15.WAVES

Single Correct Answer Type

1. The frequency of a sonometer wire is 10 Hz. When the weights producing the tension are completely immersed in water the frequency becomes 80 Hz and on immersing the weights in a certain liquid the frequency becomes 60 Hz. The specific gravity of the liquid is
   a) 1.42 b) 1.77 c) 1.82 d) 1.21
2. The mathematical form of three travelling waves are given by
   $Y_1 = (2\text{ cm}) \sin(3x - 6t)$
   $Y_2 = (3\text{ cm}) \sin(4x - 12t)$
   And $Y_3 = (4\text{ cm}) \sin(5x - 11t)$
   of these waves
   a) Wave 1 has greatest wave speed and greatest maximum transverse string speed
   b) Wave 2 has greatest wave speed and wave 1 has greatest maximum transverse string speed
   c) Wave 3 has greatest wave speed and wave 1 has greatest maximum transverse string speed
   d) Wave 2 has greatest wave speed and wave 3 has greatest maximum transverse string speed
3. A sound wave of frequency n travels horizontally to the right with speed c. It is reflected from a board wall moving to the left with speed v. The number of beats heard by a stationery observer to the left of the wall is

   a) Zero b) $\frac{n(c+v)}{c-v}$ c) $\frac{nv}{c-v}$ d) $\frac{2\,nv}{c-v}$
4. A closed organ pipe and an open organ pipe of same length produce 2 beats when they are set into vibration simultaneously in their fundamental mode. The length of the open organ pipe is now halved and of the closed organ pipe is doubled; the number of beats produced will be
   a) 8 b) 7 c) 4 d) 2
5. The amplitude of a wave disturbance propagating along positive X-axis is given by $y = 1/(1 + x^2)$ at $t = 0$ and $y = 1/[1 + (x - 2)^2]$ at $t = 4$ s where x and y are in metre. The shape of wave disturbance does not change with time. The velocity of the wave is
   a) 0.5 m/s b) 1 m/s c) 2 m/s d) 4 m/s
6. The equation of a progressive wave is
   $y = 0.02 \sin 2\pi \left[\frac{t}{0.01} - \frac{x}{0.30}\right]$
   Here x and y are in metres and t is in second. The velocity of propagation of the wave is
   a) 300 m/s b) 30 m/s c) 400 m/s d) 40 m/s
7. An air column closed at one end and opened at the other end, resonates with a tuning fork of frequency v when its length is 45 cm and 99 cm and at two other lengths in between these values. The wavelength of sound in air column is
   a) 180 cm b) 108 cm c) 54 cm d) 36 cm
8. Two waves having intensity I and $9I$ produce interference. If the resultant intensity at a point is $7I$, what is the phase difference between the two waves?
   a) 0° b) 60° c) 90° d) 120°
9. A siren placed at a railway platform is emitting sound of frequency 5 kHz. A passenger sitting in a moving train A records a frequency of 5.5 kHz while the train approaches the siren. During his return journey in a different train B he records a frequency of 6.0 kHz while approaching the same siren. The ratio of velocity of train B to that of train A is
   a) 242/252 b) 2 c) 5/6 d) 11/6
10. A closed organ pipe has length 'l'. The air in it is vibrating in 3rd overtone with maximum amplitude 'a'.

The amplitude at a distance of $l/7$ from closed end of the pipe is equal to

a) a b) $a/2$ c) $\frac{a\sqrt{3}}{2}$ d) Zero

11. Spherical sound waves are emitted uniformly in all directions from a point source. The variation in sound level SL as a function of distance $'r'$ from the source can be written as
Where a and b are positive constants
a) $\mathrm{SL} = -b \log r^a$ b) $\mathrm{SL} = a - b\,(\log r)^2$ c) $\mathrm{SL} = a - b \log r$ d) $\mathrm{SL} = a - b/r^2$

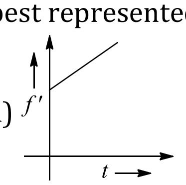
12. Two separated sources emit sinusoidal travelling waves but have the same wavelength λ and are in phase at their respective sources. One travels a distance l_1 to get to the observation point while the other travels a distance, l_2. The amplitude is minimum at the observation point, if $l_1 - l_2$ is an
a) Odd integral multiple of λ b) Even integral multiple of λ
c) Odd integral multiple of $\lambda/2$ d) Odd integral multiple of $\lambda/4$

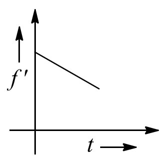
13. If $x = a \sin[\omega t + \pi/6]$ and $x' = a \cos \omega t$, then what is the phase difference between the two waves?
a) $\frac{\pi}{3}$ b) $\frac{\pi}{6}$ c) $\frac{\pi}{2}$ d) π

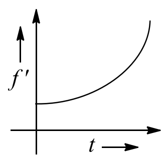
14. A thin plane membrane separates hydrogen at 7°C from hydrogen at 47°C, both being at the same pressure. If a collimated sound beam travelling from cooler gas makes an angle of incidence of 30° at the membrane, the angle of refraction is
a) $\sin^{-1}\sqrt{\frac{7}{32}}$ b) $\sin^{-1}\sqrt{\frac{2}{7}}$ c) $\sin^{-1}\sqrt{\frac{4}{7}}$ d) $\sin^{-1}\sqrt{\frac{7}{4}}$

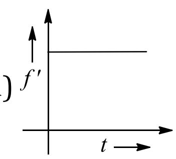
15. A police car with a siren of frequency 8 kHz is moving with uniform velocity 36 km/h towards a tall building which reflects the sound waves. The speed of sound in air is 320 m/s. the frequency of the siren heard by the car driver is
a) 8.5 kHz b) 8.25 kHz c) 7.25 kHz d) 7.5 kHz

16. A transverse sinusoidal wave is generated at one end of a long horizontal string by a bar that moves the end up and down through a distance by 2.0 cm. The motion of bar is continuous and is repeated regularly 125 times per second. If the distance between adjacent wave crests is observed to be 15.6 cm and the wave is moving along positive x-direction, and at $t = 0$ the element of the string at $x = 0$ is at means position $y = 0$ and is moving downward, the equation of the wave is best described by
a) $y = (1\text{ cm}) \sin[(40.3\text{ rad/m})\,x - (786\text{ rad/s})\,t]$
b) $y = (2\text{ cm}) \sin[(40.3\text{ rad/m})\,x - (786\text{ rad/s})\,t]$
c) $y = (1\text{ cm}) \cos[(40.3\text{ rad/m})\,x - (786\text{ rad/s})\,t]$
d) $y = (2\text{ cm}) \cos[(40.3\text{ rad/m})\,x - (786\text{ rad/s})\,t]$

17. A source of frequency 'f' is stationary and an observer starts moving towards it at $t = 0$ with constant small acceleration. Then the variation of observed frequency 'f' registered by the observer with time is best represented as
a) 

b) 

c) 

d) 

18. A progressive wave is given by
$y = 3 \sin 2\pi[(t/0.04) - (x/0.01)]$
Where x, y are in cm and t in s. The frequency of wave and maximum accelerartion will be:
a) $100\text{ Hz}, 4.7 \times 10^3\text{ m/s}^2$ b) $50\text{ Hz}, 7.5 \times 10^3\text{ m/s}^2$
c) $25\text{ Hz}, 4.7 \times 10^4\text{ m/s}^2$ d) $25\text{ Hz}, 7.5 \times 10^4\text{ m/s}^2$

19. The ratio of the speed of sound in nitrogen gas to that in helium gas at 300 K is
a) $\sqrt{(2/7)}$ b) $\sqrt{(1/7)}$ c) $(\sqrt{3})/5$ d) $(\sqrt{6})/5$

20. The difference between the apparent frequencies of a source of sound as perceived by a stationary observer during its approach and recession is 2% of the actual frequency of the source. If the speed of

sound is 300 m/s the speed of source is

a) 1.5 m/s b) 3 m/s c) 6 m/s d) 12 m/s

21. A travelling wave $y = A\sin(kx - \omega t + \theta)$ passes from a heavier string to a lighter string. The reflected wave has amplitude 0.5 A. The junction of the stings is at $x = 0$. The equation of the reflected wave is

a) $y' = 0.5A\sin(kx + \omega t + \theta)$

b) $y' = -0.5A\sin(kx + \omega t + \theta)$

c) $y' = -0.5A\sin(kx - \omega t - \theta)$

d) $y' = -0.5A\sin(kx + \omega t - \theta)$

22. Two vibrating tuning forks produce progressive waves given by, $y_1 = 4\sin(500\pi t)$ and $y_2 = 2\sin(506\,\pi t)$. These tuning forks are held near the ear of person. The person will hear

a) 3 beats/s with intensity ratio between maxima and minima equal to 2

b) 3 beats/s with intensity ratio between maxima and minima equal to 9

c) 6 beats/s with intensity ratio between maxima and minima equal to 2

d) 6 beats/s with intensity ratio between maxima and minima equal to 9

23. A sound wave of frequency 440 Hz is passing through air. An O_2 molecule (mass $= 5.3 \times 10^{-26}$kg) is set in oscillation with an amplitude of 10^{-6}m. Its speed at the centre of its oscillation is

a) 1.70×10^{-5}m/s b) 17.0×10^{-5}m/s c) 2.76×10^{-3}m/s d) 2.77×10^{-5}m/s

24. A string of length $2L$, obeying Hooke's law, is stretched so that its extension is L. The speed of the transverse wave travelling on the string is v. If the string is further stretched so that the extension in the string becomes $4L$. The speed of transverse wave travelling on the string will be (n is an integer)

a) $\frac{1}{\sqrt{2}}v$ b) $\sqrt{2}v$ c) $\frac{1}{2}v$ d) $2v$

25. The vibrations of string of length 60 cm fixed at both ends are represented by the equations

$y = 4\sin(\pi x/15)\cos(19\pi t)$

Where x and y are in cm and t in s. the maximum displacement at $x = 5$ cm is

a) $2\sqrt{3}$ cm b) 4 cm c) Zero d) $4\sqrt{2}$ cm

26. Two identical sonometer wires have a fundamental frequency of 500 Hz when kept under the same tension. The percentage change in tension of one of the wires that would cause an occurrence of 5 beats/s, when both wires vibrate together is

a) 0.5% b) 1% c) 2% d) 4%

27. In expressing sound intensity, we take 10^{-12} W/m^2 as the reference level. For ordinary conversation, the intensity level is about 10^{-6}W/m^2. Expressed in decibel, this is

a) 10^6 b) 6 c) 60 d) $\log_e(10^6)$

28. 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 standing wave having nodes at $x = \left(n + \frac{1}{2}\right)\frac{\lambda}{2}, n = 0,1,2$

b) A wave travelling along + x direction

c) A wave travelling along - x direction

d) A standing wave having nodes at $x = \frac{n\lambda}{2}; n = 0,1,2$

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

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

30. The frequency of a car horn is 400 Hz. If the horn is honked as the car moves with a speed $u_s = 34$ m/s through still air towards a stationery receiver, the wavelength of the sound passing the receiver is [velocity of sound is 340 m/s]

a) 0.765 m b) 0.850 m c) 0.935 m d) 0.425 m

31. In a Kundt's tube, the length of the iron rod is 1 m. the stationery waves of frequency 2500 Hz are produces in it. The velocity of sound in iron is

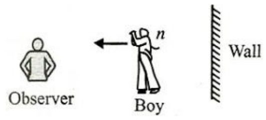
a) 1250 m/s b) 2500 m/s c) 5000 m/s d) 10,000 m/s

32. An increase in intensity level of 1 dB implies an increase in density of (given $\text{antilog}_{10}\, 0.1 = 1.2589$)
a) 1% b) 3.01% c) 26% d) 0.1%

33. A wave is represented by the equation
$y = 7\sin\left(7\pi t - 0.04\pi x + \frac{\pi}{3}\right)$
x is in metres and t is in seconds. The speed of the wave is
a) 175 m/s b) 49 π m/s c) $49/\pi$ m/s d) 0.28 π m/s

34. A simple harmonic wave is represented by the relation
$y = (x, t) = a_0 \sin 2\pi\left(vt - \frac{x}{\lambda}\right)$
If the maximum particle velocity is three times the wave velocity, the wavelength λ of the wave is
a) $\pi a_0/3$ b) $2\pi a_0/3$ c) πa_0 d) $\pi a_0/2$

35. A boy is walking away from a wall at a speed of 1.0 m/s in a direction at right angles to the wall. The boy blows a whistle steadily. An observer towards whom the boy is moving hears 4 beats/s. If the speed of sound is 340 m/s, the frequency of whistle is



a) 480 Hz b) 680 Hz c) 840 Hz d) 1000 Hz

36. A string of length 1.5 m with its two ends clamped is vibrating in fundamental mode. Amplitude at the centre of the string is 4 mm. Distance between the two points having amplitude 2 mm is
a) 1m b) 75 cm c) 60 cm d) 50 cm

37. Regarding an open organ pipe, which of the following is correct?
a) Both the ends are pressure antinodes
b) Both the ends are displacement nodes
c) Both the ends are pressures nodes
d) Both (a) and (b)

38. Microwaves from a transmitter are directed normally towards a plane reflector. A detector moves along the normal to the reflector. Between positions of 14 successive maxima, the detector travels a distance 0.14 m. If the velocity of light is 3×10^8m/s, find the frequency of the transmitter
a) 1.5×10^{10} Hz b) 10^{10} Hz c) 3×10^{10} Hz d) 6×10^{10} Hz

39. Two wires of radii r and $2r$ are welded together end to end. The combination is used as a sonometer wire and is kept under a tension T. The welded point lies midway between the bridges. The ratio of the number of loops formed in the wires, such that the joint is a node when the stationary waves are set up in the wire is
a) 2/3 b) 1/3 c) 1/4 d) 1/2

40. A standard tuning fork of frequency f is used to find the velocity of sound in air by resonance column apparatus. The difference between two resonating length is 1.0 m. Then the velocity of sound in air is
a) f m/s b) $2f$m/s c) $f/2$ m/s d) $3f$ m/s

41. Two uniform strings A and B made of steel are made to vibrate under the same tension. If the first overtone of A is equal to the second overtone of B and if the radius of A is twice that of B, the ratio of the length of the string is
a) 2:1 b) 3:2 c) 3:4 d) 1:3

42. A wave is represented by the equation
$y = y_0 \sin[10\,\pi x - 15\pi t + (\pi/3)]$
Where x is in metres and t in seconds. The equation represents a travelling wave:
a) In the positive direction with a velocity 1.5 m/s and wavelength 0.2 m
b) In the negative direction with a velocity 1.5 m/s and wavelength 0.2 m
c) In the positive direction with a velocity 2 m/s and wavelength 0.2 m
d) In the negative direction with a velocity 2 m/s and wavelength 1.5 m

43. A person speaking normally produces a sound of intensity 40 dB at a distance of 1 m. If the threshold intensity for reasonable audibility is 20 dB. The maximum distance at which he can be heard clearly is

a) 4 m b) 5 m c) 10 m d) 20 m

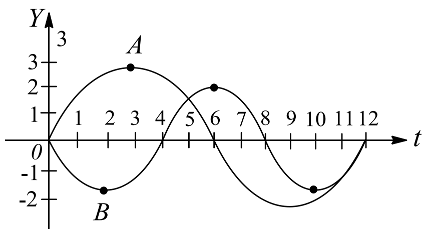
44. A wave equation is represented as
$r = A\sin\left[\alpha\left(\frac{x-y}{2}\right)\right]\cos\left[\omega t - \alpha\left(\frac{x+y}{2}\right)\right]$
Where x and y are in metres and t is in seconds. Then,
a) The wave is a stationery wave
b) The wave is a progressive wave propagating along $+x$-axis
c) The wave is a progressive wave propagating at right angle to the $+x$-axis
d) All points lying on line $y = x + (4\pi/\alpha)$ are always at rest

45. If a wave is going from one medium to another, then
a) Its frequency changes b) Its wavelength does not change
c) Its speed does not change d) Its amplitude may change

46. The frequency of a man's voice is 300 Hz and its wavelength is 1m. If the wavelength of a child's voice is 1.5 m, then the frequency of the child's voice is
a) 200 Hz b) 15 Hz c) 400 Hz d) 350 Hz

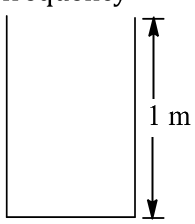
47. A harmonic wave has been set up on a very long string which travels along the length of spring. The wave has frequency of 50 Hz, amplitude 1 cm and wavelength 0.5 m. for the above described wave
Statement I: Time taken by wave to travel a distance of 8 m along the length of string is 0.32 s
Statement II: Time taken by a point on the string to travel a distance of 8 m, once the wave has reached at that point and set it into motion is 0.32 s
a) Both are statements are correct
b) Statement I is correct but Statement II is incorrect
c) Statement I is incorrect but Statement II is correct
d) Both the statements are incorrect

48. The displacement *vs* time graph for two waves A and B which travel along the same string are shown in the figure. Their intensity ratio I_A/I_B is



a) $\frac{9}{4}$ b) 1 c) $\frac{81}{16}$ d) $\frac{3}{2}$

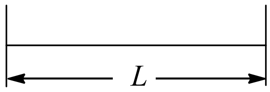
49. Velocity of sound in air is 320 m/s. The resonant pipe shown in figure cannot vibrate with a sound of frequency

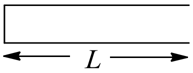


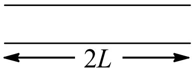
a) 80 Hz b) 240 Hz c) 320 Hz d) 400 Hz

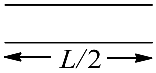
50. Two factories are sounding their sirens at 800 Hz. A man goes from one factory to the other at a speed of 2 m/s. The velocity of sound is 320 m/s. The number of beats heard by the person in 1 s will be
a) 2 b) 4 c) 8 d) 10

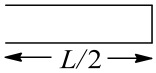
51. Figure shows a stretched string of length L and pipes of length $L, 2L, L/2$ and $L/2$ in options (a), (b), (c) and (d) respectively. The string's tension is adjusted until the speed of on the string equals the speed of sound waves in the air. The fundamental mode of oscillation is then set up on the string. In which pipe will the sound produced by the string causes resonance?



a) 

b) 

c) 

d) 

52. The linear density of a vibrating string is 10^{-4} kg/m. A transverse wave is propagating on the string. Which is described by the equation $y = 0.02\sin(x + 30t)$, where x and y are in metres and time t in seconds. Then tension in the string is

a) 0.09 N b) 0.36 N c) 0.9 N d) 3.6 N

53. The extension in a string, obeying Hooke's law, is x. The speed of sound in the stretched string is v. If the extension in the string is increased to $1.5x$, the speed of sound will be

a) 1.22 v b) 0.61 v c) 1.50 v d) 0.75 v

54. The apparent frequency of the whistle of an engine changes in the ratio of 6:5 as the engine passes a stationary observer. If the velocity of sound is 330 m/s, then the velocity of the engine is

a) 3 m/s b) 30 m/s c) 0.33 m/s d) 660 m/s

55. A tuning fork A of frequency as given by the anufacture is 512 Hz is being tested using an accurate oscillator. It is found that they produce 2 beats/s when the oscillator reads 514 Hz and 6 beats/s when it reads 510 Hz. The actual frequency of the fork in Hz is

a) 508 b) 512 c) 516 d) 518

56. The equation of a stationery wave is $y = 0.8\cos\left(\frac{\pi x}{20}\right)\sin 200\pi t$ where x is in cm and t is in s. The separation between consecutive nodes will be

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

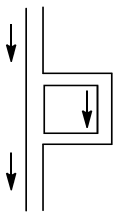
57. A sound wave of wavelength λ travels towards the right horizontally with a velocity V. It strikes and reflects from a vertical plane surface, travelling at a speed v towards the left. The number of positive crests striking in a time interval of 3 s on the wall is

a) $3(V + v)\lambda$ b) $3(V - v)\lambda$ c) $(V + v)3\lambda$ d) $(V - v)3\lambda$

58. A man is watching two trains, one leaving and the other coming in with equal speed of 4 m/s. If they sound their whistles, each of frequency 240 Hz, the number of beats heard by the man (velocity of sound in air is 320 m/s) will be equal to

a) 6 b) 3 c) 0 d) 12

59. A sound consists of four frequencies: 300 Hz, 600 Hz. 1200 Hz and 2400 Hz. A sound 'filter' is made by passing this sound through a bifurcate pipe as shown. The sound wave has to travel a distance of 50 cm more in the right branch-pipe than in the straight pipe. The speed of sound in air is 300 m/s. Then, which of the following frequencies will be almost completely muffled or 'silenced' at the outlet?



a) 300 Hz b) 600 Hz c) 1200 Hz d) 2400 Hz

60. If the velocity of sound in air is 320 m/s, then the maximum and minimum length of a pipe closed at one and, that would produce a just audible sound would be

a) 2.6 m and 3.6 mm b) 4 m and 4.2 mm c) 3 m and 3 mm d) 4 m and 4 mm

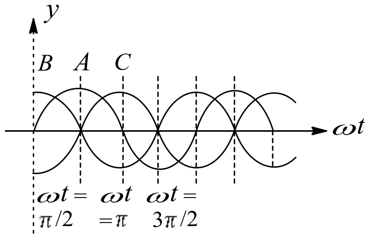
61. Two bodies M and N, of equal masses, are suspended from two separate massless springs of spring constants k_1 and k_2, respectively. If the two bodies oscillate vertically such that their maximum velocities are equal, the ratio of the amplitude of vibration of M to that of N is

a) $\frac{k_1}{k_2}$ b) $\sqrt{k_1/k_2}$ c) $\frac{k_2}{k_1}$ d) $\sqrt{k_2/k_1}$

62. A travelling wave is having wavelength of 3 cm. At any instant the two particles at a distance of 16.5 cm apart have a phase difference of

a) $\frac{\pi}{2}$ b) 5π c) $10.5\,\pi$ d) $11.5\,\pi$

63. The figure shows three progressive waves A, B and C. What can be concluded from the figure that with respect to wave A?

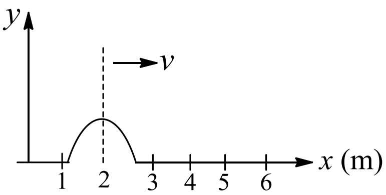


a) The wave C is ahead by a phase angle of $\pi/2$ and the wave B lags behind by a phase angle $\pi/2$
b) The wave C is lag behind by a phase angle of $\pi/2$ and the wave B is ahead by a phase angle $\pi/2$
c) The wave C is ahead by a phase angle of π and the wave B lags behind by a phase angle π
d) The wave C lags behind by a phase angle of π and the wave B is ahead by a phase angle π

64. The ends of a stretched wire of length L are fixed at $x = 0$ and $x = L$. In one experiment, the displacement of the wire is $y_1 = A\sin(\pi x/L)\sin\omega t$ and energy is E_1 and in another experiment its displacement is y $y_2 = A\sin(2\pi x/L)\sin 2\omega t$ and energy is E_2. Then

a) $E_2 = E_1$ b) $E_2 = 2E_1$ c) $E_2 = 4E_1$ d) $E_2 = 16E_1$

65. Wave pulse on a string shown in figure is moving to the right without changing shape. Consider two particles at positions $x_1 = 1.5$m and x_2=2.5 m. their transverse velocities at the moment shown in figure are along directions



a) Positive y-axis and positive y-axis repectively
b) Negative y-axis and positive y-axis repectively
c) Positive y-axis and negative y-axis repectively
d) Negative y-axis and negative y-axis repectively

66. A glass tube of 1.0 m length is filled with water. The water can be drained out slowly at the bottom of the tube. If a vibrating tuning fork of frequency 500 c/s is brought at the upper end of the tube and the velocity of sound is 330 m/s, then the total number of resonances obtained will be

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

67. In a large room, a person receives direct sound waves from a source 120 m away from him. He also receives waves from the same source which reach, being reflected from the 25 m high ceiling at a point halfway between them. The two waves interfere constructively for a wavelength of

a) $20, \frac{20}{3}, \frac{20}{5}$ etc b) 10, 5, 2, 5 etc c) 10,20,30 etc d) 15,25,35 etc

68. One train is approaching an observer at rest and another train is receding from him with the same velocity 4 m/s. Both the trains blow whistle of same frequency of 243 in Hz. The beat frequency in Hz as heard by the observer is (speed of sound in air is 320 m/s)

a) 10 b) 6 c) 4 d) 1

69. An object of specific gravity ρ is hung from a thin steel wire. The fundamental frequency for transverse standing waves in the wire is 300 Hz. The object is immersed in water so that one half of its volume is submerged the new fundamental frequency in Hz is

a) $300\left(\frac{2\rho-1}{2\rho}\right)^{1/2}$ b) $300\left(\frac{2\rho}{2\rho-1}\right)^{1/2}$ c) $300\left(\frac{2\rho}{2\rho-1}\right)$ d) $300\left(\frac{2\rho-1}{2\rho}\right)$

70. A transverse wave is described by the equation

$y = y_0 \sin 2\pi \left(ft - \frac{x}{\lambda}\right)$

The maximum particle velocity is equal to four times the wave velocity if

a) $\lambda = \pi \frac{y_0}{4}$ b) $\lambda = \pi \frac{y_0}{2}$ c) $\lambda = \pi y_0$ d) $\lambda = 2\pi\, y_0$

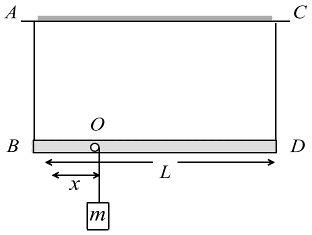
71. Two cars are moving on two perpendicular roads towards a crossing with uniform speeds of 72 km/h and 36 km/h. If second care blows horn of frequency 280 Hz, then the frequency of horn heard by the driver of first car when the line joining the cars makes angle of 45° with the roads, will be (velocity of sound is 330 m/s)

a) 321 Hz b) 298 Hz c) 289 Hz d) 280 Hz

72. A simple pendulum has a time period T_1 when on the earth's surface and T_2 when taken to a height R Above the earth surface, where R is the radius of the earth. The value of T_2/T_1 is

a) 1 b) $\sqrt{2}$ c) 4 d) 2

73. A massless rod is suspended by two identical strings AB and CD of equal length. A block of mass m is suspended from point O such that BO is equal to $''x''$ Further, it is observed that the frequency of 1st harmonic (fundamental frequency) in AB is equal to 2nd harmonic frequency in CD. Then, length of BO is



a) $\frac{L}{5}$ b) $\frac{4L}{5}$ c) $\frac{3L}{4}$ d) $\frac{L}{4}$

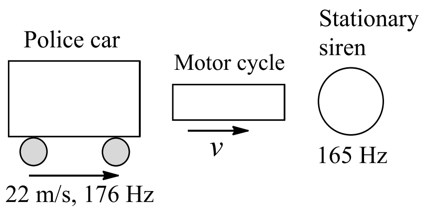
74. A source of sound produces waves of wavelength 60 cm when it is stationery. If the speed of sound in air is 320 m/s and source moves with speed 20 m/s, the wavelength of sound in the forward direction will be nearest to

a) 56 cm b) 60 cm c) 64 cm d) 68 cm

75. The intensity level of two sounds are 100 dB and 50 dB. What is the ratio of their intensities?

a) 10^1 b) 10^3 c) 10^5 d) 10^{10}

76. A police car moving at 22 m/s chases a motorcyclist. The police man sounds his horn of frequency 176 Hz, while both of them move towards a stationary siren of frequency 165 Hz. Calculate the speed of motorcyclist if it is given that he does not hear any beat (speed of sound in air is 330 m/s)



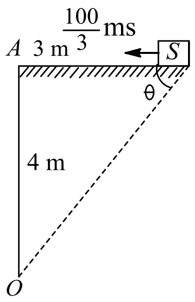
a) 33 m/s b) 22 m/s c) 11 m/s d) Zero

77. To decrease the fundamental frequency of a stretched string fixed at both ends one might

a) Increase its tension b) Increase its wave velocity

c) Increase its length d) Decrease its linear mass density

78. A sources of sound S is travelling at 100/3 m/s along a road towards a point A. When the source is 3 m away from A, a person standing at a point O on a road perpendicular to AS hears a sound of frequency v'. The distance of O from A at that time is 4 m. If the original frequency is 640 Hz, then the value of v' is (velocity of sound is 340 m/s)



a) 620 Hz b) 680 Hz c) 720 Hz d) 840 Hz

79. A 75 cm string fixed at both ends produces resonant frequencies 384 Hz and 288 Hz without there being any other resonant frequency between these two. Wave speed for the string is
a) 144 m/s b) 216 m/s c) 108 m/s d) 72 m/s

80. A long glass tube is held vertically in water. A tuning fork is struck and held over the tube. Strong resonances are observed at two successive lengths 0.50 m and 0.84 m above the surface of water. If the velocity of sound is 340 m/s, then the frequency of the tuning fork is
a) 128 Hz b) 256 Hz c) 384 Hz d) 500 Hz

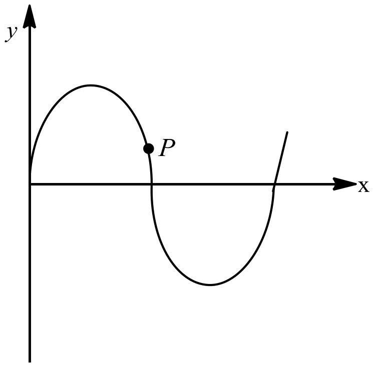
81. A transverse wave is describe by the equation
$Y = y_0 \sin 2\pi \left(ft - \frac{x}{\lambda}\right)$
The maximum particle velocity is for times the wave velocity if
a) $\lambda = \frac{\pi y_0}{4}$ b) $\lambda = \frac{\pi y_0}{2}$ c) $\lambda = \pi y_0$ d) $\lambda = 2\pi y_0$

82. The displacement y of a particle executing periodic motion is given by
$y = 4\cos^2\left(\frac{1}{2}t\right)\sin(1000t)$
This expression may be considered as a result of the superposition of
a) Two b) Three c) Four d) Five

83. A train moves towards a stationery observer with speed 34 m/s. The train sounds a whistle and its frequency registered by the observer is f_1. If the train's speed is reduced to 17 m/s, the frequency registered is f_2. If the train's speed is reduced to 17 m/s, the frequency registered is f_2. If the speed of the sound is 340 m/s, then the ratio f_1/f_2 is
a) 18/19 b) 1/2 c) 2 d) 19/18

84. A stone is hung in air from a wire which is stretched over a sonometer. The bridges of the sonometer are 40 cm apart when the wire is in unison with a tuning fork of frequency 256 Hz. When the stone is completely immersed in water, the length between the bridges is 22 cm for re-establishing unison. The specific gravity of the material of the stone is
a) $\frac{(40)^2}{(40)^2 + (22)^2}$ b) $\frac{(40)^2}{(40)^2 - (22)^2}$ c) $256 \times \frac{22}{40}$ d) $256 \times \frac{40}{22}$

85. A transverse sinusoidal wave moves along a string in positive x-direction at a speed of 10cms^{-2}. The wavelength of the wave is 0.5 m and its amplitude is 10.cm at a particular time t, the snap-shot of the wave is shown in figure. The velocity of point P when its displacement is 5 cm is



a) $\frac{\sqrt{3}\pi}{50}\hat{j}ms^{-1}$ b) $-\frac{\sqrt{3}\pi}{50}\hat{j}ms^{-1}$ c) $\frac{\sqrt{3}\pi}{50}\hat{\imath}ms^{-1}$ d) $-\frac{\sqrt{3}\pi}{50}\hat{\jmath}ms^{-1}$

86. Due to a point isotropic sonic source, loudness at a point is $L = 60$ dB. If density of air is $\rho = (15/11)$ kg/m^3 and velocity of sound in air is $v = 33$ m/s, the pressure oscillation amplitude at the point of observation is $[I_o = 10^{-12}\text{W/m}^2]$

a) 0.3 N/m^2 b) 0.03 N/m^2 c) 3×10^{-3} N/m^2 d) 3×10^{-4} N/m^2

87. A whistle emitting a sound of frequency 440 Hz is tied to a string of 1.5 m length of rotated awith an angular velocity of 20 rad/s in the horizontal plane. Then the range of frequencies heard by an observer stationed at a large distance from the whistle will be ($v = 330$ m/s)

a) 400.0 Hz to 484.0 Hz b) 403.3 Hz to 480.0 Hz c) 400.0 Hz to 480.0 Hz d) 403.3 Hz to 484.0 Hz

88. Two tuning forks of frequency 250 Hz and 256 Hz produce beats. If a maximum is observed just now, after how much time the minimum is observed at the same place?

a) $\frac{1}{18}$s b) $\frac{1}{6}$s c) $\frac{1}{12}$s d) $\frac{1}{24}$s

89. Two travelling waves $y_1 = A\sin[k(x - ct)]$ and $y_2 = A\sin[k(x + ct)]$ are superimposed on string. The distance between adjacent nodes is

a) ct/π b) $ct/2\pi$ c) $\pi/2k$ d) π/k

90. A 20 cm long string, having a mass of 1.0 g, is fixed at both the ends. The tension in the string is 0.5 N. the string is set into vibration using an external vibrator of frequency 100 Hz. Find the separation (in cm) between the successive nodes on the string

a) 5 b) 6 c) 2 d) 3/2

91. Sinusoidal waves 5.00 cm in amplitude are to be transmitted along a string having a linear mass density equal to 4.00×10^{-2}kg/m. If the source can deliver a maximum power of 90 W and the string is under a tension of 100 N, then the highest frequency at which the source can operate it, is (take $\pi^2 = 10$)

a) 45.3 Hz b) 50 Hz c) 30 Hz d) 62.3 Hz

92. The driver of a car approaching a vertical wall notices that the frequency of the horn of his car changes from 400 Hz to 450 Hz after being reflected from the wall. Assuming speed of sound to be 340 m/s, the speed of approach of car towards the wall is

a) 10 m/s b) 20 m/s c) 30 m/s d) 40 m/s

93. What percentage change in the tension is necessary in a sonometer of fixed length to produce a note one octave lower (half of original frequency) than before

a) 25% b) 50% c) 67% d) 75%

94. A transverse wave on a string has an amplitude of 0.2 m and a frequency of 175 Hz. Consider a particle of the string at $x = 0$. It beings with a displacement $y = 0$, at $t = 0$, according to equation $y = 0.2\sin(kx \pm \omega t$. How much time passes between the first two instant when this particle has a displacement of y=*0.1* m?

a) 1.9 ms b) 3.9 ms c) 2.4 ms d) 0.5 ms

95. A particle executes simple harmonic motion with a frequency f. The frequency with which its kinetic energy oscillates is

a) $f/2$ b) f c) $2f$ d) $4f$

96. The pressure variation that corresponds to pain threshold (i.e., the ear can tolerate in loud sound) is about 30 Pa. Velocity of sound in water is $\sqrt{2} \times 10^3$ m/s. The intensity of sound wave produced in water corresponding to loud sound is

a) 1 W/m^2 b) 0.3×10^{-3} W/m^2 c) 10^3 W/m^2 d) 10^{-12} W/m^2

97. A sufficiently long closed organ pipe has a small hole at its bottom. Initially, the pipe is empty. Water is poured into the pipe at a constant rate. The fundamental frequency of the air column in the pipe

a) Continuously increases

b) First increases and then becomes constant

c) Continuously decreases

d) First decreases and then becomes constant

98. There is a set of four tuning forks, one with the lowest frequency vibrating at 550 Hz. By using any two tuning forks at a time, the following beat frequencies are heard: 1, 2, 3, 5, 7, 8. The possible frequencies of the other three forks are

a) 552, 553, 560 b) 557, 558, 560 c) 552, 553, 558 d) 551, 553, 558

99. A 40 dB sound wave strikes an eardrum whose area is 10^{-6}m^2. To receive a total energy of 1 J, time received is ($I_0 = 10^{-2}$ W/m^2)

a) 10^{-8}s b) 10^{10}s c) 10^{6}s d) 10^{14}s

100. A source of sound attached to the bob of a simple pendulum execute SHM. The difference between the apparent frequency of sound as received by an observer during its approach and recession at the mean position of the SHM motion is 2% of the natural frequency of the source. The velocity of the source at the mean position is (velocity of sound in the air is 340 m/s)
[Assume velocity of sound source<< velocity of sound in air]

a) 1.4 m/s b) 3.4 m/s c) 1.7 m/s d) 2.1 m/s

101. When the string of a sonometer of length L between the bridges viabrates in the first overtone, the amplitude of vibration in the first overtone, the amplitude of vibration is maximum at

a) $L/2$ b) $(L/4)$ and $(3L/4)$
c) $(L/6)$, $(3L/6)$ and $(5L/6)$ d) $\frac{L}{8}, \frac{3L}{8}, \frac{5L}{8}, \frac{7L}{8}$

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

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

103. Two identical straight wires are stretched so as to produce 6 beats/s when vibrating simultaneously. On changing the tension slightly in one of them, the beats frequency remains unchanged. If T_1 and T_2 are initial tensions in strings such that $T_1 > T_2$ then it may be said while making above changes in tension:

a) T_2 was decreased b) T_1 was increased
c) Both T_1 and T_2 were increased d) Either T_2 was increased or T_1 was decreased

104. An observer moves towards a stationary source of sound with a speed (1/5)th of the speed of sound. The wavelength and frequency of the source emitted are λ and f, respectively. The apparent frequency and wavelength recorded by the observer are, respectively,

a) $1.2f$ and λ b) f and 1.2λ c) $0.8f$ and 0.8λ d) $1.2f$ and 1.2λ

105. Two canoes are 10 m apart in a lake. Each bobs up and down with a period of 4.0 s. When one canoe is at its highest point, the other canoe is at its lowest point. Both canoes are always within a single cycle of the waves. Determine the speed of the wave

a) 2.5 m/s b) 5 m/s c) 40 m/s d) 4 m/s

106. Waves of frequency 1000 Hz are produced in a Kundt's tude. The total distance between 6 successive nodes is 82.5 cm. The speed of sound in the gas filled in the tube is

a) 33 cm/s b) 33 m/s c) 330 m/s d) 660 m/s

107. A wave represented by the equation $y = a\cos(kx - \omega t)$ is superposed with another wave to from a stationery wave such that point $x = 0$ is a node. The equation for the other wave is

a) $a\sin(kx + \omega t)$ b) $a\sin(kx - \omega t)$ c) $-a\cos(kx + \omega t)$ d) $-a\sin(kx - \omega t)$

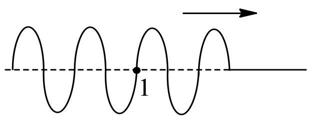
108. Two blocks of masses 40 kg and 20 kg are connected by a wire that has a linear mass density of 1 g/m. These blocks are being pulled across horizontal frictionless floor by a horizontal force F that is applied to 20 kg block. A transverse wave travels on the wave between the blocks with a speed of 400 m/s (relative to the wire). The mass of the wire is negligible compared to the mass of the blocks. The magnitude of F is

a) 160 N b) 240 N c) 320 N d) 400 N

109. The equation for the fundamental standing sound wave in a tube that is closed at both ends if the tube is 80 cm long and speed of the wave is 330 m/s is (assume that amplitude of wave at antinode to be s_0)

a) $y = s_0\cos(3.93\,t)\sin(1295\,x)$ b) $y = s_0\sin(7.86t)\cos(1295\,x)$
c) $y = s_0\cos(7.86\,t)\sin(1295\,x)$ d) $y = s_0\cos(1295\,x)\sin(3.93\,t)$

