14

Waves

TOPIC 1 Basic of Mechanical Waves, Progressive and Stationary Waves

1. Assume that the displacement (s) of air is proportional to the pressure difference (Δp) created by a sound wave. Displacement (s) further depends on the speed of sound (v), density of air (ρ) and the frequency (f). If $\Delta p \sim$ 10Pa, $v \sim 300$ m/s, $\rho \sim 1$ kg/m^3 and $f \sim 1000$ Hz, then s will be of the order of (take the multiplicative constant to be 1) **[Sep. 05, 2020 (I)]**

(a) $\frac{3}{100}$ mm (b) 10 mm

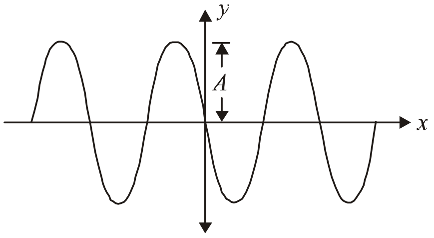
(c) $\frac{1}{10}$ mm (d) 1 mm

2. For a transverse wave travelling along a straight line, the distance between two peaks (crests) is 5 m, while the distance between one crest and one trough is 1.5 m. The possible wavelengths (in m) of the waves are : **[Sep. 04, 2020 (I)]**

(a) 1, 3, 5, ... (b) $\frac{1}{1}, \frac{1}{3}, \frac{1}{5}$, ...

(c) 1, 2, 3, ... (d) $\frac{1}{2}, \frac{1}{4}, \frac{1}{6}$, ...

3. A progressive wave travelling along the positive x-direction is represented by $y(x,t) = A\sin(kx - \omega t + \phi)$. Its snapshot at $t = 0$ is given in the figure. **[12 April 2019 I]**



For this wave, the phase ϕ is :

(a) $-\frac{\pi}{2}$ (b) π (c) 0 (d) $\frac{\pi}{2}$

4. A small speaker delivers 2 W of audio output. At what distance from the speaker will one detect 120 dB intensity sound ? [Given reference intensity of sound as 10^{-12}W/m^2] **[12 April 2019 II]**

(a) 40 cm (b) 20 cm (c) 10 cm (d) 30 cm

5. The pressure wave,
$P = 0.01 \sin[1000t - 3x]$ Nm^{-2}, corresponds to the sound produced by a vibrating blade on a day when atmospheric temperature is 0°C. On some other day when temperature is T, the speed of sound produced by the same blade and at the same frequency is found to be 336 ms^{-1}. Approximate value of T is : **[9 April 2019 I]**

(a) 4°C (b) 11°C (c) 12°C (d) 15°C

6. A travelling harmonic wave is represented by the equation $y(x, t) = 10^{-3} \sin(50t + 2x)$, where x and y are in meter and t is in seconds. Which of the following is a correct statement about the wave? **[12 Jan. 2019 I]**

(a) The wave is propagating along the negative x-axis with speed 25 ms^{-1}.
(b) The wave is propagating along the positive x-axis with speed 100 ms^{-1}.
(c) The wave is propagating along the positive x-axis with speed 25 ms^{-1}.
(d) The wave is propagating along the negative x-axis with speed 100 ms^{-1}.

7. A transverse wave is represented by

$$y = \frac{10}{\pi}\sin\left(\frac{2\pi}{T}t - \frac{2\pi}{\lambda}x\right)$$

For what value of the wavelength the wave velocity is twice the maximum particle velocity? **[Online April 9, 2014]**

(a) 40 cm (b) 20 cm (c) 10 cm (d) 60 cm

8. In a transverse wave the distance between a crest and neighbouring trough at the same instant is 4.0 cm and the distance between a crest and trough at the same place is 1.0 cm. The next crest appears at the same place after a time interval of 0.4s. The maximum speed of the vibrating particles in the medium is : **[Online April 25, 2013]**

(a) $\frac{3\pi}{2}$ cm/s (b) $\frac{5\pi}{2}$ cm/s

(c) $\frac{\pi}{2}$ cm/s (d) 2π cm/s

9. When two sound waves travel in the same direction in a medium, the displacements of a particle located at 'x' at time 't' is given by :

$y_1 = 0.05 \cos(0.50\,\pi x - 100\,\pi t)$

$y_2 = 0.05 \cos(0.46\,\pi x - 92\,\pi t)$

where y_1, y_2 and x are in meters and t in seconds. The speed of sound in the medium is : **[Online April 9, 2013]**

(a) 92 m/s (b) 200 m/s (c) 100 m/s (d) 332 m/s

10. The disturbance $y(x, t)$ of a wave propagating in the positive x-direction is given by $y = \frac{1}{1+x^2}$ at time $t = 0$ and by $y = \frac{1}{\left[1+(x-1)^2\right]}$ at $t = 2$ s, where x and y are in meters. The shape of the wave disturbance does not change during the propagation. The velocity of wave in m/s is **[Online May 26, 2012]**

(a) 2.0 (b) 4.0 (c) 0.5 (d) 1.0

11. The transverse displacement $y(x, t)$ of a wave is given by

$y(x,t) = e^{-\left(ax^2+bt^2+2\sqrt{ab}\,xt\right)}$.

This represents a: **[2011]**

(a) wave moving in $-x$ direction with speed $\sqrt{\frac{b}{a}}$

(b) standing wave of frequency $\sqrt{b}$

(c) standing wave of frequency $\frac{1}{\sqrt{b}}$

(d) wave moving in $+x$ direction speed $\sqrt{\frac{a}{b}}$

12. A wave travelling along the x-axis is described by the equation $y(x, t) = 0.005 \cos(\alpha x - \beta t)$. If the wavelength and the time period of the wave are 0.08 m and 2.0s, respectively, then α and β in appropriate units are **[2008]**

(a) $\alpha = 25.00\,\pi$, $\beta = \pi$ (b) $\alpha = \frac{0.08}{\pi}, \beta = \frac{2.0}{\pi}$

(c) $\alpha = \frac{0.04}{\pi}, \beta = \frac{1.0}{\pi}$ (d) $\alpha = 12.50\pi, \beta = \frac{\pi}{2.0}$

13. A sound absorber attenuates the sound level by 20 dB. The intensity decreases by a factor of **[2007]**

(a) 100 (b) 1000 (c) 10000 (d) 10

14. 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 **[2004]**

(a) 20 m/s (b) 5 m/s
(c) 2000 m/s (d) 5π m/s

15. The displacement y of a wave travelling in the x-direction is given by $y = 10^{-4} \sin\left(600t - 2x + \frac{\pi}{3}\right)$ metres where x is expressed in metres and t in seconds. The speed of the wave - motion, in ms^{-1}, is **[2003]**

(a) 300 (b) 600 (c) 1200 (d) 200

16. When temperature increases, the frequency of a tuning fork **[2002]**

(a) increases
(b) decreases
(c) remains same
(d) increases or decreases depending on the material

TOPIC 2 Vibration of String and Organ Pipe

17. In a resonance tube experiment when the tube is filled with water up to a height of 17.0 cm from bottom, it resonates with a given tuning fork. When the water level is raised the next resonance with the same tuning fork occurs at a height of 24.5 cm. If the velocity of sound in air is 330 m/s, the tuning fork frequency is : **[Sep. 05, 2020 (I)]**

(a) 2200 Hz (b) 550 Hz
(c) 1100 Hz (d) 3300 Hz

18. A uniform thin rope of length 12 m and mass 6 kg hangs vertically from a rigid support and a block of mass 2 kg is attached to its free end. A transverse short wave-train of wavelength 6 cm is produced at the lower end of the rope. What is the wavelength of the wavetrain (in cm) when it reaches the top of the rope ? **[Sep. 03, 2020 (I)]**

(a) 3 (b) 6
(c) 12 (d) 9

19. Two identical strings X and Z made of same material have tension T_X and T_Z in them. If their fundamental frequencies are 450 Hz and 300 Hz, respectively, then the ratio T_X/T_Z is: **[Sep. 02, 2020 (I)]**

(a) 2.25 (b) 0.44
(c) 1.25 (d) 1.5

20. A wire of density 9×10^{-3} kg cm^{-3} is stretched between two clamps 1 m apart. The resulting strain in the wire is 4.9×10^{-4}. The lowest frequency of the transverse vibrations in the wire is (Young's modulus of wire $Y = 9 \times 10^{10}$ Nm^{-2}), (to the nearest integer), ___________. **[Sep. 02, 2020 (II)]**

21. A one metre long (both ends open) organ pipe is kept in a gas that has double the density of air at STP. Assuming the speed of sound in air at STP is 300 m/s, the frequency difference between the fundamental and second harmonic of this pipe is ______ Hz. **[NA 8 Jan. 2020 (I)]**

22. A transverse wave travels on a taut steel wire with a velocity of v when tension in it is 2.06×10^4 N. When the tension is changed to T, the velocity changed to $v/2$. The value of T is close to: **[8 Jan. 2020 (II)]**

(a) 2.50×10^4 N (b) 5.15×10^3 N
(c) 30.5×10^4 N (d) 10.2×10^2 N

23. Speed of a transverse wave on a straight wire (mass 6.0 g, length 60 cm and area of cross-section 1.0 mm^2) is 90 ms^{-1}. If the Young's modulus of wire is 16×10^{11} Nm^{-2} the extension of wire over its natural length is: **[7 Jan. 2020 (I)]**

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

24. Equation of travelling wave on a stretched string of linear density 5 g/m is $y = 0.03 \sin(450t - 9x)$ where distance and time are measured in SI units. The tension in the string is: **[11 Jan 2019 (I)]**

(a) 10 N (b) 7.5 N (c) 12.5 N (d) 5 N

25. A heavy ball of mass M is suspended from the ceiling of a car by a light string of mass m (m<<M). When the car is at rest, the speeed of transverse waves in the string is 60 ms^{-1}. when the car has acceleration a, the wave-speed increases to 60.5 ms^{-1}. The value of a, in terms of gravitational acceleration g, is closest to: **[9 Jan. 2019 (I)]**

