqrt{\frac{T}{m}}$ (d) $\nu = 2L\sqrt{\frac{T}{m}}$

33. The SI unit of propagation constant k is
(a) rad m^{-1} (b) m rad^{-1}
(c) rad m (d) unitless

34. The intensity of harmonic wave
(a) depends upon its frequency and not on its amplitude
(b) depends upon its amplitude and not on its frequency
(c) depends upon both, its frequency and not on amplitude
(d) depends neither on frequency nor on its amplitude

35. Standing waves in a string are due to
(a) beats (b) reflection of waves
(c) interference of waves (d) Doppler's effect

36. Of the following, the equation of plane progressive wave is
(a) $y = r \sin \omega t$ (b) $y = r \sin(\omega t - kx)$
(c) $y = \frac{a}{\sqrt{r}} \sin(\omega t - kx)$ (d) $y = \frac{a}{r} \sin(\omega t - kr)$

37. In ordinary talk, the amplitude of vibration is approximately
(a) 10^{-12} m (b) 10^{-11} m
(c) 10^{-8} m (d) 10^{-7} m

38. Phon is unit of
(a) wavelength (b) loudness
(c) frequency (d) intensity

39. The equation of plane progressive wave motion is
$y = a\sin\frac{2\pi}{\lambda}(vt - x)$. Velocity of the particle is
(a) $y\frac{dv}{dx}$ (b) $v\frac{dy}{dx}$ (c) $-y\frac{dv}{dx}$ (d) $-v\frac{dy}{dx}$

40. The rate of transfer of energy in a wave depends
(a) directly on the square of the wave amplitude and square of the wave frequency
(b) directly on the square of the wave amplitude and root of the wave frequency
(c) directly on the wave amplitude and square of the wave frequency
(d) None of these

41. Two waves are said to be coherent, if they have
(a) same phase but different amplitude
(b) same frequency but different amplitude
(c) same frequency, phase & amplitude
(d) different frequency, phase and amplitude

42. If the intensities of two interfering waves be I_1 and I_2, the contrast between maximum and minimum intensity is maximum, when
(a) $I_1 >> I_2$ (b) $I_1 << I_2$
(c) $I_1 = I_2$ (d) either I_1 or I_2 is zero

43. When a wave is reflected from a denser medium, the change in phase is
(a) 0 (b) π
(c) 2π (d) 3π

44. On reflection of a wave from a rarer medium, change in phase is
(a) zero (b) $\pi/2$
(c) π (d) $3\pi/4$

45. A progressive wave $y = A\sin(kx - \omega t)$ is reflected by a rigid wall at x = 0. Then the reflected wave can be represented by
(a) $y = A\sin(kx + \omega t)$ (b) $y = A\cos(kx + \omega t)$
(c) $y = -A\sin(kx - \omega t)$ (d) $y = -A\sin(kx + \omega t)$

46. When temperature increases, the frequency of a tuning fork
(a) increases
(b) decreases
(c) remains same
(d) increases or decreases depending on the material

47. The equation $y = a\sin\frac{2\pi}{\lambda}(vt - x)$ is expression for
(a) stationary wave of single frequency along x-axis
(b) a simple harmonic motion
(c) a progressive wave of single frequency along x-axis
(d) the resultant of two SHMs of slightly different frequencies

48. Consider the three waves z_1, z_2 and z_3 as
$z_1 = A\sin(kx - \omega t)$
$z_2 = A\sin(kx + \omega t)$
$z_3 = A\sin(ky - \omega t)$
Which of the following represents a standing wave?
(a) $z_1 + z_2$ (b) $z_2 + z_3$
(c) $z_3 + z_1$ (d) $z_1 + z_2 + z_3$

49. Shock waves are produced by objects
(a) carrying electric charge and vibrating
(b) vibrating with frequency greater than 20000 Hz
(c) vibrating with very large amplitude
(d) moving with a speed greater than that of sound in the medium

50. A travelling wave reflected at an open boundary undergoes a phase change of
(a) π (b) 0
(c) $\frac{\pi}{2}$ (d) $\frac{\pi}{3}$

51. Which of the following changes at an antinode in a stationary wave?
(a) Density only
(b) Pressure only
(c) Both pressure and density
(d) Neither pressure nor density

52. The notes of frequencies which are integral multiple of the fundamental frequencies are called
(a) beats (b) harmonics
(c) antinodes (d) tones

53. Beats is a phenomenon which arises from .... of waves
(a) reflection (b) diffraction
(c) superposition (d) interference

54. The essential condition for the formation of beats is
(a) difference in frequencies of two sources should be ≥ 10
(b) difference in frequencies of two sources should be < 10
(c) difference in frequencies of two sources should be > 10
(d) difference in frequencies of two sources should be ≤ 10

55. Possible wavelength of stationary waves are constrained by the relation

(A) $\lambda = \frac{L}{n}$ (B) $\lambda = \frac{2L}{n}$

(C) $\lambda = \frac{L}{2n}$ (D) $\lambda = \frac{L}{3n}$

56. The pipe open at both ends will produce
(a) all the harmonics
(b) all the odd harmonics
(c) all the even harmonics
(d) None of the harmonics

57. Reverberation time does not depend upon
(a) temperature (b) volume of room
(c) size of window (d) carpet and curtain

58. The reason for introducing Laplace correction in the expression for the velocity of sound in a gaseous medium is
(a) no change in the temperature of the medium during the propagation of the sound through it
(b) no change in the heat of the medium during the propagation of the sound through it
(c) change in the pressure of the gas due to the compression and rarefaction
(d) change in the volume of the gas

59. On account of damping, the frequency of a vibrating body
(a) remains unaffected (b) increases
(c) decreases (d) changes erratically

60. Frequencies of sound produced from an organ pipe open at both ends are
(a) only fundamental note
(b) only even harmonics
(c) only odd harmonics
(d) even and odd harmonics

61. The tenth harmonic is set up in a pipe. The pipe is
(a) open pipe (b) close pipe
(c) any of them (d) none

62. Beats are the result of
(a) diffraction
(b) destructive interference
(c) constructive and destructive interference
(d) superposition of two waves of nearly equal frequency

63. Maximum number of beats frequency heard by a human being is
(a) 10 (b) 4
(c) 20 (d) 6

64. A closed organ pipe (closed at one end) is excited to support the third overtone. It is found that air in the pipe has
(a) three nodes and three antinodes
(b) three nodes and four antinodes
(c) four nodes and three antinodes
(d) four nodes and four antinodes

65. When two sound waves are superimposed, beats are produced when they have different
(a) amplitudes and phases
(b) velocities
(c) phases
(d) frequencies

66. Two sound waves of slightly different frequencies propagating in the same direction produce beats due to
(a) Interference (b) Diffraction
(c) Polarization (d) Refraction

67. For which of the following cases, there will be no Doppler effect ?
(a) If source and listener, both move in the same direction with same speed.
(b) If one of the source/listener is at the centre of a circle, while the other is moving on it.
(c) When both the source and listener are at rest.
(d) All of these

68. Doppler's effect in sound takes place when source and observer are
(a) stationary
(b) moving with same velocity
(c) in relative motion
(d) None of these

69. Doppler's effect is not applicable for
(a) audio waves (b) electromagnetic waves
(c) shock waves (d) None of these

70. A train moving at a speed v_s towards a stationary observer on a platform emits sound of frequency f and velocity v. Then the apparent frequency heard by him is

(a) $f\left(1+\frac{v}{v_s}\right)$ (b) $f\left(1-\frac{v_s}{v}\right)$

(c) $f\left(1+\frac{v_s}{v}\right)$ (d) $f\left(1-\frac{v}{v_s}\right)$

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

72. Doppler effect is applicable for
(a) moving bodies
(b) one is moving and other is stationary
(c) for relative motion
(d) None of these

73. Doppler phenomena is related with
(a) Pitch (Frequency) (b) Loudness
(c) Quality (d) Reflection

STATEMENT TYPE QUESTIONS

74. Which of the following statements is/are correct about waves ?

I. Waves are patterns of disturbance which move without the actual physical transfer of flow of matter as a whole.

II. Waves cannot transport energy.

III. The pattern of disturbance in the form of waves carry information that propagate from one point to another.

IV. All our communications essentially depend on transmission of signals through waves.

(a) I and III (b) Only IV
(c) I, II and III (d) I, III and IV

75. A pebble is dropped in a pond of a still in water disturb the water surface.
Which of the given statements are correct for the above situation ?