110. A transverse wave on a string travelling along+ ve x-axis has been shown in the figure below:



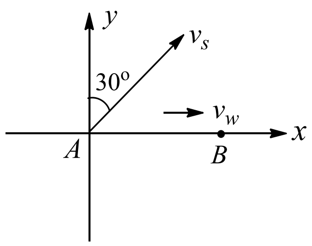
The mathematical form of the shown wave is

$y = (3.0\text{ cm})\sin\left[2\pi \times 0.1t - \frac{2\pi}{100}x\right]$

Where t is in second and x is in centimeters. Find the total distance travelled by the particle at (1) in 10 min 15 s, measured from the instant shown in the figure and direction of its motion at the end of this time

a) 6 cm, in upward direction
b) 6 cm, in downward direction
c) 738 cm, in upward direction
d) 732 cm, in upward direction

111. In the figure shown, a source of sound of frequency 510 Hz moves with constant velocity $v_s = 20$ m/s in the direction shown. The wind is blowing at a constant velocity v_w=20 m/s towards an observer who is at rest at point B. Corresponding to the sound emitted by the source at initial position A, the frequency detected by the observer is equal to (speed of sound relative to air is 330 m/s)



a) 510 Hz
b) 500 Hz
c) 525 Hz
d) 550 Hz

112. The two waves are represented by

$y_1 = 10^{-6}\sin\left(100t + \frac{x}{50} + 0.5\right)$ m

$y_2 = 10^{-2}\cos\left(100t + \frac{x}{50}\right)$ m

Where x is in metres and t in seconds. The phase difference between the waves is approximately:

a) 1.07 rad
b) 2.07 rad
c) 0.5 rad
d) 1.5 rad

113. A string under a tension of 100 N, emitting its fundamental mode, gives 5 beats/s with a tuning fork. When the tension is increased to 121 N, again 5 beats/s are heard. The frequency of the fork is

a) 105 Hz
b) 95 Hz
c) 210 Hz
d) 190 Hz

114. The following equations represent progressive transverse waves

$z_1 = A\cos(\omega t - kx)$

$z_1 = A\cos(\omega t + kx)$

$z_3 = A\cos(\omega t + ky)$

$z_4 = A\cos(2\omega t - 2ky)$

A stationery wave will be formed by superposing

a) z_1 and z_2
b) z_1 and z_4
c) z_2 and z_3
d) z_3 and z_4

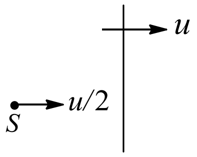
115. A source emitting a sound of frequency f is placed at a large distance from an observer. The source starts moving towards the observer with uniform acceleration 'a'. Find frequency heard by the observer corresponding to the wave emitted just after the source starts. The speed of sound in medium is v

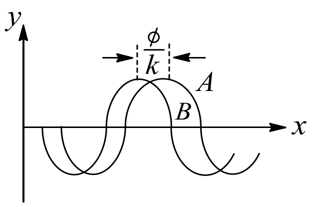
a) $\frac{vf^2}{2vf - a}$
b) $\frac{2vf^2}{2vf + a}$
c) $\frac{2vf^2}{3vf - a}$
d) $\frac{2vf^2}{2vf - a}$

116. A point source of sound is placed in a non-absorbing medium. Two points A and B are at the distance of 1 m and 2 m respectively, from the source. The ratio of amplitudes of waves at A to B is

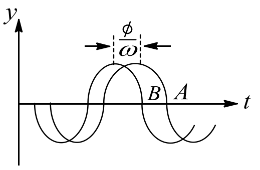
a) 1:1
b) 1:4
c) 1:2
d) 2:1

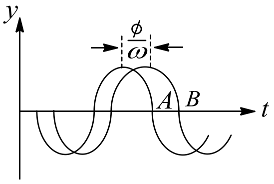
117. A plane longitudinal wave a angular frequency 10^3 rad/s is travelling along negative x-direction in a homogenous gaseous medium of density $\rho = 1\text{ kg/m}^3$. Intensity of the wave is $I = 10^{-10}\text{W/m}^2$ and maximum pressure change is $(\Delta P)_m = 2 \times 10^{-4}\text{ N/m}^2$. Assuming at $x = 0$, initial phase of medium particles to be $\pi/2$, the equation of the wave is

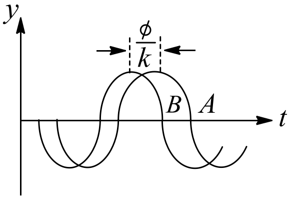
a) $y = 10^{-9} \sin\left(1000t - 5x + \frac{x}{2}\right)$
b) $y = 10^{-9} \cos(1000t + 5x)$
c) $y = 10^{-9} \tan(1000t - 5x)$
d) $y = 10^{-9} \cos(1000t - 5x)$
118. A wall is moving with velocity u and a source of sound moves with velocity $u/2$ in the same direction as shown in the figure. Assuming that the sound travels with velocity $10u$, the ratio of incident sound wavelength on the wall to the reflected sound wavelength by the wall is equal to


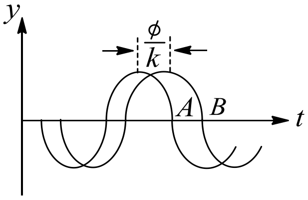
a) 9:11 b) 11:9 c) 4:5 d) 5:4
119. A string of length 0.4 m and mass 10^2 kg is tightly clamped at its ends. The tension in the string is 1.6 N. Identical wave pulse is produced at one end at equal intervals of time, Δt. The minimum value of Δt which allows constructive interface between successive pulse is
a) 0.05 s b) 0.10 s c) 0.20 s d) 0.40 s
120. A standing wave can be produced by combining
a) Two longitudinal travelling waves
b) Two transverse travelling waves
c) Two sinusoidal travelling waves travelling in opposite directions
d) All of the above
121. An air column in a pipe which is closed at one end will be in resonance with a vibrating tuning fork of frequency 264 Hz. The length of the air column in cm is (velocity of sound in air =330 m/s)
a) 31.25 b) 62.5 c) 93.75 d) 25
122. The displacement y of a particle executing periodic motion is given by
$y = 4\cos^2 \frac{t}{2} \sin 1000t$
How many independent harmonic motions may be considered to superpose to result this expression:
a) Two b) Three c) Four d) Five
123. The ratio of intensities between two coherent sound sources is 4:1. The difference of loudness in decibels (dB) between maximum and minimum intensities when they interfere in space is
a) $10 \log(2)$ b) $20 \log(3)$ c) $10 \log(3)$ d) $20 \log(2)$
124. If the sound waves produced by the tuning fork can be expressed as $y = 0.2$ (cm) $\sin(kx - \omega t)$, where $K = 2\pi/\lambda$ and $\omega = 2\pi f (f = 512$ Hz), maximum value of amplitude in a beat will be
a) 0.4 cm b) 0.6 cm c) 0.8 cm d) 0.2 cm
125. A particle executes simple harmonic motion between $x = -A$ and $x = +A$. The time taken for it to go from 0 to $A/2$ is T_1 and go from $A/2$ to A is T_2. Then
a) $T_1 < T_2$ b) $T_1 > T_2$ c) $T_1 = T_2$ d) $T_1 = 2T_2$
126. Adjoining figure shows the snapshot of two waves A and B at any time t. The equation for A is $y = A\sin(kx - \omega t - \phi)$, and for B it is $y = A\sin(kx - \omega t)$. It is clearly shown in the figure that wave A is ahead of B by a distance ϕ/k


The motion of a single point in time, i.e., y versus t for two waves is best represented by

a) 

b) 

c) 

d) 

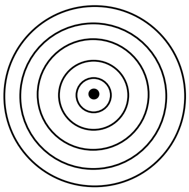
127. Two tuning forks A and B give 4 beats/s when sounded together. The frequency of A is 320 Hz. When some wax is added to B and it is sounded with A, 4 beats/s per second are again heard. The frequency of B is

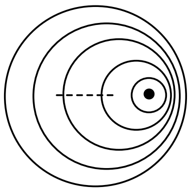
a) 312 Hz b) 316 Hz c) 324 Hz d) 328 Hz

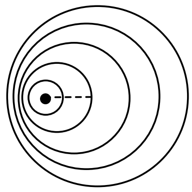
128. A harmonic wave is travelling on a stretched string. At any particular instant, the smallest distance between two particles having same displacement, equal to half of amplitude is 8 cm. Find the smallest separation between two particular which have same value of displacement (magnitude only) equal to half of amplitude

a) 8 cm b) 24 cm c) 12 cm d) 4 cm

129. If the source is moving towards right, wavefront of sound waves get modified to

a) 

b) 

c) 

d) None of these

130. Two waves are passing through a region in the same direction at the same time. If the equation of these waves are

$y_1 = a \sin \frac{2\pi}{\lambda}(vt - x)$

and $y_2 = b \sin \frac{2\pi}{\lambda}[(vt - x) + x_0]$

Then the amplitude of the resulting wave for $x_0 = (\lambda/2)$ is

a) $|a - b|$ b) $a + b$ c) $\sqrt{a^2 + b^2}$ d) $\sqrt{a^2 + b^2 + 2ab \cos x}$

131. A simple harmonic progressive wave is represented by the equation $y = 8 \sin 2\pi(0.1x = 2t)$ where x and y are in centimeters and t is in seconds. At any instant the phase difference between two particles separated by 2.0 cm along the x- direction is

a) 18° b) 36° c) 54° d) 72°

132. A stationary source is emitted sound at a fixed frequencyf_0, which is reflected by two cars approaching the source. The difference between the is frequencies of sound reflected from the car is 1.2% of f_0. What is the difference in the speed of the cars (in km per hour) to the nearest integer? The cars are moving at constant speeds much smaller than the speed of sound which is $330ms^{-1}$

a) 7.128 km/h b) 7 km/h c) 8.128 km/h d) 9 km/h

133. Equations of a stationery and a travelling waves are as follows $y_1 = \sin kx \cos \omega t$ and $y_2 = a \sin(\omega t - kx)$.The phase difference between two points $x1=\pi/3k$ and $x2=3\pi/2k$ is $\phi 1$ in the standing wave $(y1)$ and is ϕ_2 in travelling wave (y_2) then ratio ϕ_1/ϕ_2 is

a) 1 b) 5/6 c) 3/4 d) 6/7

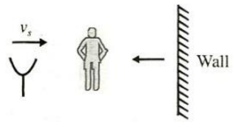
134. A sounding tuning fork whose frequency is 256 Hz is held over an empty measuring cylinder. The sound is faint, but if just the right amount of water is poured into the cylinder, it becomes loud. If the optimal amount of water produce an air column of length 0.31 m, then the speed of sound in air to a first approximation is

a) 317 m/s b) 371 m/s c) 340 m/s d) 332 m/s

135. Two vibrating strings of the same material but length L and $2L$ have radii $2r$ and r, respectively. They are stretched under the same tension. Both the strings vibrate in their fundamental modes, the one of length L with frequency n_1 and the other with frequency n_2. The ratio n_1/n_2 is given by

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

136. A tuning fork of frequency 380 Hz is moving towards a wall with a velocity of 4 m/s. then the number of beats heard by a stationery listener between direct and reflected sounds will be (velocity of sounds in air is 340 m/s)



a) 0 b) 5 c) 7 d) 10

137. Consider a wave represented by $y = a\cos^2(\omega t - kx)$ where symbols have their usual meanings. This wave has

a) An amplitude a, frequency ω, and wavelength λ
b) An amplitude a, frequency 2ω, and wavelength 2λ
c) An amplitude $a/2$, frequency 2ω, and wavelength $\lambda/2$
d) An amplitude $a/2$, frequency 2ω, and wavelength λ

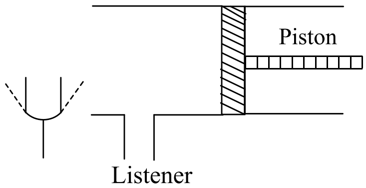
138. A whistle giving out 450 Hz approaches a stationery observer at a speed of 33 m/s. The frequency heard by the observer in Hz is (speed sound=330 m/s)

a) 409 b) 429 c) 517 d) 500

139. A point source is emitting sound in all directions. The ratio of distance of two points from the point source where the difference in loudness levels is 3 dB is ($\log_e 2 = 0.3$)

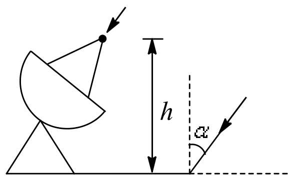
a) $\frac{1}{2}$ b) $\frac{1}{\sqrt{2}}$ c) $\frac{1}{4}$ d) $\frac{2}{3}$

140. A long cylindrical tube carries a highly polished piston and has a side opening. A tuning fork of frequency n is sounded at the open end of the tube. The intensity of the sound heard by the listener changes if the piston is moved in or out. At a particular position of the piston he hears a maximum sound. When the piston is moved through a distance of 9 cm, the intensity of sound becomes minimum. If the speed of sound is 360 m/s, the value of n is



a) 129.6 Hz b) 500 Hz c) 1000 Hz d) 2000 Hz

141. Radio waves coming at angle α to vertical are received by a ladder after reflection from a nearby water surface and also directly. What can be height of antenna from water surface so that it records a maximum intensity (a maxima)(wavelength = λ)



a) $\frac{\lambda}{2\cos\alpha}$ b) $\frac{\lambda}{2\sin\alpha}$ c) $\frac{\lambda}{4\sin\alpha}$ d) $\frac{\lambda}{4\cos\alpha}$

142. Two organ pipes, both closed at one end, have lengths l and $l + \Delta l$. Neglect end correction. If the velocity of sound in air is V, then the number of beats l s is

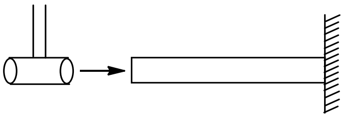
a) $\frac{V}{4l}$ b) $\frac{V}{2l}$ c) $\frac{V}{4l^2}\Delta l$ d) $\frac{V}{2l^2}\Delta l$

143. The path difference between the two waves

$y_1 = a_1 \sin\left(\omega t - \frac{2\pi x}{\lambda}\right)$ and $y_2 = a_2 \cos\left(\omega t - \frac{2\pi x}{\lambda} + \phi\right)$ is

a) $\frac{\lambda}{2\pi}\phi$ b) $\frac{\lambda}{2\pi}\left(\phi+\frac{\pi}{2}\right)$ c) $\frac{2\pi}{\lambda}\left(\phi-\frac{\pi}{2}\right)$ d) $\frac{2\pi}{\lambda}(\phi)$

144. A 100-m long rod of density 10.0×10^4 kg/m^3 and having Young's modulus $Y = 10^{11}$ Pa, is clamped at one end. It is hammered at the other free end. The longitudinal pulse goes to right end, gets reflected and again returns to the left end. How much time the pulse take to go back to initial point



a) 0.1 s b) 0.2 s c) 0.3 s d) 2 s

145. A band playing music at frequency f is moving towards a wall at a speed v_b . A motorist is following the band with a speed v_m. If v is the speed of sound, the expression for the beat frequency heard by the motorist is

a) $\frac{v+v_m}{v+v_b}f$ b) $\frac{v+v_m}{v-v_b}f$ c) $\frac{2v_b(v+v_m)}{v^2-v_b^2}f$ d) $\frac{2v_m(v+v_b)}{v^2-v_m^2}f$

146. An open and a closed pipe have same length. The ratio of frequency of their nth overtone is

a) $\frac{n+1}{2n+1}$ b) $\frac{2(n+1)}{2n+1}$ c) $\frac{n}{2n+1}$ d) $\frac{n+1}{2n}$

147. A point source of sound is placed in a non-absorbing medium. Two point A and B are at the distance of 1 m and 2 m. respectively, from the source. The ratio of amplitude of waves at A to B is

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

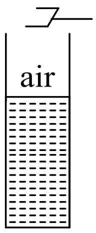
148. A source of sound S is moving with a velocity 50 m/s towards a stationery observer. He measures the frequency of the source as 1000 Hz. What will be the apparent frequency of the sound when it is moving away from the observer after crossing him? The velocity of the sound in the medium is 350 m/s

a) 750 Hz b) 857 Hz c) 1143 Hz d) 1333Hz

149. A source of sound is travelling with a velocity of 30 m/s towards a stationery observer. If actual frequency of source is 1000 Hz and the wind is blowing with velocity 20 m/s in a direction at 60° with the direction of motion of source, then the apparent frequency heard by observer is (speed of sound is 340 m/s)

a) 1011 Hz b) 1000 Hz c) 1094 Hz d) 1086 Hz

150. A resonance occurs with a tuning fork and an air column of size 12 cm. The next higher resonance occurs with an air column of 38 cm. What is the frequency of the tuning fork? Assume that the speed of sound is 312 m/s



a) 500 Hz b) 550 Hz c) 600 Hz d) 650 Hz

151. When beats are produced by two progressive waves of nearly the same frequency, which one of the following is correct?

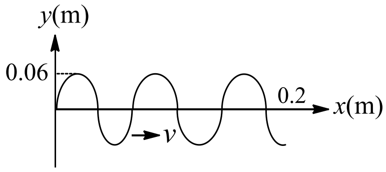
a) The particle vibrate simple harmonically, with the frequency equal to the difference in the component frequencies
b) The amplitude of vibration at any point changes simple harmonically with a frequency equal to the difference in the frequencies of the two waves
c) The frequency of beats depends upon the position, where the observer is
d) The frequency of beats changes as the time progresses

152. Two open pipes A and B are sounded together such that beats are heard between the first overtone of A and second overtone of B. If the fundamental frequency of A and B is 256 Hz and 170 Hz respectively, then the beat frequency heard is

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

153. For the wave shown in figure, write the equation of this wave if its position is shown at t=0. Speed of wave

is v=300 m/s.



a) $y = (0.06 \text{ m}) \cos[78.5 \text{ m}^{-1})x + (23562 \text{ s}^{-1})t]\text{m}$
b) $y = (0.06 \text{ m}) \sin[78.5 \text{ m}^{-1})x - (23562 \text{ s}^{-1})t]\text{m}$
c) $y = (0.06 \text{ m}) \sin[78.5 \text{ m}^{-1})x + (23562 \text{ s}^{-1})t]\text{m}$
d) $y = (0.06 \text{ m}) \cos[78.5 \text{ m}^{-1})x - (28562 \text{ s}^{-1})t]\text{m}$

154. A glass tube to length 1.5 m is filled completely with water; the water can be drained out slowly at the bottom of the tube. Find the total number of resonance obtained, when a tuning fork of frequency 606 Hz is put at the upper open end of the tube. Take velocity of sound is air = 340 m/s
a) 2 b) 3 c) 4 d) 5

155. The equation of a transverse wave travelling on a rope is given by $y = 10 \sin \pi(0.01x - 2.00t)$ where y and x are in centimeters and t in seconds. The maximum transverse speed of a particle in the rope is about
a) 63 cm/s b) 75 cm/s c) 100 cm/s d) 121 cm/s

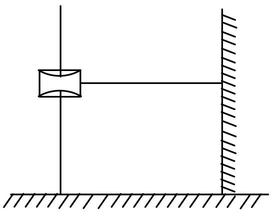
156. An ideal organ pipe resonates at successive frequencies of 50 Hz, 150Hz, 250 Hz, etc. (speed of sound=340 m/s. The pipe is
a) Open at both ends and of length 3.4 m
b) Open at both ends and of length 6.8 m
c) Closed at one end, open at the other, and of length 1.7 m
d) Closed at one end, open at the other, and of length 3.4 m

157. Five sinusoidal waves have the same frequency 500 Hz but their amplitudes are in the ratio $2: 1/2: 1/2: 1: 1$ and their phase angles $0, \pi/6, \pi/3, \pi/2$ and π, respectively. The phase angle of resultant wave obtained by the superposition of these five waves is
a) 30°
b) 45°
c) 60°
d) 90°

158. A man standing in front of a mountain at a certain distance beats a drum at regular intervals. The drumming rate is gradually increased and he finds that the echo is not heard distinctly when the rate becomes 40 per minute. He then moves nearer to the mountain by 90 m and finds that the echo is again not heard when the drumming rate becomes 60 per minute.
i. The distance between the mountain and the initial position of the man is
a) 330 m b) 300 m c) 240 m d) 270 m

159. A student is performing the experiment of Resonance Column. The diameter of the column tube is $4cm$. The frequency of the tuning fork is $512Hz$. The air temperature is 38°C in which the speed of sound is $336m/s$. The zero of the meter scale coincides with the top end of the Resonance column tube. When the first resonance occurs, the reading of the water level in the column is
a) 14.0 cm b) 15.2 cm c) 16.4 cm d) 17.6 cm

160. One end of a 2.4-m string is held fixed and the other end is attached to a weightless ring that can slide long a frictionless rod as shown in figure. The three longest possible wavelength for standing waves in this string are respectively



a) 4.8 m, 1.6 m and 0.96 m b) 9.6 m, 3.2 m and 1.92m

c) 2.4 m. 0.8 m and 0.48 m d) 1.2 m, 0.4 m and 0.24 m

161. A source of sound of frequency 600 Hz is placed inside water. The speed of sound in water is 1500 ms^{-1} and in air it is300 ms^{-1}. The frequency of sound recorded by an observer who is standing in air is

a) 200 Hz b) 300 Hz c) 120 Hz d) 600 Hz

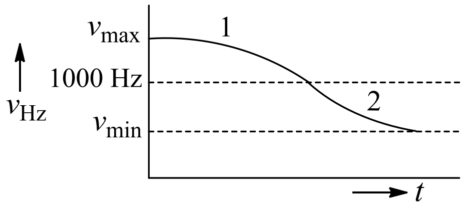
162. An open pipe is in resonance in 2nd harmonic with frequency v_1 Now one end of the tube is closed and frequency is increased to v_2 such that the resonance again occurs in nth harmonic. Choose the correct option.

a) $n = 3, v_2 = \frac{3}{4}$v_1 b) $n = 3, v_2 - \frac{5}{4} v_1$ c) $n = 5, v_2 = \frac{5}{4} v_1$ d) $n = 5, v_2 = \frac{3}{4} v_1$

163. The breaking stress of steel is 7.85×10^8 N/m^2 and density of steel is 7.7×10^3 kg/m^3. The maximum frequency to which a string 1 m long can be tuned is

a) 15.8 Hz b) 158 Hz c) 47.4 Hz d) 474 Hz

164. A stationery observer receives a sound from a sound of frequency v_0 moving with a constant $v_s = 30$ m/s. The apparent frequency varies with time as shown in figure. Velocity of sound $v = 300$ m/s. Then which of the following is incorrect?



a) The minimum value of apparent frequency is 889 Hz

b) The natural frequency of source is 1000 Hz

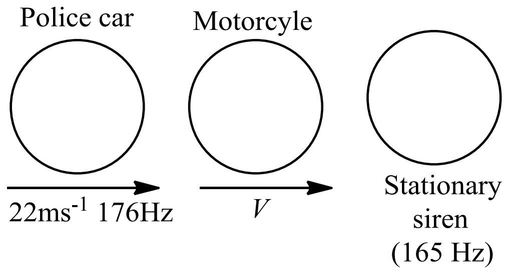
c) The frequency- time curve corresponds to a source moving at an angle to the stationery observer

d) The maximum value of apparent frequency is 1111 Hz

165. When a sound wave is reflected from a wall, the phase difference between the reflected and incident pressure wave is

a) 0 b) π c) $\pi/2$ d) $\pi/4$

166. A police car moving at22 ms^{-1}, changes a motorcyclist. The police man sounds his horn at 176 Hz, while both of them move towards a stationary siren of frequency 165 Hz. Calculate the speed of the motorcycle, if it is given that he does not observe any beats.



a) 33ms^{-1} b) 22 ms^{-1} c) Zero d) 11ms^{-1}

167. 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

a) $f/2$ b) $3f/4$ c) f d) $2f$

168. A train has just completed a U-curve in a track which is a semi-circle. The engine is at the forward end of the semi-circular part of the track while the last carriage is at the rear end of the semi-circular track. The driver blows a whistle of frequency 200 Hz. Velocity of sound is 340 m/s. Then the apparent frequency as observed by a passenger in the middle of the train, when the speed of the train is 30 m/s, is

a) 219 Hz b) 188 Hz c) 200Hz d) 181 Hz

169. A wave of frequency 100 Hz travels along a string towards its fixed end. When this wave travels back after reflection, a node is formed at a distance of 10 cm from the fixed end. The speed of the wave (incident and reflected) is

a) 5 m/s b) 10 m/s c) 20 m/s d) 40 m/s

170. Two instruments having stretched strings are being played in unison. When the tension in one of the instruments is increases by 1%, 3 beats are produced in 2 s. The initial frequency of vibration of each wire is

a) 600 Hz b) 300 Hz c) 200 Hz d) 150 Hz

171. A standing wave on a string is given by $y =$(4 cm) cos $[x\pi]$ sin$[50\pi t]$, where x is in metres and t is in seconds. The velocity of the strings section at $x = 1/3$ m at $t = 1/5$s is

a) Zero b) π m/s c) 840π m/s d) None of these

172. A source of sound emits 200p W power which is uniformly distributed over a sphere of radius 10 m. What is the loudness of sound on the surface of the sphere?

a) 70 dB b) 107 dB c) 80 dB d) 117 dB

173. A particle free to move along the x-axis has potential energy given by $U(x) = k\,[1 - \exp(-x^2)]$ for $-\infty \le x \le +\infty$, where k is a positive constant of appropriate dimension. Then

a) At points away from the origin, the particle is in unstable equilibrium

b) For any finite non-zero value of x, there is a force directed away from the origin

c) If its total mechanical energy is $k/2$, it has its minimum kinetic energy at the origin

d) For small displacements from $x = 0$, the motion is simple harmonic

174. If v_1, v_2 and v_3 are the fundamental frequencies of three segments of stretched string, then the fundamental frequency of the overall string is

a) $v_1 + v_2 + v_3$ b) $\left[\frac{1}{V_1} + \frac{1}{V_2} + \frac{1}{V_3}\right]^{-1}$ c) $v_1\, v_2 v_3$ d) $[v_1 v_2 v_3]^{1/3}$

175. Two sound sources are moving in opposite directions with velocities v_1 and v_2 $(v_1 > v_2)$. Both are moving away from a stationery observer. The frequency of both the sources is 900 Hz. What is the value of $v_1 - v_2$ so that the beat frequency observed by the observer is 6 Hz? Speed of sound v =300 m/s. Given that v_1 and $v_2 \ll v$

a) 1 m/s b) 2 m/s c) 3 m/s d) 4 m/s

176. One end of a long metallic wire of length L is tied to the ceiling. The other end is tied to a massless spring of spring constant K. A mass m hangs freely from the free end of the spring. The area of cross-section and the Young's modules of the wire are A and Y, respectively. If the mass is slightly pulled down and released, it will oscillate with a time period T equal to:

a) $2\pi(m/K)^{1/2}$ b) $2\pi\sqrt{\frac{m(YA+KL)}{YAK}}$ c) $2\pi[(mYA/KL)]^{1/2}$ d) $2\pi[(mL/YA)]^{1/2}$

177. Small amplitude progressive wave in a stretched string has a speed of 100 cm/s, and frequency 100 Hz. The phase difference between two points 2.75 cm apart on the string, in radius, is

a) 0 b) $11\pi/2$ c) $\pi/4$ d) $3\pi/8$

178. The frequency of a radar is 780 MHz. After getting reflected from an approaching aeroplane, the apparent frequency is more than the actual frequency by 2.6 kHz. The aeroplane has a speed of

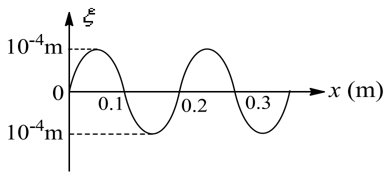
a) 2 km/s b) 1 km/s c) 0.5 km/s d) 0.25 km/s

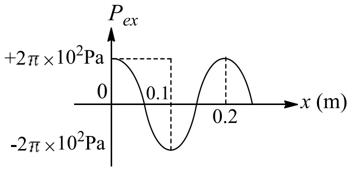
179. In a resonance column experiment, the first resonance is obtained when the level of the water in the tube is at 20 cm from the open end. Resonance will also be obtained when the water level is at a distance of

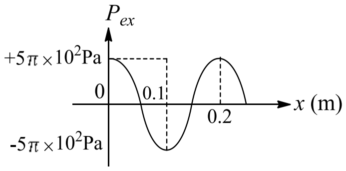
a) 40 cm from the open end b) 60 cm from the open end

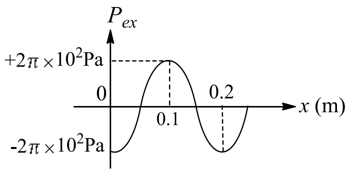
c) 80 cm from the open end d) 100 cm from the open end

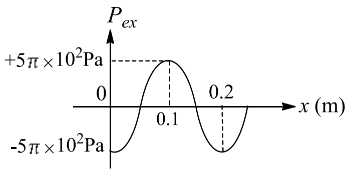
180. For a sound wave travelling towards $+x$ direction sinusoidal longitudinal displacement ξ at a certain time is given as a function of x. If bulk modulus of air is $B = 5 \times 10^5$ N/m^2, the variation of pressure excess will be



a) 

b) 

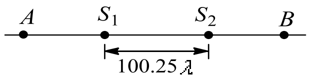
c) 

d) 

181. The intensity of a sound wave gets reduced by 20% on passing through a slab. The reduction in intensity on passage through two such consecutive slabs is

a) 40% b) 36% c) 30% d) 50%

182. S_1 and S_2 are two coherent current sources of radiation separated by distance 100.25λ where λ is the wavelength of radiation S_1 leads S_2 in phase by $\pi/2$. A and B are two points on the line joining S_1 and S_2. The ratio of amplitude of sources S_1 and S_2 is in ratio 1:2. The ratio of intensity at A to that at $B(I_A/I_B)$ is



a) ¥ b) $\frac{1}{9}$ c) 0 d) 9

183. A closed organ pipe has a frequency 'n' .If its length is doubled and radius is halved, its frequency nearly becomes

a) Halved b) Doubled c) Trebled d) Quadrupled

184. A highly rigid cubical block A of small mass M and side L is fixed rigidly on to another cubical block B of the same diamensions and of low modules of rigidity η such that the lower face of A completely covers the upper face of B. The lower face of B is rigidly held on a horizontal surface. A small force is applied perpendicular to the side faces of A. After the force is withdrawn, block A executes small oscillations the time period of which is given by

a) $2\pi\sqrt{M\eta L}$ b) $2\pi\sqrt{\frac{M-\eta}{L}}$ c) $2\pi\sqrt{\frac{M-L}{\eta}}$ d) $2\pi\sqrt{\frac{M-N}{\eta L}}$

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

a) 1 kg b) 2 kg c) 8 kg d) 16 kg

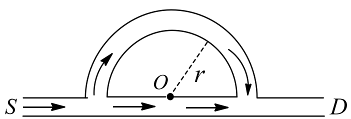
186. A metal rod 40 cm long is dropped on to a wooden floor and rebounds into air. Compressional waves of many frequencies are thereby set up in the rod. If the speed of compressional waves in the rod in 5500 m/s, what is the lowest frequency of compressional waves to which the rod resonates as it rebounds?

a) 675 Hz b) 6875 Hz c) 16875 Hz d) 0 Hz

187. An observer moves towards a stationery source of sound with a velocity one-fifth of the velocity of sound. What is the percentage increase in the apparent frequency?

a) 5% b) 20% c) 0% d) 0.5%

188. A sound wave of wavelength 0.40 m enters the tube at S. The smallest radius r of the circular segment to hear minimum at detector D must be



a) 1.75 m b) 0.175 m c) 0.93 m d) 9.3 m

189. A travelling wave in a stretched string is described by the equation $y = A\sin(kx - \omega t)$. The maximum particle velocity is

a) $A\omega$ b) ω/k c) $d\omega/dk$ d) x/t

190. A wire of length 'l' having tension T and radius 'r' vibrates with fundamental frequency 'f'. Another wire of

the same metal with length '$2l$' having tension $2T$ and radius $2r$ will vibrate with fundamental frequency:

a) f b) $2f$ c) $\frac{f}{2\sqrt{2}}$ d) $\frac{f}{2}\sqrt{2}$

191. Under similar conditions of temperature and pressure, which of the following gases will have the largest velocity of sound

a) H_2 b) N_2 c) He d) CO_2

192. A chord attached about an end to a vibrating fork divides it into 6 loops, when its tension is 36 N. The tension at which it will vibrate in 4 loops is

a) 24 N b) 36 N c) 64 N d) 814 N

193. Two sources A and B are sounding notes of frequency 680 Hz. A listener moves from A and B with a constant velocity u. If the speed of sound is 340 m/s what must be the value of u so that he hears 10 beats per second?

a) 2.0 m/s b) 2.5 m/s c) 30 m/s d) 3.5 m/s

194. When a person wears a hearing aid, the sound intensity level increases by 30 dB. The sound intensity increases by

a) e^3 b) 10^3 c) 30 d) 10^2

195. In a resonance tube experiment, the first two resonances are observed at length 10.5 cm and 29.5 cm. The third resonance is observed at the length…………cm

a) 47.5 b) 58.5 c) 48.5 d) 82.8

196. A stretched wire of same length under a tension is vibrating with its fundamental frequency. Its length is decreased by 45% and tension is increased by 21%. Now fundamental frequency

a) Increases by 50% b) Increases by 100% c) Decreases by 50% d) Decreases by 25%

197. Mark out the correct statement(s) regarding standing waves

a) Standing waves appear to be stationery but transfer of energy from one particle to another continues to take place

b) A standing wave not only appears to be stationary but net transfer of energy from one particle to the other is also equal to zero

c) A standing wave does not appear to be stationery and net transfer of energy from one particle to the other is also non-zero

d) A standing wave does not appear to be stationery, but net transfer of energy from one particle to the other is zero

198. n waves are produced on a string in 1 s. When the radius of the string is doubled and the tension is maintained the same, the number of waves produced in 1 s for the same harmonic will be

a) $2n$ b) $\frac{n}{3}$ c) $\frac{n}{2}$ d) $\frac{n}{\sqrt{2}}$

199. If a string fixed at both ends having fundamental frequency of 240 Hz is vibrated with the help of a tuning fork having frequency 280 Hz, then the

a) String will vibrate with a frequency of 240 Hz

b) String will be in resonance with the tuning fork

c) String will vibrate with the frequency of tuning fork, but resonance condition will not be achieved

d) String will vibrate with a frequency of 260 Hz

200. A string is under tension so that its length is increased by $1/n$ times its original length. The ratio of fundamental frequency of longitudinal vibrations and transverse vibrations will be

a) $1: n$ b) $n^2: 1$ c) $\sqrt{n}: 1$ d) $n: 1$

201. The minimum intensity of audibility of sound is 10^{-12} W/m^{2}s and density of air= 1.293 kg/m^2. If the frequency of sound in 1000 Hz, then the corresponding amplitude of the vibration of the air particles is [Take velocity of sound=332 m/s]

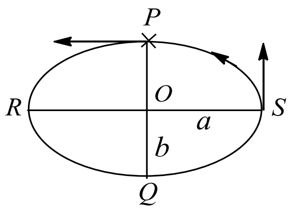
a) 1.1×10^{-7}m b) 1.1×10^{-9}m c) 1.1×10^{-11}m d) 1.1×10^{-14} m

202. Let the two waves $y_1 = A\sin(kx - \omega t)$ and $y_2 = A\sin(kx + \omega t)$ form a standing wave on a string. Now if an additional phase difference of ϕ is created between two waves, then

a) The standing wave will have a different frequency

b) The standing wave will have a different amplitude for a given point
c) The spacing between two consecutive nodes will change
d) None of the above

203. A train is moving in an elliptical orbit in anticlockwise sense with a speed of 110 m/s. Guard is also moving in the given direction with same speed as that of train. The ratio of the length of major and minor axis is 4/3. Driver blows a whistle of 1900 Hz at P, which is received by guard at S. The frequency received by guard is (velocity of sound v =330 m/s)



a) 1900 Hz b) 1800 Hz c) 2000 Hz d) 1500 Hz

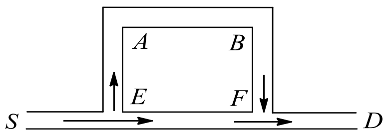
204. Forty-one forks are so arranged that each produces 5 beats/s when sounded with its near fork. If the frequency of last fork is double the frequency of first fork, then the frequencies of the first and last fork, respectively are
a) 200, 400 b) 205, 410 c) 195, 390 d) 100, 200

205. A car emitting sound of frequency 500 Hz speeds towards a fixed wall at 4 m/s. An observer in the car hears both the source frequency as well as the frequency of sound reflected from the wall. If he hears 10 beats per second between the two sounds, the velocity of sound in air will be
a) 330 m/s b) 387 m/s c) 404 m/s d) 340 m/s

206. A cylinder tube open at both ends has a frequency v in air. The tube is dipped vertically in water so that half of it is in water. The fundamental frequency of the air column is now
a) $v/2$ b) v c) $3v/4$ d) $2v$

207. A stretched string of length 1 m fixed at both ends, having a mass of 5×10^{-4} kg is under a tension of 20 N. It is plucked at a point situated at 25 cm from one end. The stretched string would vibrate with a frequency of
a) 400 Hz b) 100 Hz c) 200 Hz d) 256 Hz

208. A sound wave starting from source S, follows two paths $SEFD$ and $SEABFD$. If $AB = l, AE = BF = 0.6\,l$ and wavelength of wave is $\lambda = 11$ m. If maximum sound is heard at D, then minimum value of length l is



a) 11 m b) 6 m c) 2.5 m d) 5 m

209. Which of the following is not true for the progressive wave

$$y = 4 \sin 2\pi \left(\frac{t}{0.02} - \frac{x}{100}\right)$$

Where x and y are in cm and t in seconds
a) The amplitude is 4 cm b) The wavelength is 100 cm
c) The frequency is 50 Hz d) The velocity of propagation is 2 cm/s

210. The difference in the speeds of sound in air at $-5°$C, 60 cm pressure of mercury and 30°C, 75 cm pressure of mercury is (Velocity of sound in air at 0°C is 332 m/s)
a) 15.25 m/s b) 21.35 m/s c) 18.3 m/s d) 3.05 m/s

211. Ten tuning forks are arranged in increasing order of frequency in such a way that any two nearest forks produce 4 beats/s. The highest frequency is twice that of the lowest. Possible lowest and highest frequencies are
a) 40 and 80 b) 50 and 100 c) 22 and 44 d) 36 and 72

212. A long tube at the top is fixed vertically and water level inside the tube can be moved up or down. A vibrating tuning fork is held above the open end and the water level is pushed down gradually so as to get first and second resonance at 24.1 cm and 74.1 cm, respectively below the open end. The diameter of the

tube is

a) 5 cm b) 4 cm c) 3 cm d) 2 cm

213. A string of length 'L' is fixed at both ends. It is vibrating in its 3rd overtone with maximum amplitude 'a'. The amplitude at a distance $L/3$ from one end is

a) a b) 0 c) $\frac{\sqrt{3}a}{2}$ d) $\frac{a}{2}$

214. A sinusoidal wave is generated by moving the end of a string up and down, periodically. The generator must apply the energy at minimum rate when the end of the string attached to generator has …………X and least power when the end of the string attached to generator has………Y. The most suitable option which correctly fills blanks X and Y,is

a) Maximum displacement, least acceleration
b) Maximum displacement, maximum acceleration
c) Least displacement, maximum acceleration
d) Least displacement, least acceleration

