Chapter 10

Waves

1. 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 **[AIEEE-2009]**

   (1) 3 (2) 2

   (3) 1 (4) 4

2 A motor cycle starts from rest and accelerates along a straight path at $2\ m/s^2$. 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}) **[AIEEE-2009]**

   (1) 98 m (2) 147 m

   (3) 196 m (4) 49 m

3. 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 **[AIEEE-2010]**

   (1) 6.25 N (2) 4.0 N

   (3) 12.5 N (4) 0.5 N

4. 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 **[AIEEE-2011]**

   (1) A standing wave having nodes at

$$x = \frac{n\lambda}{2};\ n = 0, 1, 2 \ldots\ldots$$

   (2) A standing wave having nodes at

$$x = \left(n + \frac{1}{2}\right)\frac{\lambda}{2};\ n = 0, 1, 2 \ldots\ldots.$$

   (3) A wave travelling along $+x$ direction

   (4) A wave travelling along $-x$ direction

5. 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.

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

   (1) Statement-1 is true, statement-2 is true; statement-2 is not correct explanation of statement-1

   (2) Statement-1 is false, statement-2 is true

   (3) Statement-1 is true, statement-2 is false

   (4) Statement-1 is true, statement-2 is true; statement-2 is the correct explanation of statement-1

6. 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 **[AIEEE-2012]**

   (1) $\frac{f}{2}$ (2) $\frac{3f}{4}$

   (3) $2f$ (4) f

7. 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 $7.7 \times 10^3\ kg/m^3$ and $2.2 \times 10^{11}\ N/m^2$ respectively? **[JEE (Main)-2013]**

   (1) 188.5 Hz (2) 178.2 Hz

   (3) 200.5 Hz (4) 770 Hz

8. 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. **[JEE (Main)-2014]**

   (1) 12 (2) 8

   (3) 6 (4) 4

9. 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 **[JEE (Main)-2015]**

   (1) 6% (2) 12%

   (3) 18% (4) 24%

10. 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 support is

(take $g = 10\ ms^{-2}$) **[JEE (Main)-2016]**

(1) 2 s (2) $2\sqrt{2}$ s

(3) $\sqrt{2}$ s (4) $2\pi\sqrt{2}$ s

11. 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

[JEE (Main)-2016]

(1) $\frac{3f}{4}$ (2) $2f$

(3) f (4) $\frac{f}{2}$

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

(1) 5 kHz (2) 2.5 kHz

(3) 10 kHz (4) 7.5 kHz

13. 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 speed 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

[JEE (Main)-2019]

(1) $\frac{g}{30}$ (2) $\frac{g}{5}$

(3) $\frac{g}{20}$ (4) $\frac{g}{10}$

14. 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 **[JEE (Main)-2019]**

(1) 500 Hz (2) 753 Hz

(3) 333 Hz (4) 666 Hz

15. 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 $\frac{f_1}{f_2}$ is **[JEE (Main)-2019]**

(1) $\frac{21}{20}$ (2) $\frac{20}{19}$

(3) $\frac{18}{17}$ (4) $\frac{19}{18}$

16. 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

[JEE (Main)-2019]

(1) 33.3 cm (2) 10.0 cm

(3) 16.6 cm (4) 20.0 cm

17. 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) **[JEE (Main)-2019]**

(1) 7 (2) 4

(3) 6 (4) 5

18. 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 **[JEE (Main)-2019]**

(1) 10 N (2) 7.5 N

(3) 5 N (4) 12.5 N

19. 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?

[JEE (Main)-2019]

(1) The wave is propagating along the negative x-axis with speed $25\ ms^{-1}$.

(2) The wave is propagating along the positive x-axis with speed $100\ ms^{-1}$.

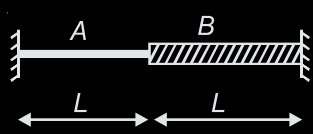
(3) The wave is propagating along the negative x-axis with speed $100\ ms^{-1}$.

(4) The wave is propagating along the positive x-axis with speed $25\ ms^{-1}$.

20. 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 **[JEE (Main)-2019]**

(1) 322 ms^{-1} (2) 341 ms^{-1}

(3) 328 ms^{-1} (4) 335 ms^{-1}

21. 

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

[JEE (Main)-2019]

(1) 4 : 9 (2) 1 : 2

(3) 3 : 5 (4) 1 : 4

22. 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 **[JEE (Main)-2019]**

(1) 4°C (2) 12°C

(3) 15°C (4) 11°C

23. 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) **[JEE (Main)-2019]**

(1) 60 m (2) 20 m

(3) 40 m (4) 80 m

24. 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})

[JEE (Main)-2019]

(1) 2150 Hz (2) 2300 Hz

(3) 2060 Hz (4) 2250 Hz

25. 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 **[JEE (Main)-2019]**

(1) 320 m/s, 120 Hz (2) 320 m/s, 80 Hz

(3) 180 m/s, 80 Hz (4) 180 m/s, 120 Hz

26. A stationary source emits sound waves of frequency 500 Hz. Two observers moving along a line passing through the source detect sound to be of frequencies 480 Hz and 530 Hz. Their respective speeds are, in ms^{-1}, **[JEE (Main)-2019]**

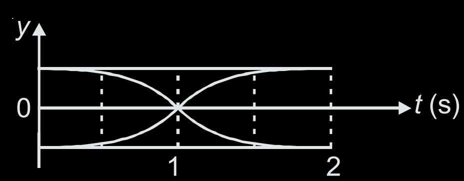
(Given speed of sound = 300 m/s)

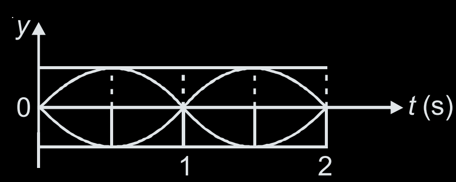
(1) 12, 16 (2) 16, 14

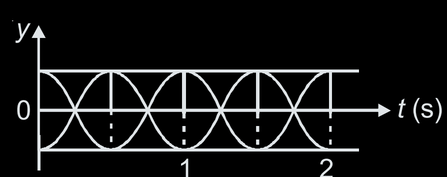
(3) 8, 18 (4) 12, 18

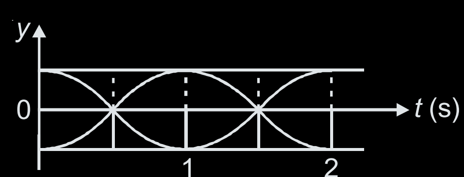
27. The correct figure that shows, schematically, the wave pattern produced by superposition of two waves of frequencies 9 Hz and 11 Hz, is :