(a) $\frac{g}{30}$ (b) $\frac{g}{5}$ (c) $\frac{g}{10}$ (d) $\frac{g}{20}$

26. A wire of length L and mass per unit length 6.0×10^{-3} kgm^{-1} is put under tension of 540 N. Two consecutive frequencies that it resonates at are: 420 Hz and 490 Hz. Then L in meters is: **[9 Jan. 2020 (II)]**

(a) 2.1 m (b) 1.1 m
(c) 8.1 m (d) 5.1 m

27. A tuning fork of frequency 480 Hz is used in an experiment for measuring speed of sound (v) in air by resonance tube method. Resonance is observed to occur at two successive lengths of the air column, $l_1 = 30$ cm and $l_2 = 70$ cm. Then, v is equal to : **[12 April 2019 (II)]**

(a) 332 ms^{-1} (b) 384 ms^{-1}
(c) 338 ms^{-1} (d) 379 ms^{-1}

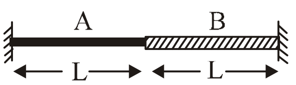
28. A string 2.0 m long and fixed at its ends is driven by a 240 Hz vibrator. The string vibrates in its third harmonic mode. The speed of the wave and its fundamental frequency is: **[9 April 2019 (II)]**

(a) 180 m/s, 80 Hz (b) 320 m/s, 80 Hz
(c) 320 m/s, 120 Hz (d) 180 m/s, 120 Hz

29. A string is clamped at both the ends and it is vibrating in its 4th harmonic. The equation of the stationary wave is $Y = 0.3 \sin(0.157x) \cos(200\pi t)$. The length of the string is: (All quantities are in SI units.) **[9 April 2019 (I)]**

(a) 20 m (b) 80 m (c) 40 m (d) 60 m

30. A wire of length 2L, is made by joining two wires A and B of same length but different radii r and $2r$ and made of the same material. It is vibrating at a frequency such that the joint of the two wires forms a node. If the number of antinodes in wire A is p and that in B is q then the ratio $p : q$ is : **[8 April 2019 (I)]**



(a) 3 : 5 (b) 4 : 9 (c) 1 : 2 (d) 1 : 4

31. A closed organ pipe has a fundamental frequency of 1.5 kHz. The number of overtones that can be distinctly heard by a person with this organ pipe will be: (Assume that the highest frequency a person can hear is 20,000 Hz) **[10 Jan. 2019 (I)]**

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

32. A string of length 1 m and mass 5 g is fixed at both ends. The tension in the string is 8.0 N. The string is set into vibration using an external vibrator of frequency 100 Hz. The separation between successive nodes on the string is close to: **[10 Jan. 2019 (I)]**

(a) 10.0 cm (b) 33.3 cm (c) 16.6 cm (d) 20.0 cm

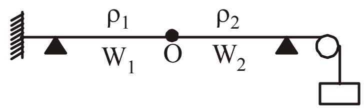
33. A granite rod of 60 cm length is clamped at its middle point and is set into longitudinal vibrations. The density of granite is 2.7×10^3 kg/m^3 and its Young's modulus is 9.27×10^{10} Pa.
What will be the fundamental frequency of the longitudinal vibrations? **[2018]**

(a) 5 kHz (b) 2.5 kHz (c) 10 kHz (d) 7.5 kHz

34. The end correction of a resonance column is 1cm. If the shortest length resonating with the tuning fork is 10cm, the next resonating length should be **[Online April 16, 2018]**

(a) 32cm (b) 40cm (c) 28cm (d) 36cm

35. Two wires W_1 and W_2 have the same radius r and respective densities ρ_1 and ρ_2 such that $\rho_2 = 4\rho_1$. They are joined together at the point O, as shown in the figure. The combination is used as a sonometer wire and kept under tension T. The point O is midway between the two bridges. When a stationary waves is set up in the composite wire, the joint is found to be a node. The ratio of the number of antinodes formed in W_1 to W_2 is : **[Online April 8, 2017]**



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

36. A uniform string of length 20 m is suspended from a rigid support. A short wave pulse is introduced at its lowest end. It starts moving up the string. The time taken to reach the supports is : **[2016]**
(take $g = 10\ ms^{-2}$)

(a) $2\sqrt{2}$s (b) $\sqrt{2}$ s (c) $2\pi\sqrt{2}$ s (d) 2 s

37. A pipe open at both ends has a fundamental frequency f in air. The pipe is dipped vertically in water so that half of it is in water. The fundamental frequency of the air column is now : **[2016]**

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

38. A pipe of length 85 cm is closed from one end. Find the number of possible natural oscillations of air column in the pipe whose frequencies lie below 1250 Hz. The velocity of sound in air is 340 m/s. **[2014]**

(a) 12 (b) 8 (c) 6 (d) 4

39. The total length of a sonometer wire between fixed ends is 110 cm. Two bridges are placed to divide the length of wire in ratio 6 : 3 : 2. The tension in the wire is 400 N and the mass per unit length is 0.01 kg/m. What is the minimum common frequency with which three parts can vibrate? **[Online April 19, 2014]**

(a) 1100 Hz (b) 1000 Hz
(c) 166 Hz (d) 100 Hz

40. 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 **[2013]**
(c) 200.5 Hz (d) 770 Hz

41. A sonometer wire of length 114 cm is fixed at both the ends. Where should the two bridges be placed so as to divide the wire into three segments whose fundamental frequencies are in the ratio 1 : 3 : 4 ? **[Online April 23, 2013]**
(a) At 36 cm and 84 cm from one end
(b) At 24 cm and 72 cm from one end
(c) At 48 cm and 96 cm from one end
(d) At 72 cm and 96 cm from one end

42. 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 : **[2012]**
(a) f (b) $f/2$ (c) $3f/4$ (d) $2f$

43. An air column in a pipe, which is closed at one end, will be in resonance wtih a vibrating tuning fork of frequency 264 Hz if the length of the column in cm is (velocity of sound = 330 m/s) **[Online May 26, 2012]**
(a) 125.00 (b) 93.75 (c) 62.50 (d) 187.50

44. A uniform tube of length 60.5 cm is held vertically with its lower end dipped in water. A sound source of frequency 500 Hz sends sound waves into the tube. When the length of tube above water is 16 cm and again when it is 50 cm, the tube resonates with the source of sound. Two lowest frequencies (in Hz), to which tube will resonate when it is taken out of water, are (approximately). **[Online May 19, 2012]**
(a) 281, 562 (b) 281, 843
(c) 276, 552 (d) 272, 544

45. The equation of a wave on a string of linear mass density 0.04 kg m^{-1} is given by

$$y = 0.02(\text{m}) \sin\left[2\pi\left(\frac{t}{0.04(s)} - \frac{x}{0.50(m)}\right)\right].$$

The tension in the string is **[2010]**
(a) 4.0 N (b) 12.5 N (c) 0.5 N (d) 6.25 N

46. While measuring the speed of sound by performing a resonance column experiment, a student gets the first resonance condition at a column length of 18 cm during winter. Repeating the same experiment during summer, she measures the column length to be x cm for the second resonance. Then **[2008]**
(a) 18 > x (b) x > 54
(c) 54 > x > 36 (d) 36 > x > 18

47. A string is stretched between 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. Then, the lowest resonant frequency for this string is **[2006]**
(a) 105 Hz (b) 1.05 Hz
(c) 1050 Hz (d) 10.5 Hz

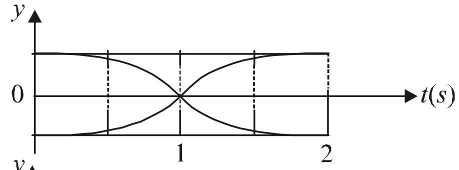
48. Tube A has both ends open while tube B has one end closed, otherwise they are identical. The ratio of fundamental frequency of tube A and B is **[2002]**
(a) 1 : 2 (b) 1 : 4 (c) 2 : 1 (d) 4 : 1

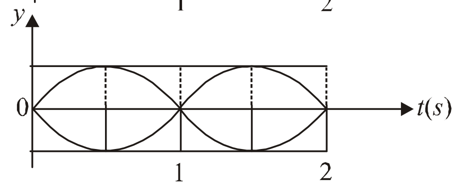
49. A wave $y = a\sin(\omega t - kx)$ on a string meets with another wave producing a node at $x = 0$. Then the equation of the unknown wave is **[2002]**
(a) $y = a\sin(\omega t + kx)$
(b) $y = -a\sin(\omega t + kx)$
(c) $y = a\sin(\omega t - kx)$
(d) $y = -a\sin(\omega t - kx)$

TOPIC 3 Beats, Interference and Superposition of Waves

50. There harmonic waves having equal frequency ν and same intensity I_0, have phase angles 0, $\frac{\pi}{4}$ and $-\frac{\pi}{4}$ respectively. When they are superimposed the intensity of the resultant wave is close to: **[9 Jan. 2020 I]**
(a) $5.8I_0$ (b) $0.2I_0$ (c) $3I_0$ (d) I_0

51. The correct figure that shows, schematically, the wave pattern produced by superposition of two waves of frequencies 9 Hz and 11 Hz is : **[10 April 2019 II]**

(a)


(b)


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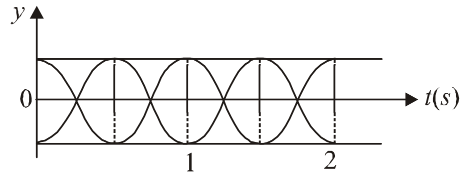