215. A motorcycle starts from rest and accelerates along a straight line at 2.2 m/s^2. The speed of sound is 330 m/s. A siren at the starting point remains stationery. When the driver hears the frequency of the siren at 90% of when the motorcycle is stationery, the distance travelled by the motorcyclist is

a) 123.75 m b) 247.5 m c) 495 m d) 990 m

216. A train moves towards a stationary observer with a speed of 34 m/s. The train sounds a whistle and its frequency registered by the observer is f_1. If the train's speed is reduced to 17 m/s, the frequency registered is f_2. If the speed of sound is 340 m/s, then the ratio f_1/f_2 is

a) 18/19 b) 1/2 c) 2 d) 19/18

217. An open organ pipe of length l is sounded together with another open organ pipe of length $l + x$ in their fundamental tones. Speed of sound in air is v. The beat frequency heard will be $(x \ll l)$

a) $\frac{vx}{4l^2}$ b) $\frac{vl^2}{2x}$ c) $\frac{vx}{2l^2}$ d) $\frac{vx^2}{2l}$

218. The displacement of a particle is given by $x = 3\sin(5\pi t) + 4\cos(5\pi t)$. The amplitude of particle is

a) 3 b) 4 c) 5 d) 7

219. An engine running at speed $v/10$ sounds a whistle of frequency 600 Hz. A passenger in a train coming from the opposite side at speed $v/15$ experiences this whistle to be of frequency f. If v is speed of sound in air and there is no wind, f is nearest to

a) 711 Hz b) 630 Hz c) 580Hz d) 510 Hz

220. A man standing on a platform hears the sound of frequency 605 Hz coming from a frequency 550 Hz from a train whistle moving towards the platform. If the velocity of sound is 330 m/s, then what is the speed of train?

a) 30 m/s b) 35 m/s c) 40 m/s d) 45 m/s

221. The equation of a wave travelling on a string is

$$y = 4\sin\frac{\pi}{2}\left(8t - \frac{x}{8}\right)$$

If x and y are in centimeters, then velocity of wave is

a) 64 cm/s in −ve x-direction b) 32 cm/s in −ve x-direction
c) 32 cm/s in +ve x-direction d) 64 cm/s in +ve x-direction

222. A stiff wire is bent into a cylinder loop of diameter D. It is clamped by knife edges at two points opposite to each other. A transverse wave is sent around the loop by means of a small vibrator which acts close to one clamp. The resonance frequency (fundamental mode) of the loop in terms of wave speed v and diameter D is

a) $\frac{v}{D}$ b) $\frac{2v}{\pi D}$ c) $\frac{v}{\pi D}$ d) $\frac{v}{2\pi D}$

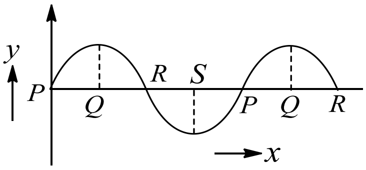
223. The sound from a very high burst of fireworks takes 5 s to arrive at the observer. The burst occurs 1662 m above the observer and travels vertically through two stratifier layers of air, the top one of thickness d_1 at 0°C and the bottom one of thickness d_2 at 20°C. then (assume velocity of sound at 0°C is 330 m/s)

a) $d_1 = 342$ m　　b) $d_2 = 1320$ m　　c) $d_1 = 1485$ m　　d) $d_2 = 342$ m

224. Two identical sounds S_1 and S_2 reach at a point P in phase the resultant loudness at point P is dB higher than the loudness of S_1. The value of n is

a) 2　　b) 4　　c) 5　　d) 6

225. Figure represents the displacement y versus distance x along the direction of propagation of a longitudinal wave. The pressure is maximum of position marked

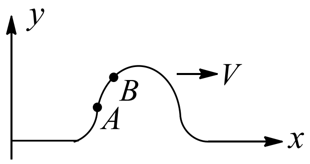


a) P　　b) Q　　c) R　　d) S

226. Speed of sound wave is v. If a reflector moves towards a stationery source emitting waves of frequency f with a speed u, the wavelength of reflected waves will be

a) $\frac{v-u}{v+u}f$　　b) $\frac{v+u}{v}f$　　c) $\frac{v+u}{v-u}f$　　d) $\frac{v-u}{v}f$

227. A wave pulse is generated in a string that lies along x-axis. At the point A and B, as shown in figure, if R_A and R_B are ratios of magnitudes of wave speed to the particle speed, then



a) $R_A > R_B$　　b) $R_B > R_A$

c) $R_B > R_A$　　d) Information is not sufficient

228. A metal bar clamped at its centre resonates in its fundamental mode to produce longitudinal waves of frequency 4 kHz. Now the clamp is moved to one end. If f_1 and f_2 be the frequencies of first overtone and second overtone respectively then,

a) $3f_2 = 5f_1$　　b) $3f_1 = 5f_2$　　c) $f_2 = 2f_1$　　d) $2f_2 = f_1$

229. The equation of displacement of two waves are given as

$y_1 = 10\sin\left(3\pi t + \frac{\pi}{3}\right); y_2 = 5[\sin 3\pi t + \sqrt{3}\cos 3\pi t]$

Then what is the ratio of their amplitudes

a) 1:2　　b) 2:1　　c) 1:1　　d) None of these

230. A hollow pipe of length 0.8m is closed a one end. At its open end a 0.5 m long uniform string is vibrating in its second harmonic and it resonates with the fundamental frequency of the pipe. If the tension in the wire is 50N and the speed of sound 320 ms^{-1}, the mass of the string is

a) 5 g　　b) 10 g　　c) 20 g　　d) 40 g

231. At $t = 0$, the shape of a travelling pulse is given by

$y(x,0) = \frac{4\times10^{-3}}{8-(x)^2}$

Where x and y are in metres. The wave function for the travelling pulse if the velocity of propagation is 5 m/s in the x direction is given by

a) $y(x,t) = \frac{4\times10^{-3}}{8-(x^2-5t)}$

b) $y(x,t) = \frac{4\times10^{-3}}{8-(x-5t)^2}$

c) $y(x,t) = \frac{4\times10^{-3}}{8-(x+5t)^2}$

d) $y(x,t) = \frac{4\times10^{-3}}{8-(x^2+5t)}$

232. A wave represented by the equation $y = a\cos(kx - \omega t)$ is superposed with another wave to form a

stationery wave such that the point $x = 0$ is a made. The equation for the other wave is

a) $a\sin(kx + \omega t)$ b) $-a\cos(kx - \omega t)$ c) $-a\cos(kx + \omega t)$ d) $-a\sin(kx - \omega t)$

233. A light pointer fixed to one prong of a tuning fork touches a vertical plate. The fork is set vibrating and the plate is allowed to fall freely. If eight oscillations are counted when the plate falls through 10 cm, the frequency of the tuning fork is

a) 360 Hz b) 280 Hz c) 560 Hz d) 56 Hz

234. A string fixed at both ends whose fundamental frequency is 240 Hz is vibrated with the help of a tuning fork having frequency 480 Hz , then

a) The string will vibrate with a frequency of 240 Hz
b) The string will vibrate in resonance with the tuning fork
c) The string will vibrate with a frequency of 480 Hz, but is not a resonance with the tuning fork
d) The string is in resonance with the tuning fork and hence vibrate with a frequency of 240 Hz

235. A plane sound wave is travelling in a medium .In reference to a frame A, its equation is $y = a\cos(\omega t - kx)$. Which reference to a frame B, moving with a constant velocity v in the direction of propagation of the wave, equation of the wave will be

a) $y = a\cos[(\omega t + kv)t - kx]$
b) $y = -a\cos[(\omega t - kv)t - kx]$
c) $y = a\cos[(\omega t - kv)t - kx]$
d) $y = a\cos[(\omega t + kv)t + kx]$

236. The amplitude of a wave disturbance propagating in the positive y- direction is given by
$y = \frac{1}{1+x^2}$ at $t = 0$ and $y = \frac{1}{[1+(x-1)^2]}$ at $t = 2$ s
The wave speed is

a) 1 m/s b) 1.5 m/s c) 0.5 m/s d) 2 m/s

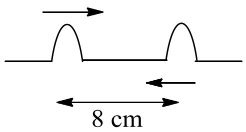
237. In a medium in which a transverse progressive wave is travelling, the phase difference between two points with a separation of 1.25 cm is $(\pi/4)$. If the frequency of wave is 1000 Hz. Its velocity will be

a) 10^4m/s b) 125 m/s c) 100 m/s d) 10 m/s

238. $S_1$and S_2 are two coherent sources of sound separated by 3 m having no initial phase difference. The velocity of sound is 330 m/s. No minima will be formed on the line passing through S_2 and perpendicular to the line joining S_1 and S_2, if the frequency of both the sources is

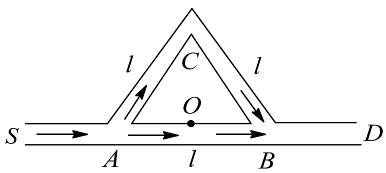
a) 50 Hz b) 60 Hz c) 70 Hz d) 80 Hz

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



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

240. A sound wave starting from source S, follows two paths AOB and ACB to reach the detector D. If ABC is an equilateral triangle, of side l and there is silence at point D, the maximum wavelength (λ) sound wave must be



a) l b) $2l$ c) $3l$ d) $4l$

241. A string of length 0.4 m and mass 10^{-2} kg is clamped at one end. The tension in the string is 1.6 N. The identical wave pulses are generated at the free end after regular interval of time, Δt. The minimum value of Δt, so that a constructive interference takes place between successive pulses is

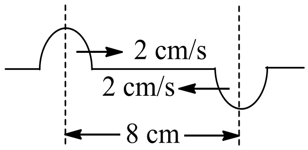
a) 0.1 s

b) 0.05 s
c) 0.2 s
d) Constructive interference cannot take place

242. A water surface is moving at a speed of 15m/s. When he is surfing in the direction of wave, he swings upwards every 0.8 s because of wave crests. While surfing in opposite direction to that of wave motion, he swing upwards every 0.6 s. Determine the wavelength of transverse component of the water wave

a) 15 m b) 10.3 m
c) 12.6 m d) Information insufficient

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



a) Zero b) Purely kinetic
c) Purely potential d) Party kinetic and partly potential

244. Two sounding bodies producing progressive waves are given by
$y_1 = 4\sin 400\pi t$ and $y_2 = 3\sin 404\pi t$
One of these bodies situated very near to the ears of a person who will hear:
a) 2 beats/s with intensity ratio 4/3 between maxima and minima
b) 2 beats/s with intensity ratio 49/1 between maxima and minima
c) 4 beats/s with intensity ratio 7/2 between maxima and minima
d) 4 beats/s with intensity ratio 4/3 between maxima and minima

245. A sonometer wire resonates with a given tuning fork forming 5 antinodes when a mass of 9 kg suspended from the wire. When this mass is replaced by a mass m, the wire resonates with the same tuning fork forming three antinodes for the same position of the bridges. The value of M is

a) 25 kg b) 5 kg c) 12.5 kg d) (1/25) kg

246. A particle of mass m is executing oscillations about the origin on the axis. Its potential energy is $V(x) = k|x|^3$ where k is a positive constant. If the amplitude of oscillation is a, then its time period T is

a) Proportional to $1/\sqrt{a}$ b) Independent of a c) Proportional to $\sqrt{a}$ d) Proportional to $a^{3/2}$

247. A train is moving with a constant speed along a circular track. The engine of the train emits a sound of frequency f. The frequency heard by the guard at the rear end of the train
a) Is less than f
b) Is greater than f
c) Is equal to f
d) May be greater than, less or equal to f depending on factors like speed of train, length of train and radius of circular track

248. An organ pipe A closed at one end vibrating in its fundamental frequency and another pipe B open at both ends is vibrating in its second overtone are in resonance with a given tuning fork. The ratio of length of pipe A to that of B is

a) 1:2 b) 3:8 c) 2:3 d) 1:6

249. An isotropic stationery source is emitting waves of frequency n and wind is blowing due north. An observer A is on north of the sources while observer B is on south the source. If both the observers are stationery, then
a) Frequency received by A is greater then n
b) Frequency received by B is less then n
c) Frequency received by A equals to that received by B
d) Frequencies received by A and B cannot be calculated unless velocity of waves in still air and velocity of wind are known

250. In a resonance tube experiment, the first resonance is obtained for 10 cm of air column and the second for

32 cm. The end correction for this apparatus is

a) 0.5 cm b) 1.0 cm c) 1.5 cm d) 2 cm

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

a) 8/3 b) 3/8 c) 1/6 d) 1/3

252. A transverse wave is travelling is a string. Study following statements

i. Equation of the wave is equal to the shape of the string at an instant t

ii. Equation of the wave is general equation for displacement of a particle of the string

iii. Equation of the wave must be sinusoidal equation

iv. Equation of the wave is an equation for displacement of the particle at one end only. Correct statements are

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

253. When source and detector are stationary but the wind is blowing at speed v_w, the apparent wavelength λ' on the wind side is related to actual wavelength λ by [take speed of sound in air as v]

a) $\lambda' = \lambda$ b) $\lambda' = \frac{v_w}{v}\lambda$ c) $\lambda' = \frac{v_w + v}{v}\lambda$ d) $\lambda' = \frac{v}{v - v_w}\lambda$

254. If the maximum speed of a particle on a travelling wave is v_0, then find the speed of a particle when the displacement is half of the maximum value

a) $\frac{v_0}{2}$ b) $\frac{\sqrt{3}v_0}{4}$ c) $\frac{\sqrt{3}v_0}{2}$ d) v_0

255. A vibrating string of certain length I under a tension T resonates with a mode corresponding to the second overtone (third harmonic) of an air column of length 75 cm inside a tube closed at one end. The string also generate 4 beats/s when excited along with a tuning fork of frequency n. now when the tension of the string also generate 4 beats/s when excited along with a tuning fork of frequency n. now when the tension of the string is slightly increased the number of beats reduces 2 per second. Assuming the velocity of sound in air to be $340ms^{-1}$, the frequency n of the tuning fork in Hz is

a) 344 b) 336 c) 117.3 d) 109.3

256. A motor car blowing a horn of frequency $124vib/sec$ moves with a velocity 72 km/hr towards a tall wall. The frequency of the reflected sound heard by the driver will be (velocity of sound in air is 330 m/s)

a) 109 vib/sec b) 132 vib/sec c) 140 vib/sec d) 248 vib/sec

257. A sound increases its decibel reading from 20 to 40 dB. This means that the intensity of the sound

a) is doubled b) is 20 times greater c) is 100 times greater d) is the old intensity 20

258. Which of the following statements is correct for stationery waves

a) Nodes and antinodes are formed in case of stationery transverse wave only

b) In case of longitudinal stationery wave, compressions and rarefactions are obtained in place of nodes and antinodes respectively

c) Suppose two plane waves, one longitudinal and the other transverse having same frequency and amplitude are travelling in a medium in opposite directions with the same speed, by superposition of these waves, stationery waves cannot be obtained

d) None of the above

259. A sinusoidal wave travelling in the positive direction on stretched string has amplitude 20 cm, wavelength 1.0 m and wave velocity 5.0 m/s. At $x = 0$ and t =0 it is given that $y = 0$ and $\partial y/\partial t < 0$. Find the wave function $y(x,t)$

a) $y(x,t) = (0.02\text{ m})\sin[(2\pi\text{m}^{-1})x + (10\pi\text{s}^{-1})t]\text{ m}$

b) $y(x,t) = (0.02\text{ m})\cos[(10\pi\text{s}^{-1})t + (2\pi\text{m}^{-1})x]\text{ m}$

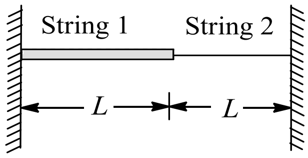
c) $y(x,t) = 0.02\text{ m})\sin[(2\pi\text{m}^{-1})x - (10\pi\text{s}^{-1})t]\text{ m}$

d) $y(x,t) = (0.02\text{ m})\sin[(\pi\text{m}^{-1})x + (5\pi\text{s}^{-1})t]\text{ m}$

260. If the length of a stretched sting is shortened by 40% and the tension increased by 44%, then the ratio of the final and initial fundamental frequencies is

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

261. A sonometer wire of length l vibrates in fundamental mode when excited by a tuning fork of frequency 416 Hz. If the length is doubled keeping other things same, the string will
a) Vibrate with a frequency of 416 Hz
b) Vibrate with a frequency of 208 Hz
c) Vibrate with a frequency of 832 Hz
d) Stop vibrating
262. Two closed-end pipes, when sounded together produce 5 beats/s. If their lengths are in the ratio 100: 101, then fundamental notes (in Hz) produced by them are
a) 245, 250
b) 250, 255
c) 495, 500
d) 500, 505
263. The equation of a wave is given by
$y = 0.2 \sin(100t + 25x)$
The ratio of maximum particle velocity to wave velocity is:
a) 12.5
b) 25
c) 4
d) 1/8
264. The frequency of B is 3% greater than that of A. The frequency of C is 2% less than that of A. If B and C produce 8 beats/s, then frequency of A is
a) 136 Hz
b) 168 Hz
c) 164 Hz
d) 160 Hz
265. A 40 cm long brass rod is dropped one end first onto a hard floor but is caught before it topple over. With an oscilloscope it is determined that the impact produces a 3 kHz tone. The speed of sound in brass is
a) 600 m/s
b) 1200 m/s
c) 2400 m/s
d) 4800 m/s
266. Two strings, one thick and other thin are connected as shown in figure



Which of the following statement(s) is correct with regard to above arrangement?
a) If a wave is travelling from string 1 to string 2, then the joint would be treated as free end
b) If a wave is travelling from string 1 to string 2, then the joint would be treated as a fixed end
c) If a wave is travelling from string 2 to string 1, then the joint would be treated as a free end
d) Both (b) and (c) are correct
267. The equation of a travelling wave is
$y = 60 \cos(1800t - 6x)$
Where y is in microns, t in seconds and x in metres. The ratio of maximum particle velocity to velocity of wave propagation is
a) 3.6
b) 3.6×10^{-6}
c) 36×10^{-11}
d) 3.6×10^{-4}
268. A uniform cylinder of length L and mass M having cross sectional area A is suspended, with its length vertical, from a fixed point by a massless spring, such that it is half-submerged in a liquid of density ρ at equilibrium position. When the cylinder is given a small downward push and released, it starts oscillating vertically with small amplitude, if the force constant of the spring is k, the frequency of oscillation of the cylinder is
a) $\frac{1}{2\pi}\left(\frac{k - A\rho g}{M}\right)^{1/2}$
b) $\frac{1}{2\pi}\left(\frac{k + A\rho g - j}{M}\right)^{1/2}$
c) $\frac{1}{2\pi}\left(\frac{k + \rho - gL}{M}\right)^{1/2}$
d) $\frac{1}{2\pi}\left(\frac{k + A - \rho g}{A\rho g}\right)^{1/2}$
269. At $t = 0$, a transverse wave pulse travelling in the + ve x-direction with a speed of 2 m/s in a wire is described by $y = 6/x^2$, given that $x \neq 0$. Transverse velocity of a particle at $x = 2$m and $t = 2$ s is
a) 3 m/s
b) −3 m/s
c) 8 m/s
d) −8 m/s
270. The amplitude of a wave represented by displacement equation
$y = \frac{1}{\sqrt{a}} \sin \omega t \pm \frac{1}{\sqrt{b}} \cos \omega t$
will be
a) $\frac{a+b}{ab}$
b) $\frac{\sqrt{a}+\sqrt{b}}{ab}$
c) $\frac{\sqrt{a}\pm\sqrt{b}}{ab}$
d) $\sqrt{\frac{a+b}{ab}}$
271. In the experiment to determine the speed of sound using a resonance column
a) Prongs of the tuning fork are kept in a vertical plane

b) Prongs of the tuning fork are kept in a horizontal plane
c) In one of the two resonance observed, the length of the resonating air column is close to the wavelength of sound in air
d) In one of the two resonance observed, the length of the resonating air column is close to half of the wavelength of sound in air

272. Mark the correct statement:
a) In case of stationery waves the maximum pressure change occurs at antinode
b) Velocity of longitudinal waves in a medium is its physical characteristic
c) Due to propagation of longitudinal wave in air, the maximum pressure change is equal to $2\pi\ na/\rho v$
d) None of the above

273. On sounding tuning fork A with another tuning fork B of frequency 384 Hz, 6 beats are produced per second. After loading the prongs of A with wax and then sounding it again with B, 4 beats are produced per second. What is the frequency of the tuning fork A
a) 388 Hz b) 80 Hz c) 378 Hz d) 390 Hz

274. At $t = 0$, a transverse wave pulse travelling in the positive x direction with a speed of 2 m/s in a wire is described by the function $y = 6/x^2$ given that $x \neq 0$. Transverse velocity of a particle at $x = 2$ m and $t = 2$ s is
a) 3 m/s b) −3 m/s c) 8 m/s d) −8 m/s

275. Which of the following travelling wave will produce standing wave, with nodes at $x = 0$, when superimposed on $y = A\sin(\omega t - kx)$
a) $A\sin(\omega t + kx)$ b) $A\sin(\omega t + kx + \pi)$ c) $A\cos(\omega t + kx)$ d) $A\cos(\omega t + kx + \pi)$

276. An open pipe is suddenly closed at one end with the result frequency of third harmonic of the closed pipe is found to be higher by 100 Hz than the fundamental frequency of the open pipe. The fundamental frequency of the open pipe is
a) 200 Hz b) 300 Hz c) 240 Hz d) 480 Hz

277. The frequency changes by 10% as the source approaches a stationery observer with constant speed v_s. What should be the percentage change in frequency as the source recedes from the observer with the same speed? Given that $v_s \ll v$(v is the speed of sound in air)
a) 14.3% b) 20% c) 16.7% d) 10%

278. In the experiment for the determination of the speed of sound in air using the resonance column the resonates in the fundamental mode, with a tuning fork is 0.1m. When this length is changed to 0.35m, the same tuning fork resonates with the first overtone. Calculate the end correction.
a) 0.012 m b) 0.025 m c) 0.05 m d) 0.024 m

279. Consider a source of sound S, and an observer/ detector D. The source emits a sound wave of frequency f_0. The frequency observed by D is found to be
I. f_1, if D approaches S and S is stationary
II. f_2 , if S approach D and D is stationary
III. f_3, if both S and D approach each other with the same speed
In all three cases, relative velocity of S wrt D is the same. For this situation which is incorrect?
a) $f_1 \neq f_2 \neq f_3$ b) $f_1 < f_2$ c) $f_3 < f_0$ d) $f_1 < f_3 < f_2$

280. An open pipe resonates with a tuning fork of frequency 500 Hz. It is observed that two successive notes are formed at distance 16 and 46 cm from the open end. The speed of sound in air in the pipe is
a) 230 m/s b) 300 m/s c) 320 m/s d) 360 m/s

281. A standing wave arises on a string when two waves of equal amplitude, frequency and wavelength travelling in opposite directions superimpose. If the frequency of two component waves is doubled, then the frequency of oscillation of the standing waves
a) Gets doubled b) Gets halved
c) Remains unchanged d) Changes but not by a factor of 2 or 1/2

282. A closed organ pipe of length L and open organ pipe contain gases of densities $p_1$and p_2 respectively. The compressibility of gases are equal in both the pipes. Both the pipes are vibrating in their first overtone

with same frequency. The length of the open organ pipe is

a) $\frac{L}{3}$ b) $\frac{4L}{3}$ c) $\frac{4L}{3}\sqrt{\frac{p_1}{p_2}}$ d) $\frac{4l}{3}\sqrt{\frac{p_2}{p_2}}$

283. A train of sound waves is propagated along an organ pipe and gets reflected from an open end. If the displacement amplitude of the waves (incident and reflected) are 0.002 cm, the frequency is 1000 Hz and wavelength is 40 cm. Then, the displacement amplitude of vibration at a point at distance 10 cm from the open end, inside the pipe, is

a) 0.002 cm b) 0.003 cm c) 0.001 cm d) 0.000 cm

284. When a source moves away from a stationary observer, the frequency is 6/7 times the original frequency. Given: speed of sound =330 m/s. The speed of the sources is

a) 40 m/s b) 55 m/s c) 330 m/s d) 165 m/s

285. A sonometer wire, 100 cm in length has fundamental frequency of 330 Hz. The velocity of propagation of transverse waves along the wire is

a) 330 m/s b) 660 m/s c) 115 m/s d) 990 m/s

286. In sports meet the timing of a 200 m straight dash is recorded at the finish point by starting an accurate stop watch on hearing the sound of starting gun fired at the starting point. The time recorded will be more accurate

a) In winter b) In summer c) In all seasons d) None of these

287. The strings of a violin are tuned to the tones G, D, A and E which are separated by a fifth from one another. That is $f(D) = 1.5\ (G), f(A) = 1.5\ (D) = 400\text{Hz}$ and $f(E) = 1.5f(A)$. The distance between the two fixed points, the bridge at the scroll and over the body of the instrument is 0.25 m. The tension on the string E is 90 N. The mass per unit length of string E is nearly

a) 1 g/m b) 2 g/m c) 3 g/m d) 4 g/m

288. The displacement y of a particle executing periodic motion is given by

$y = 4\cos^2\left(\frac{1}{2}t\right)\sin(1000t)$

This expression may be considered to be a result of the superposition of

a) Two b) Three c) Four d) five

289. The period of oscillation of a simple pendulum of length L suspended from the roof of a vehicle which moves without friction down an inclined plane of inclination α, is given by

a) $2\pi\sqrt{\frac{L}{g\cos\alpha}}$ b) $2\pi\sqrt{\frac{L}{g\sin\alpha}}$ c) $2\pi\sqrt{\frac{L}{g}}$ d) $2\pi\sqrt{\frac{L}{g\tan\alpha}}$

290. A vehicle, with a horn of frequency n, is moving with a velocity of 30 m/s in a direction perpendicular to the straight line joining the observer and the vehicle. The observer perceives the sound to have a frequency $n + n_1$. Then n_1 is equal to (take velocity of sound in air as 330 m/s)

a) $n_1 = 10n$ b) $n_1 = -n$ c) $n_1 = 0.1n$ d) $n_1 = 0$

291. In the sonometer experiment, a tuning fork of frequency 256 Hz is in resonance with 0.4 m length of the wire when the iron load attached to free end of wire is 2 kg. If the load is immersed in water, the length of the wire in resonance would be (specific gravity of iron=8)

a) 0.37 m b) 0.43 m c) 0.31 m d) 0.2 m

292. Two strings A and B, made of same material, are stretched by same tension. The radius of string A is double of the radius of B. A transverse wave travels on A with speed v_A and on B with speed v_B. The ratio v_A/v_B is

a) 1/2 b) 2 c) 1/4 d) 4

293. The displacement ξ in centimetres of a particle is $\xi = 3\sin 314.t + 4\cos 314\ t$. Amplitude and initial phase are

a) $5\text{ cm}, \tan^{-1}\frac{4}{3}$ b) $3\text{ cm}, \tan^{-1} 3/4$ c) $4\text{ cm}, \tan^{-1}\frac{4}{9}$ d) 4 cm, 0

294. A tube, closed at one end and containing air, produces, when excited, the fundamental mode of frequency

512 Hz. If the tube is open at both ends the fundamental frequency that can be excited is (in Hz)
a) 1024 b) 512 c) 256 d) 128

295. An open pipe of length 2 m is dipped in water. To what depth x is to be immersed in water so that it may resonate with a tuning fork of frequency 170 Hz when vibrating in its first overtone. Speed of sound in air is 340 m/s
a) 0.5 m b) 0.75 m c) 1 m d) 1.5 m

296. The speed of a wave in a certain medium is 960 m/s. If 3600 waves pass over a certain point of the medium in 1 min, the wavelength is
a) 2 m b) 4 m c) 8 m d) 16 m

297. A stretched rope having linear mass density 5×10^{-2} kg/m is under a tension of 80 N. The power that has to be supplied to the rope to generate harmonic waves at a frequency of 60 Hz and an amplitude of $\frac{2\sqrt{2}}{15\pi}$ m is
a) 215 W b) 251 W c) 512 W d) 521 W

298. Two particles of medium disturbed by the wave propagation are at $x_1 = 0$ and $x_2 = 1$ cm. The respective displacements (in cm) of the particles can be given by the equations:
$y_1 = 2\sin 3\pi t, \qquad y_2 = 2\sin(3\pi t - \pi/8)$
The wave velocity is
a) 16 cm/s b) 24 cm/s c) 12 cm/s d) 8 cm/s

299. At $t = 0$, a transverse wave pulse in a wire is described by the function $y = 6/(x^2 - 3)$ where x and y are in metres. The function $y\,(x, t)$ that describes this wave equation if it is travelling in the positive x direction with a speed of 4.5 m/s is
a) $y = \dfrac{6}{(x + 4.5t)^2 - 3}$ b) $y = \dfrac{6}{(x - 4.5t)^2 + 3}$ c) $y = \dfrac{6}{(x + 4.5t)^2 + 3}$ d) $y = \dfrac{6}{(x - 4.5t)^2 - 3}$

300. Two canoes are 10 m apart on a lake. Each bobs up and down with a period of 4.0 s. When one canoe is at its highest point, the other canoe is at its lowest point. Both canoes are always within a single cycle of the waves. The speed of wave is
a) 2.5 m/s b) 5 m/s c) 40 m/s d) 4 m/s

301. In the resonance tube experiment, the first resonance is heard when length of air column is l_1 and second resonance is heard when length of air column is l_2. What should be the minimum length of the tube so that third resonance can also be heard
a) $2l_2 - l_1$ b) $2l_1$ c) $5l_1$ d) $7l_1$

302. A piano wire having a diameter of 0.90 mm is replaced another wire of the same material but with a diameter of 0.93 mm. If the tension of the wire is kept the same, than the percentage change in the frequency of the fundamental tone is
a) +3% b) +3.2% c) −3.2% d) −3%

Multiple Correct Answers Type

303. A medium can carry a longitudinal wave because it has the property of
a) Mass b) Density c) Compressibility d) Elasticity

304. A wave moves at a constant speed along a stretched string. Mark the incorrect statement out of the following:
a) Particle speed is constant and equal to the wave speed
b) Particle speed is independent of amplitude of the periodic motion of the source
c) Particle speed is independent of frequency of periodic motion of the source
d) Particle speed is dependent on tension and linear mass density the string

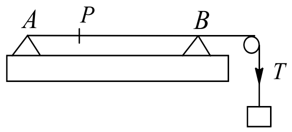
305. The linear harmonic oscillator of force constant 2×10^6 N/m and amplitude 0.01 m has a total mechanical energy of 160 J. Its
a) Maximum potential energy is 100 J b) Maximum kinetic energy of 100 J
c) Maximum potential energy is 160 J d) Minimum potential energy of zero

306. Velocity of sound in air is 320 m/s. A pipe closed at one end has a length of 1 m. Neglecting the corrections,

the air column in the pipe can resonate for sound of frequency

a) 80 Hz b) 240 Hz c) 320 Hz d) 400 Hz

307. A sonometer string AB of length 1 m is stretched by a load and the tension T is adjusted so that the string resonates to a frequency of 1 kHz. Any point P of the wire may be held fixed by use of a movable bridge that can slide along the base of sonometer



a) If point P is fixed so that $AP:PB :: 1:4$, then the smallest frequency for which the sonometer wire resonates is 5 kHz

b) If P be taken at midpoint of AB and fixed, then when the wire vibrates in the third harmonic of its fundamental, the number of nodes in the wire (including A and B) will be totally seven

c) If the fixed point P divides AB in the ratio 1:2, then the tension needed to make the string vibrate at 1 kHz will be $3T$. (neglecting the terminal effects)

d) The fundamental frequency of the sonometer wire when P divides AB in the ratio $a:b$, will be the same as the fundamental frequency when P divides AB in the ratio $b:a$

308. A thin plane membrane separates hydrogen at 27^0C from hydrogen at 127^0C, both being at the same pressure. A plane sound wave enters from the cooler to the hotter side. If angle of incidence on the membrane is 30^0C, then the angle of reflection is

a) $\sin^{-1}(1/\sqrt{3})$ b) $\sin^{-1}(2/8)$ c) $\sin^{-1}(3/8)$ d) $\sin^{-1}(2/3)$

309. A wire of density 9×10^3 kg/m^3 is stretched between two clamps 1 m apart and is stretched to an extension of 4.9×10^{-4}m. Young's modulus of material is 9×10^{10}N/m^2. Then:

a) The lowest frequency of standing wave is 35 Hz

b) The frequency of 1st overtone is 70 Hz

c) The frequency of 1st over is 105 Hz

d) The stress in the wire is 4.41×10^7N/m^2

310. Standing waves can be produced

a) On a string clamped at both the ends

b) On a string clamped at one end and free at the other

c) When incident wave gets reflected from a wall

d) When two identical waves with a phase difference of π are moving in the same direction

311. A simple harmonic progressive wave in a gas has a particle displacement of $y = a$ at time $t = T/4$ at the origin of the wave and a particle velocity of $y = v$ at the same instant but at a distance $x = \lambda/4$ from the origin where T and λ are the periodic time and wavelength of the wave respectively. Then for this wave

a) The amplitude A of the wave is $A = 2a$

b) The amplitude A of the wave is $A = a$

c) The equation of the wave can be represented by $y = a\sin\frac{v}{a}\left[t - \frac{x}{V}\right]$

d) The equation of the wave can be represented by $y = 2a\cos\frac{v}{a}\left[t - \frac{x}{V}\right]$

312. Consider the wave represented by $y = \cos(500t - 70x)$ where y is in millimeters, x in meters and t in second. Which of following are true?

a) The wave is standing wave

b) The speed of the wave is $50/7$ m/s

c) The frequency of oscillations is $500 \times 2\pi$ Hz

d) Two nearest points in the phase have separation $20\pi/7$ cm

313. Choose the correct statements from the following:

a) Any function of the form $y(x,t) = f(vt + x)$ represents a travelling wave

b) The velocity, wavelength and frequency of a wave do not undergo any change when it is reflected from the surface

c) When an ultrasonic wave travels from air into water, it bends towards the normal to air-water interface

d) The velocity of sound is generally greater in solids than in gases at NTP

314. $y(x,t) = 0.8/[(4x + 5t)^2 + 5]$ represents a moving pulse, where x and y are in metre and t in second. Then
a) Pulse is moving in $+x$-direction
b) In 2s it will travel a distance of 2.5 m
c) Its maximum displacement is 0.16 m
d) It is a symmetric pulse

315. A wave is represented by the equation
$y = A \sin 314 \left[\frac{t}{0.5\text{ s}} - \frac{x}{100\text{ m}}\right]$
The frequency is n and the wavelength is λ. Then:
a) $n = 2$ Hz b) $n = 100$ Hz c) $\lambda = 2$ m d) $\lambda = 100$ m

316. An observer A is moving directly towards a stationary sound source while another observer B is moving away from the source with the same velocity. Which of the following statements are correct?
a) Average of frequencies recorded A and B is equal to natural frequency of the source
b) Wavelength of wave received by A is less than that of wave received by B
c) Wavelength of waves received by two observers will be same
d) Both the observers will observe the wave travelling with same speed

317. For a transverse wave on a string, the string displacement is described by
$y(x,t) = f(x - at)$
Where f represents a function and a is a negative constant. Then which of the following is/ are correct statement (s)?
a) Shape of the string at time $t = 0$ is given by $f(x)$
b) The shape of wave form does not change as it moves along the string
c) Waveform moves in +ve x-direction
d) The speed of wavelength is a

318. Mark the correct option(s) out of the following:
a) Mechanical waves can be transverse in liquids
b) In some medium, the speed of a longitudinal mechanical wave is greater than the speed of transverse mechanical wave
c) Transverse waves are possible in bulk of a liquid
d) Non-mechanical waves are transverse in nature

319. In case of interference of two waves each of intensity I_0, the intensity at a point of constructive interference will be
a) $4I_0$ for coherent source b) $2I_0$ for coherent source
c) $4I_0$ for incoherent source d) $2I_0$ for incoherent source

320. A driver in a stationary car blows a horn which produces monochromatic sound waves of frequency 1000 Hz normally towards a reflecting wall. The wall approaches the car with a speed of 3.3 m/s
a) The frequency of sound reflected from wall and heard by the driver is 1020 Hz
b) The frequency of sound reflected from wall and heard by the driver is 980 Hz
c) The percentage increase in frequency of sound after reflection from wall is 2%
d) The percentage decrease in frequency of sound after reflection from wall is 2%

321. A sinusoidal wave $y_1 = a\sin(\omega t - kx)$ is reflected from a rigid support and the reflected wave superpose with the incident wave y_1. Assume the rigid support to be at $x = 0$
a) Stationery waves are obtained with antinodes at the rigid support
b) Stationery waves are obtained with nodes at the rigid support
c) Stationery waves are obtained with intensity varying periodically with distance
d) Stationery waves are obtained with intensity varying periodically with time

322. A particle is executing SHM with amplitude$A$. At displacement$x^2 = -\frac{A}{4}$, force acting on the particle is$F$, potential energy of the particle is U, velocity of particle is v and kinetic energy is K. Assuming potential

energy to be zero at mean position. At displacement $x = \frac{A}{2}$

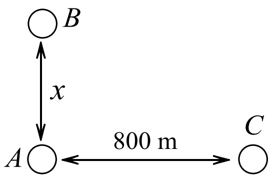
a) Force acting on the particle will be 2F

b) Potential energy of particle will be 4U

c) Velocity of particle must be $\sqrt{\frac{4}{5}}v$

d) Kinetic energy of particle will be 0.8K

323. A radio transmitter at position A operates at a wavelength of 20 m. A second, identical transmitter is located at a distance x from the first transmitter, at position B. The transmitters are phase locked together such that the second transmitter is lagging $\pi/2$ out of phase with the first. For which of the following values of $BC - CA$ will the intensity at C be maximum



a) $BC - CA = 60$ m

b) $BC - CA = 65$ m

c) $BC - CA = 55$ m

d) $BC - CA = 75$ m

324. The stationary waves set up on a string have the equation:

$y = (2\text{ mm})\sin[(6.28\text{ m}^{-1})x]\cos\omega t$

The stationary wave is created by two identical waves, of amplitude A each, moving in opposite directions along the string. Then:

a) $A = 2$mm

b) $A = 1$mm

c) The smallest length of the string is 50 cm

d) The smallest length of the string is 2 m

325. A sound wave of frequency f travels horizontally to the right. It is reflected from a large vertical plane surface moving to left with a speed v. The speed of sound in medium is c

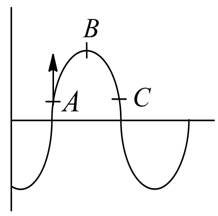
a) The number of waves striking the surface per second is $f\frac{(c+v)}{c}$

b) The wavelength of reflected wave is $\frac{c(c-v)}{f(c+v)}$

c) The frequency of the reflected wave is $f\frac{(c+v)}{(c-v)}$

d) The number of beats heard by a stationery listener to the left of the reflecting surface is $\frac{vf}{c-v}$

326. A wave is travelling along a string. At an instant shape of the string is as shown in the enclosed figure. At this instant, point A is moving upwards. Which of the following statement are correct?



a) The wave is travelling to the right

b) Displacement amplitude of the wave is equal to the displacement of B at this instant

c) At this instant velocity of C is also directed upwards

d) Phase difference between A and C may be equal to $\pi/2$

327. Which of the following statements are incorrect?

a) Wave pulses in strings are transverse waves

b) Sound waves in air are transverse waves of compression and rarefaction

c) The speed of sound in air at 20°C is twice that at 5°C

d) A 60 dB sound has twice the intensity of a 30 dB sound

328. Length of a string tied to two rigid supports is 40 cm. Maximum wavelength of a stationary wave produced on it is

a) 20 cm

b) 40 cm

c) 120 cm

d) 80 cm

329. Velocity of sound in air is 320 m/s. A pipe closed at one end has a length of 1 m. Neglecting end corrections, the air column in the pipe can resonate for sound of frequency

a) 80 Hz

b) 240 Hz

c) 320 Hz

d) 400 Hz

330. A string of length L is stretched along the x-axis and is rigidly clamped at its two ends. It undergoes transverse vibrations. If n is an integer, which of the following relations may represent the shape of the string at any time ?