[JEE (Main)-2019]

(1) 

(2) 

(3) 

(4) 

28. 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 crosssing him? (Take velocity of sound in air is 350 m/s) **[JEE (Main)-2019]**

(1) 857 Hz (2) 1143 Hz

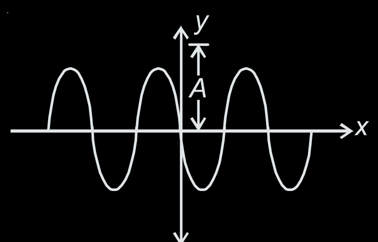
(3) 807 Hz (4) 750 Hz

29. 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 ν. The value of ν is close to : (Speed of sound in water = 1500 ms^{-1}) **[JEE (Main)-2019]**

(1) 499 Hz (2) 504 Hz

(3) 507 Hz (4) 502 Hz

30. 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. **[JEE (Main)-2019]**



For this wave, the phase ϕ is :

(1) π (2) $-\frac{\pi}{2}$

(3) $\frac{\pi}{2}$ (4) 0

31. A small speaker delivers 2 W of audio output. At what distance from the speaker will one detect 120 dB intensity sound? **[JEE (Main)-2019]**

[Given reference intensity of sound as 10^{-12} W/m^2]

(1) 30 cm (2) 40 cm

(3) 10 cm (4) 20 cm

32. 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: **[JEE (Main)-2019]**

(1) 10.0 m/s (2) 5.5 m/s

(3) 2.5 m/s (4) 15.0 m/s

33. 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 **[JEE (Main)-2019]**

(1) 332 ms^{-1} (2) 384 ms^{-1}

(3) 379 ms^{-1} (4) 338 ms^{-1}

34. Speed of 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 **[JEE (Main)-2020]**

(1) 0.01 mm (2) 0.02 mm

(3) 0.04 mm (4) 0.03 mm

35. 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 ν_0 = 1400 Hz and the velocity of sound in air 350 m/s. The speed of each tuning fork is close to **[JEE (Main)-2020]**

(1) $\frac{1}{4}$ m/s (2) $\frac{1}{2}$ m/s

(3) 1 m/s (4) $\frac{1}{8}$ m/s

36. 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 **[JEE (Main)-2020]**

(1) 30.5×10^4 N (2) 2.50×10^4 N

(3) 5.15×10^3 N (4) 10.2×10^2 N

37. Three 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 **[JEE (Main)-2020]**

(1) $3I_0$ (2) $5.8I_0$

(3) $0.2I_0$ (4) I_0

38. A wire of length L and mass per unit length 6.0×10^{-3} kg m^{-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

[JEE (Main)-2020]

(1) 1.1 m (2) 5.1 m

(3) 8.1 m (4) 2.1 m

39. 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

[JEE (Main)-2020]

(1) 1.5 (2) 2.25

(3) 0.44 (4) 1.25

40. 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 wavetrain 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?

[JEE (Main)-2020]

(1) 6 (2) 3

(3) 12 (4) 9

41. 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 **[JEE (Main)-2020]**

(1) 1, 2, 3, ... (2) 1, 3, 5, ...

(3) $\frac{1}{1}, \frac{1}{3}, \frac{1}{5}, ...$ (4) $\frac{1}{2}, \frac{1}{4}, \frac{1}{6}, ...$

42. 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}

[JEE (Main)-2020]

(1) 61 kmh^{-1} (2) 91 kmh^{-1}

(3) 81 kmh^{-1} (4) 71 kmh^{-1}

43. 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 Δp ~10 Pa, v ~300 m/s, ρ ~ 1 kg/m^3 and f ~ 1000 Hz, then s will be of the order of (take the multiplicative constant to be 1)

[JEE (Main)-2020]

(1) $\frac{3}{100}$ mm (2) 10 mm

(3) 1 mm (4) $\frac{1}{10}$ mm

44. 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 **[JEE (Main)-2020]**

(1) 2200 Hz (2) 3300 Hz

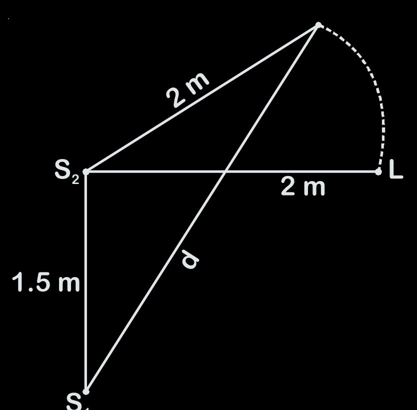
(3) 1100 Hz (4) 550 Hz

45. 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 **[JEE (Main)-2020]**

(1) 36 km/hr (2) 54 km/hr

(3) 24 km/hr (4) 18 km/hr

46. Two coherent sources of sound, S_1 and S_2, produce sound waves of the same wavelength, λ = 1 m, in phase. S_1 and S_2 are placed 1.5 m apart (see fig). A listener, located at L, directly in front of S_2 finds that the intensity is at a minimum when he is 2 m away from S_2. The listener moves away from S_1, keeping his distance from S_2 fixed. The adjacent maximum of intensity is observed when the listener is at a distance d from S_1. Then, d is **[JEE (Main)-2020]**



(1) 5 m (2) 2 m

(3) 12 m (4) 3 m

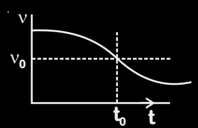
47. An object of mass m is suspended at the end of a massless wire of length L and area of cross-section, A. Young modulus of the material of the wire is Y. If the mass is pulled down slightly its frequency of oscillation along the vertical direction is **[JEE (Main)-2020]**

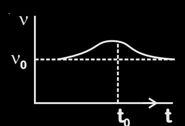
(1) $f = \frac{1}{2\pi}\sqrt{\frac{mL}{YA}}$ (2) $f = \frac{1}{2\pi}\sqrt{\frac{YA}{mL}}$

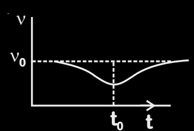
(3) $f = \frac{1}{2\pi}\sqrt{\frac{YL}{mA}}$ (4) $f = \frac{1}{2\pi}\sqrt{\frac{mA}{YL}}$