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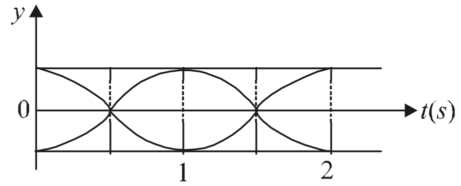


52. A resonance tube is old and has jagged end. It is still used in the laboratory to determine velocity of sound in air. A tuning fork of frequency 512 Hz produces first resonance when the tube is filled with water to a mark 11 cm below a reference mark, near the open end of the tube. The experiment is repeated with another fork of frequency 256 Hz which produces first resonance when water reaches a mark 27 cm below the reference mark. The velocity of sound in air, obtained in the experiment, is close to: **[12 Jan. 2019 II]**

(a) 322 ms^{-1} (b) 341 ms^{-1}
(c) 335 ms^{-1} (d) 328 ms^{-1}

53. A tuning fork vibrates with frequency 256 Hz and gives one beat per second with the third normal mode of vibration of an open pipe. What is the length of the pipe? (Speed of sound of air is 340 ms^{-1})
[Online April 15, 2018]

(a) 190 cm (b) 180 cm
(c) 220 cm (d) 200 cm

54. 5 beats/ second are heard when a turning fork is sounded with a sonometer wire under tension, when the length of the sonometer wire is either 0.95m or 1m . The frequency of the fork will be: **[Online April 15, 2018]**

(a) 195Hz (b) 251Hz (c) 150Hz (d) 300Hz

55. A standing wave is formed by the superposition of two waves travelling in opposite directions. The transverse displacement is given by

$$y(x,t) = 0.5\sin\left(\frac{5\pi}{4}x\right)\cos(200\pi t).$$

What is the speed of the travelling wave moving in the positive x direction ?
(x and t are in meter and second, respectively.)
[Online April 9, 2017]

(a) 160 m/s (b) 90 m/s (c) 180 m/s (d) 120 m/s

56. A wave represented by the equation $y_1 = a\cos(kx - \omega t)$ is superimposed with another wave to form a stationary wave such that the point $x - 0$ is node. The equation for the other wave is **[Online May 12, 2012]**

(a) $a\cos(kx - \omega t + \pi)$ (b) $a\cos(kx + \omega t + \pi)$
(c) $a\cos\left(kx + \omega t + \frac{\pi}{2}\right)$ (d) $a\cos\left(kx - \omega t + \frac{\pi}{2}\right)$

57. Following are expressions for four plane simple harmonic waves **[Online May 7, 2012]**

(i) $y_1 = A\cos 2\pi\left(n_1 t + \frac{x}{\lambda_1}\right)$

(ii) $y_2 = A\cos 2\pi\left(n_1 t + \frac{x}{\lambda_1} + \pi\right)$

(iii) $y_3 = A\cos 2\pi\left(n_2 t + \frac{x}{\lambda_2}\right)$

(iv) $y_4 = A\cos 2\pi\left(n_2 t - \frac{x}{\lambda_2}\right)$

The pairs of waves which will produce destructive interference and stationary waves respectively in a medium, are

(a) (iii, iv), (i, ii) (b) (i, iii), (ii, iv)
(c) (i, iv), (ii, iii) (d) (i, ii), (iii, iv)

58. A travelling wave represented by
$y = A\sin(\omega t - kx)$ is superimposed on another wave represented by $y = A\sin(\omega t + kx)$. The resultant is

(a) A wave travelling along + x direction **[2011 RS]**
(b) A wave travelling along – x direction
(c) A standing wave having nodes at
$x = \frac{n\lambda}{2}, n = 0,1,2....$
(d) A standing wave having nodes at
$x = \left(n + \frac{1}{2}\right)\frac{\lambda}{2};\ n = 0,1,2....$

59. **Statement - 1 :** 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. **[2011 RS]**
Statement - 2 : Intensity of waves of given frequency in same medium is proportional to square of amplitude only.

(a) Statement-1 is true, statement-2 is false.
(b) Statement-1 is true, statement-2 is true, statement-2 is the correct explanation of statement-1
(c) Statement-1 is true, statement-2 is true, statement-2 is not the correct explanation of statement-1
(d) Statement-1 is false, statement-2 is true.

60. Three sound waves of equal amplitudes have frequencies $(\nu - 1)$, ν, $(\nu + 1)$. They superpose to give beats. The number of beats produced per second will be : **[2009]**

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

61. When two tuning forks (fork 1 and fork 2) are sounded simultaneously, 4 beats per second are heard. Now, some tape is attached on the prong of the fork 2. When the tuning forks are sounded again, 6 beats per second are heard. If the frequency of fork 1 is 200 Hz, then what was the original frequency of fork 2? **[2005]**

(a) 202 Hz (b) 200 Hz (c) 204 Hz (d) 196 Hz

62. A tuning fork of known frequency 256 Hz makes 5 beats per second with the vibrating string of a piano. The beat frequency decreases to 2 beats per second when the tension in the piano string is slightly increased. The frequency of the piano string before increasing the tension was **[2003]**

(a) $(256 + 2)$ Hz (b) $(256 - 2)$ Hz
(c) $(256 - 5)$ Hz (d) $(256 + 5)$ Hz

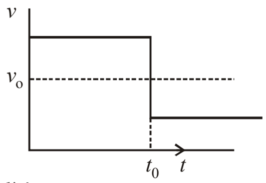
63. A tuning fork arrangement (pair) produces 4 beats/sec with one fork of frequency 288 cps. A little wax is placed on the unknown fork and it then produces 2 beats/sec. The frequency of the unknown fork is **[2002]**

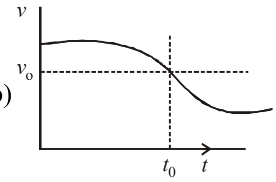
(a) 286 cps (b) 292 cps (c) 294 cps (d) 288 cps

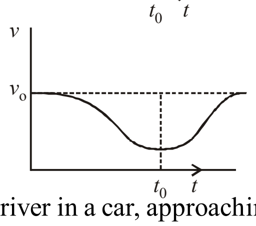
TOPIC 4 Musical Sound and Doppler's Effect

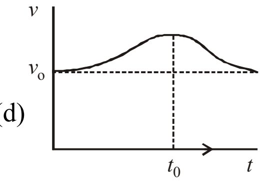
64. A sound source S is moving along a straight track with speed v, and is emitting sound of frequency v_o (see figure). An observer is standing at a finite distance, at the point O, from the track. The time variation of frequency heard by the observer is best represented by:
[Sep. 06, 2020 (I)]

(t_0 represents the instant when the distance between the source and observer is minimum)

(a) 

(b) 

(c) 

(d) 

65. A driver in a car, approaching a vertical wall notices that the frequency of his car horn, has changed from 440 Hz to 480 Hz, when it gets reflected from the wall. If the speed of sound in air is 345 m/s, then the speed of the car is : **[Sep. 05, 2020 (II)]**

(a) 54 km/hr (b) 36 km/hr
(c) 18 km/hr (d) 24 km/hr

66. The driver of a bus approaching a big wall notices that the frequency of his bus's horn changes from 420 Hz to 490 Hz when he hears it after it gets reflected from the wall. Find the speed of the bus if speed of the sound is 330 ms^{-1}. **[Sep. 04, 2020 (II)]**

(a) 91 kmh^{-1} (b) 81 kmh^{-1}
(c) 61 kmh^{-1} (d) 71 kmh^{-1}

67. Magnetic materials used for making permanent magnets (P) and magnets in a transformer (T) have different properties of the following, which property best matches for the type of magnet required? **[Sep. 02, 2020 (I)]**

(a) T : Large retentivity, small coercivity
(b) P : Small retentivity, large coercivity
(c) T : Large retentivity, large coercivity
(d) P : Large retentivity, large coercivity

68. A stationary observer receives sound from two identical tuning forks, one of which approaches and the other one recedes with the same speed (much less than the speed of sound). The observer hears 2 beats/sec. The oscillation frequency of each tuning fork is v_0 = 1400 Hz and the velocity of sound in air is 350 m/s. The speed of each tuning fork is close to: **[7 Jan. 2020 I]**

(a) $\frac{1}{2}$ m/s (b) 1m/s (c) $\frac{1}{4}$ m/s (d) $\frac{1}{8}$ m/s

69. A submarine (A) travelling at 18 km/hr is being chased along the line of its velocity by another submarine (B) travelling at 27 km/hr. B sends a sonar signal of 500 Hz to detect A and receives a reflected sound of frequency *v*. The value of *v* is close to : **[12 April 2019 I]**
(Speed of sound in water = 1500 ms^{-1})

(a) 504 Hz (b) 507 Hz
(c) 499 Hz (d) 502 Hz

70. Two sources of sound S_1 and S_2 produce sound waves of same frequency 660 Hz. A listener is moving from source S_1 towards S_2 with a constant speed *u* m/s and he hears 10 beats/s. The velocity of sound is 330 m/s. Then *u* equals: **[12 April 2019 II]**

(a) 5.5 m/s (b) 15.0 m/s
(c) 2.5 m/s (d) 10.0 m/s

71. A stationary source emits sounds waves of frequency 500 Hz. Two observers moving along a line passing through the source detect sound to be of frequencies 4801 Hz and 530 Hz. Their respective speeds are, in ms^{-1},
(Given speed of sound = 300 m/s) **[10 April 2019 I]**

(a) 12, 16 (b) 12, 18 (c) 16, 14 (d) 8, 18

72. A source of sound S is moving with a velocity of 50 m/s towards a stationary observer. The observer measures the frequency of the source as 1000 Hz. What will be the apparent frequency of the source when it is moving away from the observer after crossing him? (Take velocity of sound in air 350 m/s) **[10 April 2019 II]**