a) $y = A \sin\left(\frac{n\pi x}{L}\right) \cos\omega t$
b) $y = A \sin\left(\frac{n\pi x}{L}\right) \sin\omega t$
c) $y = A \cos\left(\frac{n\pi x}{L}\right) \cos\omega t$
d) $y = A \cos\left(\frac{n\pi x}{L}\right) \sin\omega t$

331. An air column in a pipe, which is closed at one end, is in resonance with a vibrating tuning fork of frequency 264 Hz. If $v = 330 ms^{-1}$, the length of the column in cm is

a) 31.25
b) 62.50
c) 93.75
d) 125

332. What will be the wave velocity, if the radar give 54 waves per min and wavelength of the given wave is 10m ?

a) $4 ms^{-1}$
b) $6 ms^{-1}$
c) $9 ms^{-1}$
d) $5 ms^{-1}$

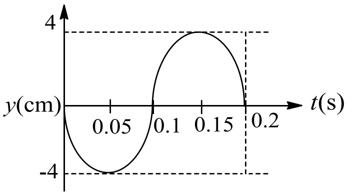
333. In the principle of superposition, the characteristic that gets added vectorially is

a) Displacement
b) Velocity
c) Amplitude
d) Frequency

334. Three simple harmonic motions in the same direction having the same amplitude a and same period are superposed. If each differs in phase from the next by 45°, then

a) The resultant amplitude is $(1+\sqrt{2})a$
b) The phase of the resultant motion relative to the first is 90°
c) The energy associated with the resulting motion is $(3+2\sqrt{2})$ times the energy associated any single motion
d) The resulting motion is not simple harmonic

335. For a certain transverse standing wave on a long string, an antinode is formed at $x = 0$ and next to it, a node is formed at $x = 0.10$m, the displacement $y(t)$ of the string particle at $x = 0$ is shown if figure



a) Transverse displacement of the particle at $x = 0.05$ m and $t = 0.05$ s is $-2\sqrt{2}$ cm
b) Transverse displacement of the particle at $x = 0.04$ m and $t = 0.025$ s is $-2\sqrt{2}$ cm
c) Speed of the travelling waves that interface to produce this standing wave is 2 m/s
d) The transverse velocity of the string particle at $x = 1/15$ m and $t = 0.1$ s is 20π cm/s

336. Consider a sources of sound S and an observer P. The sound source is of frequency n_0. The frequency observed by P is found to be n_1 if P approaches S at speed v and S is stationary; n_2 if S approaches P at a speed v and P is stationary and n_3 if each of P and S has speed $v/2$ towards one another. Now,

a) $n_1 = n_2 = n_3$
b) $n_1 < n_2$
c) $n_3 > n_0$
d) n_3 lies between n_1 and n_2

337. Two waves of equal frequency f and velocity v travel in opposite direction along the same path. The waves have amplitude A and $3A$. Then:

a) The amplitude of the resulting wave varies with position between maxima of amplitude $4A$ and minima of zero amplitude
b) The distance between a maxima and adjacent minima of amplitude is $v/2f$
c) Maxima amplitude is $4A$ and minimum amplitude is $2A$
d) The position of a maxima or minima of amplitude does not change with time

338. Which of the following statements are correct?

a) The decrease in the speed of sound at high altitudes is due to a fall in pressure
b) The standing wave on a string under tension, fixed at its ends, does not have well-defined nodes
c) The phenomenon of beats is not observable in the case of visible light waves
d) The apparent frequency is f_1 when a source of sound approached a stationery observer with a speed u and is f_2 when the observer approaches the same stationery source with the same speed. Then

$f_2 < f_1$, if $u < v$, where v is the speed of sound

339. The equation of a progressive wave is $Y = a \sin(200t - x)$ where x is in meter and t is in second. The velocity of wave is

a) $200 ms^{-1}$ b) $100 ms^{-1}$ c) $50 ms^{-1}$ d) None of these

340. Which of the following statements are correct about intensity of sound?

a) It depends only on amplitude of wave
b) It depend both on amplitude and frequency of wave
c) Its practical unit is decibel
d) Its practical unit is phono

341. A sound wave passes from a medium A to a medium B. The velocity of sound in B is greater than that in A. Assume that there is no absorption or reflection at the boundary. As the wave moves across the boundary:

a) The frequency of sound will not change
b) The wavelength will increase
c) The wavelength will decrease
d) The intensity of sound will not change

342. Coherent sources are characterized by the same

a) Phase and phase velocity
b) Wavelength, amplitude and phase velocity
c) Wavelength, amplitude and frequency
d) Wavelength and phase

343. A source S of sound wave of fixed frequency N and an observer O are located in air initially at the space points A and B, a fixed distance apart. State in which of the following cases, the observer will NOT see any Doppler effect and will receive the same frequency N as produced by the source

a) Both the source S and observer O remain stationary but a wind blows with a constant speed in an arbitrary direction
b) The observer remains stationary but the source S moves parallel to and in the same direction and with the same speed as the wind
c) The source remains stationary but the observer and the wind have the same speed away from the source
d) The source and the observer move directly against the wind but both the same speed

344. A plane wave $y = a\sin(kx + ct)$ is incident on a surface. Equation of the reflected wave is: $y' = a'\sin(ct - bx)$. Then which of the following statements are correct?

a) The wave is incident normally on the surface
b) Reflection surface is $y - z$ plane
c) Medium, in which incident wave is travelling, is denser than the other medium
d) a' cannot be greater than a

345. A string is fixed at both ends and transverse oscillations with amplitude a_0 are excited. Which of the following statements are correct?

a) Energy of oscillations in the string is directly proportional to tension in the string
b) Energy of oscillations in nth overtone will be equal to n^2 times of that in first overtone
c) Average kinetic energy of string (over an oscillation period) is half of the oscillation energy
d) None of the above

346. A wire of 9.8×10^{-3} kg/m passes over a frictional light pully fixed on the top of a frictionless inclined plane which makes an angle of 30° with the horizontal. Masses m and M are tied at the two ends of wire such that m rests on the plane and M hangs freely vertically downwards. The entire system is in equilibrium and a transverse wave propagates along the wire with a velocity of 100 m/s

a) $m = 20$ kg b) $M = 5$ kg c) $\frac{m}{M} = \frac{1}{2}$ d) $\frac{m}{M} = 2$

347. A transverse sinusoidal wave of amplitude a, wavelength λ and frequency f is travelling on a stretched string. The maximum speed of any point on the string is $v/10$, where v is the speed of propagation of the wave. If $a = 10^{-3}$m and $v = 10$ m/s, then λ and f are given by

a) $\lambda = 2\pi \times 10^{-2}$m b) $\lambda = 10^{-3}$m c) $f = \frac{10^3}{2\pi}$ Hz d) $f = 10^4$ Hz

348. The intensity of a progressing plane wave in loss-free medium is

a) Directly proportional to the square of amplitude of the wave
b) Directly proportional to the velocity of the wave
c) Directly proportional to the square of frequency of the wave
d) Inversely proportional to the density of the medium

349. Let a disturbance y be propagated as a plane wave along the x-axis. The wave profiles at the instants $t = t_1$ and $t = t_2$ are represented respectively as: $y_1 = f(x_1 - vt_1)$ and $y_2 = f(x_2 - vt_2)$. The wave is propagating without change of shape
a) The velocity of the wave is v
b) The velocity of the wave is $v = (x_2 + x_1)/(t_2 + t_1)$
c) The particle velocity is $v_p = -vf'(x - vt)$
d) The phase velocity of the wave is v

350. The displacement of particle in a string stretched in the x-direction is represented by y. Among the following expressions for y, those describing wave motion are
a) $\cos kx \sin \omega t$
b) $k^2x^2 - \omega^2t^2$
c) $\cos^2(kx + \omega t)$
d) $\cos(k^2x^2 - \omega^2t^2)$

351. A student performed the experiment to measure the speed of sound in air using resonance air-column method. Two resonances in the air-column were obtained by lowering the water level. The resonance with the shorter air-column is the first resonance and with the shorter air-column is the first resonance and that with the longer air column is the second resonance. Then,
a) The intensity of the sound heard at the first resonance was more than that at the resonance
b) The prongs of the tuning fork were kept in a horizontal plane above the resonance tube
c) The amplitude of vibration of the ends of the prongs is typically around 1 cm
d) The length of the air-column at the first resonance was somewhat shorter than 1/4 th of the wavelength of the sound in air

352. A sound wave of frequency v travels horizontally to the right. It is reflected from a large vertical plane surface moving to the left the with a speed v. The speed of sound in the medium is c, then
a) The frequency of the reflected wave is $\frac{v(c+v)}{c-v}$
b) The wavelength of the reflected waves is $\frac{c(c-v)}{v(c+v)}$
c) The number of waves striking the surface per second is $\frac{v(c+v)}{c}$
d) The number of beats heard by a stationary listener to the left of the reflecting surface is $\frac{vv}{c-v}$

353. Two identical straight wires are stretched so as to produce 6 beats per second when vibrating simultaneously. On changing the tension slightly in one of them, the beat frequency remains unchanged. Let T_1 and T_2 represent the higher and the lower initial tensions in the strings. While making the above change in tension:
a) T_2 was decreased
b) $T_2$was increased
c) $T_1$was increased
d) T_1 was decreased

354. Which one of the following represents a travelling wave
a) $y = A\sqrt{(x - vt)}$
b) $y = A\ cos\sqrt{(ax - bt)}$
c) $y = A\ \log(x - vt)$
d) $y = f(x^2 - vt^2)$

355. The (x, y) coordinates of the corners of a square plate are $(0,0)$, (L, L) and $(0, L)$. The edges of the plate are clamped and transverse standing wave are set up in it. If $u(x, y)$ denote the displacement of the plate at point (x, y) at some instant of time, the possible expression (s) for u is (are) (a =positive constant)
a) $a \cos(\pi x/2L) \cos(\pi y/2L)$
b) $a \sin(\pi x/L) \sin(\pi y/L)$
c) $a \sin(\pi x/L) \sin\ (2\pi y/L)$
d) $a \cos(2\pi x/L) \sin(\pi y/L)$

356. Which of the following statements are correct?
a) Changes in air temperature have no effect on the speed of sound
b) Changes in air pressure have no effect on the speed of sound
c) The speed of sound in water is higher than in air
d) The speed of sound in water is lower than in air

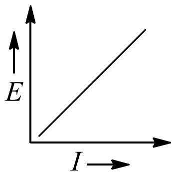
357. A person blows into open-end of a long pipe. As a result, a high-pressure pulse of air travels down the pipe.

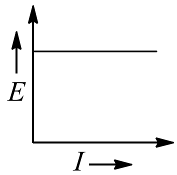
When this pulse reaches the other end of the pipe
a) A high-pressure pulse starts travelling up the pipe, if the other end of the pipe is open
b) A low-pressure pulse starts travelling up the pipe, if the other end of the pipe is open
c) A low-pressure pulse starts traveling up the pipe, if the other end of the pipe is closed
d) A high-pressure pulse starts travelling up the pipe, if the other end of the pipe is closed

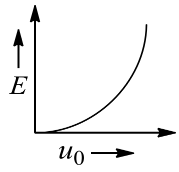
358. A wave is represented by the equation $Y = A \sin[10\pi x - 15\pi t + (\pi/3)]$ where x is in meter and t is in second. The expression represents
a) A wave travelling in positive x-direction with velocity 1.5ms^{-1}
b) A wave travelling in negative x-direction with velocity 1.5ms^{-1}
c) A wave travelling in negative x-direction with wavelength 0.2m
d) A wave travelling in positive x-direction with wavelength 0.2m

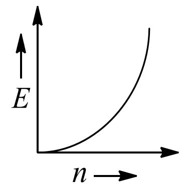
359. Two waves travel down the same string. These waves have the same velocity, frequency f and wavelength but having different phase constants ϕ_1 and $\phi_2(<\phi_1)$ and amplitudes A_1 and $A_2(<A_1)$.Mark the correct statement(s) for the resultant wave which is produced due to superposition of these two waves
a) The amplitude of the resultant waves is $A = A_1 + A_2$
b) The amplitude of the resultant wave lies between $A_1 - A_2$ to $A_1 + A_2$
c) The frequency of the resultant wave is f
d) The frequency of the resultant wave is $f/2$

360. A sonic source, located in a uniform medium, emits waves of frequency n. If intensity, energy density (energy per unit volume of the medium) and maximum speed of oscillations of medium particle are, respectively, I, E and u_0 at a point, then which of the following graphs are correct?

a) 

b) 

c) 

d) 

361. Mark out the correct statement(s) concerning waves
a) A wave can have both transverse and longitudinal components
b) A wave does not result in the bulk flow of the materials of its medium
c) A wave is a travelling disturbance
d) A wave can be there even in the absence of an elastic medium

362. Which of the following functions represent a travelling wave? Here a, b and c are constants
a) $y = a\cos(bx)\sin(ct)$
b) $y = a\sin(bx + ct)$
c) $y = a\sin(bx + ct) + a\sin(bx - ct)$
d) $y = a\sin(bx - ct)$

363. Two waves of nearly same amplitude, same frequency travelling will same velocity are superimposing to give phenomenon of interference. If a_1 and a_2 be their respectively amplitudes, ω be the frequency for both, v be the velocity for both and $\Delta\phi$ is the phase difference between the two waves then,
a) The resultant intensity varies periodically will time and distance
b) The resulting intensity with $\frac{I_{\min}}{I_{\max}} = \left(\frac{a_1 - a_2}{a_1 + a_2}\right)^2$ is
c) Both the waves must have been travelling in the same direction and must be coherent
d) $I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos(\Delta\phi)$, where constructive interference is obtained for path difference that are odd multiple of $1/2\lambda$ and destructive interference is obtained for path difference that are even multiple of $1/2\lambda$

364. Mark out the correct statement(s)
a) For a travelling wave on a string, oscillation energy of an elemental length remains constant
b) For a sinusoidal travelling wave on a string, oscillation energy of an elemental length varies periodically
c) For a travelling wave on a string, oscillation energy of all elemental parts having equal length are the same

d) For a stationary wave on a string, oscillation energy of any element part is constant

365. Two waves travelling in opposite directions produce a standing wave. The individual wave functions are given by $y_1 = 4\sin(3x - 2t)$ and $y_2 = 4\sin(3x + 2t)$ cm, where x and y are in cm

a) The maximum displacement of the motion at $x = 2.3$ cm is 4.63 cm

b) The maximum displacement of the motion at $t = 2.3$s 4.63 cm

c) Nodes are formed at x values given by $0, \pi/3, 2\pi/3, 4\pi/3, \dots\dots$

d) Antinodes are formed at x values given by $\pi/6, \pi/2, 5\pi/6, 7\pi/6, \dots\dots$

366. A loudspeaker that produces signals from 50 to 500 Hz is placed at open end of a closed tube of length 1.1 m. The lowest and the highest frequency that excites resonance in the tube are f_l and f_h respectively. The velocity of sound is 330 ms/s. Then

a) $f_l = 50$Hz	b) $f_h = 500$Hz	c) $f_l = 75$ Hz	d) $f_h = 450$ Hz

367. Two particle P and Q have a phase difference of π when a sine wave passes through the region:

a) P oscillates at half the frequency of Q

b) P and Q move in opposite directions

c) P and Q must be separated by half of the wavelength

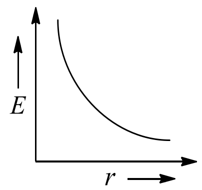
d) The displacements of P and Q have equal magnitudes

368. For the $y = 20\sin\left(\frac{x}{4} + \frac{t}{2}\right)$, the correct statement is (where x is in meter and time is in second)

a) Amplitude is 20m ad frequency is 0.25	b) Wavelength is 20m and frequency is 1

c) Frequency is $\frac{1}{2}$ and wavelength is 20 cm	d) $\omega = 2\pi$ *and* $k = \frac{\pi}{2}$

369. Energy density E (energy per unit volume) of the medium at a distance r from a sound source varies according to the curve shown in figure, which of the following are possible



a) The source may be a point isotropic source

b) If the source is a plane source then the medium particles have damped oscillations

c) If the source is a plane source then power of the source is decreasing with time

d) Density of the medium decreases with distance r from the source

370. The velocity of sound is affected by change in

a) Temperature	b) Medium	c) Pressure	d) wavelength

371. If the shift in a star light is towards red end

a) The star is a approaching the earth	b) The star is reaching from the earth

c) The apparent frequency is lesser than actual	d) The apparent wavelength is lesser than actual

372. Mark the correct statements

a) If all the particles of a string are oscillating in same phase, the string is resonating in its fundamental tone

b) To observe interference, two sources of same frequency must be placed some distance apart from each other

c) To observe beats, two sources of same amplitude must be placed some distance apart each other

d) None of the above

373. Equation of a wave travelling in a medium is: $y = a\sin(bt - cx)$. Which of the following are correct?

a) Ratio of the displacement amplitude, with which the particles of the medium oscillate, to the wavelength is equal to $ac/2\pi$

b) Ratio of the velocity oscillation amplitude of medium particle to the wave propagation velocity is equal to ac

c) Oscillation amplitude of relative deformation of the medium is directly proportional to velocity oscillation amplitude of medium particles
d) None of the above

374. Three simple harmonic waves, identical in frequency n and amplitude A moving in the same direction are superimposed in air in such a way, that the first, second and the third wave the phase angles $\phi, \phi + (\pi/2)$ and $(\phi + \pi)$, respectively at a given point P in the superposition
Then as the waves progress, the superposition will result in
a) A periodic, non-simple harmonic wave of amplitude 3A
b) A stationery simple harmonic wave of amplitude 3A
c) A simple harmonic progressive wave a amplitude A
d) The velocity of the superposed resultant wave will be the same as the velocity of each wave

375. A wave represented by the equation
$y = A\sin\left(10\pi x + 15\pi t + \frac{\pi}{3}\right)$
Where x is in metres and t is in seconds. The expression represents:
a) A wave travelling in the positive x-direction with a velocity 1.5 m/s
b) A wave travelling in the negative x-direction with a velocity 1.5 m/s
c) A wave travelling in the negative x-direction having a wavelength 0.2 m
d) A wave travelling in the positive x-direction having a wavelength 0.2 m

376. At nodes in stationary waves
a) Change in pressure and density are maximum
b) Change in pressure and density are minimum
c) Strain is zero
d) Energy is minimum

377. A wave disturbance in a medium is described by $y(x,t) = 0.02\cos\left(50\pi t + \frac{\pi}{2}\right)\cos(10\pi x)$, where x and y are in metre and t is in second
a) A node occurs at $x = 0.15$ m
b) An antinode occurs at $x = 0.3$ m
c) The speed of wave is 5 m/s
d) The wave length is 0.2 m

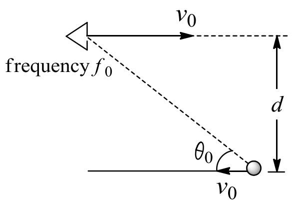
378. The equation to a transverse wave travelling in a rope is given by
$y = A\cos\frac{\pi}{2}[kx - \omega t - \alpha]$
Where $A = 0.6$ m, $k = 0.005\ \text{cm}^{-1}$, $\omega = 8.0\ \text{s}^{-1}$ and α is a non-vanishing constant. Then for this wave,
a) The wavelength of the wave is $\lambda = 8$m
b) The maximum velocity v_m of a particle of the rope will be, $v_m = 7.53$ m/s
c) The equation of a wave which, when superposed with the given wave can produce standing in the rope is
$y = A\cos\frac{\pi}{2}(kx - \omega t + \alpha)$
d) The equation of a wave which, when superposed with the given wave can produce standing waves in the rope is
$y = A\cos\frac{\pi}{2}(kx + \omega t - \alpha)$

379. It is desired to increase the fundamental resonance frequency in a tube which is closed at one end. This can be achieved by
a) Replacing the air in the tube by hydrogen gas
b) Increasing the length of the tube
c) Decreasing of length of the tube
d) Opening the closed end of the tube

380. A harmonic wave is travelling along+ ve x-axis, on a stretched string. If wavelength of the wave gets doubled, then
a) Frequency of wave may change
b) Wave speed may change
c) Both frequency and speed of wave may change
d) Only frequency will change

381. A source of sound and detector are moving as shown in Figure at $t = 0$. Take velocity of sound wave to be

v



For this situation mark out the correct statement(s)

a) The frequency received by the detector is always greater than f_0

b) Initially, frequency received by the detector is greater than f_0, becomes equal to f_0 and then decreases with the time

c) Frequency received by the detector is equal to f_0 at $t = d\cot\theta_0/(2\,v_0)$

d) Frequency received by the detector can never be equal to f_0

382. A transverse sinusoidal wave of amplitude a, wavelength λ and frequency f is travelling on a stretched string. The maximum speed at any point on the string is $(v/10)$ where v is the speed of propagation of the wave. If $a = 10^{-3}$m and $v = 10$m/s, then λ and f are given by:

a) $\lambda = 2\pi \times 10^{-2}$ m b) $\lambda = 10^{-3}$ m c) $f = 10^3/(2\pi)$ Hz d) $f = 10^4$ Hz

383. Two sine waves of slightly different frequency f_1 and $f_2 (f_1 > f_2)$ with zero phase difference, same amplitudes, travelling in the same direction superimpose

a) Phenomenon of beats is always observed by human ear

b) Intensity of resultant wave is a constant

c) Intensity of resultant wave varies periodically with time with maximum intensity $4a^2$ and minimum intensity zero

d) A maxima appears at a time $1/[2(f_1 - f_2)]$ later (or earlier) than a minima appears

384. Following are equations of four waves:

(i) $y_1 = a\sin\omega\left(t - \frac{x}{v}\right)$

(ii) $y_2 = a\cos\omega\left(t + \frac{x}{v}\right)$

(i) $z_1 = a\sin\omega\left(t - \frac{x}{v}\right)$

(i) $z_2 = a\cos\omega\left(t + \frac{x}{v}\right)$

Which of the following statements are correct?

a) On superposition of waves (i) and (iii), a travelling wave having amplitude $a\sqrt{2}$ will be formed

b) Superposition of waves (ii) and (iii) is not possible

c) On superposition of (i) and (ii), a stationery wave having amplitude $a\sqrt{2}$ will be formed

d) On superposition of (iii) and (iv), a transverse stationery wave will be formed

385. The equation of a wave is

$$y = 4\sin\left[\frac{\pi}{2}\left(2t + \frac{1}{8}x\right)\right]$$

Where y and x are in centimetres and t is in seconds

a) The amplitude, wavelength, velocity, and frequency of wave are 4 cm, 16 cm,32 cm/s and 1 Hz, respectively, with wave propagating along$+x$ direction

b) The amplitude, wavelength, velocity, and frequency of wave are 4 cm, 32 cm, 16 cm/s, and 0.5 Hz, respectively, with wave propagating along$-x$ direction

c) Two position occupied by the particle at time interval of 0.4 s have a phase difference of 0.4 π radian

d) Two position occupied by the particle at separation of 12 cm have a phase difference of 135°

386. Which of the following functions represent a stationer wave? Here a, b and c are constants:

a) $y = a\cos(bx)\sin(ct)$

b) $y = a\sin(bx)\cos(ct)$

c) $y = a\sin(bx + ct)$

d) $y = a\sin\,(bx + ct) + a\sin(bx - ct)$

387. $y = (x, t) = 0.8/[(4x + 5t)^2 + 5]$ represents a moving pulse, where x and y are in metres and t is in seconds, then
a) Pulse is moving in $+ x$ direction
b) In 2 s it will travel a distance of 2.5 m
c) Its maximum displacement is 0.16 m
d) It is a symmetric pulse
388. Mark out the correct statement (s) w.r.t. wave speed and particle velocity for a transverse travelling mechanical wave on a string
a) The wave speed is same for the entire wave, which particle velocity is different for different points at a particular instant
b) Wave speed depends upon property of the medium but not on the properties
c) Wave speed depends upon both the properties of the medium and on the properties of wave
d) Particle velocity depends upon properties of the wave and not on medium properties
389. In a wave motion $y = a \sin(kx - \omega t)$, y can represent
a) Electric field b) Magnetic field c) Displacement d) pressure
390. A vibrating tuning fork is first held in the hand and then its end is brought in contact with a table. Which of the following statement(s) is/ are correct in respect of this situation?
a) The sound is louder when the tuning fork is held in hand
b) The sound is louder when the tuning fork is in contact with table
c) The sound dies away sooner when tuning fork is brought in contact with the table
d) The sound remains for a longer duration when turning fork is held in hand
391. A point sound source is situated in a medium of bulk modulus 1.6×10^5 N/m^2. The equation for the wave emitted from it is given by $y = A \sin(7.5\,\pi x - 3000\pi t)$.
Velocity of wave is v and the displacement amplitude of the waves received by the observer standing at a distance 5 m from the source is A. The density of medium is ρ. The pressure amplitude at the observer ear is 30 Pa. The intensity of wave received by the observer is I. Then
a) $\rho = 1$ kg/m^3 b) $v = 400$ m/s c) $A = \frac{10^{-4}}{4\pi}$ d) $I = 1$ W/m^2
392. An air column in a pipe, which is closed at one end, will be in resonance with a vibrating tuning fork of frequency 264 Hz if the length of the column in cm is (speed of sound = 330 m/s)
a) 31.25 b) 62.50 c) 93.75 d) 125
393. Mark out the correct statement (s)
a) When a sound wave strikes a wall, the compression pulse is reflected as compression pulse
b) When a sound wave strikes a wall, the compression pulse is reflected as a rarefaction pulse
c) When a sound wave is coming out after passing through a narrow pipe, then reflection would be there at the open end
d) When a sound wave is coming out after passing through a narrow pipe, then compression pulse is reflected as a rarefaction pulse
394. A wave equation which gives the displacement along the y-direction is given by $y = 10^4 \sin(60t + 2x)$ where x and y are in metres and t is time in seconds. This represents a wave
a) Travelling with a velocity of 30 m/s in the negative x-direction
b) of wavelength π
c) of frequency $30/\pi$ Hz
d) of amplitude 10^{-4}m travelling along the negative x-direction
395. A wave equation which gives the displacement along Y-direction is given by
$y = 10^{-4} \sin(60t + 2x)$
Where x and y are in metres and t is time in second. This represents a wave
a) Travelling with a velocity of 30 m/s in the negative x-direction
b) of wavelength π metres
c) of frequency $30/\pi$ Hertz
d) of amplitude 10^{-4} m travelling along the negative x-direction

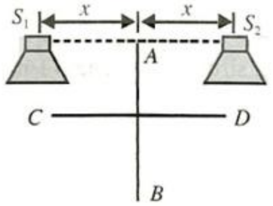
396. Plane harmonic waves of frequency 500 Hz are produced in air with displacement amplitude of 10 μm. Given that density of air is 1.29 kg/m^3 and speed of sound in air is 340 m/s. Then

a) The pressure amplitude is 13.8 N/m^2
b) The energy density is 6.4×10^{-4} J/m^3
c) The energy flux is 0.22 J (m^2s)
d) Only (a) and (c) are correct

397. A wave is going from one medium to another; then which of its property may/must change?

a) Frequency
b) Wavelength
c) Velocity
d) Amplitude

398. Two speakers are placed as shown in figure



Mark out the correct statement(s)

a) If a person is moving along AB, he will hear the sound as loud, faint, loud and so on
b) If a person moves along CD, he will hear loud, faint, loud and so on
c) If a person moves along AB, he will hear uniform intense sound
d) If a person moves along CD, he will hear uniform intense sound

399. As a wave propagates

a) The wave intensity remains constant for a plane wave
b) The wave intensity decreases as the inverse square of the distance from the source for a spherical wave
c) The wave intensity decreases as the inverse of the distance from a line source
d) Total power of the spherical wave over the spherical surface centred at the source remains constant at all the times

400. Two coherent waves represented by $y_1 = A\sin\left(\frac{2\pi}{\lambda}x_1 - \omega t + \frac{\pi}{6}\right)$ and $y_2 = A\sin\left(\frac{2\pi}{\lambda}x_2 - \omega t + \frac{\pi}{6}\right)$ are superposed. The two waves will produce

a) Constructive interference at $(x_1 - x_2) = 2\lambda$
b) Constructive interference at $(x_1 - x_2) = 23/24\lambda$
c) Destructive interference at $(x_1 - x_2) = 1.5\lambda$
d) Destructive interference at $(x_1 - x_2) = 11/24\lambda$

401. As a wave propagates

a) The wave intensity remains constant for a plane wave
b) The wave intensity decreases as the inverse of the distance from the source for a spherical wave
c) The wave intensity decreases as the inverse square of the distance from the source for a spherical wave
d) Total intensity of the spherical wave over the spherical surface centred at the source remains constant at all times

402. Two identical straight wires are stretched so as to produce 6 beats s^{-1}, when vibrating simultaneously. On changing the tension slightly in one of them, the beat frequency remains unchanged. Denoting by T_1 and T_2 the higher and lower initial tensions in the string, then it could be said that while making the above changes in tension

a) T_2 was decreased
b) T_2 was increased
c) T_1 was increased
d) T_1 was decreased

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 403 to 402. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

403

Statement 1: Speed of wave $=\frac{\text{Wave length}}{\text{Time period}}$

Statement 2: Wavelength is the distance between two nearest particles in phase

404

Statement 1: The more the velocity of a simple harmonic wave in a string, the more is the maximum velocity of the particles of string

Statement 2: $v_{\max}=\omega A$

405

Statement 1: Transverse waves are not Produced in liquids and gases.

Statement 2: Light waves are transverse waves.

406

Statement 1: In standing waves on a string, the medium particles, i.e., different string elements remain at rest

Statement 2: In standing waves all the medium particles attain maximum velocity twice in one cycle

407

Statement 1: Particle velocity and wave velocity both are independent of time

Statement 2: For the propagation of wave motion, the medium must have the properties of elasticity and inertia

408

Statement 1: Pressure and density changes do not occur in a transverse stationary wave

Statement 2: The average distance between any two particles of the wave remains the same

409

Statement 1: Displacements produced by two waves at a point are$y_1=a\sin\omega t$, $y_2=asin\left(\omega t+\frac{\pi}{2}\right)$. The resultant amplitude is$a\sqrt{2}$.

Statement 2: $R=\sqrt{a^2+b^2+2ab\cos\pi/2}$

410

Statement 1: The intensity of a plane progressive wave does not change with change in distance from the source

Statement 2: The wavefronts associates with a plane progressive wave are planner

411

Statement 1: Transverse waves travel through air in an organ pipe

Statement 2: Air possesses only volume elasticity

412

Statement 1: Sound travels faster in solids than gases

Statement 2: Solids possess greater density then gases

413

Statement 1: In a sinusoidal travelling wave on a string potential energy of deformation of string element at extreme position is maximum

Statement 2: The particles in sinusoidal travelling wave perform SHM

414

Statement 1: When there is no relative velocity between source and observer, then observed frequency is the same as emitted

Statement 2: Velocity of sound when there is no relative velocity between source and observer is zero

415

Statement 1: Violet shift indicates that a star is approaching the earth.

Statement 2: Violet shift indicates decrease in apparent wavelength of light.

416

Statement 1: A tuning fork is considered as a source of an acoustic wave of a single frequency as marked on its body

Statement 2: The tuning fork cannot produce any of its harmonics due to its special nature of construction

417

Statement 1: A 80 dB sound has twice the intensity of a 40 dB sound

Statement 2: Loudness of a sound of a certain intensity I is defined as

$$L(\text{in } dB) = 10 \log_{10} \frac{I}{I_0}$$

418

Statement 1: If two waves of same amplitude, produce a resultant wave of same amplitude, then the phase difference between them will be 120°

Statement 2: Velocity of sound is directly proportional to the square of its absolute temperature

419

Statement 1: A tuning fork is made of an alloy of steel, nickel and chromium

Statement 2: The alloy of steel, nickel and chromium is called elinvar

420

Statement 1: Solids can support both longitudinal and transverse waves, but only longitudinal waves can propagate in gases.

Statement 2: Solids possess two types of elasticity.

421

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

Statement 2: There is no atmosphere on moon

422

Statement 1: When a wave goes from one medium to other, then average power transmitted by the wave may change

Statement 2: Due to change in medium, amplitude, speed, wavelength, and frequency of wave may change

423

Statement 1: The fundamental frequency of an organ pipe increases as the temperature increases

Statement 2: As the temperature increases, the velocity of sound increases more rapidly than length of the pipe

424

Statement 1: A person is standing near a railway track. A train is moving on the track. As the train is approaching the person, apparent frequency keeps on increasing and when the train has passed the person, then apparent frequency keeps on decreasing

Statement 2: When train is approaching the person then,

$f = f_0 \left[\frac{c}{c-u}\right]$

and when train is moving away from person

$f = f_0 \left[\frac{c}{c+u}\right]$

Here, c is velocity of sound, u is velocity of train and f_0 is original frequency of whistle

425

Statement 1: Velocity of particles, while crossing mean position (in stationery waves) varies from maximum at antinodes to zero at nodes

Statement 2: Amplitude of vibration at antinodes is maximum and at nodes, the amplitudes is zero and all particles between two successive nodes cross the mean position together

426

Statement 1: When a guitar string is plucked, the frequency of the plucked string will not be the same as the wave it produces in air

Statement 2: The speeds of the waves depends on the medium in which they are propagation

427

Statement 1: Where two vibrating tuning forks having frequencies 256 Hz and 512 hz are held near each other, beats cannot be heard

Statement 2: The principle of superposition is valid only if the frequencies of the oscillators are nearly equal

428

Statement 1: The reverberation time dependent on the shape of enclosure, position of source and observer

Statement 2: The unit of absorption coefficient in mks system is metric sabine

429

Statement 1: In the case of a stationary wave, a person hear a loud sound at the nodes as compared to the antinodes

Statement 2: In a stationary wave all the particles of the medium vibrate in phase

430

Statement 1: For a travelling wave in a string, for small amplitudes the instantaneous values of kinetic and potential energies of any element are equal

Statement 2: $dU = \frac{1}{2} T\, dx \left(\frac{\partial y}{\partial x}\right)^2$

$d(\mathrm{KE}) = \frac{1}{2}(\mu\, dx) \left(\frac{\partial y}{\partial x}\right)^2$

Where T is the tension and μ is mass per unit length of the string

431

Statement 1: A plane progressive harmonic wave is propagating in a string. If tension in the string is made two times then average power transmitted through the string becomes two times

Statement 2: Average power transmission in a string is given by $P = \frac{\omega^2 A^2 F}{2V}$

432

Statement 1: When two waves interfere, one wave alters the progress of the other wave

Statement 2: In interference there is no loss of energy

433

Statement 1: A tuning fork is in resonance with a closed pipe. But the same tuning fork cannot be in resonance with an open pipe of the same length.

Statement 2: The same tuning fork will not be in resonance with open pipe of same length due to end correction of pipe.

434

Statement 1: The sound of train coming from some distance can be easily detected by placing our ears near the rails.

Statement 2: Sound travels faster in air than solids.

435

Statement 1: In a progressive longitudinal wave, the amplitude of the wave will not be the same at all points of the medium along the direction of the motion of the wave

Statement 2: There is a continuous change of the phase angle of the wave as it progresses in the direction of motion

436

Statement 1: Quality of sound depends on number and frequency of overtones produced by the instrument.

Statement 2: Pitch of sound depends on frequency of the source.

437

Statement 1: The flash of lightening is seen before the sound of thunder is heard

Statement 2: Speed of sound is greater than speed of light

438

Statement 1: Wave generated in a metal piece can be transverse of longitudinal

Statement 2: Waves generated depend upon the method of creating waves in the metal

439

Statement 1: On a rainy day sound travels slower than on a dry day

Statement 2: When moisture is present in air the density of air increases

440

Statement 1: Compression and rarefactions involve changes in density and pressure

Statement 2: When particle are compressed, density of medium increases and when they are rarefied, density of medium decreases

441

Statement 1: If two people talk simultaneously and each creates an intensity level of 60 dB at a point P, then total intensity level at the point P is 120 dB

Statement 2: Sound level is defined on a non-linear scale

442

Statement 1: The apparent frequency which is the frequency as noted by an observer or an observing detection device of the acoustic wave that moves from the source to the observer propagating in a medium may be different from its true frequency

Statement 2: A source in motion relative to an observer sends out less or more number of waves per metre distance in the medium and an observer of waves per metre distance in the medium and an observer in motion collects less or more number of waves per second than when both of them remain at rest relatively

443

Statement 1: After Laplace correction for Newton's formula for finding the speed of sound in gases, we find

Statement 2: Laplace replace p by yp in the relation v=$\frac{\sqrt{p}}{p}$

444

Statement 1: It is not possible to have interference between the waves produced by two violins

Statement 2: For interference of two waves the phase difference between the waves must remain constant

445

Statement 1: The change in air pressure effect the speed of sound

Statement 2: The speed of sound in a gas is proportional to square root of pressure

446

Statement 1: Sound produced by an open organ pipe is richer than the sound produced by a closed organ pipe

Statement 2: Outside air can enter the pipe from both ends, in case of open organ pipe

447

Statement 1: The basic of Laplace correction was that, exchange of heat between the region of compression and rarefaction in air is not possible

Statement 2: Air is a bad conductor of heat and velocity of sound in air is large

448

Statement 1: A wave of frequency 500 Hz is propagating with a velocity of$350 ms^{-1}$. Ditance between two particles with 60^0 phase difference is 12 cm.

Statement 2: $x = \frac{\lambda}{2\pi}\phi$.

449

Statement 1: The fundamental frequency of an organ pipe increases as the temperature increases

Statement 2: As the temperature increases, the velocity of sound increases more rapidly than length of the pipe

450

Statement 1: Like sound, light can not propagate in vacuum

Statement 2: Sound is a square wave. It propagates in a medium by a virtue of damping oscillation

451

Statement 1: Intensity of sound wave changes when the listener moves towards or away from the stationary source

Statement 2: The motion of listener causes the apparent change in wavelength

452

Statement 1: Two waves moving in a uniform string having uniform tension cannot have different velocities

Statement 2: Elastic and inertial properties of string are same for all waves in same string. Moreover speed of wave in a string depends on its elastic and inertial properties only

453

Statement 1: Under given conditions of pressure and temperature, sound travels faster in a monoatomic gas than in the diatomic gas.

Statement 2: Opposition to travel is more in diatomic gas than in monoatomic gas.

454

Statement 1: Sound waves cannot propagate through vacuum but light waves can

Statement 2: Sound waves cannot be polarised but light waves can be polarised

455

Statement 1: When two waves each of amplitude a produce a resultant wave of amplitude$a$, the phase difference between them must be 120^0.

Statement 2: If follows from R= $\sqrt{a^2+b^2+2ab\cos\phi}$.

456

Statement 1: Maximum changes of pressure and density occur at the nodal points of the medium in a stationery transverse wave produced in the medium

Statement 2: There will be compressions and rarefractions in a stationary longitudinal wave at the nodal points

457

Statement 1: The principle of superposition states that amplitude, velocities, and, accelerations of the particles of the medium due to the simultaneous operation of two or more progressive simple harmonic waves are the vector sum of the separate amplitude, velocity and acceleration of those particles under the effect of each such wave acting alone in the medium

Statement 2: Amplitudes, velocities and accelerations are linear functions of the displacement of the particle and its time derivatives

458

Statement 1: In a stationary wave, there is not transfer of energy.

Statement 2: There is no outward motion of the disturbance from one particle to adjoining particle in a stationary wave.