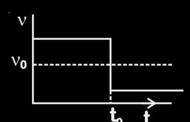
48. A sound source S is moving along a straight track with speed v, and is emitting sound of frequency ν_0 (see figure). An observer is standing at a finite distance, at the point O, from the track. The time variation of frequency heard by the observer is best represented by **[JEE (Main)-2020]**

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

(1) 

(2) 

(3) 

(4) 

49. 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 in 300 m/s, the frequency difference between the fundamental and second harmonic of this pipe is ________ Hz. **[JEE (Main)-2020]**

50. 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), __________. **[JEE (Main)-2020]**

51. Which of the following equations represents a travelling wave? **[JEE (Main)-2021]**

(1) $y = A\sin(15x - 2t)$

(2) $y = Ae^{x}\cos(\omega t - \theta)$

(3) $y = A\sin x \cos\omega t$

(4) $y = Ae^{-x^2}(vt + \theta)$

52. A signal of 0.1 kW is transmitted in a cable. The attenuation of cable is –5 dB per km and cable length is 20 km. The power received at receiver is 10^{-x} W. The value of x is **[JEE (Main)-2021]**

$$\left[\text{Gain in dB} = 10\log_{10}\left(\frac{P_0}{P_i}\right)\right]$$

53. Two cars are approaching each other at an equal speed of 7.2 km/hr. When they see each other, both blow horns having frequency of 676 Hz. The beat frequency heard by each driver will be ______ Hz. [Velocity of sound in air is 340 m/s.]

[JEE (Main)-2021]

54. A student is performing the experiment of resonance column. The diameter of the column tube is 6 cm. The frequency of the tuning fork is 504 Hz. Speed of the sound at the given temperature is 336 m/s. The zero of the metre scale coincides with the top end of the resonance column tube. The reading of the water level in the column when the first resonance occurs is:

[JEE (Main)-2021]

(1) 13 cm (2) 16.6 cm

(3) 14.8 cm (4) 18.4 cm

55. The percentage increase in the speed of transverse waves produced in a stretched string if the tension is increased by 4% will be ________%.

[JEE (Main)-2021]

56. The mass per unit length of a uniform wire is 0.135 g/cm. A transverse wave of the form $y = -0.21 \sin(x + 30t)$ is produced in it, where x is in meter and t is in second. Then, the expected value of tension in the wire is $x \times 10^{-2}$ N. Value of x is ________.

(Round-off to the nearest integer)

[JEE (Main)-2021]

57. A tuning fork A of unknown frequency produces 5 beats/s with a fork of known frequency 340 Hz. When fork A is filed, the beat frequency decreases to 2 beats/s. What is the frequency of fork A?

[JEE (Main)-2021]

(1) 335 Hz (2) 338 Hz

(3) 345 Hz (4) 342 Hz

58. A swimmer can swim with velocity of 12 km/h in still water. Water flowing in a river has velocity 6 km/h. The direction with respect to the direction of flow of river water he should swim in order to reach the point on the other bank just opposite to his starting point is ___°.

(Round off to the Nearest Integer) (Find the angle in degrees) **[JEE (Main)-2021]**

59. A sound wave of frequency 245 Hz travels with the speed of 300 ms^{-1} along the positive x-axis. Each point of the wave moves to and fro through a total distance of 6 cm. What will be the mathematical expression of this travelling wave?

[JEE (Main)-2021]

(1) $Y(x, t) = 0.06 [\sin 0.8x - (0.5 \times 10^3)t]$

(2) $Y(x, t) = 0.03 [\sin 5.1x - (1.5 \times 10^3)t]$

(3) $Y(x, t) = 0.03 [\sin 5.1x - (0.2 \times 10^3)t]$

(4) $Y(x, t) = 0.06 [\sin 5.1x - (1.5 \times 10^3)t]$

60. The frequency of a car horn encountered a change from 400 Hz to 500 Hz, when the car approaches a vertical wall. If the speed of sound is 330 m/s. Then the speed of car is _____ km/h.

[JEE (Main)-2021]

61. The amplitude of wave disturbance propagating in the positive *x*-direction is given by $y = \frac{1}{1+x^2}$ at time $t = 0$ and $y = \frac{1}{1+(x-2)^2}$ at $t = 1$ s, where x and y are in metres. The shape of wave does not change during the propagation. The velocity of the wave will be _______ m/s. **[JEE (Main)-2021]**

62. With what speed should a galaxy move outward with respect to earth so that the sodium-D line at wavelength 5890 Å is observed at 5896 Å?

[JEE (Main)-2021]

(1) 322 km/sec

(2) 306 km/sec

(3) 336 km/sec

(4) 296 km/sec

63. Two travelling waves produces a standing wave represented by equation. **[JEE (Main)-2021]**

$y = 1.0 \text{ mm} \cos(1.57 \text{ cm}^{-1})x \sin(78.5 \text{ s}^{-1})t$. The node closest to the origin in the region

$x > 0$ will be at $x =$ _______ cm.

64. A source and a detector move away from each other in absence of wind with a speed of 20 m/s with respect to the ground. If the detector detects a frequency of 1800 Hz of the sound coming from the source, then the original frequency of source considering speed of sound in air 340 m/s will be ______ Hz. **[JEE (Main)-2021]**

65. Two waves are simultaneously passing through a string and their equations are :

$y_1 = A_1 \sin k(x - vt)$, $y_2 = A_2 \sin k(x - vt + x_0)$. Given amplitudes $A_1 = 12$ mm and $A_2 = 5$ mm, $x_0 = 3.5$ cm and wave number $k = 6.28 \text{ cm}^{-1}$. The amplitude of resulting wave will be ___ mm.

[JEE (Main)-2021]

66. The cars X and Y are approaching each other with velocities 36 km/h and 72 km/h respectively. The frequency of a whistle sound as emitted by a passenger in car X, heard by the passenger in car Y is 1320 Hz. If the velocity of sound in air is 340 m/s, the actual frequency of the whistle sound produced is _____ Hz. **[JEE (Main)-2021]**

67. A tuning fork is vibrating at 250 Hz. The length of the shortest closed organ pipe that will resonate with the tuning fork will be ________ cm.

(Take speed of sound in air as 340 ms^{-1})

[JEE (Main)-2021]

68. A wire having a linear mass density 9.0×10^{-4} kg/m is stretched between two rigid supports with a tension of 900 N. The wire resonates at a frequeucy of 500 Hz. The next higher frequency at which the same wire resonates is 550 Hz. The length of the wire is ___ m.