(a) 750 Hz (b) 857 Hz (c) 1143 Hz (d) 807 Hz

73. Two cars A and B are moving away from each other in opposite directions. Both the cars are moving with a speed of 20 ms^{-1} with respect to the ground. If an observer in car A detects a frequency 2000 Hz of the sound coming from car B, what is the natural frequency of the sound source in car B? (speed of sound in air = 340 ms^{-1}) **[9 April 2019 II]**

(a) 2250 Hz (b) 2060 Hz
(c) 2300 Hz (d) 2150 Hz

74. A train moves towards a stationary observer with speed 34 m/s. The train sounds a whistle and its frequency registered by the observer is f_1 If the speed of the train is reduced to 17 m/s, the frequency registered is f_2 If speed of sound is 340 m/s, then the ratio f_1/f_2 is: **[10 Jan. 2019 I]**

(a) 18/17 (b) 19/18 (c) 20/19 (d) 21/20

75. A musician using an open flute of length 50 cm produces second harmonic sound waves. A person runs towards the musician from another end of a hall at a speed of 10 km/h. If the wave speed is 330 m/s, the frequency heard by the running person shall be close to: **[9 Jan. 2019 II]**

(a) 666 Hz (b) 753 Hz
(c) 500 Hz (d) 333 Hz

76. Two sitar strings, A and B, playing the note 'Dha' are slightly out of tune and produce beats and frequency 5 Hz. The tension of the string B is slightly increased and the beat frequency is found to decrease by 3 Hz . If the frequency of A is 425 Hz, the original frequency of B is **[Online April 16, 2018]**

(a) 430 Hz (b) 428 Hz (c) 422 Hz (d) 420 Hz

77. A toy–car, blowing its horm, is moving with a steady speed of 5 m/s, away from a wall. An observer, towards whom the toy car is moving, is able to hear 5 beats per second. If the velocity of sound in air is 340 m/s, the frequency of the horn of the toy car is close to : **[Online April 10, 2016]**

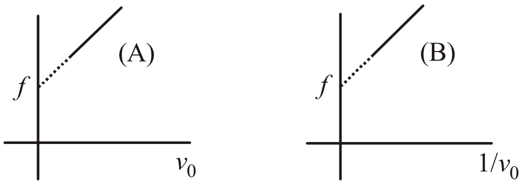
(a) 680 Hz (b) 510 Hz (c) 340 Hz (d) 170 Hz

78. Two engines pass each other moving in opposite directions with uniform speed of 30 m/s. One of them is blowing a whistle of frequency 540 Hz. Calculate the

frequency heard by driver of second engine before they pass each other. Speed of sound is 330 m/sec:
[Online April 9, 2016]
(a) 450 Hz (b) 540 Hz (c) 270 Hz (d) 648 Hz

79. A train is moving on a straight track with speed 20 ms^{-1}. It is blowing its whistle at the frequency of 1000 Hz. The percentage change in the frequency heard by a person standing near the track as the train passes him is (speed of sound = 320 ms^{-1}) close to : **[2015]**
(a) 18% (b) 24% (c) 6% (d) 12%

80. A source of sound emits sound waves at frequency f_0. It is moving towards an observer with fixed speed v_s ($v_s < v$, where v is the speed of sound in air). If the observer were to move towards the source with speed v_0, one of the following two graphs (A and B) will given the correct variation of the frequency f heard by the observer as v_0 is changed.



The variation of f with v_0 is given correctly by :
[Online April 11, 2015]

(a) graph A with slope = $\frac{f_0}{(v+v_s)}$

(b) graph B with slope = $\frac{f_0}{(v-v_s)}$

(c) graph A with slope = $\frac{f_0}{(v-v_s)}$

(d) graph B with slope = $\frac{f_0}{(v+v_s)}$

81. A bat moving at 10 ms^{-1} towards a wall sends a sound signal of 8000 Hz towards it. On reflection it hears a sound of frequency *f*. The value of *f* in Hz is close to (speed of sound = 320 ms^{-1})
[Online April 10, 2015]
(a) 8516 (b) 8258 (c) 8424 (d) 8000

82. A source of sound A emitting waves of frequency 1800 Hz is falling towards ground with a terminal speed v. The observer B on the ground directly beneath the source receives waves of frequency 2150 Hz. The source A receives waves, reflected from ground of frequency nearly: (Speed of sound = 343 m/s)
[Online April 12, 2014]
(a) 2150 Hz (b) 2500 Hz
(c) 1800 Hz (d) 2400 Hz

83. Two factories are sounding their sirens at 800 Hz. A man goes from one factory to other at a speed of 2m/s. The velocity of sound is 320 m/s. The number of beats heard by the person in one second will be:
[Online April 11, 2014]
(a) 2 (b) 4
(c) 8 (d) 10

84. A and B are two sources generating sound waves. A listener is situated at C. The frequency of the source at A is 500 Hz. A, now, moves towards C with a speed 4 m/s. The number of beats heard at C is 6. When A moves away from C with speed 4 m/s, the number of beats heard at C is 18. The speed of sound is 340 m/s. The frequency of the source at B is : **[Online April 22, 2013]**

(a) 500 Hz (b) 506 Hz (c) 512 Hz (d) 494 Hz

85. An engine approaches a hill with a constant speed. When it is at a distance of 0.9 km, it blows a whistle whose echo is heard by the driver after 5 seconds. If the speed of sound in air is 330 m/s, then the speed of the engine is :
[Online April 9, 2013]
(a) 32 m/s (b) 27.5 m/s (c) 60 m/s (d) 30 m/s

86. This question has Statement 1 and Statement 2. Of the four choices given after the Statements, choose the one that best describes the two Statements.
Statement 1: Bats emitting ultrasonic waves can detect the location of a prey by hearing the waves reflected from it.
Statement 2: When the source and the detector are moving, the frequency of reflected waves is changed.
[Online May 12, 2012]
(a) Statement 1 is false, Statement 2 is true.
(b) Statement 1 is true, Statement 2 is false.
(c) Statement 1 is true, Statement 2 is true, Statement 2 is not the correct explanation of Statement 1.
(d) Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation of Statement 1.

87. A motor cycle starts from rest and accelerates along a straight path at 2m/s^2. At the starting point of the motor cycle there is a stationary electric siren. How far has the motor cycle gone when the driver hears the frequency of the siren at 94% of its value when the motor cycle was at rest? (Speed of sound = 330 ms^{-1}) **[2009]**
(a) 98 m (b) 147 m (c) 196 m (d) 49 m

88. A whistle producing sound waves of frequencies 9500 HZ and above is approaching a stationary person with speed v ms^{-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 **[2006]**

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

(c) 15 ms^{-1} (d) 30 ms^{-1}

89. An observer moves towards a stationary source of sound, with a velocity one-fifth of the velocity of sound. What is the percentage increase in the apparent frequency ? **[2005]**
(a) 0.5% (b) zero (c) 20% (d) 5%

Hints & Solutions

1. **(a)** As we know,

Pressure amplitude, $\Delta P_0 = aKB = S_0KB = S_0 \times \frac{\omega}{V} \times \rho V^2$

$$\left[\because K = \frac{\omega}{V}, V = \sqrt{\frac{B}{\rho}}\right]$$

$$\Rightarrow S_0 = \frac{\Delta P_0}{\rho V \omega} \approx \frac{10}{1 \times 300 \times 1000} \text{m} = \frac{1}{30} \text{ mm} \approx \frac{3}{100} \text{ mm}$$

2. **(b)** Given : Distance between one crest and one trough $= 1.5\,\text{m}$

$$= (2n_1 + 1)\frac{\lambda}{2}$$

Distance between two crests = 5 m $= n_2\lambda$

$$\frac{1.5}{5} = \frac{(2n_1+1)}{2n_2} \Rightarrow 3n_2 = 10n_1 + 5$$

Here n_1 and n_2 are integer.

If $n_1 = 1, n_2 = 5$ $\quad \therefore \lambda = 1$

$n_1 = 4, n_2 = 15$ $\quad \therefore \lambda = 1/3$

$n_1 = 7, n_2 = 25$ $\quad \therefore \lambda = 1/5$

Hence possible wavelengths $\frac{1}{1}, \frac{1}{3}, \frac{1}{5}$ metre.

3. **(b)** At $t = 0, x = 0, y = 0$

$\phi = \pi$ rad

4. **(a)** Using, $\beta = 10$

or $120 = 10 \log 10\left(\frac{I}{10^{-12}}\right)$ ...(i)

Also $I = \frac{P}{4\pi r^2} = \frac{2}{4\pi r^2}$ ...(ii)

On solving above equations, we get

$r = 40$ cm.