459

Statement 1: For a closed pipe the first resonance length is 60 cm. The second resonance position will be obtained at 120 cm

Statement 2: In a closed pipe $n_2 = 3n_1$

460

Statement 1: When a closed organ pipe vibrates, the pressure of the gas at the closed end remains constant

Statement 2: In a stationery-wave system, is placement nodes are pressure antinodes, and displacement antinodes are pressure nodes

461

Statement 1: A standing wave pattern is formed in a string. The power transfer through a point (other than node and antinode) is zero always

Statement 2: At antinode tension is perpendicular to the velocity

462

Statement 1: In a standing wave on a string, the spacing between nodes is Δx. If the tension in string is increased 4 times, keeping the frequency of compounent wave same as before, then the separation between nearest node and antinode will be Δx

Statement 2: Spacing between nodes (consecutive) in the standing wave is equal to half of the wavelength of component waves

463

Statement 1: A tuning fork produces 4 beats s^{-1} with 49 cm lengths of a stretched sonometer wire. The frequency of fork is 396 Hz.

Statement 2: $n = 4\ (49 + 50) = 396$ Hz.

464

Statement 1: When two vibrating tuning forks have $f_1 = 300$ Hz and $f_2 = 350$Hz and held close to each other; beats cannot be heard

Statement 2: The principle of superposition is valid only when $f_1 - f_2 < 10$ Hz

465

Statement 1: When a beetle moves along the sand with in a few tens of centimeters of a sand scorpion the scorpion immediately turn towards the beetle and dashes to it

Statement 2: When a beetle disturbs the sand, it sends pulses along the sands surface one set of pulses is longitudinal while other set is transverse

466

Statement 1: The speed of sound in solids is maximum through their density is large

Statement 2: This is because their coefficient of elasticity is large

467

Statement 1: Sound would travel faster on a hot summer day than a cold winter day

Statement 2: Velocity of sound is directly proportional to the square of its absolute temperature

468

Statement 1: If speed of sound in a gas is336.6ms^{-1}, number of beat s^{-1} by 2 waves of length 1m and 1.01m is 3.

Statement 2: Using the relation $v = n\lambda$

469

Statement 1: The change in air pressure effects the speed of sound

Statement 2: The speed of sound in gases is proportional to the square of pressure

470

Statement 1: In a small segment of string carrying sinusoidal wave, total energy is conserved

Statement 2: Every small part moves is SHM and in SHM total energy is conserved

471

Statement 1: The equation of a stationary wave is $y = 20sin\frac{\pi x}{4}\cos\omega t$.the distance between two consecutive antinodes will be 4m.

Statement 2: The data is insufficient

Matrix-Match Type

This section contain(s) 0 question(s). Each question contains Statements given in 2 columns which have to be matched. Statements (A, B, C, D) in **columns I** have to be matched with Statements (p, q, r, s) in **columns II**.

472. A string fixed at both ends is vibrating in resonance. In Column I some statement(s) are given which can match with one or more entries of Column II. Match these entries

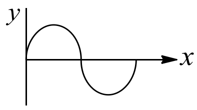
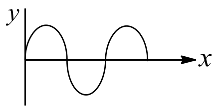
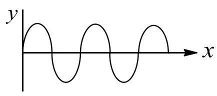
	Column-I		**Column- II**
(A)	All the particles of the string are vibrating in phase	(p)	Fundamental tone
(B)	The particles near both the ends of the string are vibrating in phase	(q)	Ist harmonic

(C) The particles near the ends of the string are vibrating in opposite phase	(r)	Even harmonic
(D) All the particles of string cross mean and extreme positions simultaneously twice in one cycle	(s)	Odd harmonic

CODES :

	A	**B**	**C**	**D**
a)	C,a	d,b,a	a,b	d
b)	a,d	a,b,d	c	a,b,c,d
c)	c	b,a	a,b,a	c,a
d)	a,b,c	c,d	a	b

473. Three travelling sinusoidal waves are on identical strings having same tension. The mathematical from of the waves are $y_1 = A\sin(3x - 6t), y_2 = A\sin(4x - 8t)$ and $y_3 = A\sin(6x - 12\ t)$

Column-I		**Column- II**
(A) Speed of each wave is	(p)	
(B) y_1 is best represented by	(q)	
(C) y_2 is best represented by	(r)	
(D) y_3 is best represented by	(s)	2 m/s

CODES :

	A	**B**	**C**	**D**
a)	D	a	b	c
b)	c	b	a	d
c)	d	c	b	a
d)	c	d	b	a

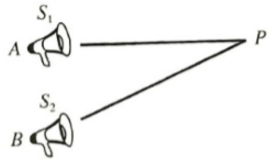
474. For transverse wave on a string

Column-I		**Column- II**
(A) If amplitude increases,	(p)	Maximum instantaneous power increases
(B) If frequency increases,	(q)	Average power increases
(C) If amplitude decreases,	(r)	Maximum instantaneous power decreases
(D) If frequency decreases,	(s)	Average power decreases

CODES :

	A	B	C	D
a)	D,a	b	a,d,c	c
b)	a,b	b,d	c	d,c
c)	a,b	a,b	c,d	c,d
d)	c,a	b	d	a

475. Two identical speakers emit sound waves of frequency 10^3 Hz uniformly in all directions. The audio output of each speaker is $9\pi/10$mW. A point 'P' is at a distance 3 m from the speaker S_1 and 5m from speaker S_2. Resultant intensity at P is I_R. Match the items in column I with the items in Column II:



Column-I		Column- II	
(A)	If the speakers are incoherent, then	(p)	$I_R = 64\ \mu\ W/m^2$
(B)	If the speakers are driven coherently and in phase at P	(q)	$I_R = 25\mu\ W/m^2$
(C)	If the speaker are driven coherently and out of phase by 180° at P, then	(r)	$I_B = 34\ \mu\ W/m^2$
(D)	If the speaker S_2 is switched off, then	(s)	$I_R = 4\mu\ W/m^2$

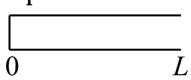
CODES :

	A	B	C	D
a)	C	a	d	b
b)	a	b	c	a
c)	b	d	c	a
d)	d	a	b	c

476. Column I shows four systems, each of the same length L, for producing standing waves. The lowest possible natural frequency of a system is called its fundamental frequency, whose wavelength is denoted as λ_f. Match each system with statements given in Column II describing the nature and wavelength of the standing waves

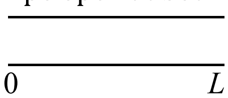
Column-I | **Column- II**

(A) Pipe closed at one end



(p) Longitudinal waves A

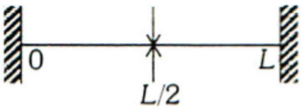
(B) Pipe open at both ends



(q) Transverse waves

(C) Stretched wire clamped at both ends

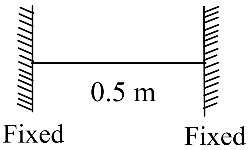
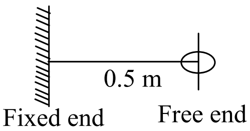
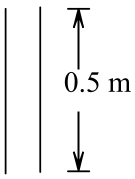
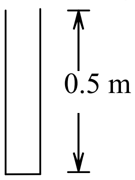
(r) $\lambda_f = L$

(D)	Stretched wire clamped at both ends and at mid-point 	(s)	$\lambda_f = 2L$
		(t)	$\lambda_f = 4L$

CODES :

	A	B	C	D
a)	P,t	p,s	q,s	q,r
b)	p,s	p,t	q,r	q,s
c)	q,s	p,s	p,t	q,r
d)	q,r	q,s	p,s	p,t

477. In each of the four situations of column I a stretched string or an organ pipe is given along with the required data. In case of strings the tension in string is $T = 102.4$ N and the mass per unit length of string is 1g/m. Speed of sound in air is 320 m/s. Neglect end corrections. The frequencies of resonance are given in Column II. Match each situation in Column I with the possible resonance frequencies given in Column II

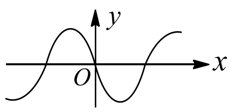
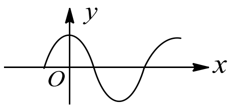
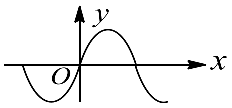
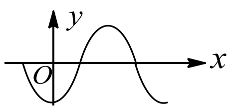
	Column-I		Column- II
(A)	String fixed at both ends 	(p)	320 Hz
(B)	String fixed at one end and free at other end 	(q)	480 Hz
(C)	Open organ pipe 	(r)	640 Hz
(D)	Closed organ pipe 	(s)	800 Hz

CODES :

	A	B	C	D
a)	A,c	b,d	a,c	b,d
b)	b	c	d	a

c)	a,b	c,d	b,c	d
d)	a	b,c	d	b,c

478. For four sine waves, moving on a string along positive x-direction, displacement distance curves ($y - x$ curves) as shown at time $t = 0$. In the right column, expression for y as function of distance x and time t for sinusoidal waves are given. All terms in the equations have their usual meanings. Correctly match $y - x$ curve with corresponding equations

Column-I	Column- II
(A) 	(p) $y = A\cos(\omega t - kx)$
(B) 	(q) $y = -A\cos(kx - \omega t)$
(C) 	(r) $y = A\sin(\omega t - kx)$
(D) 	(s) $y = A\sin(kx - \omega t)$

CODES :

	A	**B**	**C**	**D**
a)	a	c	b	d
b)	b	d	a	c
c)	a	c	d	a
d)	c	a	d	b

479. Match the columns I and II

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

CODES :

	A	**B**	**C**	**D**
a)	A,b	d	a,c	d
b)	c	d	a	b

c)	b,c	c	b	a
d)	d,a	b,a	d	c,d

480. With respect to various types of strings on piano, match the entries of Column I with that of Column II

	Column-I		**Column- II**
(A)	Bass string (low frequency)	(p)	Thick
(B)	Treble strings (high frequency and small wavelength)	(q)	Thin
(C)	To have larger wavelengths, string should be	(r)	Long
(D)	To have shorter wavelengths string should be	(s)	Short

CODES :

	A	**B**	**C**	**D**
a)	C	b,a	a,b,a	c,a
b)	a,b,c	c,d	a	b
c)	a,c	b,d	c	d
d)	b,c	a	d	b

481. In case of mechanical wave a particle wave a particle oscillates and during oscillation its kinetic energy and potential energy changes

	Column-I		**Column- II**
(A)	When particle of travelling wave is passing through mean position	(p)	Kinetic energy is maximum
(B)	When particle of travelling wave is at extreme position	(q)	Potential energy is maximum
(C)	When particle between node and antinode in standing wave passing through mean position	(r)	Kinetic energy is minimum
(D)	When particle between node and antinode in standing wave is at extreme position	(s)	Potential energy is minimum

CODES :

	A	**B**	**C**	**D**
a)	B,c	d,a	c,d	a,d
b)	a,b	c,d	a,d	b,c
c)	a	c	d	b,a
d)	c,d	a,b	a,c	a,d

482. A closed organ pipe of length L vibrating in second overtone, then match the following:

	Column-I		**Column- II**
(A)	Displacement node	(p)	Closed end

(B) Displacement antinode	(q) Open end
(C) Pressure node	(r) $4L/5$ from closed end
(D) Pressure antinode	(s) $L/5$ from closed end

CODES :

	A	B	C	D
a)	B	a	d	c
b)	a,d	b,c	d	a
c)	a,c	b,d	b,d	a,c
d)	d	c,a	d	a,c

483. Suppose a wave pulse has been created at free end of a taut string by moving the hand up and down once. The string is attached at its other end to a distant wall

Column-I	Column- II
(A) Moving hand more quickly but still up and down once by the same amount indifferent time	(p) The amplitude changes
(B) Moving hand more quickly but still up and down once by more amount in same time	(q) The width of the pulse changes
(C) Moving hand at same speed, but still up and down once by same more amount	(r) The wave speed changes
(D) Moving hand more quickly, but still up and down once by less amount	(s) The particle speed changes

CODES :

	A	B	C	D
a)	A,d	b,d	d	b
b)	b,d	a,d	a,b	a,b,d
c)	a	ad	bd	ad
d)	d	d	a	bd

484. Each of the properties of sound in list I primarily depends on one of the quantities in List II. Select the correct answer (matching List I with List II) as per code given below the lists.

Column-I	Column- II
(A) Loudness	(1) Waveform
(B) Pitch	(2) Frequency
(C) Quality	(3) Intensity

CODES :

	A	B	C	D

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

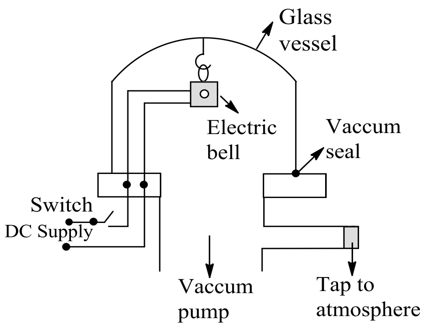
485. Select the quantities from Column II which will change with respect to the case when observer, source and air are stationery. Consider all motion along the line joining source and observer:

	Column-I		**Column- II**
(A)	Source moves, observer stationary	(p)	Frequency of sound received by observer
(B)	Sound reaches observer after reflection from fixed wall, source and observer stationary	(q)	Speed of sound with respect to medium
(C)	Observer moves, source stationery	(r)	Wavelength of waves in medium
(D)	Wind blows, source and observer stationary	(s)	None

CODES :

	A	**B**	**C**	**D**
a)	A,c	d	a	c
b)	b	d	c	a
c)	d	c	b	a
d)	a,b	c	d,a	b

486. The diagram below shows the apparatus which could be used to demonstrate that the transmission of sound wave requires a material medium. The electric bell in the figure consists of a striker and is a steel hemispherical type structure. Vacuum pump is used to create the vacuum in vessel and when the tap to atmosphere is opened the jar will be filled with air. In column I some operations carried out are mentioned, while in column II, the effect, i.e., what is observed and heard along with the conclusions are mentioned. Match the entries of column I with the entries of column II



	Column-I		**Column- II**
(A)	Switch is closed and tap is opened	(p)	Sound heard
(B)	Switch is closed, tap is closed and vacuum pump is ON	(q)	Striker seen vibrating
(C)	Switch is closed and vacuum pump is OFF and tap opened	(r)	Sound is not heard
(D)	Switch is opened and tap is closed	(s)	Light passes through vacuum but sound

cannot

CODES :

	A	B	C	D
a)	D	a,c	b,d	ab,c
b)	a,b	b,c,d	a,b	c,d
c)	d,a	b	a	c
d)	a	b,c	c	d

487. Match the statements in Column I with the statements in Column II:

Column-I		Column- II	
(A)	A right string is fixed at both ends and sustaining standing wave	(p)	At the middle, antinode is formed in odd harmonic
(B)	A tight string is fixed at one end and free at the other end	(q)	At the middle, node is formed in even harmonic
(C)	Standing wave is formed in an open organ pipe. End correction is not negligible	(r)	At the middle, neither node nor antinode is formed
(D)	Standing wave is formed in a closed organ pipe. End correction is not negligible	(s)	Phase difference between SHMs of any two particles will be either π or zero

CODES :

	A	B	C	D
a)	A,d	c,b,a	d	c,a
b)	b,a	d,c	c,b	a
c)	a,b,d	c,d	d	c,d
d)	d	a	b	c

488. These successive resonance frequencies in an organ pipe are 1310, 1834 and 2358 Hz. Velocity of sound in air is 340 m/s, then match the items given in column I with that in Column II:

Column-I		Column- II	
(A)	Length of the pipe in cm	(p)	262
(B)	Fundamental frequency (Hz)	(q)	786
(C)	Frequency of fifth harmonic (Hz)	(r)	32.4
(D)	Frequency of 1 overtone (Hz)	(s)	1310

CODES :

	A	B	C	D
a)	A	b	c	d
b)	c	a	d	b

c)	b	d	c	a
d)	d	a	b	c

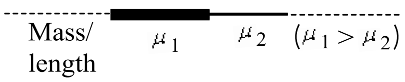
489. A loudspeaker diaphragm 0.2 m in diameter is vibrating at 1 kHz with an amplitude of 0.01×10^{-3} m. Assume that the air molecules in the vicinity have the same amplitude of vibration. Density of air is $1.29\ \mathrm{kg/m^2}$. Then match the item given in column I to that in column II. Take velocity of sound $= 340\ \mathrm{m/s}$

	Column-I		Column- II
(A)	Pressure amplitude immediately in front of the diaphragm (in $\mathrm{N/m^2}$)	(p)	2.7×10^{-2}
(B)	Sound intensity in front of the diaphragm (in $\mathrm{W/m^2}$)	(q)	2.15×10^{-5}
(C)	The acoustic power radiated (in W)	(r)	27.55
(D)	Intensity at 10 m from the loud speaker (in $\mathrm{W/m^2}$)	(s)	0.865

CODES :

	A	**B**	**C**	**D**
a)	C	d	a	b
b)	d	b	a	c
c)	a	b	c	d
d)	b	a	d	c

490. Two strings are joined as shown in figure (assume the strings under tension)



	Column-I		Column- II
(A)	Wave speed is	(p)	Same on both the strings
(B)	Wavelength is	(q)	Different on both the strings
(C)	Frequency is	(r)	More on the Ist string
(D)	Power, assuming same amplitude, is	(s)	Less on the Ist string

CODES :

	A	**B**	**C**	**D**
a)	B,a	d	a	c
b)	c	b,a	a,b,a	c,a
c)	a,b,c	c,d	a	b
d)	b,d	b,d	a	b,c

491. For transverse wave on a string

Column-I **Column- II**

(A)	If amplitude increases	(p)	Maximum instantaneous power increases
(B)	If frequency increases	(q)	Average power increases
(C)	If amplitude decreases	(r)	Maximum instantaneous power decreases
(D)	If frequency decreases	(s)	Average power decreases

CODES :

	A	**B**	**C**	**D**
a)	A,b	a,b	c,d	c,d
b)	b,c	b,c	d,a	d,c
c)	a,d	d,b	d,c	b,c
d)	b,a	b,d	c,d	b,a

Linked Comprehension Type

This section contain(s) 66 paragraph(s) and based upon each paragraph, multiple choice questions have to be answered. Each question has atleast 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

Paragraph for Question Nos. 492 to -492

The cell potential (E_{cell}) of a reaction is related as $\Delta G = -nFE_{\text{cell}}$, where ΔG represents maximum useful electronic work. $n =$ number of moles of electrons exchanged during the reaction for reversible cell reaction

$d(\Delta G) = (\Delta_r V)dp - (\Delta_r S)\ \cdot dT$

At constant pressure, $d(\Delta G) = -(\Delta_r S) \cdot dT$

∵At constant pressure, $\Delta G = \Delta H - T \cdot \Delta S$

$\therefore\ \Delta G = \Delta H + T\left(\frac{d\Delta G}{dT}\right)_p$

492. How many times in a second does a stationary ay observer hear loud sound (maximum intensity)

a) 4 b) 8 c) 10 d) 12

Paragraph for Question Nos. 493 to - 493

A sinusoidal wave is propagating in negative x-direction in a string stretched along x −axis. A particle of string at $x = 2$ cm is found at its mean position and it is moveig in positive y-direction at $t = 1$s. The amplitude of the wave, the wavelength and the angular frequency of the wave are 0.1 m, $\pi/4$ m and 4π rad/s, respectively

493. Determine the speed of the wave

a) 20/3 m/s b) 10/3 m/s c) 20 m/s d) 10 m/s

Paragraph for Question Nos. 494 to - 494

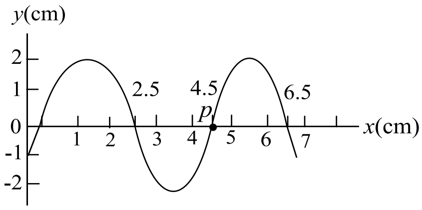
A long string having a cross-sectional area 0.80 mm^2 and density 12.5 g/cm^3 is subjected to a tension of 64 N along the x-axis. One end (at $x = 0$) of this string is attached to a vibrator moving in transverse direction at a frequency of 20 Hz. At $t = 0$, the source is at a maximum displacement $y = 1.0$ cm

494. Find the speed of the wave travelling on the string

a) 20 m/s b) 10 m/s c) 80 m/s d) 40 m/s

Paragraph for Question Nos. 495 to - 495

Consider a sinusoidal travelling wave shown in figure. The wave velocity is +40 cm/s



495. Find the frequency of the wave

a) 20 Hz b) 30Hz c) 25 Hz d) 10 Hz

Paragraph for Question Nos. 496 to - 496

A plane wave propagates along positive x-direction in a homogeneous medium of density $\rho = 200$ kg/m^3. Due to propagation of the wave medium particles oscillate. Space density of their oscillation energy is $E = 0.16\,\pi^2$J/m^3 and maximum shear strain produced in the medium is $\phi_0 = 8\pi \times 10^{-5}$. If at an instant, phase difference between two particle located at points (1m, 1m,1m) and (2m, 2m, 2m) is $\Delta\theta = 144°$, assuming at $t = 0$ phase of particle at $x = 0$ to be zero

496. Wave velocity is

a) 300 m/s b) 400 m/s c) 500 m/s d) 100 m/s

Paragraph for Question Nos. 497 to - 497

A sinusoidal wave is propagating in negative x-direction in a string stretched along x —axis. A particle of string at $x = 2$ cm is found at its mean position and it is moveig in positive y-direction at $t = 1$s. The amplitude of the wave, the wavelength and the angular frequency of the wave are 0.1 m, $\pi/4$ m and 4π rad/s, respectively

497. The equation of the wave is

a) $y = 0.1\sin(4\pi(t-1) + 8(x-2))$

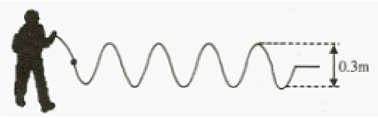
b) $y = 0.1\sin((t-1) - (x-2))$

c) $y = 0.1\sin(4\pi(t-1) - 8(x-2))$

d) None of these

Paragraph for Question Nos. 498 to - 498

Four pieces of string each of length L are joined end to end to make a long string of length $4L$: The linear mass density of the strings are $\mu, 4\mu, 9\mu$ and 16μ, respectively. One end of the combined string is tied to a fixed support and a transverse wave has been generated at the other end having frequency f (ignore any reflection and absorptions). String has been stretched under a tension F

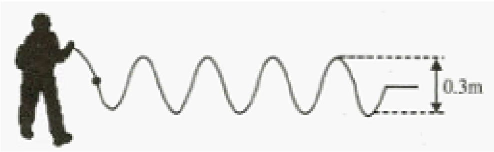


498. Find the time taken by wave to reach from source end to fixed end

a) $\frac{25}{12} \times \frac{L}{\sqrt{F/\mu}}$ b) $\frac{10L}{\sqrt{F/\mu}}$ c) $\frac{4L}{\sqrt{F/\mu}}$ d) $\frac{L}{\sqrt{F/\mu}}$

Paragraph for Question Nos. 499 to - 499

Figure shows a student setting up wave on a long stretched string. The student's hand makes one complete up and down movement in 0.4 s and in each up and down movement the hand moves by a height of 0.3 m. the wavelength of the waves on the string is 0.8 m



499. The frequency of the wave is
a) 2.5 Hz
b) 5 Hz
c) 1.25 Hz
d) Cannot be predicated

Paragraph for Question Nos. 500 to - 500

A child playing with a long rope ties one end and holds the other. The rope is stretched taut along the horizontal. The child shakes the end he is holding, up and down, in a sinusoidal manner with amplitude 10 cm and frequency 3 Hz. Speed of the wave is 15 m/s and , at $t = 0$, displacement at the child's end is maximum positive. Assuming that there is no wave reflected from the fixed end, so that the waves in the rope are plane progressive waves, answer the following questions
(Also assume that the wave propagates along the positive x- direction)

500. A wave function that describes the wave in the given situation is
a) $y = (0.1\text{m})\cos[(2\text{ rad/s})x - (12.5\text{ rad/s})t]$
b) $y = (0.1\text{m})\cos[(1.26\text{ rad/m})x - (18.8\text{ rad/s})t]$
c) $y = (0.1\text{m})\sin[(1.5\text{ rad/m})x - (10\text{ rad/s})t]$
d) $y = (0.1\text{m})\sin[(1.5\text{ rad/m})x - (4\text{ rad/s})t]$

Paragraph for Question Nos. 501 to - 501

One end of a long rope is tied to a fixed vertical pole. The rope is stretched horizontally with a tension 8 N. Let us consider to length of the rope to be along x- axis. A simple harmonic oscillator at $x = 0$ generates a transverse wave of frequency 100 Hz and amplitude 2 cm along the rope. Mass of a unit length of the rope is 20 g/m. Ignoring the effect of gravity, answer the following questions

501. Wavelength of the wave is

a) 50 cm b) 20 cm c) 8 cm d) 32 cm

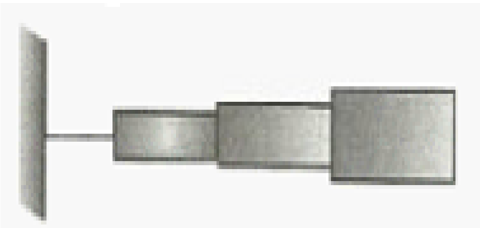
Paragraph for Question Nos. 502 to - 502

A rope is attached at one end to a fixed vertical pole. It is stretched horizontally with a fixed value of tension T. Suppose at $t = 0$, a pulse is generated by moving the free end of the rope up and down with your hand. The pulse arrives at the pole at instant t.
Ignoring the effect of gravity, answer the following questions

502. If you move your hand up and down once by the same amount but do it more rapidly, say, twice as fast as in the earlier case,
a) Time taken for the pulse to reach the pole will increase and it will be doubled
b) Time taken for the pulse to reach the pole will decrease and it will become half
c) Time taken for the pulse to reach the pole will not change
d) Cannot say

Paragraph for Question Nos. 503 to - 503

A simple harmonic plane wave propagates along x-axis in a medium. The displacement of the particles as a function of time is shown in figure, for $x = 0$ (curve 1) and $x = 7$ (curve 2)

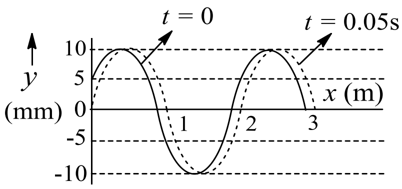


The two particles are within a span of one wavelength

503. The wavelength of the wave is
a) 6 cm b) 24 cm c) 12 cm d) 16 cm

Paragraph for Question Nos. 504 to - 504

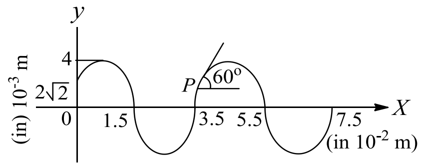
The figure represents two snaps of a travelling wave on a string of mass per unit length $\mu = 0.25$ kg/m. The first snap is taken at $t = 0$ and the second is taken at $t = 0.05$ s



504. Velocity of the wave is
a) $\frac{1700}{3}$ m/s b) $\frac{1700}{5}$ m/s c) $\frac{2500}{7}$ m/s d) $\frac{2500}{3}$ m/s

Paragraph for Question Nos. 505 to - 505

The figure shows a snap photograph of a vibrating string at $t = 0$. The particle P is observed moving up with velocity $20\sqrt{3}$ cm/s. The tangent at P makes an angle $60°$ with x-axis



505. Find the wave speed and direction in which the wave is moving
   a) 40 cm/s   b) 60 cm/s   c) 80 cm/s   d) 20 cm/s

Paragraph for Question Nos. 506 to - 506

A railroad train is travelling at 30 m/s in still air. The frequency of the note emitted by locomotive whistle is 500 Hz. Speed of sound is 345 m/s

506. What is the frequency of the sound waves heard by a stationary listener in front of the train?
   a) 547.6 Hz   b) 690.6 Hz   c) 590.9 Hz   d) 520.3 Hz

Paragraph for Question Nos. 507 to - 507

A source of sonic oscillations with frequency $n_0 = 600$ Hz moves away and at right angles to a wall with velocity $u = 30$ m/s. A stationary receiver is located on the line of source in succession wall →source → receiver. If velocity of sound propagation is $v = 330$ m/s, then

507. The beat frequency recorded by the receiver is
   a) 110 Hz   b) 210 Hz   c) 150 Hz   d) 220 Hz

Paragraph for Question Nos. 508 to - 508

A source S of acoustic wave of the frequency $v_0 = 1700$ Hz and a receiver R are located at the same point. At the instant $t = 0$, the source starts from rest to move away from the receiver with a constant acceleration ω. The velocity of sound in air is $v = 340$ m/s

508. If $\omega = 10$ m/s^2, the apparent frequency that will be recorded by the stationary receiver at $t = 10$ s will be
   a) 1700 Hz   b) 1.35 Hz   c) 850 Hz   d) 1.27 Hz

Paragraph for Question Nos. 509 to - 509

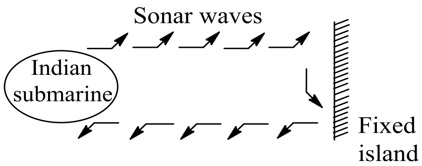
A small source of sound vibrating at frequency 500 Hz is rotated in a circle of radius $100/\pi$ cm at a constant angular speed of 5.0 revolutions per second. The speed of sound in air is 330 m/s

509. For an observer situated at a great distance on a straight line perpendicular to the plane of the circle, through its centre, the apparent frequency of the source will be
   a) Greater than 500 Hz
   b) Smaller than 500 Hz

c) Always remain 500 Hz
d) Greater for half the circle and smaller during the other half

Paragraph for Question Nos. 510 to - 510

An Indian submarine is moving in the Arabian sea with a constant velocity. To detect enemy it sends out sonar waves which travel with velocity 1050 m/s in water. Initially the waves are getting reflected from a fixed island and the reflected waves are coming back to submarine. The frequency of reflected waves are detected by the submarine and found to be 10% greater than the sent waves



Now an enemy ship comes in front, due to which the frequency of reflected waves detected by submarine becomes 21% greater than the sent waves

510. The speed of Indian submarine is
a) 10 m/s b) 50 m/s c) 100 m/s d) 20 m/s

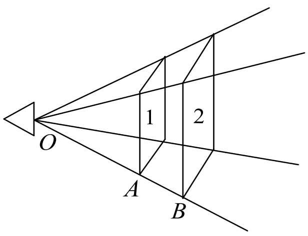
Paragraph for Question Nos. 511 to - 511

Due to a point isotropic sound source, the intensity at a point is observed as 40 dB. The density of air is $\rho = (15/11)\ \mathrm{kg/m^3}$ and velopcity of sound in air is 330 m/s. Based on this information answer the following questions

511. The pressure amplitude at the observation point is
a) $3\ \mathrm{N/m^2}$ b) $3 \times 10^3 \mathrm{N/m^2}$ c) $3 \times 10^{-3} \mathrm{N/m^2}$ d) $6 \times 10^{-2} \mathrm{N/m^2}$

Paragraph for Question Nos. 512 to - 512

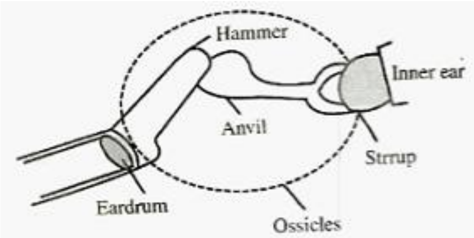
In the figure shown below, a source of sound having power 12×10^{-6}W is kept at O, which is emitting sound waves in the directions as shown. Two surfaces are labelled as 1 and 2 having areas $A_1 = 2 \times 10^3 \mathrm{m^2}$ and $A_2 = 4 \times 10^3 \mathrm{m^2}$, respectively



512. Find the intensity at both the surfaces
a) $I_1 = 12 \times 10^{-6} \mathrm{W/m^2}, I_2 = 12 \times 10^{-6} \mathrm{W/m^2}$
b) $I_1 = 6 \times 10^{-9} \mathrm{W/m^2}, I_2 = 12 \times 10^{-9} \mathrm{W/m^2}$
c) $I_1 = 6 \times 10^{-9} \mathrm{W/m^2}, I_2 = 3 \times 10^{-9} \mathrm{W/m^2}$
d) $I_1 = 12 \times 10^{-9} \mathrm{W/m^2}, I_2 = 3 \times 10^{-9} \mathrm{W/m^2}$

Paragraph for Question Nos. 513 to - 513

When a sound wave enters the ear, it sets the eardrum into oscillation, which in turn causes oscillation of 3 tiny bones in the middle ear called ossicles. This oscillation is finally transmitted to the fluid filled in inner portion of the ear termed as inner ear, the motion of the fluid disturbs hair cells within the inner ear which transmit nerve impulses to the brain with the information that a sound is present. The three bones present in the middle ear are named as hammer, anvil and stirrup. Out of these the stirrup is the smallest one and this only connects the middle ear to inner ear as shown in the figure below. The area of stirrup and its extent of connection with the inner ear limits the sensitivity of the human ear. Consider a person's ear whose moving part of the eardrum has an area of about 50 mm^2 and the area of stirrup is about 5 mm^2. The mass of ossicles is negligible. As a result, force exerted by sound wave in air on eardrum and ossicles is same as the force exerted by ossicles on the inner ear. Consider a sound wave having maximum pressure fluctuation of 4×10^{-2} Pa from its normal equilibrium pressure value which is equal to 10^5 Pa. Frequency of sound wave is 1200 Hz
Data: Velocity of sound wave in air is 332 m/s. velocity of sound wave in fluid (present in inner ear) is 1500 m/s. Bulk modulus of air is 1.42×10^5 Pa. Bulk modulus of fluid is 2.18×10^9 Pa

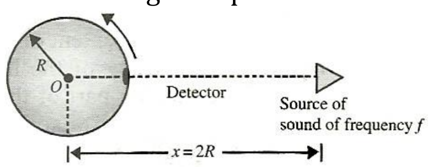


513. Find the pressure amplitude of given sound wave in the fluid of inner ear

a) 0.03 Pa
b) 0.04 Pa
c) 0.3 Pa
d) 0.4 Pa

Paragraph for Question Nos. 514 to - 514

A source of sound and detector are arranged as shown in figure. The detector is moving along a circle with constant angular speed ω. It starts from the shown location in anticlockwise direction at $t = 0$

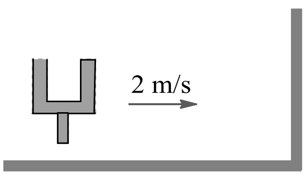


(Take velocity of sound in air as v.)
Based on this information answer the following questions

514. What is the frequency as received by detector, when it rotates by an angle $\pi/2$?

a) f
b) $\dfrac{v - \omega R}{v} \times f$
c) $\dfrac{v - \omega R/2}{v} \times f$
d) $\dfrac{v - \omega R \times 2/\sqrt{5}}{v} \times f$

Paragraph for Question Nos. 515 to - 515



As shown in figure a vibrating tuning fork of frequency 512 Hz is moving towards the wall with a speed 2 m/s. Take speed of sound as $v = 340$ m/s and answer the following questions

515. Suppose that a listener is located at rest between the tuning fork and the wall. Number of beats heard by the listener per second will be

a) 4 b) 3 c) 0 d) 1

Paragraph for Question Nos. 516 to - 516

A source of sound with natural frequency $f_0 = 1800$ Hz moves uniformly along a straight line separated from a stationary observer by a distance $l = 250$ m. The velocity of the source is equal to $\eta = 0.80$ fraction of the velocity of the sound

516. Find the frequency of sound received by the observer at the moment when the source gets closest to him

a) 2000 Hz b) 6000 Hz c) 3000 Hz d) 5000 Hz

Paragraph for Question Nos. 517 to - 517

A steel wire 0.5 m long, of mass 5g, is stretched with a force of 400 N

517. What is the minimum possible frequency with which this wire can vibrate?

a) 200 Hz b) 300 Hz c) 250 Hz d) 150 Hz

Paragraph for Question Nos. 518 to - 518

A closed air column 32 cm long is in resonance with a tuning fork. Another open air column of length 66 cm is in resonance with another tuning fork. If the two forks produce 8 beats/s when sounded together, fine

518. The speed of sound in the air

a) 33792 cm/s b) 35790 cm/s c) 31890 cm/s d) 40980 cm/s

Paragraph for Question Nos. 519 to - 519

A tube of a certain diameter and length 48 cm is open at both ends. Its fundamental frequency is found to be 320 Hz. The velocity of sound in air is 320 m/s

519. Estimate the diameter of the tube

a) 5.29 cm b) 3.33 cm c) 4.78 cm d) 4.29 cm

Paragraph for Question Nos. 520 to - 520

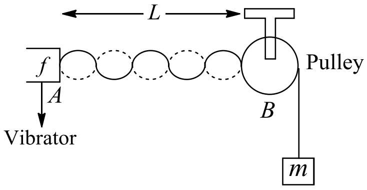
Find the number of possible natural oscillations of air column in a pipe whose frequencies lie below $f_0 = 1250$ Hz. The length of the pipe is $l = 85$cm. The velocity of sound is $v = 340$ m/s. Consider two cases

520. The pipe is closed from one end

a) 2 b) 4 c) 8 d) 6

Paragraph for Question Nos. 521 to - 521

In the arrangement shown in figure, a mass can be hung from a string with a linear mass density of 2×10^{-3} kg/m that passes over a light pulley. The string is connected to a vibrator of frequency 700 Hz and the length of the string between the vibrate and the pulley is 1 m



521. If the standing waves are observed, the largest mass to be hung is
a) 16 kg b) 25 kg c) 32 kg d) 400 kg

Paragraph for Question Nos. 522 to - 522

Both neon $[M_{\mathrm{Ne}} = 20 \times 10^{-3}\mathrm{kg}]$ and helium $[M_{\mathrm{He}} = 4 \times 10^{-3}\mathrm{kg}]$ are monoatomic gases and can be assumed to be ideal gases. The fundamental frequency of a tube (open at both ends) of neon is 300 Hz at 270 K
$(R = (25/3)\ \mathrm{J/K\ mol})$

522. The length of the tube is
a) $\frac{5}{12}$ m b) $\frac{\sqrt{3}}{12}$ m c) $\frac{5\sqrt{3}}{12}$ m d) $5\sqrt{3}$ m

Paragraph for Question Nos. 523 to - 523

A long tube contains air at a pressure of 1 atm and a temperature of 59°C. The tube is open at one end closed at the other by a movable piston. A tuning fork near the open end is vibrating with a frequency of 500 Hz. Resonance is produced when the piston is at distances 16 cm, 49.2 cm and 82.4 cm from open end. Molar mass of air is 28.8 g/ mol

523. The speed of sound in air at 59°C is
a) 332 m/s b) 342 m/s c) 352 m/s d) 362 m/s

Paragraph for Question Nos. 524 to - 524

A turning fork vibrating at 500 Hz falls from ret accelerates at 10 $\mathrm{m/s^2}$

524. Velocity of the tuning fork when waves with a frequency of 475 Hz reach the release point is (Take the speed of sound in air to be 340 m/s)
a) 1.79 m/s b) 17.9 m/s c) 35.8 m/s d) 3.58 m/s

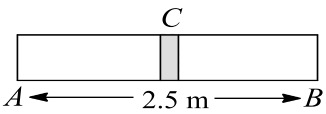
Paragraph for Question Nos. 525 to - 525

A long tube contains air at a pressure of 1 atm and a temperature of 107°C. The tube is open at one end and closed at the other by a movable piston. A tuning fork near the open end is vibrating with a frequency of 500 Hz. Resonance is produced when the piston is at distance 19, 58.5 and 98 cm from the open end

525. The speed of sound at 107°C is
a) 330 m/s b) 340 m/s c) 395 m/s d) 495 m/s

Paragraph for Question Nos. 526 to - 526

A steel rod 2.5 m long is rigidly clamped at its centre C and longitudinal waves are set up on both sides of C by rubbing along the rod. Young's modulus for steel $= 2 \times 10^{11} \mathrm{N/m^2}$, density of steel $= 8000 \mathrm{~kg/m^3}$



526. If two antinodes are observed on either side of C, the frequency of the mode in which the rod is vibrating will be
a) 1000 Hz b) 3000 Hz c) 7000 Hz d) 1500 Hz

Paragraph for Question Nos. 527 to - 527

A longitudinal standing wave $y = a \cos \omega t$ is maintained in a homogenous medium of density ρ. Here ω is the angular speed and k, the wave number and a is the amplitude of the standing wave. This standing wave exists all over a given region of space

527. The space density of the potential energy PE $= E_P(x, t)$ at a point (x, t) in the space is
a) $E_P = \frac{\rho a^2 \omega^2}{2}$
b) $E_P = \frac{\rho a^2 \omega^2}{2} \cos^2 kx \sin^2 \omega t$
c) $E_P = \frac{\rho a^2 \omega^2}{2} \sin^2 kx \cos^2 \omega t$
d) $E_P = \frac{\rho a^2 \omega^2}{2} \sin^2 kx \sin^2 \omega t$

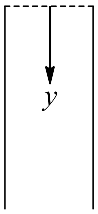
Paragraph for Question Nos. 528 to - 528

In a standing wave experiment, a 1.2–kg horizontal rope is fixed in place at its two ends ($x = 0$ and $x = 2.0$ m) and made to oscillate up and down in the fundamental mode, at frequency of 5.0 Hz. At $t = 0$, the point at $x = 1.0$ m has zero displacement and is moving upward in the positive directive of y-axis with a transverse velocity 3.14 m/s

528. Tension in the rope is
a) 60 N b) 100 N c) 120 N d) 240 N

Paragraph for Question Nos. 529 to - 529

In an organ pipe (may be closed or open) of 99 cm length standing wave is set up, whose equation is given by longitudinal displacement



$\xi = (0.1 \text{ mm}) \cos\frac{2\pi}{0.8}(y + 1 \text{ cm}) \cos(400)t$

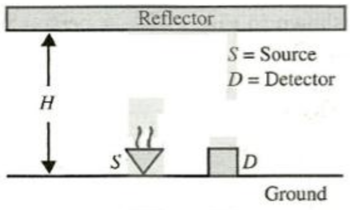
Where y is measured from the top of the tube in metres and t in seconds. Here 1 cm is the end correction

529. The upper end and the lower end of the tube are respectively

a) Open-closed b) Closed-open c) Open-open d) Closed-closed

Paragraph for Question Nos. 530 to - 530

A source of sound and a detector are placed at the same place on ground. At $t = 0$, the source S is projected towards reflector with velocity v_0 in vertical upwards direction and reflector starts moving down with constant velocity v_0. At $t = 0$, the vertical separation between the reflector ans source is $H(> v_0^2/2g)$ the speed of sound in air is $v(\gg v_0)$. Take f_0 as the frequency of sound waves emitted by source.