I. The disturbance produced does not remain confined to one place but propagates outward along a circle.

II. If a cork piece is put on the disturbed surface, it moves along with the disturbance in the same direction.

III. The water mass does not flow outward with the circles formed but rather a moving disturbance is created.

(a) I and III (b) II and III
(c) I and II (d) I, II and III

76. Consider the following statements and select the correct option.

I. Mechanical wave can travel without a medium

II. When a wave motion passes through a medium particle of medium only vibrate simple harmonically about their mean position

III. There is no phase difference amongst successive particles of the medium.

(a) I only (b) II only
(c) I and III (d) II and III

77. Consider the following statements and select the incorrect statement(s) from the following.

I. Mechanical waves transfer energy and matter both from one point to another.

II. Mechanical waves transfer only energy from one point to another.

III. Mechanical waves transfer only matter from one point to another.

(a) I only (b) II only
(c) I and III (d) I, II and III

78. Which of the following statements are correct ?

I. A steel bar possesses both bulk and shear elastic moduli.

II. A steel bar propagate both longitudinal as well as transverse waves having different speeds.

III. Air can propagate both longitudinal and transverse wave.

(a) I and III (b) II and III
(c) I, and II (d) I, II and III

79. Choose the false statement(s) about speed of transverse waves on a stretched string.

I. It depends on linear mass density of the string

II. It depends on the tension in the string

III. It depends on the frequency of the wave

(a) I only (b) II only
(c) III only (d) I, II and III

80. Which of the following statements is/are correct about the standing wave?

I. In a standing wave the disturbance produce is confined to the region where it is produced.

II. In a standing wave, all the particles cross their mean position together.

III. In a standing wave, energy is transmitted from one region of space to other.

(a) I and II (b) Only II
(c) Only III (d) I, II and III

81. Which of the following statements related to organ pipe is/ are correct ?

I. In a closed organ pipe closed at one end longitudinal standing waves are present.

II. In a closed organ pipe only odd harmonics are present.

III. The harmonics which are present in a pipe, open at both ends are odd harmonics only.

(a) Only I (b) II and III
(c) I and II (d) I, II and III

82. Choose the false statement(s) from the following.

I. Change in frequency due to Doppler effect will be positive if the distance between source and listener increases.

II. Change in frequency due to Doppler effect will be negative if the distance between source and listener

(a) I only (b) II only
(c) I and II (d) None of these

MATCHING TYPE QUESTIONS

83. Match the Columns I and II.

	Column I		**Column II**
(A)	A region of low pressure and low density	(1)	Particles oscillate at right angle
(B)	A region of high pressure and high density	(2)	Particles oscillate in the same direction
(C)	Longitudinal wave	(3)	Compression
(D)	Transverse wave	(4)	Rarefaction

(a) (A) $\rightarrow$ (3) ; (B) $\rightarrow$ (4) ; (C) $\rightarrow$ (1) ; (D) $\rightarrow$ (2)
(b) (A) $\rightarrow$ (1) ; (B) $\rightarrow$ (2) ; (C) $\rightarrow$ (3) ; (D) $\rightarrow$ (4)
(c) (A) $\rightarrow$ (4) ; (B) $\rightarrow$ (3) ; (C) $\rightarrow$ (2) ; (D) $\rightarrow$ (1)
(d) (A) $\rightarrow$ (3) ; (B) $\rightarrow$ (4) ; (C) $\rightarrow$ (2) ; (D) $\rightarrow$ (2)

84.

	Column I		Column II
(A)	Mechanical waves	(1)	Disturbance for short time
(B)	Pulse	(2)	Independent of amplitude of vibrations
(C)	Velocity of sound in air	(3)	SONAR
(D)	Tracking of fish in ocean	(4)	Require a material medium

(a) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A)→ (4) ; (B) → (1) ; (C) → (2) ; (D) → (3)
(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (2)

85.

	Column I		Column II
(A)	$y = 4\sin(5x - 4t) + 3\cos(4t - 5x + \pi/6)$	(1)	Particles at every position are performing SHM
(B)	$y = 10\cos\left(t - \frac{x}{330}\right)\sin(100)\left(t - \frac{x}{330}\right)$	(2)	Equation of travelling wave
(C)	$y = 10\sin(2\pi x - 120t) + 10\cos(120t + 2\pi x)$	(3)	Equation of standing wave
(D)	$y = 10\sin(2\pi x - 120t) + 8\cos(118t - 59/30\pi x)$	(4)	Equation of Beats

(a) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A)→ (4) ; (B) → (3) ; (C) → (1) ; (D) → (2)
(d) (A) → (1,2) ; (B) → (4) ; (C) → (1,3) ; (D) → (4)

86.

	Column I		Column II
(A)	Sound	(1)	Frequency
(B)	SONAR	(2)	Mechanical wave
(C)	Reflection of sound	(3)	Finding depth of the sea
(D)	Pitch	(4)	Echo

(a) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A)→ (4) ; (B) → (3) ; (C) → (1) ; (D) → (2)
(d) (A) → (2) ; (B) → (3) ; (C) → (4) ; (D) → (1)

87.

	Column I		Column II
(A)	Pitch	(1)	Waveform
(B)	Quality	(2)	Frequency
(C)	Loudness	(3)	Intensity
(D)	Nodes	(4)	Position of zero amplitude

(a) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(b) (A) → (2) ; (B) → (1) ; (C) → (3) ; (D) → (4)
(c) (A)→ (3) ; (B) → (1) ; (C) → (4) ; (D) → (2)
(d) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)

88.

	Column I		Column II
(A)	Change in apparent frequency due to the relative motion between source and listner	(1)	Beats
(B)	Intensity of sound varies with	(2)	Transverse Wave
(C)	Sound waves in air	(3)	Doppler's effect
(D)	Light waves	(4)	Longitudinal wave

(a) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(b) (A) → (2) ; (B) → (3) ; (C) → (4) ; (D) → (1)
(c) (A)→ (3) ; (B) → (1) ; (C) → (4) ; (D) → (2)
(d) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)

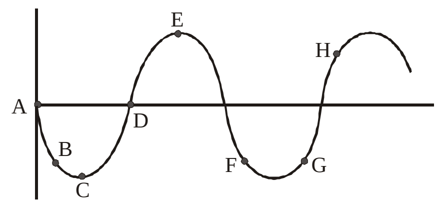
89. Source has frequency *f*. Source and observer both have same speed. For the apparent frequency observed by observer match the following.

	Column-I		Column-II
(A)	Observer is approaching the source but source is receding from the observer	(1)	More than *f*
(B)	Observer and source both approaching towards each other	(2)	Less than *f*
(C)	Observer and source both receding from each other	(3)	Equal to *f*
(D)	Source is approaching but observer is receding	(4)	Infinite

(a) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A)→ (4) ; (B) → (3) ; (C) → (1) ; (D) → (2)
(d) (A) → (3) ; (B) → (1) ; (C) → (2) ; (D) → (3)

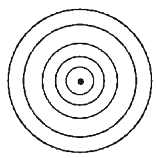
DIAGRAM TYPE QUESTIONS

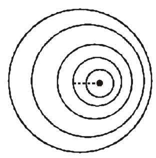
90. The diagram below shows the propagation of a wave. Which points are in same phase ?