5. **(a)** On comparing with $P = P_0 \sin(wt - kx)$, we have $w = 1000$ rad/s, $K = 3\ \text{m}^{-1}$

$$\therefore v_0 = \frac{w}{k} = \frac{1000}{3} = 333.3\text{m/s}$$

$$\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$$

or $\frac{333.3}{336} = \sqrt{\frac{273+0}{273+t}}$

$\therefore$ t = 4°C

6. **(a)** Comparing the given equation

$y = 10^{-3}\sin(50t + 2x)$ with standard equation,

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

$\Rightarrow$ wave is moving along –ve x-axis with speed

$$v = \frac{\omega}{K} \Rightarrow v = \frac{50}{2} = 25 \text{ m/sec.}$$

7. **(a)** Given, amplitude a = 10 cm

wave velocity = 2 × maximum particle velocity

i.e, $\frac{\omega\lambda}{2\pi} = 2\frac{a\omega}{\pi}$

or, $\lambda = 4a = 4 \times 10 = 40$ cm

8. **(b)**

9. **(b)** Standard equation

$$y(x, t) = A\cos\left(\frac{\omega}{V}x - \omega t\right)$$

From any of the displacement equation

Say y_1

$$\frac{\omega}{V} = 0.50\pi \text{ and } \omega = 100\pi$$

$$\therefore \frac{100\pi}{V} = 0.5\pi$$

$$\therefore V = \frac{100\pi}{0.5\pi} = 200 \text{ m/s}$$

10. **(c)** The equation of wave at any time is obtained by putting $X = x - vt$

$$y = \frac{1}{1+x^2} = \frac{1}{1+(x-vt)^2} \quad ...(i)$$

We know at $t = 2$ sec,

$$y = \frac{1}{1+(x-1)^2} \quad ...(ii)$$

On comparing (i) and (ii) we get

$vt = 1$

$$V = \frac{1}{t}$$

As $t = 2$ sec

$$\therefore V = \frac{1}{2} = 0.5 \text{ m/s.}$$

11. **(a)** Given

$$y(x, t) = e^{\left(-ax^2 + bt^2 + 2\sqrt{ab}\,xt\right)}$$

$$= e^{-[(\sqrt{a}x)^2 + (\sqrt{b}t)^2 + 2\sqrt{a}x.\sqrt{b}t]}$$

$$= e^{-(\sqrt{a}x + \sqrt{b}t)^2}$$

$$= e^{-\left(x + \sqrt{\frac{b}{a}}t\right)^2}$$

It is a function of type $y = f(x + vt)$

$\therefore y(x, t)$ represents wave travelling along –ve x direction

$$\Rightarrow \text{Speed of wave} = \frac{w}{k} = \sqrt{\frac{b}{a}}$$

12. (a) Given,
Wavelength, $l = 0.08$m
Time period, T = 2.05

$y(x,t) = 0.005 \cos(\alpha x - \beta t)$ (Given)

Comparing it with the standard equation of wave

$y(x,t) = a\cos(kx - \omega t)$ we get

$$k = \alpha = \frac{2\pi}{l} \text{ and } \omega = \beta = \frac{2\pi}{T}$$

$$\therefore\ \alpha = \frac{2\pi}{0.08} = 25\pi \quad \text{and } \beta = \frac{2\pi}{2} = \pi$$

13. (a) Loudness of sound. $L_1 = 10\log\left(\frac{I_1}{I_0}\right)$;

$$L_2 = 10\log\left(\frac{I_2}{I_0}\right)$$

$$\therefore\ L_1 - L_2 = 10\log\left(\frac{I_1}{I_0}\right) - 10\log\left(\frac{I_2}{I_0}\right)$$

$$\text{or, } \Delta L = 10\log\left(\frac{I_1}{I_0} \times \frac{I_0}{I_2}\right)$$

$$\text{or, } \Delta L = 10\log\left(\frac{I_1}{I_2}\right)$$

The sound level attenuated by 20 dB ie
$L_1 - L_2 = 20$ dB

$$\text{or, } 20 = 10\log\left(\frac{I_1}{I_2}\right) \text{ or, } 2 = \log\left(\frac{I_1}{I_2}\right)$$

$$\text{or, } \frac{I_1}{I_2} = 10^2 \text{ or, } I_2 = \frac{I_1}{100}.$$

$\Rightarrow$ Intensity decreases by a factor 100.

14. (b) Given, $y = 10^{-6}\sin\left(100t + 20x + \frac{\pi}{4}\right)m$

Comparing it with standard equation, we get
$\omega = 100$ and $k = 20$

$$v = \frac{\omega}{k} = \frac{100}{20} = 5\,\text{m/s}$$

15. (a) $y = 10^{-4}\sin\left(600t - 2x + \frac{\pi}{3}\right)$

On comparing with standard equation
$y = A\sin(\omega t - kx + \phi)$
we get $\omega = 600$; k=2
Velocity of wave

$$v = \frac{\omega}{k} = \frac{600}{2} = 300\ \text{ms}^{-1}$$

16. (b) The frequency of a tuning fork is given by

$$f = \frac{m^2 k}{4\sqrt{3}\pi\ell^2}\sqrt{\frac{Y}{\rho}}$$

As temperature increases, the length or dimension of the prongs increases and also young's modulus increases therefore f decreases.

17. (a) Here, $l_1 = 17$ cm and $l_2 = 24.5$ cm, $V = 330$ m/s, $f = ?$

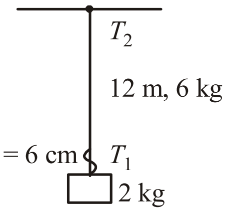
$$\lambda = 2(l_2 - l_1) = 2 \times (24.5 - 17) = 15 \text{ cm}$$

Now, from $v = f\lambda \Rightarrow 330 = \lambda \times 15 \times 10^{-2}$

$$\therefore \lambda = \frac{330}{15} \times 100 = \frac{1100 \times 100}{5} = 2200 \text{ Hz}$$

18. (c) Using, $V = f\lambda$

$$\frac{V_1}{\lambda_1} = \frac{V_2}{\lambda_2} \Rightarrow \lambda_2 = \frac{V_2}{V_1}\lambda_1$$



Again using,

$$n = \frac{V}{\lambda} = \sqrt{\frac{T}{M}}\lambda_2 = \sqrt{\frac{T_2}{T_1}}\lambda_1 \qquad T_2 = 8g \text{ (Top)}$$

$$= \sqrt{\frac{8g}{2g}}\lambda_1 = 2\lambda_1 = 12 \text{ cm} \quad T_1 = 2g \text{ (Bottom)}$$

19. (a) Using $f = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}}$,

where, T = tension and $\mu = \frac{\text{mass}}{\text{length}}$

$$f_x = \frac{1}{2\ell}\sqrt{\frac{T_x}{\mu}} \text{ and } f_z = \frac{1}{2\ell}\sqrt{\frac{T_z}{\mu}}$$

$$\frac{f_x}{f_z} = \frac{450}{300} = \sqrt{\frac{T_x}{T_z}}$$

$$\therefore \frac{T_x}{T_z} = \frac{9}{4} = 2.25.$$

20. (35.00)
Given,
Denisty of wire, $\sigma = 9 \times 10^{-3}$ kg cm^{-3}
Young's modulus of wire, $Y = 9 \times 10^{10}$ Nm^{-2}
Strain = 4.9×10^{-4}

$$Y = \frac{\text{Stress}}{\text{Strain}} = \frac{T/A}{\text{Strain}}$$

$$\therefore \frac{T}{A} = Y \times \text{Strain} = 9 \times 10^9 \times 4.9 \times 10^{-4}$$

Also, mass of wire, $m = Al\sigma$

Mass per unit length, $\mu = \frac{m}{J} = A\sigma$

Fundamental frequency in the string

$$f=\frac{1}{2l}\sqrt{\frac{T}{\mu}}=\frac{1}{2l}\sqrt{\frac{T}{\sigma A}}$$

$$=\frac{1}{2\times 1}\sqrt{\frac{9\times 10^9\times 4.9\times 10^{-4}}{9\times 10^3}}$$

$$=\frac{1}{2}\sqrt{49\times 10^{9-4-3}}=\frac{1}{2}\times 70=35\text{ Hz}$$

21. **(106)** Given : $V_{air}=300$ m/s, $\rho_{gas}=2\rho$ air

Using, $V=\sqrt{\frac{B}{\rho}}$

$$\frac{V_{gas}}{V_{air}}=\frac{\sqrt{\frac{B}{2\rho_{air}}}}{\sqrt{\frac{B}{\rho_{air}}}}$$

$$\Rightarrow V_{gas}=\frac{V_{air}}{\sqrt{2}}=\frac{300}{\sqrt{2}}=150\sqrt{2}\text{m/s}$$

And f_{nth} harmonic $=\frac{nv}{2L}$ (in open organ pipe)

(L = 1 metre given)

$$\therefore f_{2nd}\text{ harmonic}-f_{fundamental}=\frac{2v}{2\times 1}-\frac{v}{2\times 1}=\frac{v}{2}$$

$$\therefore f_{2n}\text{ harmonic}-f_{fundamental}=\frac{150\sqrt{2}}{2}=\frac{150}{\sqrt{2}}\approx 106\,Hz$$

22. **(b)** The velocity of a transverse wave in a stretched wire is given by

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

Where,

T = Tension in the wire

μ = linear density of wire

$(\because V\propto T)$

$$\therefore \frac{v_1}{v_2}=\sqrt{\frac{T_1}{T_2}}$$

$$\Rightarrow \frac{v}{v}\times 2=\sqrt{\frac{2.06\times 10^4}{T_2}}$$

$$\Rightarrow T_2=\frac{2.06\times 10^4}{4}=0.515\times 10^4\,N$$

$\Rightarrow T_2 = 5.15\times 10^3\,N$

23. **(a)** Given, l = 60 cm, m = 6 g, A = 1 mm^2, v = 90 m/s and Y = 16×10^{11} Nm^{-2}

Using, $v=\sqrt{\frac{T}{m}\times l}\Rightarrow T=\frac{mv^2}{I}$

Again from, $Y=\frac{T}{A}\Delta L/L_0$

$$\Delta L=\frac{Tl}{YA}=\frac{mv^2\times l}{l(\text{YA})}$$

$$=\frac{6\times 10^{-3}\times 90^2}{16\times 10^{11}\times 10^{-6}}=3\times 10^{-4}\,m$$

= 0.03 mm

24. **(c)** We have given,

y = 0.03 sin(450 t – 9x)

Comparing it with standard equation of wave, we get ω = 450 k = 9

$$\therefore\ v=\frac{\omega}{k}=\frac{450}{9}=50\text{ m/s}$$

Velocity of travelling wave on a stretched string is given by

$$v=\sqrt{\frac{T}{\mu}}\Rightarrow\frac{T}{\mu}=2500$$

μ = linear mass density

$\Rightarrow T = 2500\times 5\times 10^{-3}$

$\Rightarrow$ 12.5 N

25. **(b)** Wave speed $V=\sqrt{\frac{T}{\mu}}$

when car is at rest a = 0

$$\therefore 60=\sqrt{\frac{Mg}{\mu}}$$

Similarly when the car is moving with acceleration a,

$$60.5=\sqrt{\frac{M\left(g^2+a^2\right)^{1/2}}{\mu}}$$

$$\frac{60.5}{60}=\sqrt{\sqrt{\frac{g^2+a^2}{g^2}}}$$

$$\left(1+\frac{0.5}{60}\right)^4=\frac{g^2+a^2}{g^2}=1+\frac{2}{60}$$

$$\Rightarrow g^2+a^2=g^2+g^2\times\frac{2}{60}$$

$$a=g\sqrt{\frac{2}{60}}=\frac{g}{\sqrt{30}}$$ [which is closest to g/5]

26. **(a)** Fundamental frequency, f = 70 Hz.