Based on above information answer the following questions

530. Frequency of sound waves emitted by source at $t = v_0/2g$ is

a) f_0 b) $f_0\left[\frac{v}{v+\frac{v_0}{2}}\right]$ c) $f_0\left[\frac{v - v_0/2}{v}\right]$ d) $f_0\left[\frac{v - v_0/2}{v + v_0/2}\right]$

Paragraph for Question Nos. 531 to - 531

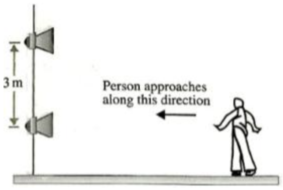
Two waves $y_1 = A\cos(0.5\pi x - 100\pi t)$ and $y_2 = A\cos(0.46\pi x - 92\pi t)$ are travelling in a pipe placed along the x-axis

531. Find the number of times intensity is maximum in time interval of 1 s

a) 4 b) 6 c) 8 d) 10

Paragraph for Question Nos. 532 to - 532

An oscillator of frequency 680 Hz drives two speakers. The speakers are fixed on a vertical pole at a distance 3 m from each other as shown in figure. A person whose height is almost the same as that of the lower speaker walks towards the lower speaker in a direction perpendicular to the pole. Assuming that there is no reflection of sound from the ground and speed of sound is v =340 m/s, answer the following questions



532. As the person walks towards the pole, his distance from the pole when he first hears a minimum in sound intensity is nearly
a) 14.6 m　　b) 17.9 m　　c) 10.1 m　　d) 22.4 m

Paragraph for Question Nos. 533 to - 533

Consider a standing wave formed on a string. It results due to the superposition of two waves travelling on opposite direction. The waves are travelling along the length of the string in the x-direction and displacement of elements on the string are along the y-direction. Individual equations of the two waves can be expressed as
$Y_1 = 6(\text{cm}) \sin[5\ \text{rad/cm})x - 4\ (\text{rad/s})t]$
$Y_1 = 6(\text{cm}) \sin[5\ \text{rad/cm})x + 4\ (\text{rad/s})t]$
Here x and y are is cm
Answer the following questions

533. Maximum values of the y-positions coordinate in the simple harmonicd motion of an element of the string that is located at an antinode will be
a) $\pm$ 6 cm　　b) $\pm$8 cm　　c) $\pm$12 cm　　d) $\pm$3 cm

Paragraph for Question Nos. 534 to - 534

A vertical pipe open at both ends is partially submerged in water. A tuning fork of unknown fork of unknown frequency is placed near the top of the pipe and made to vibrate. The pipe can be moved up and down and thus length of air column in the pipe can be adjusted. For definite lengths of air column in the pipe, standing waves will be set up as a result of superposition of sound waves travelling in opposite directions. Smallest value of length of air column, for which sound intensity is maximum is 10 cm [take speed of sound $v = 344$ m/s]
Answer the following questions

534. The air column here is closed at one end because the surface of water acts as a well. Which of the following is correct?
a) At the closed end of the air column, there is a displacement node and also a pressure node
b) At the closed end of the air column, there is a displacement node and a pressure antinode
c) At the closed end of the air column, there is a displacement antinode and a pressure node
d) At the closed end of the air column, there is a displacement antinode and also a pressure antinode

Paragraph for Question Nos. 535 to - 535

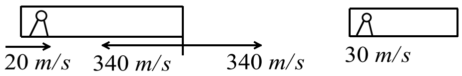
Two plane harmonic sound waves are expressed by the equations
$y_1(x,t) = A\cos(0.5\pi x - 100\pi t)$
$y_x(x,t) = A\cos(0.46\pi x - 92\pi t)$
(All parameter are is MKS)

535. How many times does an observer hear maximum intensity in one second

a) 4
b) 10
c) 6
d) 8

Paragraph for Question Nos. 536 to - 536

Two trains A and B are moving with speeds 20 m/s and 30 m/s respectively in the same direction on the same straight track, with B ahead of A. The engines are at the front ends. The engine of train A blows a long whistle. Assume that the sound of the whistle is composed of components varying in frequency from $f_1 = 800Hz$ to $f_2 = 1120Hz$, as shown in the figure. The spread in the frequency (highest frequency-lowest frequency) is thus 320 Hz. The speed of sound in still are is 340 m/s

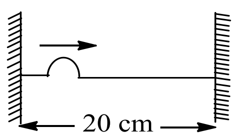


536. The speed of sound of the whistle is

a) 340 m/s for passengers in A and 310 m/s for passengers in B
b) 360 m/s for passengers in A and 360 m/s for passengers in B
c) 310 m/s for passengers in A and 360 m/s for passengers in B
d) 340 m/s for passengers in both the trains

Integer Answer Type

537. A plane progressive wave is given by $x = (40\text{ cm})\cos(50\pi t - 0.02\pi y)$ where y is in and t in s. The particle velocity at $y = 25$ m in time $t = \frac{1}{100}$ s will be $10\pi\sqrt{n}$ m/s. What is the value of n
538. For a certain organ pipe, three successive resonance observed are 425, 595 and 765 Hz. Taking the speed of sound to be 340 ms^{-1}, find the length of the pipe, in meter
539. An ambulance sounding a horn of frequency 264 Hz is moving towards a vertical wall with a velocity of 5 ms^{-1}. If the speed of the sound is 330 ms^{-1}, how many beats per second will be heard by an observer standing a few meters behind the ambulance?
540. The resultant loudness at a point P is n dB higher than the loudness of S_1which is one of the two identical sound sources $S_1$and S_2 reaching at that point in phase. Find the value of n
541. If the intensity of sound is doubled, by how many decibels does the sound level increase? (in dB)
542. A glass tube of 1.0 m length is filled with water. The water can be drained out slowly at the bottom of the tube. A vibrating tuning fork of frequency 500 Hz is brought at the upper end of the tube and the velocity of sound is 300 ms^{-1}. Find the number of resonances that can be obtained
543. A tube, opened from both ends is vibrated in its second overtone. At how many points inside the tube maximum pressure variation is observed?
544. A string of length 40 cm and weighing 10 g is attached to a spring at one end and to a fixed wall at the other end. The spring has a spring constant of 160 N/m and is stretched by 1.0 cm. If a wave pulse is produced on the sting near the wall. How much time will it take to reach the spring? (in $\times 10^{-2}$s)
545. A particle on a stretched string supporting a travelling wave, takes 5.0 ms to move from its mean position to the extreme position. The distance between two consecutive particles, which are at their mean positions, is 3.0 cm. find the wave speed (in m/s)
546. A string of length 20 cm and linear mass density 0.40 g/cm is fixed at both ends and is kept under a tension of 16 N. A wave pulse is produced at $t = 0$ near an end as shown in figure which travels towards the other end



When will the string have the shape shown in the figure again? (in $\times 10^{-2}$s)

547. Two sound sources are moving away from a stationary observer in opposite directions with velocities V_1 and $V_2 (V_1 > V_2)$. The frequency of the sources is 900 Hz. V_1 and V_2 are both quite less than speed of sound, $V = 300$ m/s. Find the value of $(V_1 - V_2)$ so that beat frequency observed by observer is 9 Hz. (in m/s)

548. A travelling wave is given by

$$y = \frac{0.8}{(3x^2 + 24xt + 48t^2 + 4)}$$

Where x and y are in metres and t is in seconds. Find the velocity in m/s

549. The speed of a transverse wave, going on a wire having a length 50 cm and mass 5 g is 80 m/s. The area of cross section of the wire is 1.0 mm^2 and its Young's modulus is 8×10^{11} N/m^2. Find the extension in (in $\times 10^{-2}$ mm) of the wire over its natural length

550. A wave pulse passing on a string with a speed of 40 cm/s in the negative x-direstion has its maximum at $x = 0$ at $t = 0$. Where will this maximum be located at $t = 5$ s? If the coordinate of required maximum is $x = -$μm. What is the value to be filled in box

551. The intensity of sound from a point source is 1.0×10^{-8}W/m^2 at a distance of 5.0 m from the source. What will be the intensity at a distance of 25 m from the source? (in$\times 10^{-10}$W/m^2)

552. A closed and an open organ pipe of same length are set into vibrations simultaneously in their fundamental mode to produce 2 beats. The length of open organ pipe is now halved and of closed organ pipe is doubled. Now find the number of beats produced

553. A 4.0 kg block is suspended from the ceiling of an elevator through a string having a linear mass density of 19.2×10^{-3}kg/m. The speed (with respect to the string) with which a wave pulse can proceed on the string if the elevator accelerates up at the rate of 2.0 m/s^2 is $12.5n$. What is the value of n. Take $= \mathrm{g} = 10$ m/s^2

554. The average power transmitted across a cross-section by two sound waves moving in the same direction are equal. The wavelengths of two sound waves are in the ratio of 1:2, then find the ratio of their pressure amplitudes

555. Two identical sinusoidal waves travel in opposite direction in a wire 15 m long and produce a standing wave in the wire. If the speed of the waves is 12 ms^{-1} and there are 6 nodes in the standing wave. Find the frequency

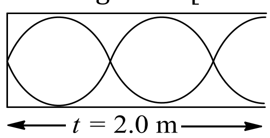
556. An ant with mass m is standing peacefully on top of a horizontal, stretched rope. The rope has mass per unit length μ and is under tension F. Without warning, a student starts a sinusoidal transverse wave of wavelength λ propagating along the rope. The motion of the rope is in a vertical plane. What minimum wave amplitude (in mm) will make the ant feel weightless momentarily? Assume that m is so small that the presence of the ant has no effect on the propagation of the wave
[Given : $\lambda = 0.5$ m, $\mu = 0.1$ kg/m, $F = 3.125$ N, take $\mathrm{g} = \pi^2$]

557. A tuning fork of frequency 200 Hz is in unison with a sonometer wire. How many beats are heard in 30 s if the tension is increased by 1% (in terms of $\times$ 10]

558. The length, radius, tension and density of string A are twice the same parameters of string B. Find the ratio of fundamental frequency of B to the fundamental frequency of A

559. nth harmonic of a closed organ pipe is equal to mth harmonic of an open pipe. First overtone frequency of the closed organ pipe is also equal to first overtone frequency of the open organ pipe. Find the value of n, if $m = 6$

560. The standing wave pattern shown in the tube has a wave speed of 5.0 ms^{-1}. What is the frequency of the standing wave [in Hz approx.]?



561. Loudness of sound from an isotropic point source at a distance at a distance of 70 cm is 20 dB. What is the distance (in m) at which it is not heard

562. A point source of sound is located somewhere along the x-axis. Experiments show that the same wave

front simultaneously reaches listeners at $x = -8$ m and $= +2.0$ m . A third listener is positioned along the positive y-axis. What is her y- coordinate (in m) if the same wave front reaches her at the same instant as it does the first two listeners?

: ANSWER KEY :

1)	b	2)	d	3)	d	4)	b	189)	a	190)	c	191)	a	192)	d
5)	a	6)	b	7)	d	8)	d	193)	b	194)	b	195)	c	196)	b
9)	b	10)	a	11)	c	12)	c	197)	b	198)	d	199)	c	200)	c
13)	a	14)	b	15)	a	16)	a	201)	c	202)	b	203)	b	204)	a
17)	a	18)	d	19)	b	20)	b	205)	c	206)	b	207)	c	208)	d
21)	d	22)	b	23)	c	24)	d	209)	d	210)	b	211)	d	212)	c
25)	a	26)	c	27)	c	28)	a	213)	c	214)	c	215)	b	216)	d
29)	c	30)	a	31)	c	32)	c	217)	c	218)	c	219)	a	220)	a
33)	a	34)	b	35)	b	36)	a	221)	d	222)	c	223)	d	224)	d
37)	c	38)	a	39)	d	40)	b	225)	c	226)	c	227)	a	228)	a
41)	d	42)	a	43)	c	44)	d	229)	c	230)	b	231)	b	232)	c
45)	d	46)	a	47)	b	48)	b	233)	d	234)	b	235)	c	236)	c
49)	c	50)	d	51)	b	52)	a	237)	c	238)	a	239)	b	240)	b
53)	a	54)	b	55)	c	56)	a	241)	c	242)	b	243)	b	244)	b
57)	a	58)	a	59)	a	60)	d	245)	a	246)	a	247)	c	248)	d
61)	d	62)	b	63)	b	64)	c	249)	c	250)	b	251)	c	252)	a
65)	b	66)	b	67)	b	68)	b	253)	c	254)	c	255)	a	256)	c
69)	a	70)	b	71)	b	72)	d	257)	c	258)	c	259)	c	260)	d
73)	a	74)	a	75)	c	76)	b	261)	a	262)	d	263)	a	264)	d
77)	c	78)	b	79)	a	80)	d	265)	c	266)	a	267)	d	268)	b
81)	b	82)	b	83)	d	84)	b	269)	b	270)	d	271)	a	272)	b
85)	a	86)	b	87)	d	88)	c	273)	d	274)	b	275)	b	276)	a
89)	d	90)	a	91)	c	92)	b	277)	d	278)	b	279)	c	280)	b
93)	d	94)	a	95)	c	96)	b	281)	a	282)	c	283)	d	284)	b
97)	b	98)	d	99)	d	100)	b	285)	b	286)	b	287)	a	288)	b
101)	b	102)	b	103)	d	104)	a	289)	a	290)	d	291)	a	292)	a
105)	b	106)	c	107)	c	108)	b	293)	a	294)	a	295)	a	296)	d
109)	d	110)	c	111)	c	112)	a	297)	c	298)	b	299)	d	300)	b
113)	a	114)	a	115)	d	116)	d	301)	a	302)	c	1)	b,d	2)	
117)	b	118)	a	119)	b	120)	d		a,b,c,d	3)	b,c	4)	a,b,d		
121)	a	122)	d	123)	b	124)	a	5)	a,b,d	6)	a	7)	a,b,d	8)	
125)	a	126)	b	127)	c	128)	d		a,b,c						
129)	b	130)	a	131)	d	132)	a	9)	b,c	10)	b,d	11)	a,b,d	12)	
133)	d	134)	a	135)	d	136)	a		b,c,d						
137)	c	138)	d	139)	b	140)	c	13)	b,c	14)	a,c	15)	a,b	16)	
141)	d	142)	c	143)	b	144)	b		a,b,d						
145)	c	146)	b	147)	d	148)	a	17)	a,d	18)	a,c	19)	b,c	20)	
149)	c	150)	c	151)	b	152)	c		b,d						
153)	b	154)	d	155)	a	156)	c	21)	c,d	22)	b,c	23)	a,b,c	24)	
157)	b	158)	d	159)	b	160)	b		b,d						
161)	d	162)	c	163)	b	164)	a	25)	b,c,d	26)	d	27)	a,b,d	28)	
165)	a	166)	b	167)	c	168)	c		a,b						
169)	c	170)	b	171)	b	172)	d	29)	a,c	30)	c	31)	a,c	32)	
173)	d	174)	b	175)	b	176)	b		a,c						
177)	b	178)	c	179)	b	180)	d	33)	a,c,d	34)	b,c,d	35)	c,d	36)	
181)	b	182)	b	183)	a	184)	d		b,c,d						
185)	d	186)	b	187)	b	188)	b	37)	a	38)	b,c	39)	a,b,d	40)	

	b,c						
41)	a,d	42)	a,b,c,d	43)	a,c	44)	
	a,d						
45)	a,c	46)	a,b,c	47)	a,c,d	48)	
	a,c						
49)	a,b,d	50)	a,b,c	51)	b,d	52)	
	a,b,c						
53)	b,c	54)	b,c	55)	b,d	56)	
	b,c						
57)	b,c	58)	a,c,d	59)	a,b,c,d	60)	
	b,d						
61)	b,c	62)	b,d	63)	a,c,d	64)	
	c,d						
65)	b,c,d	66)	a	67)	a,b,d	68)	
	a,b						
69)	b,c	70)	a,b	71)	a,b,c	72)	
	c,d						
73)	b,c	74)	a,d	75)	a,b,c,d	76)	
	a,b,d						
77)	a,c,d	78)	a,b,c	79)	b,c	80)	
	a,c						
81)	c,d	82)	a,d	83)	b,c,d	84)	
	a,b,d						
85)	b,c,d	86)	a,b,d	87)	a,b,c,d	88)	
	b,c,d						
89)	a,b,c	90)	a,c	91)	a,c,d	92)	
	a, b, c, d						
93)	a,b,c,d	94)	a,b,c	95)	b,c,d	96)	
	b,c						
97)	a,b,c,d	98)	b, d	99)	a,c,d	100)	
	b,d						
1)	b	2)	d	3)	b	4)	d
5)	e	6)	b	7)	a	8)	a
9)	e	10)	b	11)	d	12)	c
13)	b	14)	a	15)	d	16)	c
17)	b	18)	b	19)	a	20)	c
21)	a	22)	d	23)	a	24)	d

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

: HINTS AND SOLUTIONS :

1 **(b)**

Frequency $f \propto \sqrt{mg}$

or $f \propto \sqrt{g}$

In water $f_w = 0.8\, f_{\text{air}}$

$\therefore \frac{g'}{g} = (0.8)^2 = 0.64$

or $1 - \frac{\rho_w}{\rho_m} = 0.64$

or $\frac{\rho_w}{\rho_m} = 0.36$ (i)

or $-\frac{\rho_L}{\rho_m} = 0.36$

or $\frac{\rho_L}{\rho_m} = 0.64$ (ii)

From Eqs. (i) and (ii),

$\frac{\rho_L}{\rho_m} = \frac{0.64}{0.36} = 1.77$

2 **(d)**

For the wave, $y = A\sin(kx - \omega t)$, the wave speed is ω/k and the maximum transverse string is $A\omega$

3 **(d)**

Initially wall behaves as an approaching observer, so frequency of sound reaching the wall is

$n_1 = \frac{c+v}{c} n$

While reflecting, the wall behaves as an approaching source, so frequency received by stationary observer is

$n_2 = \frac{c}{c-v} n_1 = \frac{c}{c-v} \times \frac{c+v}{c} n = \frac{c+v}{c-v} n$

Direct frequency received by observer is n. the number of beat is

$x = n_2 - n = \frac{c+v}{c-v} n - n = \frac{2nv}{c-v}$

4 **(b)**

$f_0 - f_c = 2$

For $\frac{v}{2l} - \frac{v}{4l} = 2$ or $\frac{v}{4l} = 2$

or $\frac{v}{l} = 8$

When length of OOP is halved and that of COP is doubled, the beat frequency will be

$f_0' - f_c' = \frac{v}{l} - \frac{v}{8l} = \frac{7}{8}\frac{v}{l} = \frac{7}{8} \times 8 = 7$

5 **(a)**

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

and $y = \frac{1}{1+(x-2)^2}$ at $t = 4$ s

$v = \frac{\Delta x}{\Delta t} = \frac{x-(x-2)}{4-0} = \frac{2}{4} = 0.5$ m/s

6 **(b)**

$\omega = \frac{2\pi}{0.01}$ and $k = \frac{2\pi}{0.30}$

$v = \frac{\omega}{k} = \frac{2\pi}{0.01} \times \frac{0.30}{2\pi} = 30$ m/s

7 **(d)**

45 cm= 5(9 cm) and 99 cm=11(9 cm)

So two other lengths between these two values are 7(9 cm) 9(9 cm), i.e., 63 cm and 81 cm respectively so the fundamental length is 9 cm

$9 = \frac{\lambda}{4}$ (for a closed organ pipe)

$\lambda = 36$ cm

8 **(d)**

$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

$\Rightarrow 7I = I + 9I + 2\sqrt{I9I}\cos\phi$

$\cos\phi = -1/2$ or $\phi = 120°$

9 **(b)**

$(f_{\text{approach}})_A = 5.5 \text{ kHz} = \left(\frac{v+v_A}{v}\right)5$ (i)

$(f_{\text{approach}})_B = 6 \text{ kHz} = \left(\frac{v+v+_B}{v}\right)5$ (ii)

Where v is the velocity of sound. Now,

$5.5 = \left(1 + \frac{v_A}{v}\right)5$

$\Rightarrow \frac{v_A}{v} = 0.1$ (iii)

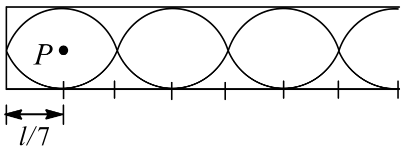
Similarly, $6 = \left(1 + \frac{v_B}{v}\right)5$

$\Rightarrow \frac{v_B}{v} = 0.2$ (iv)

$\Rightarrow \frac{v_B}{v_A} = 2$ (iv)

10 **(a)**

Figure shows variation of displacement of particle in a closed organ pipe for 3rd overtone



For third overtone

$l = \frac{7\lambda}{4}$ or $\lambda = \frac{4l}{7}$ or $\frac{\lambda}{4} = \frac{l}{7}$

Hence the amplitude at P at a distance $l/7$ from closed end is 'a' because there is an antinode at that point

Alternate: Because there is node at $x = 0$ the displacement amplitude as function of x can be written as

$A = a\sin kx = a\sin\frac{2\pi}{\lambda}x$

For third overtone

$l = \frac{7\lambda}{4}$ or $\lambda = \frac{4l}{7}$

$A = a \sin \frac{2\pi 7x}{4l}$

At $x = \frac{l}{7}$ $A = a$

11 **(c)**

$SL = 10 \log \frac{I}{I_0}$

$= 10 \log \frac{k}{I_0 r^2}$

$= 10 \log K - 10 \log(I_0 r^2)$

$= 10 \log k - 10 \log I_0 - 20 \log r$

$= a - b \log r$

12 **(c)**

For destructive interference, path difference has to be equal to an odd integral multiple of $\lambda/2$

13 **(a)**

$x = a \sin\left(\omega t + \frac{\pi}{6}\right)$

$x' = a \cos \omega t = a \sin\left(\omega t + \frac{\pi}{2}\right)$

Therefore, phase difference $= (\pi/2) - \pi/6$

$= (\pi/3)$

14 **(b)**

$$v_7 = \sqrt{\frac{3R(273+7)}{M}}$$

$$v_{47} = \sqrt{\frac{3R(273+47)}{M}}$$

$$\frac{v_7}{v_{47}} = \sqrt{\frac{280}{320}} = \sqrt{\frac{7}{8}}$$

Now $\frac{\sin i}{\sin r} = \frac{v_2}{v_{47}} = \sqrt{\frac{7}{8}}$

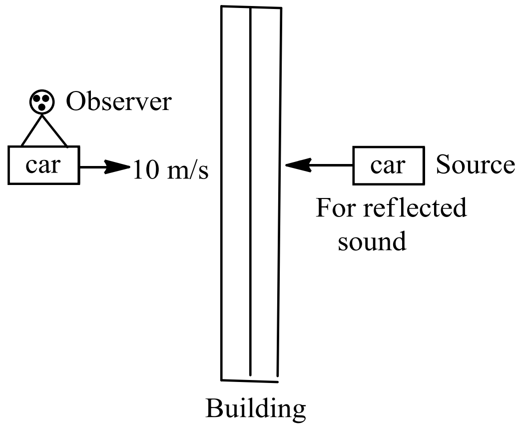
$$\sin r = \sin 30° \times \sqrt{\frac{8}{7}} = \sqrt{\frac{2}{7}}$$

or $r = \sin^{-1}\sqrt{\frac{2}{7}}$

15 **(a)**

36 km/h= $36 \times \frac{5}{18}$

=10m/s



Apart frequency of sound heard by car driver (observer)

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

$= 8\left(\frac{320 + 10}{320 - 10}\right)$

$f' = 8.5\ kHz$

16 **(a)**

Amplitude of wave,

$A = \frac{2.0 \text{ cm}}{2} = 1 \text{ cm}$

Frequency of wave, $f = 125$ Hz

Wavelength of , $\lambda = 15.6$ cm= 0.156 m

Let equation of wave be, $y = A \sin(kx - \omega t + \phi)$

where $k = 2\pi/\lambda = 40.3$ rad/m and $\omega = 2\pi f = 786$ rad/s

Using initial conditions,

$y(0,0) = 0 = A \sin \phi$

and $\frac{\partial y}{\partial t}(0,0) = -A\omega \cos \phi < 0$

We get, $\phi = 0$

So, the equation of wave is

$y = (1 \text{ cm}) \sin[(40.3 \text{ rad/m})\, x - (786 \text{ rad/s})t]$

17 **(a)**

After a time t, velocity of observer $V_0 = at$

$f_0 = \left(\frac{V + V_0}{V}\right) f_s = \left(\frac{V + at}{V}\right) f_s$

Which is a straight line graph of positive slope

18 **(d)**

We know $\omega = 2\pi f = \frac{2\pi}{0.04}$

$\Rightarrow f = 25$ Hz

Differentiating y w.r.t. twice, we have

$y" = \frac{-3 \times 4\pi^2}{(0.004)^2} \sin\left(2\pi\left[\left(\frac{t}{0.04}\right) - \left(\frac{x}{0.01}\right)\right]\right)$

For maximum acceleration

$y_0" = \frac{3 \times 4\pi^2}{(0.004)^2} = 7.5 \times 10^4 \text{ m/s}^2$

19 **(b)**

$$\frac{(C)N_2}{(C)He} = \sqrt{\frac{M_{He}}{M_{N_2}}} = \sqrt{\frac{4}{28}} = \sqrt{\frac{1}{7}}$$

20 **(b)**

$$\frac{f_{\text{approach}} - f_{\text{recede}}}{f} = \frac{\Delta f}{f} = \frac{v}{v - v_s} - \frac{v}{v + v_s}$$

$$\therefore \frac{\Delta f}{f} = \frac{v(v + v_s - v + v_s)}{v^2 - v_s^2} = \frac{2vv_s}{v^2 - v_s^2}$$

But $\frac{\Delta f}{f} \times 100 = 2\%$

$$\Rightarrow 0.02 = \frac{2(300)v_s}{(300)^2 - v_s^2}$$

$$\Rightarrow 0.02 = \frac{2(300)v_s}{(300)^2} = \frac{2}{300}v_s$$

$\therefore v_s = (0.01)300$

$= 3$ m/s

21 **(d)**

As wave has been reflected from a rare medium; therefore there is no change in phase. Hence equation for the opposite direction can be written as

22 **(b)**

$v_1 = 250$ Hz, $v_2 = 253$ Hz, $v_2 - v_1 = 3$

Now,

$$\frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{(4+2)^2}{(4-2)^2} = \frac{36}{4} = 9$$

23 **(c)**

$v_{\max} = \omega_n A = (2\pi f)A = (2\pi)(440)(10^{-6})$

$= 2.76 \times 10^{-3}$ m/s

24 **(d)**

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

T can be calculated by using Hooke's law and on stretching μ also changes

25 **(a)**

For $x = 5, y = 4\sin\left(\frac{5\pi}{15}\right)\cos(96\pi t)$

$= 2\sqrt{3}\cos(96\pi t)$

So, y will be maximum when $\cos(96\pi t) = \max = 1$

$y_{\max} = 2\sqrt{3}$ cm at $x = 5$

26 **(c)**

$$f = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

$$\frac{\Delta f}{f} = \frac{1}{2}\frac{\Delta T}{T}$$

$$\frac{\Delta T}{T} = 2\left(\frac{\Delta f}{f}\right)$$

$\frac{\Delta T}{T} \times 100 =$ percentage chnage in tension

$$\frac{\Delta T}{T} = 2\left(\frac{5}{500}\right)$$

$$\frac{\Delta T}{T} = \frac{1}{50}$$

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

27 **(c)**

$$B = 10\log_{10}\left(\frac{I}{I_0}\right)$$

$$= 10\log_{10}\left(\frac{10^{-6}}{10^{-12}}\right)$$

$= 60$ dB

28 **(a)**

$y = y_1 + y_2 = a\sin(\omega t - kx) = a\sin(\omega t - kx)$

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

Clearly it is equation of standing wave for position of nodes y=0.

$$i.e., x = (2n+1)\frac{\lambda}{4}$$

$$\Rightarrow \left(n + \frac{1}{2}\right)\lambda = 0,1,2,3$$

29 **(c)**

$$3 \times \frac{v}{4l_c} = 2 \times \frac{v}{2l_0} \text{ or } \frac{l_c}{l_0} = \frac{3}{4}$$

30 **(a)**

The wavelength in front of the car is

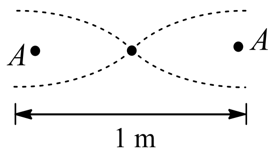
$$\lambda = \frac{v - u_s}{f_s} = \frac{340\text{m/s} - 34\text{ m/s}}{400\text{ Hz}}$$

$= 0.765$ m

31 **(c)**

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

$v = f\lambda = 2500 \times 2$ m/s $= 5000$ m/s



32 **(c)**

Intensity level is decibel is given by

$$L = 10\log_{10}\frac{I}{I_0}$$

$$L + 1 = 10\log_{10}\frac{I_1}{I_0}$$

Substracting, $1 = 10\log_{10}\frac{I_1}{I_0} - 10\log_{10}\frac{I}{I_0}$

Or $\frac{1}{10} = \log_{10}\frac{I_1}{I}$

Or $0.1 = \log_{10}\frac{I_1}{I}$

Or $\frac{I_1}{I} = 1.26$

33 **(a)**

Standard equation

$y = A\sin(\omega t - kx + \phi_0)$

In a given equation $\omega = 7\pi, k = 0.04\pi$

$$v = \frac{\omega}{k} = \frac{7\pi}{0.04\pi} = 175 \text{ m/s}$$

34 **(b)**

Maximum particle velocity $= a_0\omega = 2\pi a_0 v$

Wave velocity $= v\lambda$

Given that $2\pi a_0 v = 3v\lambda$

or $\lambda = (2\,\pi\,a_0/3)$

35 **(b)**

The frequency of direct sound of whistle heard by observer is

$n_1 = \frac{v}{v-v_s}n = \frac{340}{340-1} \times n = \frac{340}{339}n$ (i)

Frequency of sound of whistle reflected by wall is

$n_2 = \frac{v}{v+v_s}n = \frac{340}{341}n$ (ii)

Given, $n_1 - n_2 = 4$

Therefore, $\frac{340}{339}n - \frac{340}{341}n = 4$

$\Rightarrow n = 680$ Hz

36 **(a)**

$\lambda = 2l = 3$ m

Equation of standing wave

(As $x = 0$ is taken as a node)

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

Given $2A = 4$ mm

To find value of x for which amplitude is 2 mm, we have 2 mm = (4 mm) sin kx

$$\frac{2\pi}{\lambda}x = \frac{\pi}{6} \Rightarrow x_1 = \frac{1}{4}\text{m}$$

$$\frac{2\pi}{\lambda}x = \frac{\pi}{2} + \frac{\pi}{3} \Rightarrow x_2 = 1.25 \text{ m}$$

$x_2 - x_1 = 1$ m

37 **(c)**

In an open organ pipe, both the ends are free ends, hence both are displacement antinodes and hence pressure nodes

38 **(a)**

If detector moves x distance, distance from direct sound increases by x and distance from reflected sound decreaseds by x so path difference created $= 2x$

$2(0.14) = 14\lambda = 14\,c/f$

$$f = \frac{14 \times 3 \times 10^8}{0.14 \times 2} = 1.5 \times 10^{10} \text{ Hz}$$

39 **(d)**

$$\frac{n_1}{2\left(\frac{l}{2}\right)}\sqrt{\frac{T}{\pi r^2 \rho}} = \frac{n_2}{2\left(\frac{l}{2}\right)}\sqrt{\frac{T}{\pi(4r^2)\rho}}$$

$$\Rightarrow \frac{n_1}{n_2} = \frac{1}{2}$$

40 **(b)**

$v = n\lambda$

$= 2n(l_1 - l_2) = 2f \times 1 = 2f$ m/s

41 **(d)**

According to equation

$2n_1 = 3n_2$

or $\frac{2}{2l_1}\sqrt{\frac{T}{m_1}} = \frac{3}{2l_2}\sqrt{\frac{T}{m_2}}$

or $\frac{l_1}{l_2} = \frac{2}{3}\sqrt{\frac{m_2}{m_1}} = \frac{2}{3}\sqrt{\frac{a_2\rho}{a_1\rho}}$

or $\frac{l_1}{l_2} = \frac{2}{3}\sqrt{\frac{r_2^2}{r_1^2}} = \frac{2}{3}\sqrt{\left(\frac{1}{2}\right)^2}$

or $\frac{l_1}{l_2} = \frac{1}{3}$

42 **(a)**

Negative sign with 'ω' indicates that wave is propagating along positive x-axis

$$\lambda = \frac{2\pi}{k} = \frac{2\pi}{10\pi} = 0.2 \text{ m}$$

and $v = \frac{\omega}{k} = \frac{15\pi}{10\pi} = 1.5$ m/s

43 **(c)**

$$40 = 10\log_{10}\left(\frac{I_1}{I_0}\right)$$

$\therefore \frac{I_1}{I_0} = 10^4$ (i)

Also, $20 = 10\log_{10}\left(\frac{I_2}{I_0}\right)$

$\Rightarrow \frac{I_2}{I_0} = 10^2$ (ii)

$$\therefore \frac{I_2}{I_1} = 10^{-2} = \frac{r_1^2}{r_2^2}$$

$\therefore r_2 = 100\,r_1^2 \Rightarrow r_2 = 10$ m ($\because r_1 = 1$ m)

44 **(d)**

For $y = x + \frac{4\pi}{\alpha}$

$$\frac{\partial r}{\partial t} = 0$$

i.e., all point lying on the $y = x + \frac{4\pi}{\alpha}$ are always at rest

45 **(d)**

On going for one medium to another, frequency remains the same while wavelength and wave speed, both change. Amplitude may decreases or remain same depending on the fact that whether there is some absorption of energy at the boundary or not

46 **(a)**

$f_1\lambda_1 = f_2\lambda_2$

$(300)(1) = (f_2)(1.5)$

$200 \text{ Hz} = f_2$

47 **(b)**

The wave is travelling along the length of a string, while particles constituting the string are oscillation in a direction perpendicular to the length to string. In one time period (cycle), the wave moves forward by one wavelength while the particle on string travels a distance of 4 times the amplitude

Here, $T = 1/f = 0.02\text{s}$

Wave speed, $v = f\lambda = 25$ m/s

Time taken by wave to travel a distance of 8 m,

$t_1 = 8/25\text{s} = 0.32$ s

Time taken by particle on string to travel a distance of 8 m,

$$t_2 = \frac{8 \times T}{4 \text{ times amplitude}} = \frac{8}{4 \times 0.01} \times 0.02 = 4 \text{ s}$$

48 **(b)**

$$\frac{I_1}{I_2} = \frac{a_1^2 f_1^2}{a_2^2 f_2^2} = \frac{(3)^2(8)^2}{(2)^2(12)^2} = 1$$

49 **(c)**

$$f = \frac{v}{4l} = \frac{320}{4}\text{Hz} = 80 \text{ Hz}$$

Since even harmonic cannot be present therefore 320 Hz ($= 4 \times 80$) is ruled out

50 **(d)**

When the man is approaching the factory,

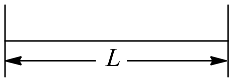
$$n' = \left(\frac{v + v_0}{c}\right) n = \left(\frac{320 + 2}{320}\right) 800 = \left(\frac{322}{320}\right) 800$$

When the man is going away from the factory,

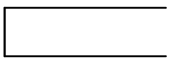
$$n'' = \left(\frac{v - v_0}{v}\right) n = \left(\frac{320 - 2}{320}\right) 800 = \left(\frac{318}{320}\right) 800$$

$$\therefore n' - n'' = \left(\frac{322 - 318}{320}\right) 800 = 10\text{Hz}$$

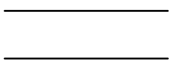
51 **(b)**



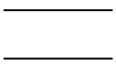
Fundamental frequency of wire (f_{wire}) $= v/2l$

a. 

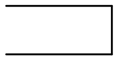
$f = \frac{v}{4l}, \frac{3v}{4l}, \frac{5v}{4l}$ cannot match with f_{wire}

b. 

$f = \frac{v}{2(2l)}, \frac{2v}{2(2l)}, \frac{3v}{2(2l)}$ its second harmonic $\frac{2v}{2(2l)}$ matches with f_{wire}

c. 

$f = \frac{v}{2(l/2)}, \frac{2v}{2(l/2)}$ cannot match with f_{wire}

d. 