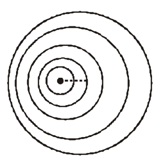


(a) *F* and *G* (b) *C* and *E*
(c) *B* and *G* (d) *B* and *F*

91. If the source is moving towards right, wave front of sound waves get modified to

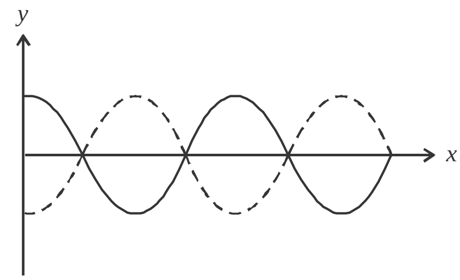
(a) 

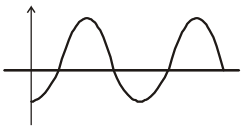
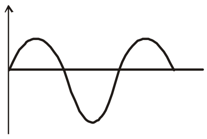
(b) 

(c) 

(d) None of these

92. For the graph given, the resultant wave will be



(a)

(b)


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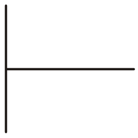
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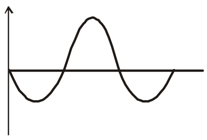
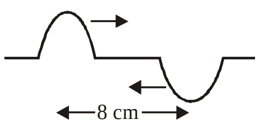
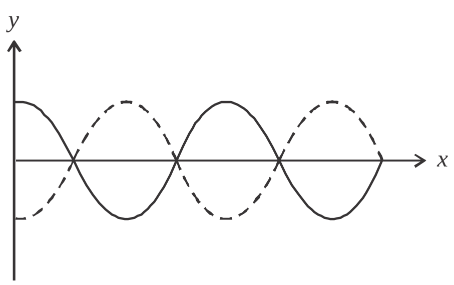


93. Two pulses in a stretched string whose centres are initially 8 cm apart are moving towards each other as shown in the figure. The speed of each pulse is 2 cm/s. After 2 s, the total energy of the pulses will be



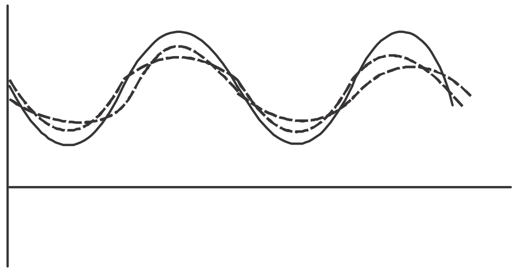
(a) Zero
(b) Purely kinetic
(c) Purely potential
(d) Partly kinetic and partly potential

94. For the graph given below for superposition of two waves, which of the following holds true ?



(a) Phase difference, $\phi = 0$
(b) Phase difference, $\phi = \frac{\pi}{2}$
(c) Phase difference, $\phi = \pi$
(d) Phase difference, $\phi = 2\pi$

95. The wave curves shown below represent:

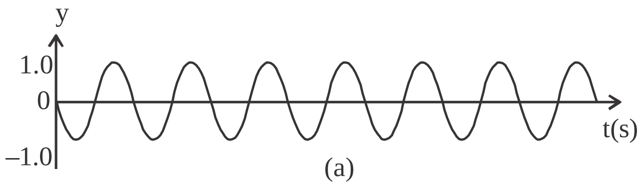


(a) Progressive wave formed from superposition of two harmonic waves travelling in same directions.
(b) Progressive waves formed from superposition of two harmonic waves travelling in opposite directions.
(c) Stationary wave formed from superposition of two harmonic waves travelling in same directions.
(d) Stationary wave formed from superposition of two harmonic waves travelling in opposite directions

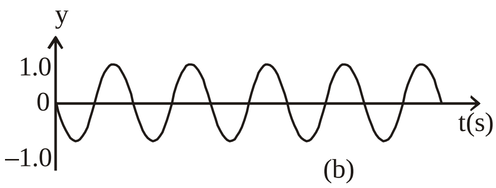
96. The fifth harmonic for vibrations of a stretched string is shown in figure. How many nodes are present here?

(a) 4 (b) 6
(c) 5 (d) 10

97. What will be the frequency of beats formed from the superposition of two harmonic waves shown below?



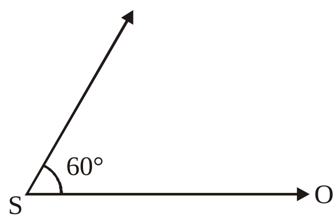
(a)



(b)

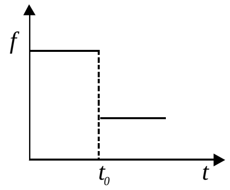
(a) 20 Hz (b) 11 Hz
(c) 9 Hz (d) 2 Hz

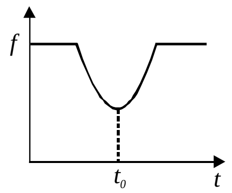
98. A source of sound S emitting waves of frequency 100 Hz and an observor O are located at some distance from each other. The source is moving with a speed of 19.4 ms^{-1} at an angle of 60° with the source observer line as shown in the figure. The observor is at rest. The apparent frequency observed by the observer is (velocity of sound in air 330 ms^{-1})

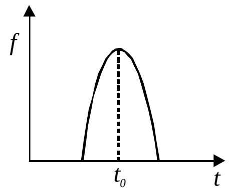


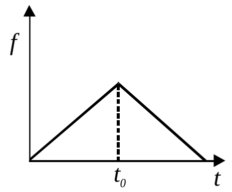
(a) 103 Hz (b) 106 Hz
(c) 97 Hz (d) 100 Hz

99. A man is standing on a railway platform listening to the whistle of an engine that passes the man at constant speed without stopping. If the engine passes the man at time t_0. How does the frequency f of the whistle as heard by the man changes with time ?

(a) 

(b) 

(c) 

(d) 

ASSERTION- REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

100. 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.

101. Assertion : Solids can support both longitudinal and transverse waves but only longitudinal waves can propagate in gases.
Reason : For the propagation of transverse waves, medium must also necessarily have the property of rigidity.

102. Assertion : Sound wave is an example of longitudinal wave.
Reason : In longitudinal waves, the constituents of the medium oscillate perpendicular to the direction of wave propagation.

103. 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.

104. Assertion : Waves on strings are always transverse.
Reason : It is because a string is non stretchable so compressions and rarefaction cannot be produced in string but strings have elasticity of shape, so waves on string are transverse.

105. Assertion : The change in air pressure affect the speed of sound.
Reason : The speed of sound in a gas is proportional to the square root of pressure.

106. Assertion : Two waves moving in a uniform string having uniform tension cannot have different velocities.
Reason : Elastic and inertial properties of string are same for all waves in same string. Moreover speed of wave in a string depends on its elastic and inertial properties only.

107. Assertion : A transverse waves are produced in a very long string fixed at one end. Only progressive wave is observed near the free end.
Reason : Energy of reflected wave does not reach the free end.

108. Assertion: Explosions on other planets are not heard on Earth.
Reason: Sound waves cannot travel to a far off distance

109. Assertion: Two astronauts can talk to each other on moon through microphone.
Reason: Microphone can convert their sound signals into transverse waves which can travel even in vacuum.

110. Assertion : The base of Laplace correction was that exchange of heat between the region of compression and rarefaction in air is negligible.
Reason : Air is bad conductor of heat and velocity of sound in air is quite large.

111. Assertion : Two longitudinal waves given by equations – $y_1(x, t) = 2a \sin(\omega t - kx)$ and $y_2(x, t) = a \sin(2\omega t - 2kx)$ will have equal intensity.
Reason : Intensity of waves of given frequency in same medium is proportional to square of amplitude only.

112. Assertion : Principle of superposition can be used for any physical quantity.
Reason : Principle of superposition can be used only when amplitude of quantity is small.

113. Assertion : It is not possible to have interference between the waves produced by two independent sources of same frequency.
Reason : For interference of two waves the phase difference between the waves remain constant.

114. Assertion : On reflection from a rigid boundary there takes place a complete reversal of phase.
Reason: On reflection from a denser medium, both the particle velocity and wave velocity are reversed in sign.

115. Assertion : Velocity of particles, while crossing mean position in case of stationary waves varies from maximum at antinodes to zero at nodes.
Reason : Amplitude of vibration at antinodes is maximum and at nodes, the amplitude is zero, and all particles between two successive nodes cross the mean position together.

116. **Assertion :** To hear distinct beats, difference in frequencies of two sources should not be greater than 10.
Reason : Persistance of human ear is 10 per second.

117. **Assertion :** In the case of a stationary wave, a person hear a loud sound at the nodes as compared to the antinodes.
Reason : In a stationary wave all the particles of the medium vibrate in phase.

118. **Assertion :** Sound produced by an open organ pipe is richer than the sound produced by a closed organ pipe.
Reason : Outside air can enter the pipe from both ends, in case of open organ pipe.

119. **Assertion :** The fundemental frequency of an open organ pipe increases as the temperature is increased.
Reason : As the temperature increses, the velocity of sound increases more rapidly than length of the pipe.