[JEE (Main)-2021]

69. The equations of two waves are given by :

$y_1 = 5 \sin 2\pi(x - vt)$ cm

$y_2 = 3 \sin 2\pi(x - vt + 1.5)$ cm

These waves are simultaneously passing through a string. The amplitude of the resulting wave is :

[JEE (Main)-2022]

(1) 2 cm (2) 4 cm

(3) 5.8 cm (4) 8 cm

70. The first overtone frequency of an open organ pipe is equal to the fundamental frequency of a closed organ pipe. If the length of the closed organ pipe is 20 cm. The length of the open organ pipe is ___ cm.

[JEE (Main)-2022]

71. An observer moves towards a stationary source of sound with a velocity equal to one-fifth of the velocity of sound. The percentage change in the frequency will be:

[JEE (Main)-2022]

(1) 20%

(2) 10%

(3) 5%

(4) 0%

72. The velocity of sound in a gas, in which two wavelengths 4.08 m and 4.16 m produce 40 beats in 12 s, will be: **[JEE (Main)-2022]**

(1) 282.8 ms^{-1}

(2) 175.5 ms^{-1}

(3) 353.6 ms^{-1}

(4) 707.2 ms^{-1}

73. A tuning fork of frequency 340 Hz resonates in the fundamental mode with an air column of length 125 cm in a cylindrical tube closed at one end. When water is slowly poured in it, the minimum height of water required for observing resonance once again is ____ cm.

(Velocity of sound in air is 340 ms^{-1})

[JEE (Main)-2022]

74. A longitudinal wave is represented by $x = 10\sin 2\pi\left(nt - \frac{x}{\lambda}\right)$ cm. The maximum particle velocity will be four times the wave velocity if the determined value of wavelength is equal to :

[JEE (Main)-2022]

(1) 2π (2) 5π

(3) π (4) $\frac{5\pi}{2}$

75. In an experiment to determine the velocity of sound in air at room temperature using a resonance tube, the first resonance is observed when the air column has a length of 20.0 cm for a tuning fork of frequency 400 Hz is used. The velocity of the sound at room temperature is 336 ms^{-1}. The third resonance is observed when the air column has a length of ______ cm

[JEE (Main)-2022]

76. An observer is riding on a bicycle and moving towards a hill at 18 kmh^{-1}. He hears a sound from a source at some distance behind him directly as well as after its reflection from the hill. If the original frequency of the sound as emitted by source is 640 Hz and velocity of the sound in air is 320 m/s, the beat frequency between the two sounds heard by observer will be ___ Hz.

[JEE (Main)-2022]

77. 4. When a car is approaching the observer, the frequency of horn is 100 Hz. After passing the observer, it is 50 Hz. If the observer moves with the car, the frequency will be $\frac{x}{3}$ Hz where x = ______. **[JEE (Main)-2022]**

78. A wire of length 30 cm, stretched between rigid supports, has it's n^{th} and $(n + 1)^{th}$ harmonics at 400 Hz and 450 Hz, respectively. If tension in the string is 2700 N, it's linear mass density is _____ kg/m. **[JEE (Main)-2022]**

79. In the wave equation **[JEE (Main)-2022]**

$$y = 0.5\sin\frac{2\pi}{\lambda}(400t - x)\text{m}$$

the velocity of the wave will be :

(1) 200 m/s

(2) $200\sqrt{2}$ m/s

(3) 400 m/s

(4) $400\sqrt{2}$ m/s

80. The frequency of echo will be _______ Hz if the train blowing a whistle of frequency 320 Hz is moving with a velocity of 36 km/h towards a hill from which an echo is heard by the train driver. Velocity of sound in air is 330 m/s.

[JEE (Main)-2022]

81. The speed of a transverse wave passing through a string of length 50 cm and mass 10 g is 60 ms^{-1}. The area of cross-section of the wire is 2.0 mm^2 and its Young's modulus is 1.2×10^{11} Nm^{-2}. The extension of the wire over its natural length due to its tension will be $x \times 10^{-5}$ m. The value of x is _____.

[JEE (Main)-2022]

82. A transverse wave is represented by $y = 2\sin(\omega t - kx)$ cm. The value of wavelength (in cm) for which the wave velocity becomes equal to the maximum particle velocity, will be **[JEE (Main)-2022]**

(1) 4π
(2) 2π
(3) π
(4) 2

83. A set of 20 tuning forks is arranged in a series of increasing frequencies. If each fork gives 4 beats with respect to the preceding fork and the frequency of the last fork is twice the frequency of the first, then the frequency of last fork is _______Hz. **[JEE (Main)-2022]**

84. Two travelling waves of equal amplitudes and equal frequencies move in opposite directions along a string. They interfere to produce a stationary wave whose equation is given by

$$y = \left(10\cos\pi x \sin\frac{2\pi t}{T}\right)\text{cm}$$

The amplitude of the particle at $x = \frac{4}{3}$ cm will be _________ cm. **[JEE (Main)-2022]**

❑ ❑ ❑

Chapter 10

Waves

1. Answer (3)

If we assume that all the three waves are in same phase at t = 0 they will be again in same phase at t = 1

2. Answer (1)

$$f' = f\left(\frac{v - v_0}{v}\right) \qquad \begin{pmatrix} v = \text{speed of sound} \\ v_0 = \text{speed of observer} \end{pmatrix}$$

$$\Rightarrow 0.94 = 1 - \frac{v_0}{v}$$

$$\Rightarrow \frac{v_0}{v} = 0.06$$

$$\Rightarrow v_0 = 19.8 \text{ m/s}$$

$$\Rightarrow \text{Distance covered} = \frac{v_0^2}{2a} = 98 \text{ m}$$

3. Answer (1)

$$v = \frac{\omega}{k} = \frac{\left(\frac{2\pi}{0.04}\right)}{\left(\frac{2\pi}{0.50}\right)} = \frac{0.50}{0.04} = 12.5 \text{ m/s}$$

$$v = \sqrt{\frac{T}{\mu}} \Rightarrow T = \mu v^2 = (12.5)^2 \times 0.04 = 6.25 \text{ N}$$

4. Answer (2)

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

At nodes,

$\cos kx = 0$

$$\Rightarrow kx = \frac{(2n+1)\pi}{2}$$

5. Answer (1)

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

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

6. Answer (4)

7. Answer (2)

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}} = \frac{1}{2l}\sqrt{\frac{\text{Stress}}{\text{Density}}} = \frac{1}{2l}\sqrt{\frac{\gamma \times \text{strain}}{\text{Density}}}$$

$$\Rightarrow f = \frac{1}{2 \times 1.5} \times \sqrt{\frac{2.2 \times 10^{11} \times \frac{1}{100}}{7.7 \times 10^3}}$$

$$= \frac{1}{3}\sqrt{\frac{2}{7} \times 10^6}$$

$$= \frac{1000}{3} \times \frac{\sqrt{2}}{\sqrt{7}} \approx 178.2 \text{ Hz}$$

8. Answer (3)

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

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

$\Rightarrow 2n - 1 \le 12.5$

$\therefore$ Answer is 6.