The fundamental frequency of wire vibrating under tension T is given by

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

Here, μ = mass per unit length of the wire
L = length of wire

$$70 = \frac{1}{2L}\sqrt{\frac{540}{6\times10^{-3}}}$$

$\Rightarrow L \approx 2.14$ m

27. **(b)** $V = f\lambda = f \times 2\ (\ell_2 - \ell_1)$
$= 480 \times 2(0.70 - 0.30)$
$= 384$ m/s

28. **(b)** $\frac{3\lambda}{2} = 2$ or $\lambda = \frac{4}{3}m$

Velocity, $v = f_\lambda = 240 \times \frac{4}{3} = 320$ m/sec

Also $f_1 = \frac{240}{3} = 80$ Hz

29. **(b)** Given, $y = 0.3 \sin(0.157x)\cos(200\pi t)$
So $k = 0.157$ and $w = 200\pi$

or f = 100 Hz, $v = \frac{w}{k} = \frac{200\pi}{0.157} = 4000$ m/s

Now, using $f = \frac{nv}{2l} = \frac{4v}{2l} = \frac{2v}{l}$

$\therefore l = \frac{2v}{f} = \frac{2\times4000}{100} = 80m$

30. **(c)** As there must be node at both ends and at the joint of the wire A and B so

$$\frac{V_A}{V_B} = \sqrt{\frac{u_B}{u_A}} = \frac{r_B}{r_A} = 2 = \frac{\lambda_A}{\lambda_B}$$

$\Rightarrow \lambda_A = 2\lambda_B$

$\Rightarrow \frac{P}{q} = \frac{1}{2}$

31. **(a)** If a closed pipe vibration in Nth mode then frequency of vibration $n = \frac{(2N-1)v}{4l} = (2N-1)n_1$
(where n_1 = fundamental frequency of vibration)
Hence $20{,}000 = (2N - 1) \times 1500$
$\Rightarrow N = 7.1 \approx 7$
$\therefore$ Number of over tones = (No. of mode of vibration) – 1
= 7 – 1 = 6

32. **(d)** Velocity of wave on string

$$V = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{8}{5}\times1000} = 40\text{m/s}$$

Here, T = tension and μ = mass/length

Wavelength of wave $\lambda = \frac{v}{n} = \frac{40}{100}$ m

Separation b/w successive nodes,

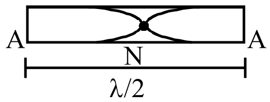
$$\frac{\lambda}{2} = \frac{40}{2\times100} = \frac{20}{100}\text{m} = 20\text{ cm}$$

33. **(a)** In solids, Velocity of wave

$$V = \sqrt{\frac{Y}{\rho}} = \sqrt{\frac{9.27\times10^{10}}{2.7\times10^3}}$$

$v = 5.85 \times 10^3$ m/sec

Since rod is clamped at middle fundamental wave shape is as follow



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

$\lambda = 1.2$m ($\because$ L = 60 cm = 0.6m (given))
Using $v = f\lambda$

$\Rightarrow f = \frac{v}{\lambda} = \frac{5.85\times10^3}{1.2}$
$= 4.88 \times 10^3$ Hz $\simeq 5$ KHz

34. **(a)** For first resonance, $\frac{\lambda}{4} = \ell_1 + e = 11$ cm
($\because$ end correction e = 1 cm given)
For second resonance, $\frac{3\lambda}{4} = \ell_2 + e$
$\Rightarrow \ell_2 = 3\times11 - 1 = 32$ cm

35. **(b)** $n_1 = n_2$
T $\rightarrow$ Same
r $\rightarrow$ Same
$l \rightarrow$ Same
Frequency of vibration

$$n = \frac{p}{2l}\sqrt{\frac{T}{\pi r^2\rho}}$$

As T, r, and l are same for both the wires
$n_1 = n_2$

$$\frac{p_1}{\sqrt{\rho_1}} = \frac{p_2}{\sqrt{\rho_2}}$$

$\Rightarrow \frac{p_1}{p_2} = \frac{1}{2}$ $\qquad \because \rho_2 = 4\rho_1$

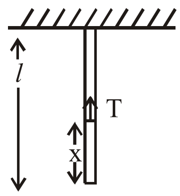
36. **(a)** We know that velocity in string is given by

$v = \sqrt{\frac{T}{\mu}}$ ...(i)

where $\mu = \frac{m}{1} = \frac{\text{mass of string}}{\text{length of string}}$

The tension $T = \frac{m}{\ell} \times x \times g$ ..(ii)

From (1) and (2)



$\frac{dx}{dt} = \sqrt{gx}$

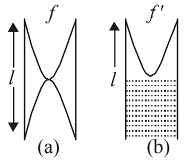
$x^{-1/2}dx = \sqrt{g}\,dt$

$\therefore \int_0^\ell x^{-1/2}dx - \sqrt{g}\int_0^\ell dt$

$\Rightarrow 2\sqrt{l}$

$= \sqrt{g} \times t \quad \therefore\ t = 2\sqrt{\frac{\ell}{g}} = 2\sqrt{\frac{20}{10}} = 2\sqrt{2}$

37. **(b)**



The fundamental frequency in case (a) is $f = \frac{v}{2\ell}$

The fundamental frequency in case (b) is

$f' = \frac{v}{4(\ell/2)} = \frac{v}{2\ell} = f$

38. **(c)** Length of pipe = 85 cm = 0.85m

Frequency of oscillations of air column in closed organ pipe is given by,

$f = \frac{(2n-1)\upsilon}{4L}$

$f = \frac{(2n-1)\upsilon}{4L} \le 1250$

$\Rightarrow \frac{(2n-1)\times 340}{0.85\times 4} \le 1250$

$\Rightarrow 2n-1 \le 12.5 \approx 6$

39. **(b)** Total length of sonometer wire, l = 110 cm = 1.1 m

Length of wire is in ratio, 6 : 3 : 2 i.e. 60 cm, 30 cm, 20 cm.

Tension in the wire, T = 400 N

Mass per unit length, m = 0.01 kg

Minimum common frequency = ?

As we know,

Frequency, $\nu = \frac{1}{2l}\sqrt{\frac{T}{m}} = \frac{1000}{11}$ Hz

Similarly, $\nu_1 = \frac{1000}{6}$ Hz

$\nu_2 = \frac{1000}{3}$ Hz

$\nu_3 = \frac{1000}{2}$ Hz

Hence common frequency = 1000 Hz

40. **(b)** Fundamental frequency,

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

Also, $Y = \frac{T\ell}{A\Delta\ell} \Rightarrow \frac{T}{A} = \frac{Y\Delta\ell}{\ell}$

$\Rightarrow f = \frac{1}{2\ell}\sqrt{\frac{y\Delta\ell}{\ell\rho}}$ ....(i)

$\ell = 1.5$ m, $\frac{\Delta\ell}{\ell} = 0.01$,

$\rho = 7.7 \times 10^3$ kg/m^3 (given)

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

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

$f = \sqrt{\frac{2}{7}} \times \frac{10^3}{3}$ or $f \approx 178.2$ Hz

41. **(d)** Total length of the wire, L = 114 cm

$n_1 : n_2 : n_3 = 1 : 3 : 4$

Let L_1, L_2 and L_3 be the lengths of the three parts

As $n \propto \frac{1}{L}$

$\therefore\ L_1 : L_2 : L_3 = \frac{1}{1} : \frac{1}{3} : \frac{1}{4} = 12 : 4 : 3$

$\therefore\ L_1 = \left(\frac{12}{12+4+3} \times 114\right) = 72\,\text{cm}$

$L_2 = \left(\frac{4}{19} \times 114\right) = 24$ cm

and $L_3 = \left(\frac{3}{19} \times 114\right) = 18$ cm

Hence the bridges should be placed at 72 cm and 72 + 24 = 96 cm from one end.

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

$\nu_0 = \frac{v}{2l_0}$ ...(i)

where l_0 is the length of the tube

v = speed of sound

But when it is half dipped in water, it becomes closed organ pipe of length $\frac{\ell_0}{2}$.

Fundamental frequency of closed organ pipe

$\nu_c = \frac{v}{4l_c}$ ...(ii)

New length, $l_c = \frac{l_0}{2}$

Thus $\nu_c = \frac{v}{4l_0/2} \Rightarrow \nu_c = \frac{v}{2l}$ ...(iii)

From equations (i) and (iii)

$\nu_0 = \nu_c$

Thus, $\nu_c = f$ ($\because \nu_0 = f$ is given)

43. **(b)** Given : Frequency of tuning fork, n = 264 Hz

Length of column L = ?

For closed organ pipe

$n = \frac{v}{4l}$

$\Rightarrow l = \frac{v}{4n} = \frac{330}{4\times 264} = 0.3125$

or, l = 0.3125 × 100 = 31.25 cm

In case of closed organ pipe only odd harmonics are possible.

Therefore value of l will be $(2n - 1)\, l$

Hence option (b) i.e. 3 × 31.25 = 93.75 cm is correct.

44. **(d)** Two lowest frequencies to which tube will resonates are 272 Hz and 544 Hz.