120. **Assertion:** Stringed instruments are provided with hollow boxes.
Reason: It increases the surface area of vibration which in turn increases the loudness of the sound.

121. **Assertion :** Speed of mechanical wave in the medium depends on the velocity of source, relative to an observer at rest.
Reason : Speed of mechanical wave is independent of the elastic and other properties such as mass density of the medium.

122. **Assertion :** Doppler formula for sound wave is symmetric with respect to the speed of source and speed of observer.
Reason : Motion of source with respect to stationary observer is not equivalent to the motion of an observer with respect to stationary source.

CRITICAL THINKING TYPE QUESTIONS

123. Two waves are represented by the equations $y_1 = a\sin(\omega t + kx + 0.57)\, m$ and $y_2 = a\cos(\omega t + kx)\, m$, where x is in meter and t in sec. The phase difference between them is
(a) 1.0 radian (b) 1.25 radian
(c) 1.57 radian (d) 0.57 radian

124. A transverse wave is represented by $y = A\sin(\omega t - kx)$. For what value of the wavelength is the wave velocity equal to the maximum particle velocity?
(a) $\frac{\pi A}{2}$ (b) πA
(c) $2\pi A$ (d) A

125. A balloon is filled with hydrogen. For sound waves, this balloon behaves like
(a) a converging lens (b) a diverging lens
(c) a concave mirror (d) Nothing can be said

126. A wave travelling in the +ve x-direction having displacement along y-direction as 1m, wavelength 2π m and frequency $\frac{1}{\pi}$ Hz is represented by
(a) $y = \sin(2\pi x - 2\pi t)$ (b) $y = \sin(10\pi x - 20\pi t)$
(c) $y = \sin(2\pi x + 2\pi t)$ (d) $y = \sin(x - 2t)$

127. The pressure variations in the propagation of sound waves in gaseous medium are
(a) adiabatic (b) isothermal
(c) isobaric (d) isochoric

128. The displacement y of a particle in a medium can be expressed as, $y = 10^{-6}\sin\left(100t + 20x + \frac{\pi}{4}\right) m$ where t is in second and x in meter. The speed of the wave is
(a) 20 m/s (b) 5 m/s
(c) 2000 m/s (d) 5π m/s

129. Velocity of sound waves in air is 330 m/s. For a particular sound wave in air, a path difference of 40 cm is equivalent to phase difference of 1.6π. The frequency of this wave is
(a) 165 Hz (b) 150 Hz
(c) 660 Hz (d) 330 Hz

130. The equation of a wave on a string of linear mass density 0.04 kg m^{-1} is given by
$$y = 0.02(m)\sin\left[2\pi\left(\frac{t}{0.04(s)} - \frac{x}{0.50(m)}\right)\right]$$
The tension in the string is
(a) 4.0 N (b) 12.5 N
(c) 0.5 N (d) 6.25 N

131. A sinusoidal travelling wave described by the equation $y(x, t) = a\sin(kx - \omega t + \phi)$. The value of displacement will
(a) vary 0 to a (b) vary 0 to $-a$
(c) vary $-a$ to a (d) None of these

132. The equation of a resultant wave obtained after superposition of two waves is given by $y(x, t) = 2a\sin kx\cos\omega t$. The position of nodes will be given by
(a) $\sin kx = -1$ (b) $\sin kx = 0$
(c) $\sin kx = 1$ (d) $\sin kx = \frac{n\pi}{2}$

133. A string is stretched between two fixed points separated by 75.0 cm. It is observed to have resonant frequencies of 420 Hz and 315 Hz. There are no other resonant frequencies between these two. The lowest resonant frequency for this string is :
(a) 205 Hz (b) 10.5 Hz
(c) 105 Hz (d) 155 Hz

134. Which of the following represents the equation of a spherical progressive wave ?
(a) $y = a\sin\omega t$ (b) $y = a\sin(\omega t - kr)$
(c) $y = \frac{a}{\sqrt{2}}\sin(\omega t - kr)$ (d) $y = \frac{a}{r}\sin(\omega t - kr)$

135. Two sound waves travel in the same direction in a medium. The amplitude of each wave is A and the phase difference between the two waves is 120°. The resultant amplitude will be

(a) $\sqrt{2}A$ (b) 2A
(c) 3A (d) A

136. A sonometer wire supports a 4 kg load and vibrates in fundamental mode with a tuning fork of frequency 416 Hz. The length of the wire between the bridges is now doubled. In order to maintain fundamental mode, the load should be changed to

(a) 1 kg (b) 2 kg
(c) 4 kg (d) 16 kg

137. A sonometer wire of length 1.5 m is made of steel. The tension in it produces an elastic strain of 1%. What is the fundamental frequency of steel if density and elasticity of steel are 7.7×10^3 kg/m^3 and 2.2×10^{11} N/m^2 respectively ?

(a) 188.5 Hz (b) 178.2 Hz
(c) 200.5 Hz (d) 770 Hz

138. If n_1, n_2 and n_3 are the fundamental frequencies of three segments into which a string is divided, then the original fundamental frequency n of the string is given by

(a) $\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3}$

(b) $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}} + \frac{1}{\sqrt{n_3}}$

(c) $\sqrt{n} = \sqrt{n_1} + \sqrt{n_2} + \sqrt{n_3}$

(d) $n = n_1 + n_2 + n_3$

139. A cylindrical tube, open at both ends, has a fundamental frequency, *f*, in air. The tube is dipped vertically in water so that half of it is in water. The fundamental frequency of the air-column is now

(a) f (b) $\frac{f}{2}$
(c) $\frac{3f}{4}$ (d) $2f$

140. Tube *A* has both ends open while tube *B* has one end closed, otherwise they are identical. The ratio of fundamental frequency of tube *A* and *B* is

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

141. An organ pipe P_1 closed at one end vibrating in its first overtone and another pipe P_2 open at both ends vibrating in third overtone are in resonance with a given tuning fork. The ratio of the length of P_1 to that of P_2 is

(a) 8/3 (b) 3/8
(c) 1/2 (d) 1/3

142. The number of possible natural oscillation of air column in a pipe closed at one end of length 85 cm whose frequencies lie below 1250 Hz are : (velocity of sound = 340 ms^{-1})

(a) 4 (b) 5
(c) 7 (d) 6

143. The fundamental frequency of a closed organ pipe of length 20 cm is equal to the second overtone of an organ pipe open at both the ends. The length of organ pipe open at both the ends is

(a) 100 cm (b) 120 cm
(c) 140 cm (d) 80 cm

144. Two identical piano wires kept under the same tension T have a fundamental frequency of 600 Hz. The fractional increase in the tension of one of the wires which will lead to occurrence of 6 beats/s when both the wires oscillate together would be

(a) 0.02 (b) 0.03
(c) 0.04 (d) 0.01

145. Two vibrating tuning forks produce progressive waves given by $Y_1 = 4 \sin 500 \pi t$ and $Y_2 = 2 \sin 506 \pi t$. Number of beats produced per minute is

(a) 360 (b) 180
(c) 60 (d) 3

146. A tuning fork of frequency 512 Hz makes 4 beats per second with the vibrating string of a piano. The beat frequency decreases to 2 beats per sec when the tension in the piano string is slightly increased. The frequency of the piano string before increasing the tension was

(a) 510 *Hz* (b) 514 *Hz*
(c) 516 *Hz* (d) 508 *Hz*

147. The velocity of a moving galaxy is 300 km s^{-1} and the apparent change in wavelength of a spectral line emitted from the galaxy is observed as 0.5 nm. Then, the actual wavelength of the spectral line is

(a) 3000 Å (b) 5000 Å
(c) 6000 Å (d) 4500 Å

148. Two sources of sound placed close to each other are emitting progressive waves given by $y_1 = 4 \sin 600 \pi t$ and $y_2 = 5 \sin 608 \pi t$. An observer located near these two sources of sound will hear

(a) 4 beats per second with intensity ratio 25 : 16 between waxing and waning.
(b) 8 beats per second with intensity ratio 25 : 16 between waxing and waning
(c) 8 beats per second with intensity ratio 81 : 1 between waxing and waning
(d) 4 beats per second with intensity ratio 81 : 1 between waxing and waning

149. Length of a sonometer wire between two fixed ends is 110 cm. If the fundamental frequencies are in the ratio of 1 : 2 : 3, then what is the ratio of lengths of these segments of the wire ?