9. Answer (2)

$$f_1 = f\left[\frac{v}{v - v_s}\right] = f\left[\frac{320}{320 - 20}\right] = f \times \frac{320}{300}\text{Hz}$$

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

$$100 \times \left(\frac{f_2}{f_1} - 1\right) = \left(\frac{f_2 - f_1}{f_1}\right) \times 100$$

$$= 100\left[\frac{300}{340} - 1\right] = 12\%$$

10. Answer (2)

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

$$\frac{dx}{dt} = \sqrt{\frac{\mu x g}{\mu}}$$

$$\int_0^L \frac{dx}{\sqrt{xg}} = \int_0^t dt$$

$\Rightarrow \; t = 2\sqrt{2}$ s

11. Answer (3)

Before dipping

$$f = \frac{v}{2L}$$

After dipping

$$f' = \frac{v}{4\frac{L}{2}} = f$$

12. Answer (1)

$$f_0 = \frac{V}{2L} = \frac{1}{2L}\sqrt{\frac{Y}{\rho}}$$

$$= \frac{1}{2\times 0.6}\sqrt{\frac{9.27\times 10^{10}}{2.7\times 10^{3}}} = 4.88 \text{ kHz} \approx 5 \text{ kHz}$$

13. Answer (2)

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

$$v' = \sqrt{\frac{m\sqrt{g^2+a^2}}{\mu}}$$

$$\Rightarrow \frac{v'}{v} = \sqrt{\frac{\sqrt{g^2+a^2}}{g}}$$

$\Rightarrow a \simeq 1.83$

$$\Rightarrow a = \frac{g}{5}$$

14. Answer (4)

$\lambda = 0.50$

$$\lambda = \frac{1}{2}\text{ m}$$

$$\nu = 330\times 2 = 660 \text{ Hz}$$

$$\nu' = \frac{\left(330+\frac{50}{18}\right)\nu}{330} \approx 666 \text{ Hz}$$

15. Answer (4)

$$f_1 = f_0\left(\frac{340}{340-34}\right)$$

$$f_2 = f_0\left(\frac{340}{340-17}\right)$$

$$\frac{f_1}{f_2} = \frac{340-17}{340-34} = \frac{19}{18}$$

16. Answer (4)

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{8\times 1}{5\times 10^{-3}}} = 40 \text{ m/s}$$

$$\lambda = \frac{v}{f} = \frac{40}{100} = 0.4\text{m}$$

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

= 0.2 m ≃ 20 cm

17. Answer (3)

$$f_o = \frac{v}{4L}$$

Also, $f_n = (2n + 1)\, f_o$

So $(2n + 1)$ would take value of $\frac{20,000}{1500} = 13.33$

$\Rightarrow$ 1, 3, 5, 7, 9, 11, 13

So overtones are 3, 5, 7, 9, 11, 13

Total 6 No. of overtones would be heard

18. Answer (4)

$$Y = A\sin\omega\left(t - \frac{x}{v}\right)$$

V = 50 m/s by comparison.

$$50 = \sqrt{\frac{T}{\mu}}$$

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

T = 12.5 N

19. Answer (1)

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

$$\Rightarrow v = \frac{\omega}{k} = \frac{50}{2} = 25 \text{ ms}^{-1}$$

And wave is travelling in –ve x-direction.

20. Answer (3)

$$\frac{\lambda_1}{4} = l_0 + 11$$

$$\frac{\lambda_2}{4} = l_0 + 27$$

$$\frac{\lambda_2 - \lambda_1}{4} = 16 \text{ cm}$$

$$\Rightarrow V\left[\frac{1}{256} - \frac{1}{512}\right] = 0.64 \text{ m}$$

$$\Rightarrow V = 512 \times 0.64 \text{ m/s}$$

$$= 328 \text{ m/s}$$

21. Answer (2)

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

$$\Rightarrow \lambda_A = 2\lambda_B$$

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

22. Answer (1)

$$V_1 = \frac{1000}{3} \text{ m/s}$$

$$V \propto \sqrt{T}$$

$$\frac{dV}{V} = \frac{1}{2}\frac{dT}{T}$$

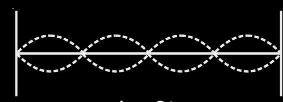
$$\frac{8 \times 3}{3 \times 1000} = \frac{1}{2} \times \frac{dT}{273}$$

$$dT = \frac{273 \times 2 \times 8}{1000} = 4.36°\text{C}$$

23. Answer (4)

$$\lambda = 0.157 = \frac{3.14}{20} = \frac{\pi}{20}$$

In 4th harmonic,



$L = 2\lambda$

$$\therefore \frac{2\pi}{\lambda} = \pi/20$$

$$\lambda = 40 \text{ m}$$

$$\therefore L = \frac{4\lambda}{2} = 80 \text{ m}$$

24. Answer (4)

$$f = \frac{(v \pm u_0)}{(v \pm u_s)} \cdot f_0 = \frac{(v - 20)}{(v + 20)} \cdot f_0$$

$$\Rightarrow 2000 = \frac{320}{360} \cdot f_0$$

$$\Rightarrow \frac{2000 \times 9}{8} = f_0 = 2250 \text{ Hz}$$

25. Answer (2)

$$\frac{\lambda}{2} = \frac{2}{3}$$

$$\Rightarrow \lambda = \frac{4}{3} \text{ m}$$

$$\therefore \nu = \frac{4}{3} \times 240 = 320 \text{ m/s}$$

3rd harmonic

$$f_n = nf_0$$

$$f_0 = \frac{240}{3} = 80 \text{ Hz}$$

26. Answer (4)

Frequency of sound source (f_0) = 500 Hz

When observer is moving away from the source

Apparent frequency $f_1 = 480 = f_0\left(\frac{\nu - \nu_0'}{\nu}\right)$ ...(i)