45. **(d)** $y = 0.02(m)\sin\left[2\pi\left(\frac{t}{0.04(s)}\right) - \frac{x}{0.50(m)}\right]$

Comparing it with the standard wave equation

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

we get

$\omega = \frac{2\pi}{0.04}$ rad s^{-1}

and $k = \frac{2\pi}{0.50}$

Wave velocity, $v = \frac{w}{k}$

$\Rightarrow v = \frac{2\pi/0.04}{2\pi/0.5} = 12.5\ m/s$

Velocity on a string is given by

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

$\therefore\ T = v^2 \times \mu = (12.5)^2 \times 0.04 = 6.25\,N$

46. **(b)** Fundamental frequency for first resonant length

$\nu = \frac{v}{4\ell_1} = \frac{v}{4\times 18}$ (in winter)

Fundamental frequency for second resonant length

$\nu' = \frac{3v'}{4\ell_2} = \frac{3v'}{4x}$ (in summer)

According to questions,

$\therefore\ \frac{v}{4\times 18} = \frac{3v'}{4\times x}$

$\therefore\ x = 3\times 18\times \frac{v'}{v}$

$\therefore\ x = 54\times \frac{v'}{v}\,cm$

v' > v because velocity of light is greater in summer as compared to winter $(v \propto \sqrt{T})$

$\therefore\ x > 54\,cm$

47. **(a)** It is given that 315 Hz and 420 Hz are two resonant frequencies, let these be n^{th} and $(n+1)^{th}$ harmonies, then

we have $\frac{nv}{2\ell} = 315$

and $(n+1)\frac{v}{2\ell} = 420$

$\Rightarrow \frac{n+1}{n} = \frac{420}{315}$

$\Rightarrow n = 3$

Hence $3\times\frac{v}{2\ell} = 315 \Rightarrow \frac{v}{2\ell} = 105\ Hz$

The lowest resonant frequency is when n = 1

Therefore lowest resonant frequency = 105 Hz.

48. **(c)** The fundamental frequency for tube B closed at one end is given by

$\upsilon_B = \frac{v}{4\ell}$ $\left[\because \ell = \frac{\lambda}{4}\right]$

Where ℓ = length of the tube and v is the velocity of sound in air.

The fundamental frequency for tube A open with both ends is given by

$\upsilon_A = \frac{v}{2\ell}$ $\left[\because \ell = \frac{\lambda}{2}\right]$

$\therefore\ \frac{\upsilon_A}{\upsilon_B} = \frac{v}{2\ell}\times\frac{4\ell}{v} = \frac{2}{1}$

49. **(b)** To form a node there should be superposition of this wave with the reflected wave. The reflected wave should travel in opposite direction with a phase change of π. The equation of the reflected wave will be

$y = a\sin(\omega t + kx + \pi)$

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

50. **(a)**

51. **(c)** Beat frequency

= difference in frequencies of two waves

= 11 – 9 = 2 Hz

52. **(d)**

53. **(d)** According to question, tuning fork gives 1 beat/second with (N) 3^{rd} normal mode. Therefore, organ pipe will have frequency (256 ± 1) Hz. In open organ pipe, frequency

$n = \frac{NV}{2\ell}$

or, $255 = \frac{3\times 340}{2\times\ell} \Rightarrow \ell = 2\,m = 200\,cm$

54. **(a)** Probable frequencies of tuning fork be $n \pm 5$

Frequency of sonometer wire, $n \propto \frac{1}{l}$

$\therefore\ \frac{n+5}{n-5} = \frac{100}{95} \Rightarrow 95(n+5) = 100(n-5)$

or, $95\,n + 475 = 100\,n - 500$

or, $5\,n = 975$

or, $n = \frac{975}{5} = 195$ Hz

55. **(a)** Given, $y(x,t) = 0.5\sin\left(\frac{5\pi}{4}x\right)\cos(200\,\pi t)$,

comparing with equation – $y(x,t) = 2a\sin kx\cos\omega t$

$\omega = 200\,\pi,\ k = \frac{5\pi}{4}$

speed of travelling wave $v = \frac{\omega}{k} = \frac{200\pi}{5\pi/4} = 160$ m/s

56. **(b)** Since the point $x = 0$ is a node and reflection is taking place from point $x = 0$. This means that reflection must be taking place from the fixed end and hence the reflected ray must suffer an additional phase change of π or a path change of $\frac{\lambda}{2}$.

So, if $y_{incident} = a\cos(kx - \omega t)$

$\Rightarrow y_{incident} = a\cos(-kx - \omega t + \pi)$

$= -a\cos(\omega t + kx)$

Hence equation for the other wave

$y = a\cos(kx + \omega t + \pi)$

57. **(d)** In case of destructive interference

Phase difference $\phi = 180°$ or π

So wave pair (i) and (ii) will produce destructive interference.

Stationary or standing waves will produce by equations (iii) & (iv) as two waves travelling along the same line but in opposite direction.

$n' = n + x$

58. **(d)** $y = A\sin(\omega t - kx) + A\sin(\omega t + kx)$

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

This is an equation of standing wave. For position of nodes

$\cos kx = 0$

$\Rightarrow \frac{2\pi}{\lambda}.x = (2n+1)\frac{\pi}{2}$

$\Rightarrow x = \frac{(2n+1)\lambda}{4}$, $n = 0,1,2,3,$...........

59. **(a)** Intensity of a wave

$I = \frac{1}{2} pw^2 A^2 v$

Since, $I \propto A^2\omega^2$

$\therefore \quad I_1 \propto (2a)^2 \omega^2$

and $I_2 \propto a^2 (2\omega)^2$

$I_1 = I_2$

In the same medium, p and v are same.

Intensity depends on amplitude and frequency.

60. **(b)** Maximum number of beats

= Maximum frequency – Minimum frequency

= (ν + 1) – (ν – 1) = 2 Beats per second

61. **(d)** Frequency of fork 1, no = 200 Hz

No. of beats heard when fork 2 is sounded with fork 1 = Δn = 4

Now on loading (attaching tape) on unknown fork, the mass of tuning fork increases, So the beat frequency increases (from 4 to 6 in this case) then the frequency of the unknown fork 2 is given by,

$n = n_0 - \Delta n = 200 - 4 = 196$ Hz

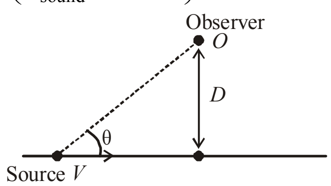
62. **(c)** It is given that tuning fork of frequency 256 Hz makes 5 beats/second with the vibrating string of a piano. Therefore, possible frequency of the piano are (256 ± 5) Hz. i.e., either 261Hz or 251 Hz. When the tension in the piano string increases, its frequency will increases. As the original frequency was 261Hz, the beat frequency should decreases, we can conclude that the frequency of piano string is 251Hz

63. **(b)** Frequency of unknown fork = known frequency ± Beat frequency = 288 + 4 cps or 288 – 4 cps i.e. 292 cps or 284 cps. When a little wax is placed on the unknown fork, it produces 2 beats/sec. When a little wax is placed on the unknown fork, its frequency decreases and simultaneously the beat frequency decreases confirming that the frequency of the unknown fork is 292 cps.

Note : Had the frequency of unknown fork been 284 cps, then on placing wax its frequency would have decreased thereby increasing the gap between its frequency and the frequency of known fork. This would produce high beat frequency.

64. **(b)** Frequency heard by the observer

$$v_{\text{observed}} = \left(\frac{v_{\text{sound}}}{v_{\text{sound}} - v\cos\theta}\right) v_0$$



Initially θ will be less so cos θ more.

$\therefore$ v_{observed} more, then it will decrease.

65. **(a)** Let f_1 be the frequency heard by wall,

$$f_1 = \left(\frac{v}{v - v_c}\right) f_0$$

Here, v = Velocity of sound,

v_c = Velocity of Car,

f_0 = actual frequency of car horn

Let f_2 be the frequency heard by driver after reflection from wall.

$$f_2 = \left(\frac{v + v_c}{v}\right) f_1 = \left(\frac{v+v_c}{v-v_c}\right) f_0$$

$$\Rightarrow 480 = \left[\frac{345 + v_c}{345 - v_c}\right] 440 \Rightarrow \frac{12}{11} = \frac{345 + v_c}{345 - v_c}$$

$\Rightarrow v_c = 54$ km/hr

66. **(a)** From the Doppler's effect of sound, frequency appeared at wall

$$f_w = \frac{330}{330 - v} \cdot f \qquad \text{...(i)}$$

Here, v = speed of bus,

f = actual frequency of source

Frequency heard after reflection from wall (f') is

$$f' = \frac{330 + v}{330} \cdot f_w = \frac{330 + v}{330 - v} \cdot f$$

$$\Rightarrow 490 = \frac{330 + v}{330 - v} \cdot 420$$

$$\Rightarrow v = \frac{330 \times 7}{91} \approx 25.38 \text{ m/s} = 91 \text{ km/s}$$

67. **(d)** Permanent magnets (P) are made of materials with large retentivity and large coercivity. Transformer cores (T) are made of materials with low retentivity and low coercivity.