(a) 3 : 2 : 1 (b) 6 : 3 : 2
(c) 6 : 2 : 3 (d) 2 : 3 : 6

150. A source of sound is moving with a uniform speed along a circle. The frequency of sound as heard by listener stationed at the centre of the path

(a) increases
(b) decreases
(c) remains the same
(d) may increase and decrease alternately

151. If we study the vibration of a pipe open at both ends, then which of the following statements is not true ?

(a) Odd harmonics of the fundamental frequency will be generated
(b) All harmonics of the fundamental frequency will be generated
(c) Pressure change will be maximum at both ends
(d) Antinode will be at open end

152. If wind blows from a stationary sounding object to a stationary listener, then the apparent frequency n' and actual frequency n are related as

(a) $n' \geq n$ (b) n' < n
(c) n' = n (d) n' > n

153. A source of unknown frequency gives 4 beats/s, when sounded with a source of known frequency 250 Hz. The second harmonic of the source of unknown frequency gives five beats per second, when sounded with a source of frequency 513 Hz. The unknown frequency is

(a) 246 Hz (b) 240 Hz
(c) 260 Hz (d) 254 Hz

154. A car is moving towards a high cliff. The car driver sounds a horn of frequency *f*. The reflected sound heard by the driver has as frequency 2*f*. If v be the velocity of sound, then the velocity of the car, in the same velocity units, will be

(a) v /2 (b) $v/\sqrt{2}$
(c) v /3 (d) v /4

155. A speeding motorcyclist sees trafic jam ahead of him. He slows down to 36 km/hour. He finds that traffic has eased and a car moving ahead of him at 18 km/hour is honking at a frequency of 1392 Hz. If the speeds of sound is 343 m/s, the frequency of the honk as heard by him will be

(a) 1332 Hz (b) 1372 Hz
(c) 1412 Hz (d) 1464 Hz

156. A train moving at a speed of 220 ms^{-1} towards a stationary object, emits a sound of frequency 1000 Hz. Some of the sound reaching the object gets reflected back to the train as echo. The frequency of the echo as detected by the driver of the train is (speed of sound in air is 330 ms^{-1})

(a) 3500 Hz (b) 4000 Hz
(c) 5000 Hz (d) 3000 Hz

157. A whistle producing sound waves of frequencies 9500 HZ and above is approaching a stationary person with speed vms^{-1}. The velocity of sound in air is 300 ms^{-1}. If the person can hear frequencies upto a maximum of 10,000 HZ, the maximum value of v upto which he can hear whistle is

(a) $15\sqrt{2}\ ms^{-1}$ (b) $\frac{15}{\sqrt{2}}\ ms^{-1}$
(c) $15\ ms^{-1}$ (d) $30\ ms^{-1}$

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(c)** Water waves are both longitudinal and transverse.
2. **(d)** Longitudinal waves like sound require material medium.
3. **(d)** Both are longitudinal waves not transverse waves.
4. **(d)** In a stationary wave, the wave only expand and shrink at their position without any forward or backward motion. Therefore, there is no transmission of energy in stationary waves.
5. **(c)** When vibrations are produced in a sitar wire the superposition takes place between incident and reflected wave from the rigid ends and a new wave is produced which appears stationary in the medium. This wave is called stationary wave and its nature is transverse.
6. **(c)** **7. (d)** **8. (d)**
9. **(b)** Sound waves in air are longitudinal while light waves are transverse. Sound waves require material medium to propagate but transverse waves do not require any material medium.
10. **(b)** With the propagation of a longitudinal wave, energy alone is propagated.
11. **(a)** Frequency of wave is a function of the source of waves. Therefore, it remains unchanged.
12. **(a)** speed, $v = n\lambda = \frac{\lambda}{T}$
13. **(c)** Sound can travel longitudinally as well as transversly in solids.
14. **(a)** Because they are absorbed by the atmosphere.
15. **(d)** **16. (c)**
17. **(a)** Speed of sound in decreasing order: Solids > liquid > gases
18. **(a)** Perception of sound is due to pressure variations which is maximum at nodes.
19. **(d)** Velocity of sound in gas $V_g = \sqrt{\frac{\gamma p}{\rho}}$

    where ρ is density of the gas.
20. **(b)** Sound waves are mechanical waves whose velocity $v = \sqrt{\gamma RT / M}$

    Light are non-mechanical or electromagnetic for which speed $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3 \times 10^8$ m/s
21. **(a)** Velocity of sound at t°C is given by

    $v_t = v_0 + 0.61t$

    where v_0 is the velocity of sound at 0°C.

    $\therefore \quad v_t - v_0 = 0.61t$

    When temperature is increased by 1° C, then

    $v_t - v_0 = 0.61$ m/s

    Therefore, velocity of sound in a gas increases by 0.61 m/s when the temperature rises by 1°C.
22. **(b)** Speed of wave is given by

    $v = n\lambda$

    $\therefore$ Frequency of wave $n = \frac{v}{\lambda}$

    Therefore, the frequency of wave varies directly with speed of wave.

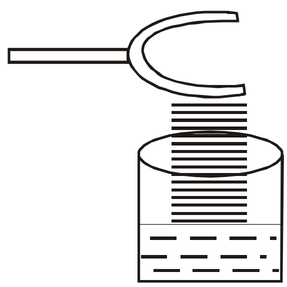
    Frequencies, $n_u \geq n_a \geq n_i$

    Therefore speeds of waves

    $v_u \geq v_a \geq v_i$
23. **(a)** The correct form of differential eqn. of a wave is

    $$\frac{d^2y}{dt^2} = v^2 \frac{d^2y}{dx^2}$$
24. **(b)** $v = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{E}{\rho}}$
25. **(a)** For a perfectly rigid rod, $\eta = \infty$

    $\therefore \quad v = \sqrt{\eta / \rho} \to$ infinite
26. **(a)** $\frac{\text{speed of body}}{\text{speed of sound}} = \text{mach number}$
27. **(a)** As shown in the figure, the prongs of the tuning fork are kept in a vertical plane.



28. **(a)** Velocity of sound in a gas is

    $v = \sqrt{\gamma P / \rho}$ and from $P = \frac{1}{3}\rho v_{r.m.s.}^2$

    $v_{r.m.s.} = \sqrt{3P/\rho} \qquad \therefore \qquad \frac{v}{v_{r.m.s.}} = \sqrt{\frac{\gamma}{3}}$
29. **(a)** Velocity of sound $= \sqrt{\frac{\gamma RT}{M}}$

    When water vapour are present in air, average molecular weight of air decreases and hence velocity increases.

30. **(d)** The speed of sound in liquid,

$$v = \sqrt{\frac{k}{\rho}} = \sqrt{\frac{2\times10^9}{8000}} = \sqrt{\frac{1}{4}\times10^6}$$

$$v = \frac{1}{2}\times10^3 = 500\text{m s}^{-1}.$$

31. **(b)** Time period, $T = \frac{2\pi}{\omega}$; from given eqn.

$\omega = 3.0\ s^{-1}$

or $T = \frac{2\pi}{3} = 2.09$ s

32. **(c)**

33. **(a)** $\lambda = \frac{2\pi}{k}$ or $k = \frac{2\pi\ (\text{rad})}{\lambda\ \ (m)}$

34. **(c)** The intensity of wave

$I = 2\pi^2 a^2 n^2 \rho v$

$\therefore\ \ I \propto a^2 \propto n^2$

Therefore the intensity of a wave depends upon both, its frequency and amplitude.

35. **(c)** When two waves, one incident and other reflected wave, interfere with each other in the string than a new type of wave is produced, which appears stationary in the medium. This wave is called stationary or standing wave. Therefore, standing wave in a string are produced due to interference of waves.

36. **(b)** The position of such a wave changes in two dimensional plane with time.

37. **(c)** In ordinary talk, the amplitude of vibration is about 10^{-8} m

38. **(b)** Phon is the unit of loudness.

39. **(d)**

40. **(a)** The intensity of wave, $I = 2\pi^2 f^2 A^2 \rho v$, so $I \propto f^2$ and $I \propto A^2$.

41. **(c)** The waves, whose frequencies, phases and amplitudes are same at a given time or at a given place in space are known as coherent waves.