And when observer is moving towards the source

$f_2 = 530 = f_0\left(\frac{\nu + \nu_0''}{\nu}\right)$ ...(ii)

From equation (i)

$$480 = 500\left(\frac{300 - \nu_0'}{300}\right)$$

$\nu_0' = 12$ m/s

From equation (ii)

$$530 = 500\left(1 + \frac{\nu_0''}{\nu}\right)$$

$\therefore \quad \nu_0'' = 18$ m/s

27. Answer (3)

Beat frequency = $|f_1 - f_2| = 11 - 9 = 2$ Hz

28. Answer (4)

$$f_{\text{app}} = f_{\text{act}}\left(\frac{V \pm V_0}{V \mp V_s}\right)$$

$$1000 = f_{\text{act}}\left(\frac{350 - 0}{350 + (-50)}\right) \text{ and } f' = f_{\text{act}}\left(\frac{350}{350 + 50}\right)$$

$$\Rightarrow \quad f_{\text{act}} = \frac{1000 \times 300}{400}$$

$f_{\text{act}} \approx 750$ Hz

29. Answer (4)

f_1 (frequency received by A)

$$= \nu_0\left[\frac{1500 - 5}{1500 - 7.5}\right]$$

f_2 [frequency received by B]

$$= \nu_0 \times \frac{1495}{1492.5} \times \frac{1507.5}{1505}$$

= 502 Hz.

30. Answer (1)

$y = A \sin (\omega t - kx + \phi)$

At $t = 0$ and $x = 0$ particle is at mean position and will proceed in positive y direction

31. Answer (2)

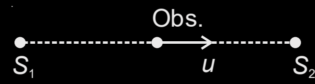
$$120 = 10 \log_{10} \frac{I}{10^{-12}}$$

$$\Rightarrow \quad \frac{I}{10^{-12}} = 10^{12} \qquad \Rightarrow \quad I = 1 \text{ W/m}^2$$

$$\frac{2}{4\pi r^2} = 1 \qquad \Rightarrow \quad r = \sqrt{\frac{2}{4\pi}}\, m = 0.399 \text{ m}$$

= 40 cm

32. Answer (3)



$$n_1 = \frac{v - u}{v} \times n_0$$

$$n_2 = \frac{v + v}{v} \times n_0$$

$$\Rightarrow \quad n_2 - n_1 = \frac{2u \times n_0}{v}$$

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

$\Rightarrow \quad u = 2.5$ m/s

33. Answer (2)

$l_1 = 30$ cm, $l_2 = 70$ cm

$$\therefore \quad \frac{\lambda}{2} = (l_2 - l_1) = 40 \text{ cm}$$

$\Rightarrow \quad \lambda = 80$ cm

$\therefore \quad U = \nu\lambda = 480 \times (0.8)$ m/s

= 384 m/s

34. Answer (4)

l = 60 cm, m = 6 g, A = 1 mm^2, v = 90 m/s

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

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

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

= 0.03 mm

35. Answer (1)

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

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

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

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

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

36. Answer (3)

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

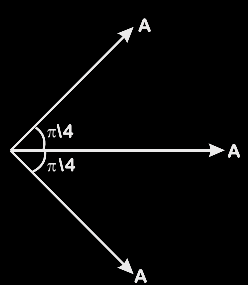
$$\Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}} \quad \Rightarrow \quad \frac{v}{v} \times 2 = \sqrt{\frac{2.06 \times 10^4}{T_2}}$$

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

$$\Rightarrow T_2 = 5.15 \times 10^3 \text{N}$$

37. Answer (2)

$I_0 = CA^2$



$$A_R = A + A\sqrt{2} = A(1+\sqrt{2})$$

$$I_R = CA_R^2$$

$$= CA^2\left(1+\sqrt{2}\right)^2$$

$$I_R = I_0\left(1+\sqrt{2}\right)^2 = 5.8279\, I_0$$

38. Answer (4)

Fundamental frequency = 70 Hz.

$$70 = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

$$l \approx 2.14 \text{ m}$$

39. Answer (2)

$$f = \frac{V}{2L}$$

$$\Rightarrow \frac{450}{300} = \sqrt{\frac{T_X}{T_Z}}$$

$$\Rightarrow \frac{T_X}{T_Z} = 2.25$$

40. Answer (3)

$$f = \frac{v}{\lambda}$$

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

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

$$= \lambda_1 \sqrt{\frac{T_2}{T_1}} = \lambda_1 \sqrt{\frac{8g}{2g}}$$

$$\Rightarrow \lambda_2 = 12 \text{ cm}$$

41. Answer (3)

$\left(\frac{\lambda}{2}\right) \times n = 1.5$, n is odd integer

$\lambda \times m = 5$, m is integer

$\Rightarrow \lambda$ can be $\frac{1}{1}, \frac{1}{3}, \frac{1}{5}$

as $\lambda = \frac{3}{n}$ and, $\lambda = \frac{5}{m}$

42. Answer (2)

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

$$\Rightarrow \frac{330+v}{330-v} = \frac{7}{6}$$

$$\Rightarrow 13v = 330$$

$$\Rightarrow v = \frac{330}{13} = 25.38 \text{ m/s}$$

$$= 91 \text{ km/h}$$

43. Answer (1)

$$\because \Delta P_0 = B\frac{\omega}{v} \times S_0$$

$$\Rightarrow S = \frac{\Delta P \times v}{B\omega} = \frac{\Delta P \times v}{\rho v^2 \times 2\pi\nu}$$

$$\Rightarrow S \propto \frac{\Delta P}{\rho v f}$$

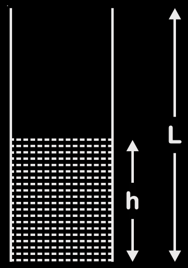
$$\Rightarrow S = \frac{\Delta P}{\rho v f}$$

$$= \frac{10}{1 \times 300 \times 1000}$$

$$= \frac{1}{30} \text{mm}$$

$$\approx \frac{3}{100} \text{mm}$$

44. Answer (1)



$$L - h_1 = n\frac{\lambda}{2} + \frac{\lambda}{4}$$

$$L - h_2 = (n-1)\frac{\lambda}{2} + \frac{\lambda}{4}$$

$$\Rightarrow \frac{\lambda}{2} = h_2 - h_1 = 24.5 - 17.0 = 7.5\ cm$$

$\Rightarrow$ λ = 15 cm

u = fλ

f = 2200 Hz

45. Answer (2)

$$\frac{345+u}{345-v}\times 440 = 480$$

$\Rightarrow$ 11 × 345 + 11v = 12 × 345 – 12v

$$\Rightarrow v = \frac{345}{23} = 15\text{ m/s}$$

= 54 km/h

46. Answer (4)

At L, $S_1L - S_2L$ = 2.5 – 2.0 = 0.5 m

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

For adjacent maximum

$S_1L - S_2L = \lambda$

$S_1L = \lambda + S_2L$

= 1 + 2

= 3 m

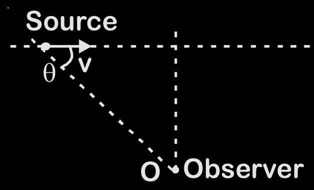
47. Answer (2)