68. **(c)** From Doppler's effect, frequency of sound heard (f_1) when source is approaching

$$f_1 = f_0 \frac{c}{c - v}$$

Here, c = velocity of sound

v = velocity of source

Frequency of sound heard (f_2) when source is receding

$$f_2 = f_0 \frac{c}{c + v}$$

Beat frequency = $f_1 - f_2$

$$\Rightarrow \quad 2 = f_1 - f_2 = f_0 c\left[\frac{1}{c - v} - \frac{1}{c + v}\right]$$

$$= f_0 c \frac{2v}{c^2\left[1 - \frac{v^2}{c^2}\right]}$$

For $c >> v$

$$\Rightarrow \quad v = \frac{2c}{2f_0} = \frac{c}{f_0} = \frac{350}{1400} = \frac{1}{4} \text{m/s}$$

69. **(d)** $f_1 = f\left(\frac{v - v_o}{v - v_s}\right) = f\left(\frac{1500 - 5}{1500 - 7.5}\right)$

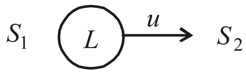
No reflected signal,

$$f_2 = f_1\left(\frac{v+v_o}{v+v_s}\right) = f_1\left(\frac{1500+7.5}{1500+5}\right)$$

$$f_2 = 500\left(\frac{1500-5}{1500-7.5}\right)\left(\frac{1500+7.5}{1500+5}\right)$$

502 Hz

70. **(c)** $f_1 = f\frac{v-v_0}{v}$ and $f_2 = f\frac{v+v_0}{v}$



But frequency,

$$f_2 - f_1 = f\times\frac{2v_0}{v}$$

or $10 = 660\times\frac{2u}{330}$

$\therefore\ u = 2.5$ m/s.

71. **(b)** Frequency of sound source (f_0) = 500 Hz

When observer is moving away from the source

Apparent frequency $f_1 = 480 = f_0\left(\frac{v-v_0'}{v}\right)$ ....(i)

And when observer is moving towards the source

$f_2 = 530 = f_0\left(\frac{v-v_0''}{v}\right)$ ....(ii)

From equation (i)

$$480 = 500\left(\frac{300-v_0'}{300}\right)$$

$v'_0 = 12$ m/s

From equation (ii)

$$530 = 500\left(1+\frac{v_0''}{v}\right)$$

$\therefore V''_0 = 18$ m/s

72. **(a)** When source is moving towards a stationary observer,

$$f_{app} = f_{source}\left(\frac{V-0}{V-50}\right)$$

$$1000 = f_{source}\left(\frac{350}{300}\right)$$

When source is moving away from observer

$$f' = f_{source}\left(\frac{350}{350+50}\right)$$

$$f' = \frac{1000\times300}{350}\times\frac{350}{400}$$

$f' \approx 750$ Hz

73. **(a)** $f' = f\frac{v-v_0}{v+v_s}$

or $2000 = f\frac{340-20}{340+20}$

$\therefore f = 2250$ Hz.

74. **(b)** According to Doppler's effect, when source is moving but observer at rest

$$f_{app} = f_0\left[\frac{V}{V-V_s}\right] \Rightarrow f_1 = f_0\left[\frac{340}{340-34}\right]$$

and, $f_2 = f_0\left[\frac{340}{340-17}\right]$

$$\therefore \frac{f_1}{f_2} = \frac{340-17}{340-34} = \frac{323}{306} \text{ or, } \frac{f_1}{f_2} = \frac{19}{18}$$

75. **(a)** Frequency of the sound produced by open flute.

$$f = 2\left(\frac{v}{2\ell}\right) = \frac{2\times330}{2\times0.5} = 660 Hz$$

Velocity of observer, $v_0 = 10\times\frac{5}{18} = \frac{25}{9} m/s$

As the source is moving towards the observer therefore, according to Doppler's effect.

$\therefore$ Frequency detected by observer,

$$f' = \left[\frac{v+v_0}{v}\right]f = \left[\frac{\frac{25}{9}+330}{330}\right]660$$

$= \frac{2995}{9\times330}\times660$ or, $f' = 665.55 \simeq 666$ Hz

76. **(d)** $n_A = 425$ Hz, $n_B = ?$

Beat frequency x = 5 Hz which is decreasing ($5\rightarrow3$) after increasing the tension of the string B.

Also tension of string B increasing so

$n_B\uparrow$ ($\because\ n\propto\sqrt{T}$)

Hence $n_A - n_B\uparrow = x\downarrow$ $\longrightarrow$ correct

$n_B\uparrow - n_A = x\downarrow$ $\longrightarrow$ incorrect

$\therefore\ n_B = n_A - x = 425 - 5 = 420$ Hz

77. **(d)** From Doppler's effect

$$f(\text{direct}) = f\left(\frac{340}{340-5}\right) = f_1$$

$$f(\text{by wall}) = f\left(\frac{340}{340+5}\right) = f_2$$

Beats = $(f_1 - f_2)$

$$5 = f\left(\frac{340}{340-5} - \frac{340}{340+5}\right)$$

$\Rightarrow f = 170$ Hz.

78. **(d)** We know that the apperent frequency

$f' = \left(\frac{v-v_0}{v-v_s}\right)f$ from Doppler's effect

where $v_0 = v_s = 30$ m/s, velocity of observer and source

Speed of sound v = 330 m/s

$\therefore\ f' = \frac{330+30}{330-30}\times540 = 648$ Hz.

$\because$ Frequency of whistle (f) = 540 Hz.

79. **(d)** $f_1 = f\left[\frac{v}{v-v_s}\right] = f\times\frac{320}{300} Hz$

$$f_2 = f\left[\frac{v}{v+v_s}\right] = f\times\frac{320}{340} Hz$$

$\left(\frac{f_2}{f_1}-1\right)\times 100=\left(\frac{300}{340}-1\right)\times 100\simeq 12\%$

80. **(c)** According to Doppler's effect,

Apparent, frequency $f=\left(\frac{V+V_0}{V-V_S}\right)f_0$

Now, $f=\left(\frac{f_0}{V-V_S}\right)V_0+\frac{V f_0}{V-V_s}$

So, slope $=\frac{f_0}{V-V_S}$

Hence, option (c) is the correct answer.

81. **(a)** Reflected frequency of sound reaching bat

$=\left[\frac{V-(-V_0)}{V-V_s}\right]f=\left[\frac{V+V_0}{V-V_s}\right]f=\frac{V+10}{V-10}f$

$=\left(\frac{320+10}{320-10}\right)\times 8000 = 8516\text{ Hz}$

82. **(b)** Given f_A = 1800 Hz

$v_t = v$

f_B = 2150 Hz

Reflected wave frequency received by A, $f_A' = ?$

Applying doppler's effect of sound,

$f'=\frac{v_s f}{v_s-v_t}$

here, $v_t=v_s\left(1-\frac{f_A}{f_B}\right)$

$=343\left(1-\frac{1800}{2150}\right)$

$v_t = 55.8372$ m/s

Now, for the reflected wave,

$\therefore\ f_A'=\left(\frac{v_s+v_t}{v_s-v_t}\right)f_A$

$=\left(\frac{343+55.83}{343-55.83}\right)\times 1800$

$= 2499.44 \approx 2500\text{Hz}$

83. **(d) Given:** Frequency of sound produced by siren, f = 800 Hz

Speed of observer, u = 2 m/s

Velocity of sound, v = 320 m/s

No. of beats heard per second = ?

No. of extra waves received by the observer per second = $\pm 4\lambda$

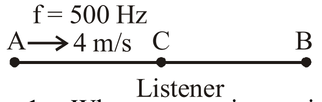
$\therefore$ No. of beats/ sec

$=\frac{2}{\lambda}-\left(-\frac{2}{\lambda}\right)=\frac{4}{\lambda}$

$=\frac{2\times 2}{\frac{320}{800}}\quad\left(\because \lambda=\frac{V}{f}\right)$

$=\frac{2\times 2\times 800}{320}=10$

84. **(c)** f = 500 Hz



Case 1 : When source is moving towards stationary listener

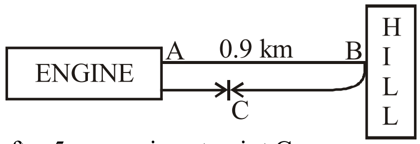
apparent frequency $\eta'=\eta\left(\frac{v}{v-v_s}\right)=500\left(\frac{340}{336}\right)$ = 506 Hz

Case 2 : When source is moving away from the stationary listener

$\eta''=\eta\left(\frac{v}{v+v_s}\right)=500\left(\frac{340}{344}\right)=494\text{ Hz}$

In case 1 number of beats heard is 6 and in case 2 number of beats heard is 18 therefore frequency of the source at B = 512 Hz

85. **(d)**



Let after 5 sec engine at point C

$t=\frac{AB}{330}+\frac{BC}{330}\quad 5=\frac{0.9\times 1000}{330}+\frac{BC}{330}$

$\therefore$ BC = 750 m

Distance travelled by engine in 5 sec = 900 m – 750 m = 150 m

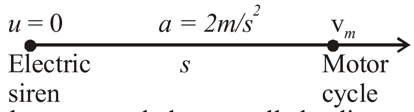
Therefore velocity of engine

$=\frac{150\text{ m}}{5\text{ sec}}=30$ m/s

86. **(c)** Bats catch the prey by hearing reflected ultrasonic waves.

When the source and the detector (observer) are moving, frequency of reflected waves change. This is according to Doppler's effect.

87. **(a)**



Let the motorcycle has travelled a distances, its velocity at that point

$v_m^2-u^2=2as\ \therefore\ v_m^2=2\times 2\times s$

$\therefore\ v_m=2\sqrt{s}$

The observed frequency will be

$\nu'=\nu\left[\frac{v-v_m}{v}\right]$

$0.94\nu=\nu\left[\frac{330-2\sqrt{s}}{330}\right]\Rightarrow s=98.01\,m$

88. **(c)** Apparent frequency $\nu'=\nu\left[\frac{v}{v-v_s}\right]$

$\Rightarrow 10000=9500\left[\frac{300}{300-v}\right]\Rightarrow 300-v=300\times 0.95$

$\Rightarrow v = 300-285 = 15\text{ ms}^{-1}$

89. **(c)** Apparent frequency

$n'=n\left[\frac{v+v_0}{v}\right]=n\left[\frac{v+\frac{v}{5}}{v}\right]=n\left[\frac{6}{5}\right]\quad \frac{n'}{n}=\frac{6}{5}$

The percentage increase in apparent frequency $\frac{n'-n}{n}=\frac{6-5}{5}\times 100=20\%$