42. **(c)** The contrast will be maximum, when $I_1 = I_2$ i.e. a = b. In that event, $I_{min} = (a - b)^2 = 0$, where a and b are the amplitudes of interfering waves.

43. **(b)** On reflection at a denser medium, change of phase = π (radian)

44. **(a)** On reflection at a rarer medium, no change of phase occures

45. **(d)** yz A sin $(kx - \omega t)$ for the wave progressing along the x-axis and for the reflected wave,

$y' = A \sin (kx + \omega t)$.

But the position of the rigid wall is at $x = 0$.

$\therefore$ For the given wave, its reflected wave

$y' = -A \sin (kx + \omega t)$.

46. **(b)**

47. **(c)** The equation of progressive wave propagating in the positive direction of X-axis is

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

$y = a \sin (\omega t - kx)$

48. **(a)** Standing waves are produced when two waves propagate in opposite direction

As z_1 & z_2 are propagating in +ve x-axis & –ve x-axis

so, $z_1 + z_2$ will represent a standing wave.

49. **(d)**

50. **(b)** In case of an open boundry :

Incident wave is $y_1 = a \sin (wt - kx)$

and reflected wave is $y_2 = a \sin (wt + kx)$

No phase change occurs,

51. **(d)** **52.** **(b)** **53.** **(d)** **54.** **(d)** **55.** **(b)**

56. **(a)** A pipe open at both ends produce all odd and even harmonics.

57. **(d)** The time for which sound continues to be heard after the source has stopped producing sound is called reverberation time. Sabine formula for reverberation time of a hall is

$$T = \frac{0.16V}{\Sigma as}$$

where V is volume of the hall in m^3 and Σas is total absorption. In particular, reverberation time of a hall is adjusted by providing a few open windows, covering the walls with absoring materials.

58. **(b)** According to Laplace when sound propagate in a gaseous medium the compressions and rarefactions are formed periodically at a very high speed. Some heat is produced at the places of compressions and some heat is lost at the places of rarefactions, but there is no transfer of heat between the compressions and rarefactions in the gaseous medium.

59. **(c)** Damping is caused by opposing force, which decreases the frequency.

60. **(d)**

61. **(a)** The even number of harmonics possible in open pipe.

62. **(d)**

63. **(a)** Persistence of hearing is $\frac{1}{10}$ s.

64. **(d)** Third overtone has a frequency 7 n, which means $L = \frac{7\lambda}{4}$ = three full loops + one half loop, which would make four nodes and four antinodes.

65. **(d)** For producing beats, their must be small difference in frequency.

66. **(a)** **67.** **(d)**

68. **(c)** These apparent change in frequency due to motion of source and observer relative to the medium along the line of sight is called Doppler's effect.

69. (c)

70. (c) The apparent frequency heard by the stationary observer

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

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

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

71. (d) 72. (c) 73. (a)

STATEMENT TYPE QUESTIONS

74. (d) Waves are kind of disturbances which moves from one place to another without the actual physical transfer of matter of the medium as a whole. The particles of the medium only oscillate but do not travel from one place to another.
Waves transport energy and the pattern of disturbance has information that propagate from one point to another. Here, wave pattern propagates.
All our communication essentially depend on transmission of signals through the waves.

75. (a) When a stone is dropped in a pond still water following observation/conclusion may deduced.
I. The disturbance produced propagates outwards from the point of disturbance along a circle-observation.
II. If a cork piece is put on the disturbed surface, it moves up and down, but do not move away from the centre of disturbance-observation.
III. Conclusion This shows that the water mass does not flow outward with the circle, but rather a moving disturbance is created.

76. (b)

77. (b) Mechanical waves only transfer energy from one point to another.

78. (c) A steel bar possessing both bulk and shear elastic moduli can propagate longitudinal as well as transverse waves. But air can propagate only longitudinal pressure waves (sound).
Moreover, when a medium such as a steel bar propagates both longitudinal and transverse waves, their speeds can be different, since they arise from different elastic moduli.

79. (c) Speed of a transverse wave in a stretched string,

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

Speed of transverse wave on a stretched string does not depend upon the frequency of the wave.

80. (a) In a standing wave energy of one region is always confined in that region. All particles cross their mean position together.

81. (c) In a closed organ pipe, two waves travelling in opposite direction (one incident and other reflected wave from boundary) superimpose with each other to develop a wave pattern which is standing or stationary.
Harmonics in closed organ pipe :
$v_1 : v_2 : v_3 .... = 1 : 3 : 5 : ......$
So, only odd harmonics are present. ⇒ II correct
Natural frequencies $= v = \frac{nv}{2L}$; $n = 1, 2, 3, ...$
Thus, even and odd i.e., all the harmonics are present.

82. (c) Change in frequency has nothing to do with distance between source and listener.

MATCHING TYPE QUESTIONS

83. (c) $A \to (4);\ B \to (3);\ C \to (2);\ D \to (1)$

84. (c) $A \to (4);\ B \to (1);\ C \to (2);\ D \to (3)$

85. (d) $(A) \to (1, 2), (B) \to (4), (C) \to (1, 3), (D) \to (4)$
(A) $y = 4\sin(5x - 4t) + 3\cos\left(4t - 5x + \frac{\pi}{6}\right)$
is super position of two coherent waves, so their equivalent will be an another travelling wave
(B) $y = 10\cos\left(t - \frac{x}{330}\right)\sin(100)\left(t - \frac{x}{330}\right)$
Lets check at any point, say at x = 0, y = (10 cos t) sin (100t) at any point amplitude is changing sinusoidally. so this is equation of beats.
(C) $y = 10\sin(2\pi x - 120t) + 10\cos(120t + 2\pi x)$
= superposition of two coherent waves travelling in opposite direction.
⇒ equation of standing waves
(D) $y = 10\sin(2\pi x - 120t) + 8\cos(118t - 59/30\pi x)$
= superposition of two waves whose frequency are slightly different
$(\omega_1 = 120, \omega_2 = 118)$ ⇒ equation of beats

86. (d) $A \to (2);\ B \to (3);\ C \to (4);\ D \to (1)$

87. (b) $A \to (2);\ B \to (1);\ C \to (3);\ D \to (4)$

88. (c) Change in apparent frequency due to relative motion between source and listener is Doppler effect.
A - (3)
Intensity of sound varies with time in case of beats.
B - (1)
Sound waves in air are longitudinal in nature.
C - (4)
Light waves are transverse in nature.
D - (2)

89. (d) $A \to (3); B \to (1); C \to (2); D \to (3)$

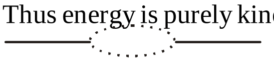
DIAGRAM TYPE QUESTIONS

90. (d) The displacement of the points *B* and *F* are equal in magnitude and sign. So these points are in same phase.

91. (b) For a moving source, $\lambda' < \lambda$ (normal wavelength).

92. (c) As two waves meet a point with opposite phase hence desctructive interference i.e., minimum sound at that point.

93. (b) After 2 s, the each wave travels a distance = 2 × 2 = 4 m.
The wave shape is shown in figure.
Thus energy is purely kinetic.

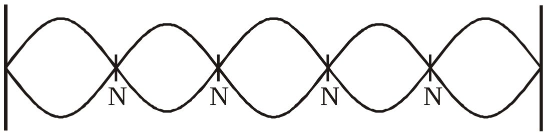


94. (c) When the waves meet a point with opposite phase, destructive interference is obtained at that point. In this case phase difference,

$$\phi = 180° \text{ or } (2n-1)\pi \quad n = 1, 2, 3, ...$$

95. (d) Two sinusoidal waves of same amplitude travel along the string in opposite directions forms stationary wave

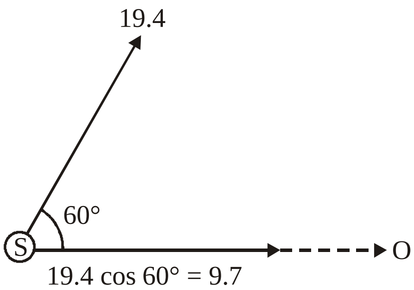
96. (a)



Total no. of nodes = 4

97. (d) Figure(a) represents a harmonic wave of frequency 7.0 Hz, figure (b) represents a harmonic wave of frequency 5.0 Hz. Therefore beat frequency $v_s = 7 - 5 = 2.0$ Hz.