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$k = \frac{YA}{L}$$

$$f = \left(\frac{1}{2\pi}\right)\sqrt{\frac{YA}{mL}}$$

48. Answer (1)



While approaching

$$\nu = \nu_0\left(\frac{c}{c - v\cos\theta}\right)$$

While receding

$$\nu = \nu_0\left(\frac{c}{c + v\cos\theta}\right)$$

49. Answer (106)

v_{air} = 300 m/s

$$v_{gas} = \sqrt{\frac{B}{2\rho_{air}}} = \frac{300}{\sqrt{2}} = 150\sqrt{2}\text{ m/s}$$

$$f_{n^{th}\text{ harmonics}} = \frac{nv}{2L}\ \text{(open organ pipe)}$$

$$\therefore\ f_1 - f_0 = \frac{v_{gas}}{2L} = \frac{150\sqrt{2}}{2\times 1} = 75\sqrt{2}\text{ Hz.}$$

= 106 Hz (approx)

50. Answer (35)

$$m = Al\sigma\ \therefore\ \mu = \left(\frac{m}{l}\right) = A\sigma$$

Now, $v = \sqrt{\frac{T}{\mu}}$ and $\frac{T}{A} = Y$ (strain)

$$\Rightarrow\quad v = \sqrt{\frac{T}{\sigma A}}\quad \Rightarrow$$

$$\frac{T}{A} = 9\times 10^{10}\times 4.9\times 10^{-4}$$

$$\therefore\quad v = \sqrt{\frac{9\times 10^{10}\times 4.9\times 10^{-4}}{9\times 10^{3}}}$$

$\Rightarrow$ v = 70 m/s

$$\therefore\quad f_0 = \frac{v}{2L} = \frac{70}{2\times 1} = 35\text{ Hz}$$

51. Answer (1)

Travelling wave equation,

$y = f(\pm kx \pm \omega t)$

$\therefore$ $y = A\sin(15x - 2t)$ is a travelling wave.

52. Answer (8)

Total attenuation = – 100 dB

$$-100 = 10\log_{10}\left(\frac{P_{out}}{P_{in}}\right)$$

$$P_{out} = P_{in} \times 10^{-10}$$

$= 100 \times 10^{-10}$ W

$= 10^{-8}$ W

53. Answer (8)

$$f' = f_0\left(\frac{V_S + V_C}{V_S - V_C}\right)\sqrt{b^2 - 4ac}$$

$$= 676\left(\frac{340+2}{340-2}\right) = 684 \text{ Hz}$$

Beat frequency $\Delta f = f' - f_0 = 8$ Hz

54. Answer (3)

$$\lambda = \frac{v}{\nu} = \frac{336}{504}\text{ m} = \frac{2}{3}\text{m}$$

$$\therefore \frac{\lambda}{4} = l + e$$

$$\Rightarrow \frac{\frac{2}{3}\times 100}{4} = l + 0.6 \times 3$$

$\Rightarrow$ l = 14.8 cm

55. Answer (2)

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

$$\frac{\Delta v}{v}\times 100 = \frac{1}{2}\frac{\Delta T}{T}\times 100 = 2\%$$

56. Answer (1215)

$$v = \frac{\omega}{k} = 30 \text{ m/s}$$

$$T = \mu v^2$$

$$= 0\cdot 0135 \times 900$$

$$= 12.15 \text{ N}$$

57. Answer (1)

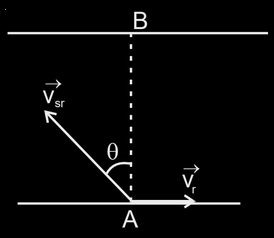
$f_A = 340 \pm 5$

If f_A increases, then beat frequency decreases

$\Rightarrow f_A = 335$

58. Answer (120)

To reach directly opposite point.



$$v_{sr}\sin\theta = v_r \qquad \sin\theta = \frac{6}{12} = \frac{1}{2}$$

$\theta = 30°$

Angle w.r.t. flow = 120°.

59. Answer (2)

2A = 0.06

A = 0.03

$$\lambda = \frac{300}{245}, k = \frac{2\pi}{300}\times 245 = 5.1$$

$\omega = 1540$

So, option (2) matches.

60. Answer (132)

$$f' = \frac{v + v_c}{v - v_c}f$$

$$\Rightarrow \frac{330 + v_c}{330 - v_c}\times 400 = 500$$

$330 = 9v$

$$\Rightarrow v = \frac{110}{3}\text{ m/s or 132 km/h}$$

61. Answer (2)

If $y = \dfrac{1}{1+x^2}$ at $t = 0$

$y = \dfrac{1}{1+(x-2)^2}$ at $t = 1$

$\Rightarrow y = \dfrac{1}{1+(x-2t)^2}$ at any time t

$v = 2$ m/s

62. Answer (2)

$$\lambda_{obs} = \lambda_{actual}\sqrt{\frac{1+\frac{V}{C}}{1-\frac{V}{C}}}$$

$$5896 = 5890\left(1+\frac{V}{C}\right) \text{ [for V << C]}$$

$$V = \frac{C\times 6}{5890} = 306 \text{ km/s}$$

63. Answer (1)

k = 1.57 cm^{-1}

$$\Rightarrow \quad \lambda = \frac{2\pi}{k} = 4 \text{ cm}$$

Closest node will be at a distance $\lambda/4$ from $x = 0$ (Antinode)

64. Answer (2025)

$$\nu_{app} = \nu_0\left(\frac{v - v_o}{v + v_s}\right)$$

$$\nu_0 = \nu_{app}\times\left(\frac{v+v_s}{v-v_o}\right) = 1800\times\frac{360}{320} = 2025$$