$f = \frac{v}{4(l/2)}, \frac{3v}{4(l/2)}, \ldots$ cannot match with f_{wire}

52 **(a)**

$y = 0.02 \sin(x + 30t)$

Comparing with standard equation

$y = A \sin(Kx + \omega t), \omega = 30, K = 1$

Velocity of wave,

$$v = \frac{\omega}{K} = \frac{30}{1} = 30 \text{ m/s}$$

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

Tension $T = v^2 \text{m} = (30)^2 \times 10^{-4}$

$= 0.09$ N

53 **(a)**

According to Hooke's law, $F_g \propto x$ [Restoring force $F_g = T$, tension of spring]

Velocity of sound by a stretched string

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

Where m is the mass per unit length

$$\therefore \frac{v}{v'} = \sqrt{\frac{T}{T'}} \Rightarrow v' = v\sqrt{\frac{T'}{T}} = v\sqrt{\frac{1.5x}{x}} = 1.22v$$

54 **(b)**

$$v' = \frac{v}{v - v_s} v, v'' = \frac{v}{v + v_s} v$$

$$\frac{v'}{v''} = \frac{v + v_s}{v - v_s} \text{ or } \frac{6}{5} = \frac{330 + v}{330 - v}$$

$11v_s = 330$ or $v_s = 30$ m/s

55 **(c)**

For 1st reading of oscillator

$f_A = (514 \pm 2)$ Hz

$f_A = 516$ Hz or 512 Hz

For 2nd reading of oscillator

$f_A = (510 \pm 6)$ Hz

$f_A = 516$ Hz or 504 Hz

A has a frequency 516 Hz

56 **(a)**

Standard equation

$$y = A \cos\frac{2\pi x}{\lambda} \sin\frac{2\pi vt}{\lambda}$$

By comparing this equation with given equation

$$\frac{2\pi x}{\lambda} = \frac{\pi x}{20} \Rightarrow \lambda = 40 \text{ cm}$$

Distance between two nodes $= \lambda/2 = 20$ cm

57 **(a)**

The relative velocity of sound waves w.r.t. the wall is $V + v$. Hence, the apparent frequency of the waves striking the surface of the wall is $(V + v)/\lambda$. The number of positive crests striking per second is same as frequency. In 3 s, the number is $[3\,(V + v)]/\lambda$

58 **(a)**

Apparent frequency due to train which is coming in is

$$n_1 = \frac{v}{v - v_s} n$$

Apparent frequency due to train which is leaving is

$$n_2 = \frac{v}{v + v_s} n$$

So the number of beats is

$$n_1 - n_2 = \left(\frac{1}{316} - \frac{1}{324}\right) 320 \times 240 \Rightarrow n_1 - n_2 = 6$$

59 **(a)**

For minima,

$$\Delta x = (2n + 1)\frac{\lambda}{2} \text{ and } \lambda = \frac{v}{f}$$

$$0.5 = \frac{(2n + 1)}{2}\frac{300}{f}$$

$$f = (2n + 1)300$$

Therefore, all odd multiples of 300 are silenced

60 **(d)**

For closed organ pipe,

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

For minimum and maximum length of pipe the fundamental frequency of pipe must be 20 kHz and 20 Hz, respectively

$$20 = \frac{320}{4L_{\max}}$$

$$L_{\max} = 4 \text{ m}$$

$$20 \times 10^3 = \frac{320}{4L_{\min}}$$

$$L_{\min} = 4 \text{ mm}$$

61 **(d)**

Both the bodies oscillate in simple harmonic motion for which the maximum velocities will be

$$v_1 = a_1\omega_1 = a_1 \times \frac{2\pi}{T_1}$$

$$v_2 = a_2\omega_2 = a_2 \times \frac{2\pi}{T_2}$$

Given that $v_1 = v_2$

$$a_1 \times \frac{2\pi}{T_1} = a_2 \times \frac{2\pi}{T_2}$$

$$\Rightarrow \frac{a_1}{a_2} = \frac{T_1}{T_2} = \frac{2\pi\sqrt{\frac{m}{k_1}}}{2\pi\sqrt{\frac{m}{k_2}}} = \sqrt{\frac{k_2}{k_1}}$$

62 **(b)**

Phase difference, $\Delta\phi = k\Delta x$

$$\Delta\phi = \frac{2\pi}{\lambda} \times \Delta x = \frac{2\pi}{3\text{cm}} \times 16.5 \text{ cm} = 11\pi$$

So, the phase difference between two waves among the given option is 5π

63 **(b)**

In the figure, 'C' reaches the position where 'A' already reaches after $\omega t = \pi/2$ and 'A' reaches the position where 'B' already reaches after $\omega t = \pi/2$

64 **(c)**

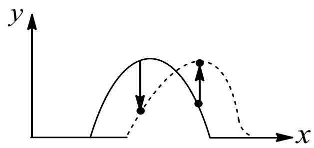
We know that $E \propto A^2 v^2$,where $A =$ amplitude and $v =$frequency. Also, $\omega = 2\pi v = \omega \propto v$

In case 1: Amplitude $= A$ and $v_1 = v$

In case 2: Amplitude $= A$ and $v_2 = 2v$

$$\therefore \frac{E_2}{E_1} = \frac{A^2 v_2^2}{A^2 v_1^2} = 4 \Rightarrow E_2 = 4E_1$$

65 **(b)**



Dotted shape shows pulse position after a short time interval. Direction of the velocities are decided according to direction of displacements of the particle

66 **(b)**

$$\lambda = \frac{330}{500} = 0.66 \text{ m}$$

The resonance occurs at

$$\frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}, \frac{7\lambda}{4}, \ldots$$

i.e., at 0.165 m, 0.495 m, 0.825 m, 1.115 m. As the length of the tube is only 1.0 m, hence 3 resonances will be observed

67 **(b)**

Length of the path for direct sound = 120 m

Length of the path for reflected sound

$= 2\sqrt{[(60)^2 + (25)^2]} = 130$ m

Geometrical path difference

$= 130 - 120 = 10$ m

Two waves interfere constructively when

$10 = n\lambda$

Putting, $n = 1,2,3, \ldots, \lambda = 10,5,2.5, \ldots$

68 **(b)**

When the train is approaching,

$$n_1 = \frac{v}{v - v_s} \times n = \frac{320}{320 - 4} \times 243 = \frac{80}{79} \times 243$$
When the train is receding,
$$n_2 = \frac{v}{v + v_s} \times n = \frac{320}{324} \times 243 = \frac{80}{81} \times 243$$
Beat frequency is
$$n = n_1 - n_2 = 80 \times 243 \left(\frac{1}{79} - \frac{1}{81}\right) = 6 \text{ Hz}$$

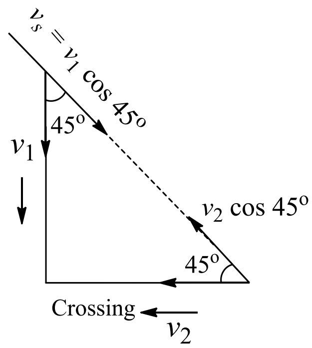
69 **(a)**

We know that
$$f = \frac{1}{2l}\sqrt{\frac{T}{m}}$$
In air $T = mg = \rho V g$
$$\therefore f = \frac{1}{2l}\sqrt{\frac{\rho V g}{m}} \qquad \text{(i)}$$
In water, $T = mg -$upthrust
$$= V\rho g - \frac{V}{2}\rho_\omega g = \frac{Vg}{2}(2\rho - \rho_\omega)$$
Therefore,
$$\therefore f' = \frac{1}{2l}\sqrt{\frac{\frac{Vg}{2}(2\rho - \rho_\omega)}{m}}$$
$$= \frac{1}{2l}\sqrt{\frac{Vg\rho}{m}}\sqrt{\frac{(2\rho - \rho_\omega)}{2\rho}} = 300\left[\frac{2\rho - 1}{2\rho}\right]^{\frac{1}{2}}$$
$\because \rho_\omega = 1$ g/cc and from Eq. (i)

70 **(b)**
$$y = y_0 \sin 2\pi\left[ft - \frac{x}{\lambda}\right]$$
$$\therefore \frac{dy}{dt} = \left[y_0 \cos 2\pi\left(ft - \frac{x}{\lambda}\right)\right] \times 2\pi f$$
$$\Rightarrow \left[\frac{dy}{dt}\right]_{\max} = y_0 \times 2\pi f$$
Given that the maximum particle velocity is equal to four times the wave velocity ($c = f\lambda$)
$$\therefore \; y_0 \times 2\pi f = 4f \times \lambda$$
$$\lambda = \frac{\pi y_0}{2}$$

71 **(b)**

The component of velocity of source along the line joining the car is
$$v_s = v_1 \cos 45° = 36 \times \frac{1}{\sqrt{2}} \text{km/h}$$
$$= 5\sqrt{2} \text{ m/s}$$
Component of velocity of observer (second car) along the line joining the car is



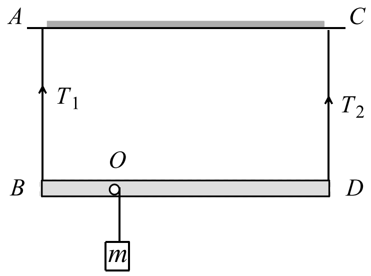
$$v_0 = v_2 \cos 45° = 72 \times \frac{1}{\sqrt{2}} \text{km/h}$$
$$= 10\sqrt{2} \text{ m/s}$$
$$n' = \frac{v + v_0}{v - v_S} n = \frac{330 + 10\sqrt{2}}{330 - 5\sqrt{2}} \times 280$$
$$= \frac{344}{323} \times 280 \text{ Hz} = 298 \text{ Hz}$$

72 **(d)**

We know that
$$T_1 = 2\pi\sqrt{\frac{l}{g}}$$
and $T_2 = 2\pi\sqrt{\frac{l}{g'}}$
$$\therefore \frac{T_2}{T_1} = \sqrt{\frac{g'}{g}} \qquad \text{(i)}$$
Also $g = \frac{GM}{R^2}$
$$\therefore g' = \frac{GM}{(2R)^2} = \frac{GM}{4R^2}$$
$$\therefore \frac{g}{g'} = 4 \Rightarrow \frac{T_2}{T_1} = 2$$

73 **(a)**

According to question,



$$\frac{1}{2l}\sqrt{\frac{T_1}{\mu}} = \frac{1}{l}\sqrt{\frac{T_2}{\mu}}$$
$$T_2 = T_1/4$$
For rotational equilibrium,
$$T_1 x = T_2(L - x) \Rightarrow x - L/5$$

74 **(a)**
$$\lambda' = \left(\frac{v - v_s}{v}\right)\lambda = \left(\frac{320 - 20}{320}\right)60$$
$$= 56.25 \text{ cm}$$

75 **(c)**

$100 = 10 \log_{10} \frac{I_1}{I_0}$

$50 = 10 \log_{10} \frac{I_2}{I_0}$

Or $\frac{I_1}{I_0} = 10^{10}$ and $\frac{I_2}{I_0} = 10^5$

Dividing, $\frac{I_1}{I_2} = 10^5$

76 **(b)**

$n_1 = n_2 \Rightarrow \frac{v - v_m}{v - v_C} n' = \frac{v + v_m}{v} n$

$\Rightarrow \frac{v - v_m}{v - 22} \times 176 = \frac{v + v_m}{v} \times 165$

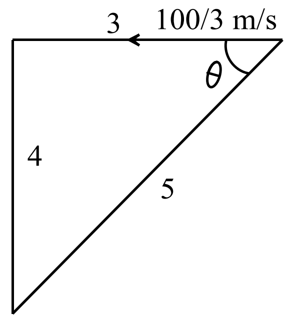
$\Rightarrow n_m = 22$ m/s

77 **(c)**

$f_0 = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

78 **(b)**

Effective value of velocity of source is



$v_s = \frac{100}{3} \cos\theta$

$= \frac{100}{3} \times \frac{3}{5} = 20$ m/s

$v' = \frac{v}{v - v_s} v$

$v' = \frac{340}{340 - 20} \times 640 \text{ Hz} = 680 \text{ Hz}$

79 **(a)**

$\Delta v = 384 - 288 = 96$

Thus 288 and 384 ($96 \times 3; 96 \times 4$) are third and fourth harmonics

For fundamental mode:

$\frac{\lambda}{2} = 0.75$

$\lambda = 1.5$

$\eta = 96$

$v = 96 \times 1.5 = 144$ m/s

80 **(d)**

$\lambda = 2(x_2 - x_1) = 2\,(0.84 - 0.50) = 0.68$

$n = \frac{v}{\lambda} = \frac{340}{0.68} = 500$ Hz

81 **(b)**

Maximum particle velocity = 4 wave velocity

$A\omega = 4f\lambda$

$y_0 2\pi f = 4f\lambda$

$\lambda = \frac{\pi y_0}{2}$

82 **(b)**

$y = \frac{4}{2}\left[2\cos^2\left(\frac{t}{2}\right)\right]\sin(1000t)$

or $y = 2(1 + \cos t)\sin 1000t$

or $t = 2\sin 1000t + 2\sin 1000\,t\cos t$

or $y = 2\sin 1000t + \sin(1001t) + \sin(999t)$

So, the given expression is a result of the superposition of three independent harmonic motions

83 **(d)**

$n_1 = n_0 \frac{340}{340 - 34} = \frac{10}{9} n_0$

$n_2 = n_0 \frac{340}{340 - 17} = \frac{20}{19} n_0$

$\frac{n_1}{n_2} = \frac{10}{9} \times \frac{19}{20} = \frac{19}{18}$

84 **(b)**

When the stone is suspended in air:

$n = \frac{1}{2L}\sqrt{\frac{W_a}{m}}$

When the stone is suspended in water:

$n = \frac{1}{2L'}\sqrt{\frac{W_w}{m}}$

Hence, $\frac{\sqrt{W_a}}{L} = \frac{\sqrt{W_w}}{L'}$

or $\frac{W_a}{W_w} = \frac{L^2}{L'^2}$

Now, specific gravity of material of the stone

$= \frac{W_a}{W_a - W_w} = \frac{1}{1 - \frac{W_w}{W_a}} = \frac{1}{1 - \frac{L'^2}{L^2}}$

$= \frac{L^2}{L^2 - L^2} = \frac{(40)^2}{(40)^2 - (22)^2}$

85 **(a)**

Particle velocity $v_p = -v(slope\ of\ y - x\ graph)$

Here, v=+ve, as the wave is travelling in positive x-direction.

Slope at P is negative.

∴ Velocity of particle is in positive y $(+\hat{j})$ direction.

86 **(b)**

60 dB =10 dB $\log\frac{I}{I_0}$

$\Rightarrow I = (10^6 \times 10^{-12})\text{W/m}^2 = 10^6\text{W/m}^2$

$[I_0 = 10^{-12}\text{W/m}^2]$

$I = \frac{(\Delta P_m)^2}{2\rho v}$

Where $\rho = 15/11 \text{kg/m}^3, v$ =330 m/s

$\therefore (\Delta P_m)^2 = 2\rho v I = 2 \times \frac{15}{11} \times 330 \times 10^{-6}$

$\Rightarrow \Delta P_m = 0.03\ \text{N/m}^2$

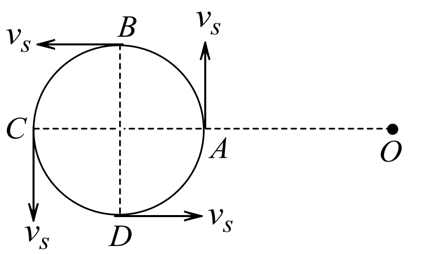
87 **(d)**

Frequency heard by the observes will be maximum when the source is in position D. in this case, source will be approaching towards the stationary observer, almost along the line of slight(as observer is stationed at a larger distance)

$n_{\max} = \frac{v}{v - v_s} n$

$= \frac{330 \times 440}{330 - 1.5 \times 20}$

$= 484\ \text{Hz}$



Similarly frequency heard by the observer will be minimum when the source reaches at position B. Now, the source will be moving away from the observer

$n_{\min} = \frac{v}{v + v_s} \times n = \frac{330}{330 + 1.5 \times 20} \times 440$

$= \frac{330 \times 440}{360} = 403.3\ \text{Hz}$

88 **(c)**

Beat frequency, $\Delta f = 6\ \text{Hz}$

Time interval between two consecutive maxima is 1/6 s. So, the required time 1/2 s

89 **(d)**

The distance between adjacent nodes $x = \frac{\lambda}{2}$

Also $k = \frac{2\pi}{\lambda}$. Hence $x = \frac{\pi}{k}$

90 **(a)**

Distance between the successive nodes,

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

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

$= \frac{\sqrt{\mathrm{T}/\mu}}{2\mathrm{f}}$

Substituting the value we get

D=5cm

91 **(c)**

$P = \frac{1}{2}\mu\omega^2 A^2 V$ using $V = \sqrt{\frac{T}{\mu}}$

$P = \frac{1}{2}\omega^2 A^2 \sqrt{T\mu}$

$\omega = \sqrt{\frac{2P}{A^2\sqrt{T\mu}}}, f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{2P}{A^2\sqrt{T\mu}}}$

Using the given data, we get $f = 30\ \text{Hz}$

92 **(b)**

$450 = 400\left(\frac{340 + v_s}{340 - v_s}\right)$

$\Rightarrow \frac{9}{8} = \frac{340 + v_s}{340 - v_s}$

$\Rightarrow 9(340) - 9v_s = 8\,(340) + 8v_s$

$\Rightarrow 17v_s = 340$

$\Rightarrow v_s = 20\ \text{m/s}$

93 **(d)**

In a sonometer,

$f \propto \sqrt{T}$

Thus, $\frac{f_1}{f_2} = 2 = \sqrt{\frac{T_1}{T_2}}$

$T_2 = \frac{T_1}{4}$

So percentage change will be

$\frac{T_1 - T_2}{T_1} \times 100 = \frac{T_1 - \frac{T_1}{4}}{T_1} \times 100 = 75\%$

94 **(a)**

$y = (0.2\ \text{m})\sin[kx \pm \omega t]$

For $x = 0, y = 0.1$ m

$0.1 = 0.2\sin(\omega t)$

$\Rightarrow \omega t = \pi/6$ or $5\pi/6$

So, $t_2 = 5\pi/6\omega$ and $t_1 = \pi/6\omega$

$t_2 - t_1 = 2\pi/3\omega = 1/3f = 1.9\ \text{ms}$

95 **(c)**

During one complete oscillation, the kinetic energy will become maximum twice. Therefore, the frequency of kinetic energy will be $2f$

96 **(b)**

Intensity of sound wave,

$I = \frac{P_0^2}{2\rho v}$

$= \frac{30 \times 30}{2 \times 10^3 \times \sqrt{2} \times 10^3} = 0.3 \times 10^{-3}\text{W/m}^2$

97 **(b)**

Fundamental frequency of a COP is given by

$f_1 = v/4l$

Length l of the column will first descrease and then become constant (when rate or inflow=rate of outflow). Therefore f_0 will first increases and then become constant

98 **(d)**

As number of beats $= \Delta v$

For option (a), the frequencies are

$v_1 = 550$ Hz, $v_2 = 552$ Hz, $v_3 = 553$ Hz, $v_4 = 560$ Hz

The beats produced will be

$\Delta v_1 = v_2 - v_1 = 2$
$\Delta v_2 = v_3 - v_1 = 3$
$\Delta v_3 = v_4 - v_1 = 10$
$\Delta v_4 = v_3 - v_2 = 1$
$\Delta v_5 = v_4 - v_2 = 8$
$\Delta v_6 = v_4 - v_3 = 7$

Which does not match with the given set of beat frequencies. Hence option (a) is not possible

Similarly options (b) and (c) are also not possible

For option (d), frequencies are $v_1 = 550, v_2 = 551, v_3 = 553, v_4 = 558$

$\Delta v_1 = v_2 - v_1 = 1$
$\Delta v_2 = v_3 - v_1 = 3$
$\Delta v_3 = v_4 - v_1 = 8$
$\Delta v_4 = v_3 - v_2 = 2$
$\Delta v_5 = v_4 - v_2 = 7$
$\Delta v_6 = v_4 - v_3 = 5$

Which matches with the given set of beat frequencies. Hence option (d)

99 **(d)**

Intensity level is given by

$40 \text{ dB} = 10 \log \frac{I}{I_0}$

$\Rightarrow \frac{I}{I_0} = 10^4 \Rightarrow I = 10^{-12} \times 10^4 = 10^{-8} \text{ W/m}^2$

Energy received by eardrum per second is

$10^{-8} \times 10^{-6} = 10^{-14}\text{W}$

To received a total energy of 1 J, time required is

$\frac{1}{10^{-14}} = 10^{14}\text{s}$

100 **(b)**

$f_1 = f_0\left(\frac{V_0}{V_0 - V}\right) f_2 = f_0\left(\frac{V_0}{V_0 + V}\right)$

$f_1 - f_2 = f_0 V_0 \left(\frac{1}{V_0 - V} - \frac{1}{V_0 + V}\right)$

$= f_0 V_0 \left(\frac{V_0 + V - V_0 + V}{V_0^2 - V^2}\right) = f_0 V_0 \times \frac{2V}{V_0^2} = f_0 \frac{2V}{V_0}$

Given $\frac{2Vf_0}{V_0} = 0.02 \times f_0 \Rightarrow V = 0.01\, V_0 = 3.4$ m/s

101 **(b)**

The string vibrates in two segments in the first overtone. Therefore the amplitude of vibration is maximum at $(L/4)$ and $(3L/4)$

102 **(b)**

$3 \times \frac{v}{4l_c} = 4 \times \frac{v}{2l_0}$ or $\frac{l_c}{l_0} = \frac{3v}{4} \times \frac{2}{4v} = \frac{3}{8}$

103 **(d)**

Either, frequency of first wire should decrease or frequency of second wire should increase

104 **(a)**

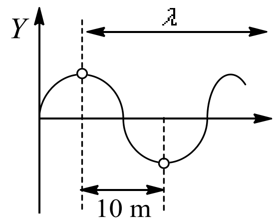
Given that velocity of source $v_s = 0$ (because it is stationary). Velocity of observer $v_0 = (1/5)v = 0.2v$ (where v is the velocity of sound). Actual frequency of source is f and actual wavelength of source is λ. We know from the Doppler's effect that the apparent frequency recorded when the observer is moving towards the stationary source, is given by

$n'' = \left(\frac{v + v_o}{v - v_s}\right) n$

$= \left(\frac{v + 0.2v}{v - 0}\right) \times n = \frac{1.2v}{v} \times n = 1.2n = 1.2f$

Since the source is stationary, therefore the apparent wavelength remains unchanged i.e., λ

105 **(b)**



Frequency of wave =1/4 Hz

Wavelength of wave = $\lambda = 2 \times 10 = 20$ m

Velocity of wave = $f\lambda = 5$ m/s

106 **(c)**

$\frac{5\lambda}{2} = 82.5$ or $\lambda = \frac{2\times 82.5}{5}$ cm or $\lambda = 33$ cm

$c = 1000 \times \frac{33}{100}$ m/s $= 300$ m/s

107 **(c)**

Stationery wave is produced when two waves travel in opposite directions. Now,

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

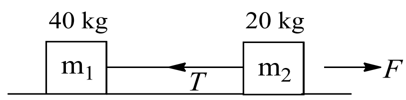
$y = 2a \sin kx \sin \omega t$ is equation of stationery wave which gives a node at $x = 0$

108 **(b)**

Tension T in then wire $= v^2\rho = (400)^2 \times 10^{-3} = 160$ N

Force applied

$F = \frac{T(m_1 + m_2)}{m_1}$



$= 160 \times \frac{(40+20)}{40} = 240$ N

109 **(d)**

Since $f_0 = n\left(\frac{v}{2L}\right) = n\left(\frac{330}{1.6}\right) = 206\, n$

$\lambda_0 = \frac{2L}{n} = \frac{1.6}{n} \quad \left\{L = \frac{n\lambda_n}{2}\right\}$

And the standing wave equation with nodes at both ends is
$s = s_0 \sin(3.93\, nx) \cos(1295\, nt)$
For fundamental mode/ frequency $n = 1$
$x = s_0 \sin(3.93\, x) \cos(1295\, t)$

110 **(c)**
At the moment shown in the figure, particle at 1 is moving in the downward direction
We have, $T = 1/0.1 \text{ s } = 10 \text{ s}$
In one complete cycle, particle travels a distance, 4 times the amplitude. So, in time 10 min 15 s, i.e., 615 s which means 61 full +1 half cycles, the distance travelled
$= (4 \times 3) \times 61 + (2 \times 3) \times 1 = 732 + 6 = 738$ cm
At time instant, the particle is moving in the upward direction

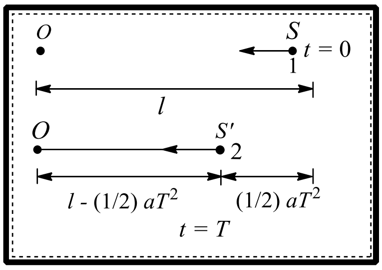
111 **(c)**
Apparent frequency is given by
$$n' = n \frac{(u + v_w)}{(u + v_w - v_s \cos 60°)}$$
$$= \frac{510(330 + 20)}{330 + 20 - 20 \cos 60°}$$
$$= 510 \times \frac{350}{340} = 525 \text{ Hz}$$

112 **(a)**
$$y_1 = 10^{-6} \sin\left(100t + \frac{x}{50} + 0.5\right) \text{m}$$
$$y_2 = 10^{-2} \cos\left(100t + \frac{x}{50}\right) \text{m}$$
$$\Rightarrow y_2 = 10^{-2} \sin\left(100t + \frac{x}{50} + \frac{\pi}{2}\right)$$
Phase difference $= \frac{\pi}{2} - 0.5$
$= 1.07$ rad

113 **(a)**
$f \propto \sqrt{T}$
$$\frac{f + 5}{f - 5} = \sqrt{\frac{121}{100}}$$
$10f + 50 = 11f - 55$
$f = 105$ Hz

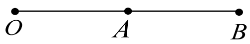
114 **(a)**
The direction of wave must be opposite and frequencies will be same then by superposition, standing wave formation takes place

115 **(d)**
Suppose at $t = 0$, distance between source and observer is l. First, wave pulse (say p_1) is emitted at this instant. This pulse will reach the observer after a time



$t_1 = \frac{l}{v}$ (i)
Source will emit the next pulse (say p_2) after a time $T(= 1/f)$
During this time the source will move a distance $(1/2)aT^2$ towards the observer. This pulse p_2 will reach the observer in a time
$t_2 = T + \frac{l - \frac{1}{2}aT^2}{v}$ (ii)
The changed time period as observed by the observer is
$$T' = t_2 - t_1 = T + \frac{l}{v} - \frac{1}{2}\frac{aT^2}{v} - \frac{l}{v}$$
Substituting $T' = 1/f'$ and $T = 1/f$ in the above equation, we get
$$f' = \frac{2vf^2}{2vf - a}$$

116 **(d)**
Let the power of source be P and it is placed at O. Then intensity at A and B would be given by



$$I_A = \frac{P}{4\pi \times 1^2} \text{ and } I_B = \frac{P}{4\pi \times 2^2}$$
Since, intensity $\propto$ (Amplitude)^2 $\times$ (Frequency)^2 (here, amplitude means displacement amplitudes), the frequency is same at both points
$$\Rightarrow \frac{(\text{Amp})_A}{(\text{Amp})_B} = \sqrt{\frac{I_A}{I_B}} = \sqrt{\frac{2^2}{1^2}} = 2:1$$

117 **(b)**
Intensity of wave is given by
$$I = \frac{(\Delta P)_m^2}{2\rho v}$$
$$v = \frac{(\Delta P)_m^2}{2\rho I} = \frac{(2 \times 10^{-4})^2}{2 \times 1 \times 10^{-10}} = 200 \text{ m/s}$$
Amplitude of wave,
$$A = \frac{(\Delta P)_m}{\omega \rho v} = \frac{2 \times 10^{-4}}{10^3 \times 1 \times 200} = 10^{-9}\text{m}$$
Here, $\omega = 10^3\ rad/s, k = \frac{\omega}{v} = \frac{10^3}{200} = 5 \text{ m}^{-1}$
Initial phase $\phi = \pi/2$
The equation of the wave travelling in the negative x-axis is
$y = A \sin(\omega t + kx + \phi)$

$= 10^{-9} \sin\left(1000t + 5x + \frac{\pi}{2}\right)$
$= 10^{-9} \cos(1000t + 5x)$

118 **(a)**

Wavelength of the incident sound is

$$\lambda_l = \frac{10u - \frac{u}{2}}{f} = \frac{19u}{2f}$$

Frequency of the incident sound is

$$F_i = \frac{10u - u}{10u - \frac{u}{2}} f = \frac{18}{19} f = f_r$$

When f_r is the frequency of the reflected sound.

Wavelength of the reflected sound is

$$\lambda_r = \frac{10u + u}{f_r} = \frac{11u}{18f} \times 19 = \frac{11 \times 19}{18} \frac{u}{f}$$

$$\therefore \frac{\lambda_i}{\lambda_r} = \frac{19u}{2f} \times \frac{18f}{11 \times 19u} = \frac{9}{11}$$

119 **(b)**

Velocity of wave: $v = \sqrt{\frac{T}{m}} = \sqrt{\frac{1.6}{10^{-2}/0.4}} = 8 \text{ m/s}$

The wave will be in same after travelling a distance of $2l = 2 \times 0.4 = 0.8$ m

And constructive interference will take place. So time Δt

$$\Delta t = \frac{0.8}{v} = \frac{0.8}{8} = 0.10 \text{ s}$$

120 **(d)**

Sound wave in an organ pipe (which are standing in nature) is an example of superposition of two longitudinal travelling wave. Standing waves on a string is an example of superposition of two transverse travelling waves on a string travelling in opposite directions

121 **(a)**

$$f = \frac{v}{4l} \text{ or } l = \frac{v}{4f} = \frac{330}{4 \times 264} \text{m}$$

$= 0.3125 \text{ m} = 31.25 \text{ cm}$

122 **(d)**

$y = 4\cos^2\left(\frac{t}{2}\right) \sin 1000\, t$
$= 2(1 + \cos t) \sin 1000\, t$
$= 2\sin 1000\, t + 2\cos t \sin 1000\, t$
$= 2\sin 1000t + \sin(1000\, t + t) + \sin(1000\, t - t)$
$= 2\sin 1000t + \sin 1001t + \sin 999\, t$
$= y_1 + y_2 + y_3 =$ Three waves

123 **(b)**

$$\frac{I_1}{I_2} = \frac{4}{1} \text{ or } \sqrt{\frac{I_1}{I_2}} = \frac{2}{1}$$

$$\therefore \frac{I_{\max}}{I_{\min}} = \left[\frac{\sqrt{I_1/I_2} + 1}{\sqrt{I_1/I_2} - 1}\right]^2 = \left[\frac{2+1}{2-1}\right]^2 = 9$$

$$\therefore L_1 - L_2 = 10\log\left(\frac{I_{\max}}{I_{\min}}\right) = 10\log 9 = 20\log 3$$

124 **(a)**

Waves expressed by tuning fork

$y = 0.2\sin(kx - \omega t)$

Maximum value of amplitude of beat is $2A$

$y = 2 \times 0.2 = 0.4$ cm

125 **(a)**

Method 1: Qualitative. The velocity of a body executing SHM is maximum at its centre and decreases as the body proceeds to the extremes. Therefore, if the time taken for the body to go from O to $A/2$ is $T_1$and to go A is T_2, then obviously $T_1 < T_2$

Method 2: Quantitative. Any SHM is given by the equation $x = \sin \omega t$, where x is the displacement of the body at any instant t. a is the amplitude and ω is the angular frequency.

When $x = 0, \omega t_1 = 0$
$\therefore t_1 = 0$
When $x = a/2, \omega t_2 = \pi/6,\ t_2 = \pi/6\omega$
When $x = a,\ \ \omega t_3 = \pi/2,\ \ t_3 = \pi/2\omega$

Time taken from O to $A/2$ will be

$$t_2 - t_1 = \frac{\pi}{6\omega} = T_1$$

Time taken from $A/2$ to A will be

$$t_3 - t_2 = \frac{\pi}{2\omega} - \frac{\pi}{6\omega} = \frac{2\pi}{6\omega} = \frac{\pi}{3\omega} = T_2$$

Hence $T_2 > T_1$

126 **(b)**

The equation for wave A can be rewritten as

$y = A\sin[kx - \omega t - \phi]$
$= A\sin[k\ (x - \phi/k) - \omega t]$
$= A\sin\left[kx - \omega\left(t + \frac{\phi}{k}\right)\right]$

While equation of wave B is $y = A\sin(kx - \omega t)$

Comparing above equations, we can easily conclude that A is at a istance ahead of ϕ/k from B or wave A is ahead of B by a time difference of ϕ/ω. So, (b) is the correct option.

Remember! In y versus t'ahead of means to the left of ' while in y versus x' ahead of means to the right of' if the wave travels in positive x- direction and vice versa

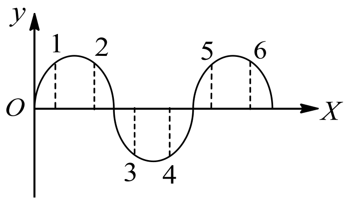
127 **(c)**

Since there is no change in beats. Therefore the original frequency of B is

$n_2 = n_1 + x = 320 + 4 = 324$

128 **(d)**

Consider the wave as shown in figure. The six particle $(1 - 6)$ have been show which all have displacement equal to $\pm A/2$ from their equilibrium positions



To get the separation between two particles having displacement of amplitude $A/2$, we have

$\frac{A}{2} = A\sin(kx - \omega t)$, at $t = 0$

$\Rightarrow kx = \frac{\pi}{6}, \frac{5\pi}{6}, \ldots$ and $x_2 - x_1 = \frac{\lambda}{3}$

Separation between particles 1 and 2 comes out to be $\lambda/3$, where λ is the wavelength. Between particles 1 and 3, it is $\lambda/2$. From given information, separation between $1-2, 3-4$ or $5-6$ is 8 cm.

$\lambda/3 = 8$ cm $\Rightarrow \lambda = 24$ cm

The separation between $2-3$ which is equal to separation between $1-3$ minus separation between $1-2$

$= \frac{\lambda}{2} - \frac{\lambda}{3} = \frac{\lambda}{6} = 4$ cm

129 **(b)**

Towards right wavelength gets compressed and towards left wavelength gets expanded

130 **(a)**

Let ϕ_1 and ϕ_2 represent angles of the first and second waves. Then

$\phi_2 = \frac{2\pi}{\lambda}[(vt - x) + x_0]$

and $\phi_1 = \frac{2\pi}{\lambda}(vt - x)$

But $x_2 = \frac{\lambda}{2}$,

$\phi_2 - \phi_1 = \pi$

Hence, phase difference, $\phi = \pi$. So, amplitude of resultant wave

$R\sqrt{a^2 + b^2 + 2\,ab\cos\phi}$

$\sqrt{a^2 + b^2 + 2\,ab\cos\pi = }\sqrt{(a-b)^2} = a - b$

or $R = |a - b|$

131 **(d)**

$y = 8\ \sin 2\pi\left(\frac{x}{10} - 2t\right)$ given by comparing with standerd equestion

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

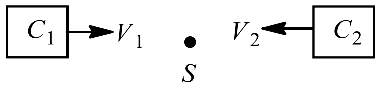
$\lambda = 10$ cm

So phase difference $= (2\pi/\lambda) \times$ path difference

$= \frac{2\pi}{10} \times 2 = \frac{2}{5} \times 180° = 72°$

132 **(a)**

Firstly, car will be treated as an observer which is approaching the source. Then, it will be treated as a source, which is moving in the direction of sound.



Hence,

$f_1 = f_o\left(\frac{v + v_1}{v - v_1}\right)$

$f_2 = f_o\left(\frac{v + v_2}{v - v_2}\right)$

$\therefore\ f_1 - f_2 = \left(\frac{1.2}{100}\right)f_o$

$= f_o\left[\frac{v + v}{v + v_1} - \frac{v + v_2}{v - v_2}\right]$

Or

$\left(\frac{1.2}{100}\right)f_o = \frac{2v(v_1 - v_2)}{(v - v_1)(v - v_2)}, f_o$

as v_1 *and* v_2 Are very very less than v.

We can write, $(v - v_1)or\ (v - v_2) \approx v$.

$\therefore \left(\frac{1.2}{100}\right)f_o = \frac{2(v_1 - v_2)}{v}f_o$

$Or\ \ (v_1 - v_2) = \frac{v \times 1.2}{200}$

$= \frac{300 \times 1.2}{200} = 1.98ms^{-1}$

$=7.128\text{km}\boldsymbol{h}^{-1}$

$\therefore$ the nearest integer is 7.