98. (a) Here, original frequency of sound, $f_0 = 100$ Hz
Speed of source $V_s = 19.4 \cos 60° = 9.7$



From Doppler's formula

$$f^1 = f_0\left(\frac{V - V_0}{V - V_s}\right)$$

$$f^1 = 100\left(\frac{V - 0}{V - (+9.7)}\right)$$

$$f^1 = 100\frac{V}{V\left(1 - \frac{9.7}{V}\right)}$$

$$f^1 = 100\left(1 + \frac{9.7}{330}\right) = 103\text{Hz}$$

Apparent frequency $f^1 = 103$ Hz

99. (a) $f_1 = f\left(\frac{v}{v - v_s}\right)$ and $f_2 = f\left(\frac{v}{v + v_s}\right)$; so the frequency of
whistle suddenly changes from f_1 to f_2.

ASSERTION- REASON TYPE QUESTIONS

100. (a)

101. (a) For the propagation of traverse

102. (c) In longitudinal waves, the constituents of the medium oscillate parallel to the direction of wave propagation. So sound wave is an example of longitudinal wave.

103. (d) Particle velocity, $v_P = \omega A \cos(\omega t - kx)$, which depends on time, $v = \sqrt{\gamma P/\rho}$.

104. (a)

105. (d) With change in pressure, density of medium also changes and so P/ρ remains constant.

106. (d) Two waves moving in uniform string with uniform tension shall have same speed and may be moving in opposite directions. Hence both waves may have velocities in opposite direction. Hence statement-1 is false.

107. (b)

108. (c) There is no material medium over a long distance between earth and other planets. So explosions on other planets are not heard on Earth.

109. (a) Two astronauts cannot talk to each other on moon because moon has no atmosphere and hence there is no medium for propagation of sound.

110. (c) Laplace assumed adiabatic process during sound propagation.

111. (b) intensity, $I = \frac{1}{2}\rho\omega^2 A^2 v$

$\therefore$ Intensity depend upon amplitude, frequency as well as velocity of wave.
Also $I_1 = I_2$

112. (d) Principle of superposition can be used for vector quantity or tensor quantity.

113. (a) In case of independent sources, the phase difference between them does not remain constant.

114. (a) Reflection from a rigid boundary is a case of reflection from a denser medium. In that case the particle velocity and wave velocity are reversed in sign.

115. (a)

116. (a)

117. (c) At nodes pressure is maximum. Particles within a loop vibrate in phase.

118. (b) Open pipe can produce more number of harmonics in comparison to close pipe.

119. (a) As $f = \frac{v}{2l}$; and so with increase in temperature v increases more than l.

Also $v = \sqrt{\frac{\gamma RT}{M}}$

120. (a)

121. (d) Relative to an observer at rest in a medium the speed of a mechanical wave in that medium depends only on elastic and other properties of the medium. It does not depend on the velocity of the source.

122. (d) In doppler effect for sound wave effect due to observer and source motion are different.

CRITICALTHINKING TYPE QUESTIONS

123. (a) Here, $y_1 = a \sin(\omega t + kx + 0.57)$

and $y_2 = a\cos(\omega t + kx)$

$$= a\sin\left[\frac{\pi}{2} + (\omega t + kx)\right]$$

Phase difference, $\Delta\phi = \phi_2 - \phi_1$

$$= \frac{\pi}{2} - 0.57$$

$$= \frac{3.14}{2} - 0.57 = 1.57 - 0.57 = 1 \text{ radian}$$

124. (c) $y = A\sin(\omega t - kx)$

Particle velocity,

$$v_p = \frac{dy}{dt} = A\,\omega\cos(\omega t - kx)$$

$$\therefore\ v_{p\,max} = A\,\omega$$

wave velocity $= \dfrac{\omega}{k}$

$$\therefore\ A\omega = \frac{\omega}{k}$$

i. e., $A = \dfrac{1}{k}$ But $k = \dfrac{2\pi}{\lambda}$

$$\therefore\ \lambda = 2\pi A$$

125. (b) As density of hydrogen is less than density of air, velocity of sound in hydrogen is greater than vel. of sound in air. Therefore hydrogen acts as a rarer medium and the balloon behaves as a diverging lens.

126. (d) As $Y = A\sin(\omega t - kx + \phi)$

$$\omega = 2\pi f = \frac{2\pi}{\pi} = 2 \qquad [\because\ f = \frac{1}{\pi}]$$

$$k = \frac{2\pi}{\lambda} = \frac{2\pi}{2\pi} = 1 \qquad [\because\ \lambda = 2\pi]$$

$\therefore\ Y = 1\sin(2t - x + \phi)[\because\ A = 1\text{ m}]$

127. (a) The pressure variations in the propagation of sound waves in gaseous medium are adiabatic.

128. (b) From equation, $\omega = 100$

$$\therefore \frac{2\pi}{T} = 100 \Rightarrow \nu = \frac{100}{2\pi}$$

$$\frac{2\pi}{\lambda} = 20 \Rightarrow \lambda = \frac{2\pi}{20}$$

$$v = \lambda\nu = \frac{2\pi}{20} \times \frac{100}{2\pi} = 5\text{m/s}$$

129. (c) From $\Delta x = \dfrac{\lambda}{2\pi}\Delta\phi$, $\lambda = 2\pi\dfrac{\Delta x}{\Delta\phi} = \dfrac{2\pi(0.4)}{1.6\pi} = 0.5\text{ m}$

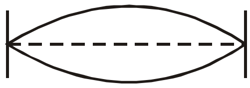
$$\nu = \frac{v}{\lambda} = \frac{330}{0.5} = 660\ \text{Hz}$$

130. (d) $T = \mu v^2 = \mu\dfrac{\omega^2}{k^2} = 0.04\dfrac{(2\pi/0.004)^2}{(2\pi/0.50)^2} = 6.25\text{ N}$

131. (c) Since the sine function varies between – 1 and 1 so, the displacement varies – *a* and *a*.

132. (b) From the equation $y(x, t) = 2a\sin kx\cos\omega t$ the position of nodes (where amplitude is zero) are given by $\sin kx = 0$ or $kx = n\pi$ where $n = 0, 1, 2, 3, ...$

133. (c) In a stretched string all multiples of frequencies can be obtained i.e., if fundamental frequency is *n* then higher frequencies will be 2n, 3n, 4n ...



So, the difference between any two successive frequencies will be 'n'

According to question, n = 420 – 315

= 105 Hz

So the lowest frequency of the string is 105 Hz.

134. (d) In the spherical source, the amplitude A of wave is inversely proportional to the distance r i.e., $A \propto \dfrac{1}{r}$

Where r is distance of source from the point of consideration.

135. (d) Here, $A_1 = A, A_2 = A, \phi = 120°$

The amplitude of the resultant wave is

$$A_R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$$

$$= \sqrt{A^2 + A^2 + 2AA\cos 120°}$$

$$= \sqrt{A^2 + A^2 - A^2} \quad \left(\because\ \cos 120° = -\frac{1}{2}\right)$$

$= A_R = A$

136. (d) Load supported by sonometer wire = 4 kg

Tension in sonometer wire = 4 g

If μ = mass per unit length

then frequency $\upsilon = \dfrac{1}{2l}\sqrt{\dfrac{T}{\mu}}$

$$\Rightarrow\ 416 = \frac{1}{2l}\sqrt{\frac{4g}{\mu}}$$

When length is doubled, i.e., $l' = 2l$

Let new load = L

As, $\upsilon' = \upsilon$

$\therefore \frac{1}{2l'}\sqrt{\frac{Lg}{\mu}} = \frac{1}{2l}\sqrt{\frac{4g}{\mu}}$

$\Rightarrow \frac{1}{4l}\sqrt{\frac{Lg}{\mu}} = \frac{1}{2l}\sqrt{\frac{4g}{\mu}}$

$\Rightarrow \sqrt{L} = 2\times 2 \Rightarrow L = 16\,\text{kg}$

137. (b) Fundamental frequency,

$$f = \frac{v}{2\ell} = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}} = \frac{1}{2\ell}\sqrt{\frac{T}{A\rho}} \left[\because v = \sqrt{\frac{T}{\mu}} \text{ and } \mu = \frac{m}{\ell}\right]$$