65. Answer (7)

$y_1 = A_1 \sin k(x - vt)$

$y_2 = A_2 \sin k\,(x - vt + x_0)$

$$A^2 = A_1^2 + A_2^2 + 2A_1A_2\cos\phi$$

where $\phi = kx_0 = 2\pi \times 3.5 = 7\pi$

$\Rightarrow$ A = $|A_1 - A_2|$ = 7 mm

66. Answer (1210)

$$f = f_0\left(\frac{v+v_0}{v-v_s}\right)$$

$$f_0 = f\left(\frac{v-v_s}{v+v_0}\right) = 1320\left(\frac{340-10}{340+20}\right)$$

= 1210 Hz

67. Answer (34)

$$f = \frac{(2n-1)\,v}{4l}$$

$$l_{min} = \frac{v}{4f} = 34 \text{ cm}$$

68. Answer (10)

$\mu = 9 \times 10^{-4}$ kg/m

T = 900 N

v = 10^3 m/s

f_n = 500 Hz, f_{n+1} = 550 Hz

Fundamental frequency = 50 Hz

$\Rightarrow$ λ = 20 m

ℓ = 10 m

69. Answer (1)

$y_1 = 5\sin(2\pi x - 2\pi vt)$

$y_2 = 3\sin(2\pi x - 2\pi vt + 3\pi)$

$\Rightarrow$ Phase difference = 3π

$$\Rightarrow \quad A_{net} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(3\pi)}$$

$\Rightarrow$ A_{net} = 2 cm

70. Answer (80)

$$2\times\left(\frac{V}{2L_0}\right) = \left(\frac{V}{4L_C}\right)$$

$\Rightarrow L_0 = 4L_C$

= 4 × 20

= 80 cm

71. Answer (1)

$$f' = f_0\left[\frac{v - v_0}{v - v_s}\right]$$

$$\Rightarrow \quad f' = f_0\left[\frac{v + \frac{v}{5}}{v}\right]$$

$$\Rightarrow \quad f' = \frac{6f_0}{5}$$

$\Rightarrow$ % change = 20

72. Answer (4)

$$\frac{v}{4.08} - \frac{v}{4.16} = \frac{40}{12}$$

$$v = \frac{40}{12}\times\frac{4.08\times 4.16}{0.08}$$

= 707.2 m/s

$\Rightarrow$ Option (4) is correct.

73. Answer (50)

Given $340 = \frac{n}{4 \times 125} v$

$\Rightarrow n = 5$

So λ = 100 cm

So minimum height is $\frac{\lambda}{2} = 50$ cm

74. Answer (2)

Particle velocity $= \frac{\partial x}{\partial t}$

$\Rightarrow$ Maximum particle velocity = $(2\pi n)(10)$

$\Rightarrow$ $(2\pi n)(10) = (n\lambda)(4)$

$\Rightarrow$ $\lambda = 5\pi$

75. Answer (104)

$$400 = \frac{v}{4(L_1 + e)} \quad \ldots\text{(i)}$$

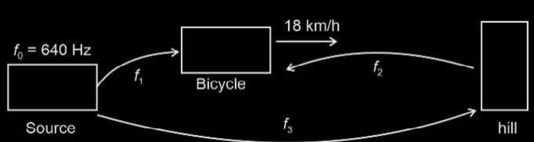
$$400 = \frac{5v}{4(L_2 + e)} \quad \ldots\text{(ii)}$$

$\Rightarrow$ $L_1 + e = \frac{\lambda}{4} = 21\text{ cm}$

$$L_2 + e = \frac{5\lambda}{4} = 105\text{ cm}$$

$\Rightarrow$ e = 1 cm & L_2 = 104 cm

76. Answer (20)



$$f_1 = f_0\left(\frac{320-5}{320}\right) = 640\left(\frac{315}{320}\right)$$

= 630 Hz

$f_3 = f_0$ [No relative motion]

$$f_2 = f_0\left[\frac{320+5}{320}\right] = 640\left(\frac{325}{320}\right)$$

= 650

Beat frequency = $f_2 - f_1$

= 650 – 630 = 20 Hz

77. Answer (200)

$$100 = v_0 \frac{v}{v - v_C}$$

$$50 = v_0 \frac{v}{v + v_c}$$

$$2 = \frac{v + v_c}{v - v_c}$$

$2v - 2v_c = v + v_c$

$$v_c = \frac{v}{3}$$

$$100 = v_0 \frac{v \times 3}{2v} \Rightarrow v_0 = \frac{200}{3} = \frac{x}{3}$$

$\Rightarrow x = 200$

78. Answer (3)

$$\frac{v}{2l} = 50\text{ Hz}$$

$$\Rightarrow T = \left[100 \times \left(\frac{30}{100}\right)\right]^2 \times \mu$$

$$\Rightarrow \mu = \frac{2700}{900} = 3$$

79. Answer (3)

$$v_{\text{wave}} = \left|\frac{\text{coefficient of } t}{\text{coefficient of } x}\right|$$

$$= \frac{400}{1} = 400\text{ m/s}$$

80. Answer (340)

$$v_s = 36 \times \frac{5}{18} = 10 \text{ m/sec}$$

$$f = \frac{v + v_s}{v - v_s} f_0$$

$$= \frac{340}{320} \times 320$$

= 340 Hz

81. Answer (15)

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

So $T = 60^2 \times \frac{10 \times 10^{-3}}{0.5} = 72 \text{ N}$

$$\Delta\ell = \frac{T\ell}{YA} = \frac{72 \times 0.5}{1.2 \times 10^{-11} \times 2 \times 10^{-6}} = 15 \times 10^{-5} \text{ m}$$

82. Answer (1)

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

$$\Rightarrow \quad k = \frac{1}{A} = \frac{1}{2 \text{ cm}}$$

$$\Rightarrow \quad \frac{2\pi}{\lambda} = \frac{1}{2 \text{ cm}}$$

$\Rightarrow$ $\lambda = 4\pi$ cm

83. Answer (152)

Given $\nu_{20} = 2\nu_1$

Also $\nu_{20} = 4 \times 19 + \nu_1$

So $\nu_{20} = 152$ Hz

84. Answer (5)

$$A = |10 \cos(\pi x)|$$

At $x = \frac{4}{3}$

$$A = \left|10 \cos\left(\pi \times \frac{4}{3}\right)\right|$$

= |– 5 cm|

$\therefore$ Amp = 5 cm

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