Also, $Y = \frac{T\ell}{A\Delta\ell} \Rightarrow \frac{T}{A} = \frac{Y\Delta\ell}{\ell} \Rightarrow f = \frac{1}{2\ell}\sqrt{\frac{\gamma\Delta\ell}{\ell\rho}}$ ....(i)

$\ell = 1.5$ m, $\frac{\Delta\ell}{\ell} = 0.01$, $\rho = 7.7\times 10^3$ kg/m^3 (given)

$\gamma = 2.2\times 10^{11}$ N/m^2 (given)

Putting the value of $\ell, \frac{\Delta\ell}{\ell}$, ρ and γ in eq^n. (i) we get,

$f = \sqrt{\frac{2}{7}}\times\frac{10^3}{3}$

or, $f \approx 178.2$ Hz

138. (a) Total length of string $\ell = \ell_1 + \ell_2 + \ell_3$

(As string is divided into three segments)

But frequency $\propto \frac{1}{\text{length}}$ $\left(\because f = \frac{1}{2\ell}\sqrt{\frac{T}{m}}\right)$

so $\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3}$

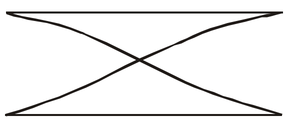
139. (a) Initially for open organ pipe, fundamental frequency,

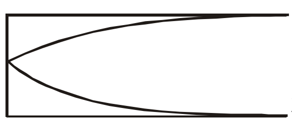
$v_0 = \frac{v}{2l} = f$ (given)

But when it is half dipped in water, then it becomes closed organ pipe of length $\frac{l}{2}$. In this case, fundamental frequency,

$$v_c = \frac{v}{4l'} = \frac{v}{4\frac{l}{2}} = \frac{v}{2l} = f$$

140. (c) $\frac{\lambda_A}{\lambda_B} = \frac{1}{2} \Rightarrow \frac{n_A}{n_B} = \frac{2}{1}$

A =  $\lambda_A = 2L$

B =  $\lambda_B = 4L$

141. (b) $3\times\frac{v}{4l_c} = 4\times\frac{v}{2l_0}$ or $\frac{l_c}{l_0} = \frac{3v}{4}\times\frac{2}{4v} = \frac{3}{8}$

142. (d) In case of closed organ pipe frequency,

$$f_n = (2n+1)\frac{v}{4l}$$

for $n = 0, f_0 = 100$ Hz
$n = 1, f_1 = 300$ Hz
$n = 2, f_2 = 500$ Hz
$n = 3, f_3 = 700$ Hz
$n = 4, f_4 = 900$ Hz
$n = 5, f_5 = 1100$ Hz
$n = 6, f_6 = 1300$ Hz

Hence possible natural oscillation whose frequencies < 1250 Hz $= 6 (n = 0, 1, 2, 3, 4, 5)$

143. (b) Fundamental frequency of closed organ pipe

$V_c = \frac{V}{4l_c}$

Fundamental frequency of open organ pipe

$V_0 = \frac{V}{2l_0}$

Second overtone frequency of open organ pipe

$= \frac{3V}{2l_0}$

From question,

$\frac{V}{4l_c} = \frac{3V}{2l_0}$

$\Rightarrow l_0 = 6l_c = 6\times 20 = 120$ cm

144. (a) For fundamental mode,

$f = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}}$

Taking logarithm on both sides, we get

$$\log f = \log\left(\frac{1}{2\ell}\right) + \log\left(\sqrt{\frac{T}{\mu}}\right)$$

$$= \log\left(\frac{1}{2\ell}\right) + \frac{1}{2}\log\left(\frac{T}{\mu}\right)$$

or $\log f = \log\left(\frac{1}{2\ell}\right) + \frac{1}{2}[\log T - \log\mu]$

Differentiating both sides, we get

$\frac{df}{f} = \frac{1}{2}\frac{dT}{T}$ (as ℓ and μ are constants)

$\Rightarrow \frac{dT}{T} = 2\times\frac{df}{f}$

Here df = 6
f = 600 Hz

$\therefore \frac{dT}{T} = \frac{2\times 6}{600} = 0.02$

145. (b) Equation of progressive wave is given by
$Y = A\sin 2\pi f t$
Given $Y_1 = 4\sin 500\pi t$ and $Y_2 = 2\sin 506\pi t$.
Comparing the given equations with equation of progressive wave, we get
$2f_1 = 500, \quad \Rightarrow f_1 = 250$
$2f_2 = 506 \quad \Rightarrow f_2 = 253$
Beats = $f_2 - f_1$ = 253 – 250 = 3 beats/sec
= 3 × 60 = 180 beats/minute.

146. (d) The frequency of the piano string = 512 ± 4 = 516 or 508. When the tension is increased, beat frequency decreases to 2, it means that frequency of the string is 508 as frequency of string increases with tension.

147. (b) Here, $\Delta\lambda = 0.5\text{ nm} = 0.5 \times 10^{-9}\text{ m}$
$\upsilon = 300\text{ km s}^{-1} = 300 \times 10^3\text{ ms}^{-1}$

As, $\frac{\Delta\lambda}{\lambda} = \frac{\upsilon}{c} \quad \therefore \lambda = \frac{\Delta\lambda c}{\upsilon}$

$$\lambda = \frac{(0.5\times10^{-9}\text{m})(3\times10^{8}\text{ms}^{-1})}{(300\times10^{3}\text{ms}^{-1})} = 5\times10^{-7}\text{m}$$

$= 5000 \times 10^{-10}\text{ m} = 5000$ Å

148. (d) $2\pi f_1 = 600\pi$
$f_1 = 300$ ... (1)
$2\pi f_2 = 608\pi$
$f_2 = 304$ ...(2)
$|f_1 - f_2| = 4$ beats

$$\frac{I_{max}}{I_{m.n}} = \frac{(A_1 + A_2)^2}{(A_1 + A_2)^2} = \frac{(5+4)^2}{(5-4)^2} = \frac{81}{1}$$

where A_1, A_2 are amplitudes of given two sound wave.

149. (b) Frequency $\nu = \frac{1}{2L}\sqrt{\frac{T}{m}} \quad \because V \propto \frac{1}{l}$

$\therefore \quad l_1 : l_2 : l_3 = \frac{1}{1}:\frac{1}{2}:\frac{1}{3} = 6:3:2$

150. (c) Pressure change will be minimum at both ends. In fact, pressure variation is maximum at $\ell/2$ because the displacement node is pressure antinode.

151. (c) The apparent frequency remains the same because distance between the source and observer does not change.

152. (c) Frequency is not affected by blowing of wind so long as source and listener are stationary.

153. (d) When sounded with a source of known frequency fundamental frequency
= 250 ± 4 Hz = 254 Hz or 246 Hz
2nd harmonic if unknown frequency (suppose) 254 Hz
= 2 × 254 = 508 Hz
As it gives 5 beats
∴ 508 + 5 = 513 Hz
Hence, unknown frequency is 254 Hz

154. (c) Let f' be the frequency of sound heard by cliff.

$\therefore f' = \frac{vf}{v - v_c}$ ......(1)

Now for the reflected wave cliff. acts as a source

$\therefore 2f' = \frac{f'(v + v_c)}{v}$ ......(2)

$2f = \frac{(v + v_c)f}{v - v_c} \Rightarrow 2v - 2v_c = v + v_c$ or $\frac{v}{3} = v_c$

155. (c) According to Doppler's effect
Apparent frequency

$$n' = n\left(\frac{v + v_0}{v + v_s}\right) = 1392\left(\frac{343 + 10}{343 + 5}\right).$$

$= 1412$ Hz

156. (c) Frequency of the echo detected by the driver of the train is
(According to Doppler effect in sound)

$$f' = \left(\frac{v + u}{v - u}\right) f$$

where f = original frequency of source of sound
f' = Apparent frequency of source because of the relative motion between source and observer.

$$f' = \left(\frac{330 + 220}{330 - 220}\right)1000 = 5000\text{ Hz}$$

157. (c) $\nu' = \nu\left[\frac{v}{v - v_s}\right]$

$\Rightarrow 10000 = 9500\left[\frac{300}{300 - v}\right]$

$\Rightarrow 300 - v = 300 \times 0.95$

$\Rightarrow v = 300 - 0.05 = 15\text{ ms}^{-1}$