133 **(d)**

x_1 and x_2 are in successive loops of stationery waves

So, $\phi_1 = \pi$

and $\phi_2 = K(\Delta x) = K\left(\frac{3\pi}{2K} - \frac{\pi}{3K}\right) = \frac{7\pi}{6}$

$= \frac{\phi_1}{\phi_2} = \frac{6}{7}$

134 **(a)**

$f_{\text{closed}} = \frac{v}{4l}$

$256 = \frac{v}{4(0.31)}$

$v = 317.44$ m/s

135 **(d)**

$n_1 = \frac{1}{2l}\sqrt{\left[\frac{T}{4\pi r^2\rho}\right]}$

and $n_2 = \frac{1}{4l}\sqrt{\left[\frac{T}{\pi r^2\rho}\right]}$

$\therefore\ \frac{n_1}{n_2} = 2 \times \frac{1}{2} = 1$

136 **(a)**

The frequency of direct and reflected sound is same

137 **(c)**

$$y = a\left[\frac{1+\cos(2\omega t - 2kx)}{2}\right]$$
$$y = \frac{a}{2} + \frac{a}{2}\cos(2\omega t - 2kx)$$

138 **(d)**

$$f' = f\left[\frac{v}{v - v_s}\right] = 450\left[\frac{330}{330 - 33}\right] = 500 \text{ Hz}$$

139 **(b)**

$$dB = 10\log\left(\frac{I}{I_0}\right) = 10\log\left(\frac{K/r^2}{I_0}\right)$$
$$= 10[\log(K') - 2\log r]$$
$$dB_1 = 10(\log K' - 2\log r_1)$$
$$dB_2 = 10(\log K' - 2\log r_2)$$
$$3 = dB_1 - dB_2 = 20\log\left(\frac{r_2}{r_1}\right)$$
$$(0.3) = \log\left(\frac{r_2}{r_1}\right)^2$$
$$\left(\frac{r_1}{r_2}\right) = \frac{1}{\sqrt{2}}$$

140 **(c)**

When piston moves a distance x_1, path difference changes by $2x$

Therefore, the path difference between maxima and consecutive minima $= \lambda/2$

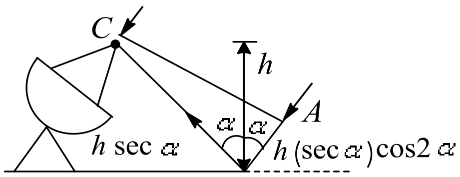
$2x = \lambda/2$

or $\lambda = 4x = 4 \times 9$ cm $= 36$ cm $= 0.36$ m

$$n = \frac{v}{\lambda} = \frac{360}{0.36} = 1000 \text{ Hz}$$

141 **(d)**

Total path difference $= AB + BC + \lambda/2 = \lambda$ for maxima



$$h\sec\alpha\cos 2\alpha + h\sec\alpha = \lambda/2$$
$$h\sec\alpha(2\cos^2\alpha) = \lambda/2$$
$$h = \frac{\lambda}{4\cos\alpha}$$

142 **(c)**

$$\text{Beats} = \frac{V}{4l} - \frac{V}{4(l+\Delta l)} = \frac{V}{4}\left[\frac{\Delta l}{l(l+\Delta l)}\right]$$
$$= \frac{V\Delta l}{4l^2} \quad (\because \Delta l \ll l)$$

143 **(b)**

$$y_1 = a_1 \sin\left(\omega t - \frac{2\pi x}{\lambda}\right)$$
$$y_2 = a_2 \sin\left(\omega t - \frac{2\pi x}{\lambda} + \phi + \frac{\pi}{2}\right)$$

Phase difference

$$= \left(\omega t - \frac{2\pi x}{\lambda} + \phi + \frac{\pi}{2}\right) - \left(\omega t - \frac{2\pi x}{\lambda}\right) = \left(\phi + \frac{\pi}{2}\right)$$

Path difference $= \frac{\lambda}{2\pi} \times$ phase difference

$$= \frac{\lambda}{2\pi}\left(\phi + \frac{\pi}{2}\right)$$

144 **(b)**

$$V_S = \sqrt{\frac{Y}{\rho}} = \sqrt{\frac{10^{11}}{10.0 \times 10^4}} = 10^3 \text{ m/s}$$
$$t = \frac{2l}{V} = \frac{2 \times 100}{1000} = 0.2 \text{ s}$$

145 **(c)**

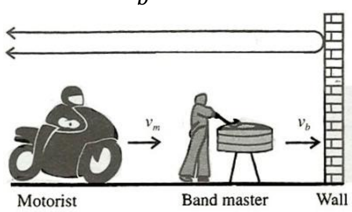
The motorist receives two sound waves: direct one and that reflected from the wall

$$f' = \frac{v + v_m}{v + v_b} f$$

For reflected sound waves:

Frequency of sound wave reflected from the wall is

$$f'' = \frac{v}{v - v_b} \times f$$



Frequency of the reflected waves as received by the moving motorist is

$$f''' = \frac{v + v_m}{v} \times f'' = \frac{v + v_m}{v - v_b} \times f$$

Therefore, the beat frequency is

$$f''' - f' = \frac{v + v_m}{v - v_b} \times f - \frac{v + v_m}{v + v_b} f$$
$$= \frac{2v_b(v + v_m)}{v^2 - v_b^2} f$$

146 **(b)**

Let l be the length of the pipes and v the speed of sound. Then frequency of open organ pipe of nth overtone is

$$f_1 = (n+1)\frac{v}{2l}$$

And frequency of closed organ pipe of nth overtone

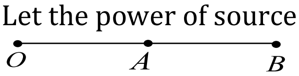
$$f_2 = (2n+1)\frac{v}{4l}$$

Therefore, the describe ratio is

$$\frac{f_1}{f_2} = \frac{2(n+1)}{(2n+1)}$$

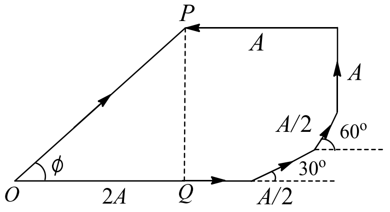
147 **(d)**

Let the power of source be P and it is placed at O



Then, intensity at A and B would be given by

$$I_A = \frac{P}{4\pi \times 1^2}$$
And $I_B = \frac{P}{4\pi \times 2^2}$
Since, intensity $\propto$(Amplitude) $\times$(Frequency $)^2$ (here, amplitude means displacement amplitude)
The frequency is same at both the points
$$\frac{(\text{Amp})_A}{(\text{Amp})_B} = \sqrt{\frac{I_A}{I_B}}$$
$$= \sqrt{\frac{2^2}{1^2}} = 2:1$$
148 **(a)**
When the source is coming to stationary observer
$$n' = \left(\frac{v}{v - v_s}\right) n$$
Or $1000 = \left(\frac{350}{350-50}\right) n$
Or $n = (1000 \times 300/350)$Hz
When the source is moving away from the stationary observer,
$$n'' = \left(\frac{v}{v + v_s}\right) n$$
$$= \left(\frac{350}{350 + 50}\right)\left(\frac{1000 \times 300}{350}\right) = 750 \text{ Hz}$$
149 **(c)**
$$f = \left(\frac{v + v_m}{v + v_m - v_{\text{source}}}\right) 1000$$
$$= \left(\frac{340 + 20 \cos 60°}{340 + 20 \cos 60° - 30}\right) 1000$$
$= 1094$ Hz
150 **(c)**
Since the standing wave mode has a displacement antinode at the opening, there is a displacement node at the water-air interface. By increasing the height of the air column, to go from one harmonic to the nest, an addition length equal to ½ wavelength is required. Hence
$$\frac{\lambda}{2} = (0.38 - 0.12)m \Rightarrow \lambda = 0.52 \text{ m}$$
Finally, from $v = f\lambda$, we find that $f = v/\lambda = 312/0.52 = 600$Hz. If one checks, this problem deals with the 1 st and 3rd harmonics
151 **(b)**
As $y = A, \sin(2\pi n_{av} t)$
Where $A_b = 2A\cos(2\pi\, n_A t)$
Where $n_A = \frac{n_1 - n_2}{2}$
152 **(c)**
Beat frequency $= 2(256 - 3(170)$
$= 512 — 510$
$= 2$ Hz
153 **(b)**
The amplitude, $A = 0.06$ m
$$\frac{5}{2}\lambda = 0.2 \text{ m}$$
$\therefore \lambda = 0.08$ m
$$f = \frac{v}{\lambda} = \frac{300}{0.08} = 3750\text{Hz}$$
$$k = \frac{2\pi}{\lambda} = 78.5 \text{ m}^{-1} \text{and } \omega = 2\pi f = 23562 \text{ rad/s}$$
At $t = 0, x = 0, \frac{dy}{dx}$ =positive
and the given curve is a sine curve
Hence, equation of wave travelling is position x-direction should have the from
$y(x, t) = A\sin(kx - \omega t)$
Substituting the values, we have
$y = (0.06 \text{ m}) \sin[(78.5 \text{ m}^{-1})x - (23562 \text{ s}^{-1})t]$ m
154 **(d)**
Wavelength of sound
$$= \frac{v}{f} = \frac{340 \text{ m/s}}{606 \text{ s}^{-1}} = 56.1 \text{ cm}$$
Since, closed pipe allows only odd harmonics, so
$$f = (2n+1)\frac{v}{4l} \text{ or, } l = (2n+1)\frac{v}{4f}; n \in I$$
or, $l = (2n+1) \times 14$ cm
$\therefore l = 14$ cm, 42 cm, 70 cm, 98 cm, 126 cm, 154 cm, etc
Since $l > 150$ cm
$\therefore$ No. of resonances $= 5$
155 **(a)**
Standard equation of travelling wave
$y = A\sin(kx - \omega t)$ By somparing with the given equation
$y = 10\sin(0.01\pi\, x - 2\pi\, t)$
$A = 10$ cm, $\omega = 2\pi$
Maximum particle velocity $= A\omega = 2\pi \times 10 = 63$ cm/s
156 **(c)**
The frequencies given are odd multiple of fundamental.
Hence close organ pipe
$$50 = \frac{1}{4l} \times 340 \Rightarrow l = 1.7 \text{ m}$$
157 **(b)**
$y_1 = 2A\sin\omega t$
$$y_2 = \frac{A}{2}\sin\left(\omega t + \frac{\pi}{6}\right)$$
$$y_3 = \frac{A}{2}\sin\left(\omega t + \frac{\pi}{3}\right)$$
$$y_4 = A\sin\left(\omega t + \frac{\pi}{2}\right)$$



$y_5 = A\sin(\omega t + \pi)$

By phaser diagram,

$\tan\phi = \frac{PQ}{OQ} = 1$

$\phi = 45°$

Alternatively: $y = 2A\sin\omega t + \frac{A}{2}(\sin\omega t\cos 30° + \cos\omega t \sin 30°)$

$$+\frac{A}{2}(\sin\omega t\cos 60° + \cos\omega t\sin 60°) + A\cos\omega t - A\sin\omega t$$

$= A'\cos\phi\sin\omega t + A'\sin\phi\cos\omega t$

Where $A'\cos\phi = \left[A + \frac{A}{4}(\sqrt{3}+1)\right]$

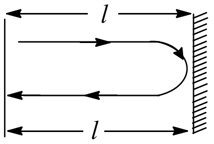
$A'\sin\phi = \left[A + \frac{A}{4}(\sqrt{3}+1)\right]$

$\tan\phi = 1$

$\phi = 45°$

158 **(d)**

Drumming frequency =40 cycle/min = 40 cycle/60 s



Drumming time period

$T = \frac{1}{f} = \frac{60\text{s}}{40\text{ cycle}} = \frac{3}{4}$ s/cycle

(time duration between consecutive drumming)

During this time interval, if sound goes to mountain and comes back then echo will be heard distinctly

$\frac{3}{4} = \frac{2l}{v}$ (i)

Now if he moves 90 m. This situation arises at $t = 60$ cycle/min,

$T = \frac{1}{f} = 1$ s/cycle

For this case sound goes to mountain and comes back after time $T/2$:

$\frac{1}{2} = \frac{2(l-90)}{v}$ (ii)

Solving Eqs. (i) and (ii)

so, $l = 270$ m

$v = 720$ m/s

159 **(b)**

$\frac{v}{4(\ell + e)} = f$

$\Rightarrow \ell + e = \frac{V}{4f}$

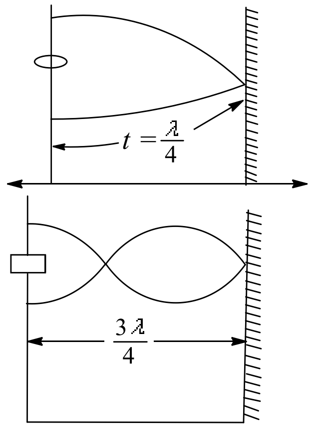
$\Rightarrow \ell = \frac{V}{4f} - e$

Here $e = (0.6)r = (0.6)(2) = 1.2\ cm$

So $\ell = \frac{336\times10^2}{4\times512} - 1.2 = 15.2\ cm$

160 **(b)**

When the end of the string is free to move, the string being attached to weightless ring that can slide freely along the rod, the phase of reflection pulse is unchanged antinode is formed at the ring



$l = \frac{\lambda}{4} \Rightarrow \lambda_1 = 4l = 9.6$ m

$\lambda_2 = \frac{4l}{3} = 3.2$ m

$\lambda_3 = \frac{4l}{5} = \frac{9.6}{5} = 1.92$ m

161 **(d)**

The frequency is a characteristic of source. It is independent of the medium.

Hence the correct option is (d).

162 **(c)**

$v_1 = \frac{v}{l}$

(2nd harmonic of open pipe)

Here, n is odd and $v_2 > v_1$

It is possible when n=5

Because with n=5

$v_2 = \frac{5}{4}\left(\frac{v}{l}\right) > v_1$

163 **(b)**

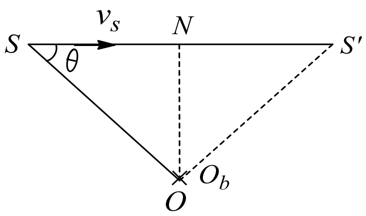
Maximum frequency

$v = \frac{1}{2l}\sqrt{\frac{T}{\mu}} = \frac{1}{2l}\sqrt{\frac{T}{A\rho}}$

$= \frac{1}{2}\sqrt{\frac{7.85\times10^8}{7.7\times10^3}} = 158$ Hz

164 **(a)**

This frequency-time curve corresponds to a source moving at an angle to a stationary observer



In the region SN, the source is moving towards the observer, i.e., the apparent frequency

$$n' = n_0\left(\frac{v}{v - v_s \cos\theta}\right)$$

$$n' = n_0\left(\frac{300}{300 - 30\cos\theta}\right)$$

When $\theta = \pi/2$, i.e., at N,

$n' = n_0 = 1000$ Hz, i.e., natural frequency of source. In the region NS' the source is moving away from the observer, i.e., apparent frequency

$$n' = n_0\left(\frac{300}{300 - 30\ \cos\theta}\right)$$

When $\theta = 0$, i.e., $\cos\theta = 1$,

$$n_{\max} = n_0\frac{v}{v - v_s} = \frac{(1000\text{ Hz})(300\text{ m/s})}{(300\text{m/s} - 30\text{m/s})}$$

$$= \frac{10}{9} \times 1000\text{ Hz} = 1111\text{ Hz}$$

$$n_{\min} = n_0\frac{v}{v + v_s} = \frac{1000 \times 300}{330} = 909\text{ Hz}$$

165 **(a)**

When a sound wave gets reflected from a rigid boundary, the particles at the boundary are unable to vibrate. Thus, a reflected wave is generated which interferes with the oncoming wave to produce zero displacement at the rigid boundary. At these points (zero displacement), the pressure vibration is maximum. Thus, a reflected pressure wave has the same phase as the incident wave

166 **(b)**

The motorcyclist observes no beats. So the apparent frequency observed by him from the two sources must be equal.

$$\therefore 176\left(\frac{330 - v}{330 - 22}\right) = 165\left(\frac{330 + v}{330}\right)$$

Solving this equation we get,

$v = 22ms^{-1}$

167 **(c)**

Case I Here $\lambda/2 = l$

$\therefore\ \lambda = 2l$

Now, $v = f \times \lambda$

$$\therefore f = \frac{v}{\lambda} = \frac{v}{2l} \quad \text{(i)}$$

Case II Here $\lambda'/4 = l/2$

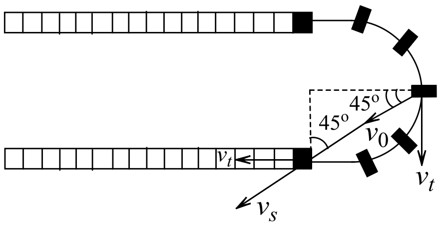
$\therefore\ \lambda' = 2l$

Now, $v = f' \times \lambda'$

$$\therefore f' = \frac{v}{\lambda'} = \frac{v}{2l} = f$$

168 **(c)**

The Doppler formula holds for non-collinear motion if v_s and v_o are taken to be the resolved component along the line of slight. In this case, we have



$$v_o = -v_t \sin 45° = -\frac{30}{\sqrt{2}}\text{m/s}$$

$$v_s = -v_t \sin 45° = -\frac{30}{\sqrt{2}}\text{m/s}$$

We have , $v = 340$ m/s, $n = 200$ Hz. The apparent frequency n' is given by

$$n' = n\left[\frac{v - v_o}{v - v_s}\right] = 200\left[\frac{340 + (30/\sqrt{2})}{340 + (30/\sqrt{2})}\right] = 200\text{ Hz}$$

169 **(c)**

$$\frac{\lambda}{2} = 10\text{ cm or } \lambda = 20\text{ cm} = 0.20\text{ m}$$

$$v = v\lambda = 100 \times 0.20\text{ m/s} = 20\text{ m/s}$$

170 **(b)**

$$v \propto \sqrt{T}, v' \propto \sqrt{T + \frac{1}{100}T}$$

$$\frac{v'}{v} = \left(1 + \frac{1}{100}\right)^{1/2} = 1 + \frac{1}{200}$$

or $\frac{v'-v}{v} = \frac{1}{200}$ or $\frac{3}{2v} = \frac{1}{200}$ or $v = 300$ Hz

171 **(b)**

Velocity of the string section can be given as

$$v = \frac{\partial y}{\partial t} = 4\cos\pi x \times (50\pi)\cos(50\pi t)$$

$$v = 4\cos\left[\pi \times \frac{1}{3}\right] \times 50\pi\cos\left[50\pi \times \frac{1}{5}\right]$$

$$= 200\pi \times \frac{1}{2} \times 1 = 100\pi\text{ cm/s} = \pi\text{ m/s}$$

172 **(d)**

Intensity,

$$I = \frac{P}{A} = \frac{200\pi}{4\pi \times (10)^2} = 0.5\text{ W/m}^2$$

No. of decibels is given by

$$10\log_{10}\frac{I}{I_0} = 10\log_{10}\frac{0.5}{10^{-12}}$$

$$= 10\log_{10}(5 \times 10^{11})$$

$= 10\log_{10}\left(\frac{10^{12}}{2}\right)$
$= 117$ dB

173 **(d)**
Let us plot the graph of the mathematical equation
$U(x) = K\left[1 - e^{-x^2}\right]$
$\therefore\ F = -\frac{dU}{dx} = -2kxe^{-x^2}$
It is clear that the potential energy is minimum at $x = 0$. Therefore, $x = 0$ is the state of stable equilibrium. Now if we displace the particle from $x = 0$, then for small displacement the particle tends to regain the position $x = 0$ with a force
$F = 2kx/e^{x^2}$ for x to be small $F \propto x$

174 **(b)**
$l = l_1 + l_2 + l_3 \quad \left[\because v \propto \frac{1}{l}\right]$
$\frac{k}{v} = \frac{k}{v_1} + \frac{k}{v_2} + \frac{k}{v_3}$
$\frac{1}{v} = \frac{1}{v_1} + \frac{1}{v_2} + \frac{1}{v_3}$
$v = \left[\frac{1}{v_1} + \frac{1}{v_2} + \frac{1}{v_3}\right]^{-1}$

175 **(b)**
$f_1 = 900\left(\frac{300}{300 + v_1}\right)$
$\cong 900\left(1 + \frac{v_1}{300}\right)^{-1}$
$= 900 - 3v_1$
Similarly,
$f_2 = 900\left(\frac{300}{300 + v_2}\right) = 900 - 3v_2$
$f_2 - f_1 = 6$
$\therefore 3(v_1 - v_2) = 6$
$\therefore 3(v_1 - v_2) = 6$
or $v_1 - v_2 = 2$ m/s

176 **(b)**
Let us consider the wire also as a spring. Then the case become two springs attached in series. The equivalent spring constant is
$\frac{1}{K_{\text{eq}}} = \frac{1}{K} + \frac{1}{K'}$
Where K' is the spring constant of the wire
$\therefore K_{\text{eq}} = \frac{KK'}{K + K'}$
Now, $Y = \frac{F/A}{\Delta L/L} = \frac{F}{A} \times \frac{L}{\Delta L}$
$\frac{F}{\Delta L} = \frac{YA}{L} = K'$
We know that time period of the system
$T = 2\pi\sqrt{\frac{m}{K_{\text{eq}}}} = 2\pi\sqrt{\frac{m(K + K')}{KK'}}$
$\Rightarrow T = 2\pi\sqrt{\frac{m}{K}\left[\frac{K + YA/L}{YA/L}\right]}$
$= 2\pi\sqrt{\frac{m(KL + YA)}{KYA}}$

177 **(b)**
$v = 1$ m/s, $v = 100$ Hz
$\lambda = \frac{v}{V} = \frac{1}{100}$ m $= 1$ cm
$\Delta\phi = \frac{2\pi}{\lambda} \times 2.75$ rad $= 5.5\,\pi$ rad $= \frac{11\pi}{2}$ rad

178 **(c)**
$f' = \left(\frac{c + v_a}{c - v_a}\right)f$
Where c is the velocity of the radio wave, an electromagnetic wave, i.e., $c = 3 \times 10^8$ m/s and v_s is velocity of aeroplane
$f - f = \left[\frac{c + v_a}{c - v_a} - 1\right]f$
$\Rightarrow \Delta f = \frac{2v_a f}{c - v_a}$
Since approaching aeroplane cannot have a speed comparable to the speed of electromagnetic wave, so $v \ll c$
$\therefore \Delta f = \frac{2v_a f}{c}$
$\Rightarrow 2.6 \times 10^3 = \frac{2v_A(780 \times 10^6)}{3 \times 10^8}$
$\Rightarrow v_A = 0.5 \times 10^3$ m/s
$= 0.5$ km/s

179 **(b)**
For second resonance
$L_2 = \frac{3\lambda}{4} = 3L_1 = 3 \times 20 = 60$ cm

180 **(d)**
$\xi = A\sin(kx - \omega t)$
$P_{ex} = -B\frac{d\xi}{dx} = -BAk\cos(kx - \omega t)$
Amplitude of P_{ex} is
$BAk = (5 \times 10)^5(10^{-4})\left(\frac{2\pi}{0.2}\right)$
$= 5\pi \times 10^2$ Pa

181 **(b)**
Intensity after passing through one slab
$I' = \left[I - \frac{20}{100} \times I\right] = \left[I - \frac{I}{5}\right] = \frac{4I}{5}$
So, intensity after passing through two slabs
$I'' = \left[I' - \frac{20}{100} \times I'\right] = \frac{4I'}{5} = \frac{16I}{25}$

$\therefore$ % decrease $= \left[\frac{\left(l-\frac{16l}{25}\right)}{l}\right] \times 100 = 36\%$

182 **(b)**

For interference at A: S_2 is behind of S_1 a distance of $100\lambda = \lambda/4$ (equal to phase difference $\pi/2$). Further S_2 lags S_1 by $\pi/2$. Hence the waves from S_1 and S_2 interfere at A with a phase difference of $200.5\pi + 0.5\pi = 201\,\pi = \pi$. Hence the net amplitude at A is $2a - a = a$. For interference at B: S_2 is ahead of S_1 by a distance of $100\,\lambda + \lambda/4$ (equal to phase difference $\pi/2$). Further S_2 lags S_1 by $\pi/2$. Hence the waves from S_1 and S_2 interfere at B with a phase difference of $200.5\,\pi - 0.5\pi = 200\pi = 0\pi$. Hence the net amplitude at A is $2a + a = 3a$

Hence, $\left(\frac{I_A}{I_B}\right) = \left(\frac{a}{3a}\right)^2 = \frac{1}{9}$

183 **(a)**

$v \propto 1/l$

On doubling the length, frequency is halved

The word 'nearly' in the statement has been used keeping is mind 'end correction'.

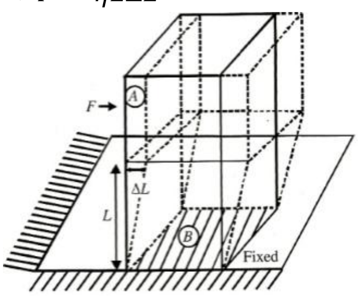
184 **(d)**

When a force is applied on cubical block A in the horizontal direction, then the lower block B will get distorted as shown by the dotted lines and A will attain a new position (without distortion as A is a rigid body) as shown by the dotted lines.

For cubical block B,

$$\eta = \frac{F/A}{\Delta L/L} = \frac{F}{A} \times \frac{L}{\Delta L} = \frac{F}{L^2} \times \frac{L}{\Delta L} = \frac{F}{L \times \Delta L}$$

$\Rightarrow F = \eta L \Delta L$



ηL is a constant

$\Rightarrow F \propto \Delta L$ and directed towards the mean position

$\Rightarrow$ Oscillation will be simple harmonic in nature.

Here,

$M\omega^2 = \eta L$

$$\Rightarrow \omega = \sqrt{\frac{\eta L}{M}} = \frac{2\pi}{T}$$

$$\Rightarrow T = 2\pi\sqrt{\frac{M}{\eta L}}$$

185 **(d)**

For the given problem,

$$\frac{\sqrt{T}}{l} = \text{constant}$$

or $T \propto l^2$

If l is to be doubled, T would be quadrupled

186 **(b)**

$$\frac{\lambda}{2} = l = \frac{40}{100} = 0.4; \lambda = 0.8\text{ m},$$

$$v = \frac{v}{\lambda} = \frac{5500}{0.8}\text{Hz} = 6875\text{ Hz}$$

187 **(b)**

$$f = f_o\left(\frac{v_s + v_o}{v_s}\right)$$

$$= f_0\left[\frac{v + \frac{v}{5}}{v}\right]$$

$$= \frac{6}{5}f_o$$

Hence, percentage increase is

$$\left[\frac{\frac{6}{5}f_0 - f_0}{f_0}\right] \times 100 = 20\%$$

188 **(b)**

Path difference $= (\pi r - 2r)$

$= (2n-1)\lambda/2$ for minima

Given $\lambda = 0.40$ m, for smallest radius $n = 1$

$(3.14 - 2)r = \lambda/2$

$$r = \frac{\lambda}{2 \times 1.14} = \frac{0.40}{2 \times 1.14} = 0.175\text{ m}$$

189 **(a)**

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

$\therefore\ V_{\max} = A\omega$

190 **(c)**

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

If radius is doubled, mass per unit length will become four times. Hence

$$f' = \frac{1}{2 \times 2l}\sqrt{\frac{2T}{4\mu}} = \frac{f}{2\sqrt{2}}$$

191 **(a)**

The speed of sound in air is

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

γ/M of H_2 is least, hence speed of sound in H_2 shall be maximum

192 **(d)**

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

$\Rightarrow p_1\sqrt{T_1} = p_2\sqrt{T_2}$

$\Rightarrow 6\sqrt{36} = 4\sqrt{T_2} \Rightarrow T_2 = 81$ N

193 **(b)**

Apparent frequency due to source A is

$n' = \dfrac{v-u}{v} \times n$

Apparent frequency due to source B is

$n'' = \dfrac{v+u}{v} \times n$

$\therefore n'' - n' = \dfrac{2u}{v} \times n = 10$

$\therefore u = \dfrac{10v}{2n} = \dfrac{10 \times 340}{2 \times 680} = 2.5$ m/s

194 **(b)**

$L_2 - L_1 = 30$ dB

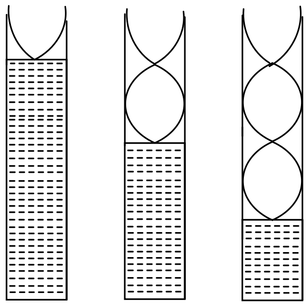
$10 \text{ dB} \log\dfrac{I_2}{I_0} - 10 \text{ dB} \log\dfrac{I_1}{I_0} = 30$ dB

$\log_{10}\dfrac{I_2}{I_1} = 3 \Rightarrow \dfrac{I_2}{I_1} = 10^3$

Hence, the sound intensity increases by 10^3

195 **(c)**

$\lambda/2 = 29.5 - 10.5 = 19$ cm



3rd resonance $= 19 + 29.5 = 48.5$ cm

196 **(b)**

$n_1 = \dfrac{1}{2l_1}\sqrt{\dfrac{T_1}{m}}, n_2 = \dfrac{1}{2l_2}\sqrt{\dfrac{T_2}{m}}$

$\therefore \dfrac{n_2}{n_1} = \dfrac{l_1}{l_2}\sqrt{\dfrac{T_2}{T_1}}$

Let $l_1 = 100l, l_2 = 55l$

$T_1 = 100T, T_2 = 121T$

$\therefore \dfrac{n_2}{n_1} = \dfrac{100l}{55l}\sqrt{\dfrac{121T}{100T}}$

$= \dfrac{100}{55} \times \dfrac{11}{10} = 2$

$\therefore n_2 = 2n_1$

197 **(b)**

Standing waves form when two waves of dual amplitude, same frequency, same wavelength travelling in opposite directions superimpose, as a result, the net transfer of energy through any cross-section in zero in standing waves

198 **(d)**

Given that the frequency of wave produced if the string is $1/n$

$\therefore \dfrac{1}{n} = \dfrac{1}{2\pi}\sqrt{\dfrac{T}{m}}$

Now $T' = 2T$

Therefore, new frequency is

$f = \dfrac{1}{2\pi}\sqrt{\dfrac{2T}{m}} = \sqrt{2} \times \dfrac{1}{n}$

Therefore, the number of waves produced per second is

$\dfrac{1}{f} = \dfrac{n}{\sqrt{2}}$

199 **(c)**

If none of the natural frequencies of the string matches with the frequency of the source, then string will finally vibrate with the frequency of tuning fork, but here resonance condition would not be found

200 **(c)**

Velocity of longitudinal waves

$v_1 = \sqrt{\dfrac{Y}{\rho}}$

And velocity of transverse waves

$v_2 = \sqrt{\dfrac{T}{m}} = \sqrt{\dfrac{T}{\rho s}}$

$\therefore \dfrac{v_1}{v_2} = \sqrt{\dfrac{y}{T/s}} = \sqrt{\dfrac{Y}{Y\left(\frac{\Delta l}{l}\right)}} = \sqrt{n}$

$\left[\because \Delta l = \dfrac{l}{n}\right]$

Now $f \propto v$

$\therefore \dfrac{f_1}{f_2} = \dfrac{v_1}{v_2} = \sqrt{n}$

In the above expression $\rho =$ density of string, $s =$ area of cross-section of string, $Y =$ Young's modulus

201 **(c)**

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

$a^2 = \dfrac{I}{2\pi^2 v^2 \rho v}$ or $a = \dfrac{1}{\pi v}\sqrt{\dfrac{I}{2\rho v}}$

or $a = \frac{7}{22 \times 1000}\sqrt{\frac{10^{-12}}{2 \times 1.293 \times 332}}$ m

or $a = 1.1 \times 10^{-11}$ m

202 **(b)**

Initially the standing wave equation is

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

If phase difference ϕ is added to one of waves. Then resulting standing wave equation is

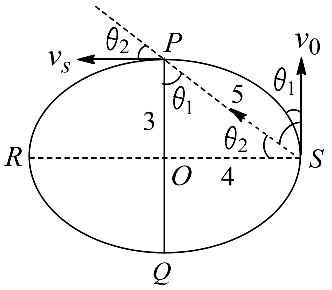
$y = 2A \sin\left(kx + \frac{\phi}{2}\right) \cos\left(\omega t - \frac{\phi}{2}\right)$

Here, frequency does not change and also spacing between two successive nodes does not changes as its value for both

is π/k. But for a paticle, in standing wave, amplitude changes

203 **(b)**

Frequency received by guard is



$n_0 = n_0 \frac{v_0(v + v_0 \cos\theta_1)}{(v + v_s \cos\theta_2)}$

$v = 330$ m/s

Here, $v_0 = v_s = v/3, \cos\theta_1 = 3/5, \cos\theta_2 = 4/5$

$\therefore n = n_0 \frac{\left(v + \frac{v}{3} \times \frac{3}{5}\right)}{\left(v + \frac{v}{3} \times \frac{4}{5}\right)}$

$= \left(\frac{6}{5} \times \frac{15}{19}\right) n_0 = \frac{18\, n_0}{19} = 1800$ Hz

204 **(a)**

Let the frequency of first tuning fork $= n$ and that of last $= 2n$

$n, n + 5, n + 10, n + 15, \ldots 2n$ this forms AP

Formula of AP $l = a + (N - 1)r$ where l =Last term, a = First term, N= number of term, r = Common difference

$2n = n + (41 - 1)5$

$2n = n + 200$

$n = 200$ and $2n = 400$

205 **(c)**

The frequency that the observer receives directly from the source has frequency $n_1 = 500$Hz. As the observer and source both move towards the fixed wall with velocity u, the apparent frequency of the reflected wave coming from the wall to the observer will have frequency

$n_2 = \left(\frac{V}{V - u}\right) 500$ Hz

Where V is the velocity of sound wave in air. The apparent frequency of this reflected wave as heard by the observer will then be

$n_3 = \left(\frac{V + u}{V}\right) n_2 = \left(\frac{V + u}{V}\right)\left(\frac{V}{V - u}\right) 500$

$= \left(\frac{V + u}{V - u}\right) 500$

It is given, that the number of beat per second is

$n_3 - n_1 = 10$

$\therefore (n_3 - n_1) = 10 = \left(\frac{V + u}{V - u}\right) 500 - 500$

$= 500\left[\frac{V + u}{V - u} - 1\right]$

$10 = \frac{2 \times u \times 500}{V - u}$

Hence,

$10V = 1000u + 10u = 1010u$

Putting $u = 4$ m/s,

We have $V = \frac{1}{10}[4040] = 404$ m/s

206 **(b)**

$f_{\text{open}} = \frac{v}{2l} = v$

$f_{\text{closed}} = \frac{v}{4\left(\frac{l}{2}\right)} = \frac{v}{2l} = v$

207 **(c)**

At 25 cm, there will be antinode. So wire will vibrate in two loops

$v = \frac{2}{2l}\sqrt{\frac{T \times l}{M}}$ or $v = \sqrt{\frac{T}{Ml}} = \sqrt{\frac{20}{5 \times 10^{-4} \times 1}}$

$= \sqrt{4 \times 10^4}$ Hz $= 200$ Hz

208 **(d)**

For maxima path difference $\Delta = n\lambda$

$2 \times 0.6\, l = \lambda$

$l = \frac{\lambda}{1.2} = \frac{6}{1.2} = 5$ m

209 **(d)**

$V = \frac{\omega}{k} = \frac{100}{0.02} = 5000$ cm/s

210 **(b)**

Velocity of sound is not affected by the change in pressure of air. Velocity of sound at 1°C,

$v_1 = (332 + 0.61\, t)$m/s

At -5°C, $v_{-5°C} = (332 - 0.61 \times 5)$m/s

At 30°C, $v_{30°C} = (332 + 0.61 \times 30)$m/s

$\therefore v_{30°C} - v_{-5C°} = (0.61 \times 35)$m/s

$= 21.35$ m/s

211 **(d)**

In ten forks, there are nine intervals

$n_2 = n_{11} + 9 \times 4$ (Also given $n_2 = 2n_1$)

$2n_1 = n_1 + 36$

$n_1 = 36$ Hz

So $n_2 = 2n_1 = 72$ Hz

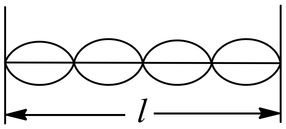
212 **(c)**

$$f_1 = \frac{v}{4(24.1 + 0.3D)}$$
$$f_3 = \frac{3v}{4(74.1 + 0.3D)}$$
$$f_1 = f_3$$
$$\Rightarrow \frac{v}{4(24.1 + 0.3D)} = 3\frac{v}{4(74.1 + 0.3D)}$$
$$3(24.1 + 0.3D) = 74.1 + 0.3D$$
$$72.3 + 0.9D = 74.1 + 0.3D$$
$$0.6D = 74.1 - 72.3$$
$$0.6\,D = 1.8$$
$$D = \frac{1.8}{0.6} = 3 \text{ cm}$$

213 **(c)**

For a string vibrating in its nth overtone $(n + 1)$ th harmonic)

$$(n + 1)\frac{\lambda}{2} = L \Rightarrow \lambda = \frac{2L}{n + 1}$$



$$kx = \frac{2\pi x}{\lambda} = \frac{\pi(n + 1)x}{L}$$
$$y = 2A \sin\left(\frac{(n + 1)\pi x}{L}\right)\cos\omega t$$

Here $2A = a$ and $n = 3$

For $x = \frac{L}{3}, y = \left[a \sin\left(\frac{\pi}{L} \times \frac{L}{3}\right)\right]\cos\omega t$

$$= a \sin\frac{4\pi}{3}\cos\omega t = -a\left(\frac{\sqrt{3}}{2}\right)\cos\omega t$$

i.e., at $x = L/3$; the amplitude is $\sqrt{3}a/2$

214 **(c)**

Power for a travelling wave on a string is given by $P = pv\,A^2\omega^2\cos^2(kx - \omega t)$

For the displacement wave,

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

Power delivered is maximum when $\cos^2(kx - \omega t)$ is maximum, which would be the case when $\sin(kx - \omega t)$ is the least, i.e., displacement is minimum (acceleration is minimum). Power delivered is minimum when $\cos^2(kx - \omega t)$ is minimum, which would be when $\sin(kx - \omega t)$ is maximum, i.e., displacement is maximum (acceleration is maximum)

215 **(b)**

Let v_m be the velocity of motorcyclist and v be the velocity of sound

$$v' = \frac{90}{100}v_0 = \frac{v_0(v - v_m)}{v} \Rightarrow 9v = 10v - 10v_m$$
$$v_m = \frac{v}{10}$$
$$v_m^2 - 0 = 2as = \frac{v^2}{100}$$
$$\therefore S = \frac{v^2}{200a} = \frac{(330)^2}{200 \times 2.2} = 247.5 \text{ m}$$

216 **(d)**

$$f_1 = \left(\frac{340}{340 - 34}\right)f = \frac{10}{9}f$$
$$f_2 = \left(\frac{340}{340 - 17}\right)f = \frac{20}{19}f$$
$$\therefore \frac{f_1}{f_2} = \frac{\frac{10}{9}}{\frac{20}{19}} = \frac{19}{18}$$

217 **(c)**

Beat frequency $= f_1 - f_2 = \frac{v}{2l} - \frac{v}{2(1+x)}$

$$= \frac{v}{2l}\left[1 - \left(1 + \frac{x}{l}\right)^{-1}\right]$$
$$= \frac{v}{2l}\left[1 - 1 + \frac{x}{l}\right]$$
$$= \frac{vx}{2l^2}$$

218 **(c)**

Standard equation: $x = a\sin\omega t + b\cos\omega t$

$x = \sqrt{a^2 + b^2}\sin(\omega t + \tan^{-1}(b/a))$

Given equation $x = 3\sin(5\pi t) + 4\cos(5\pi t)$

$x = \sqrt{9 + 16}\sin(5\pi t + \tan^{-1} 4/3)$

$x = 5\sin(5\pi t + \tan^{-1}(4/3))$

219 **(a)**

As the source and the observer are approaching one another, so n' would be larger

$$f = \left(\frac{v + v/15}{v - v/10}\right)600 = 711 \text{ Hz}$$

220 **(a)**

$$n' = n\left(\frac{v - v_0}{v - v_s}\right)$$
$$\Rightarrow 605 = 550\left(\frac{330 - 0}{330 - v_s}\right)$$
$$\therefore v_s = 30 \text{ m/s}$$

221 **(d)**

$$y = 4\sin\left(4\pi t - \frac{\pi}{16}x\right)$$
$$\omega = 4\pi, k = \pi/16$$
$$v = \frac{\omega}{k} = \frac{4\pi}{\pi/16} = 16 \text{ cm/s}$$

in positive x-direction

222 **(c)**

Supports for the loop are reasonable for nodes at two points

$$\pi t = n\left(\frac{\lambda}{2}\right)$$
$$\pi\frac{D}{2} = n\frac{\lambda}{2}$$
$$f = n\left(\frac{v}{\pi D}\right)$$

Fundamental frequency $= v/\pi D$

223 **(d)**

Time taken is given by

$T = t_1 + t_2 = \frac{d_1}{v_1} + \frac{d_2}{v_2}$

$v_1 = v_{0C^\circ} = 330$ m/s

$v_2 = (330 + 0.6t) = 342$ m/s

$d = 1662$ m

$\therefore T = \frac{d_1}{330} + \frac{(d - d_1)}{342} = 5$ s

$\frac{d_1(342 - 330)}{330 \times 342} + \frac{d}{342} = 5$s

$12d_1 = 5(342 \times 330) - 330 \times 1662$

$d_1 = 1320$ m

$d_2 = 342$ m

224 **(d)**

Let a be the amplitude due to $S_1$and S_2 individually

Intensity due to $S_1 = I_1 = Ka^2$

Intensity due to $S_1 + S_2 = I = K(2a)^2$

$= 4I_1$

$\therefore\ n = 10 \log_{10} \left(\frac{4I_1}{I_1}\right)$

$= 10 \log_{10}(4) = 6$

225 **(c)**

$P = -B\ \frac{dy}{dx}$

At R, dy/dx is most negative. So pressure is maximum

226 **(c)**

A apparent frequency for reflector (which will act here as an observer) would be $f_1 = \left(\frac{v+u}{v}\right) f$

Where f is the actual frequency of source. The reflector will now behave as a source. The apparent frequency will now become

$f_2 = \left(\frac{v}{v-u}\right) f_1$

Substituting the value of f_1 we get

$f_2 = \left(\frac{v+u}{v-u}\right) f$

227 **(a)**

Slope at any point on the string in wave motion represents the ratio of particle speed to wave speed

Therefore, slope $B <$ slope A

Hence $R_A > R_B$

228 **(a)**

With clamp at the centre $L = \lambda/2$ for the fundamental

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

When clamp is moved to one end then

$L = \frac{L}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}, \dots, (2n-1)\frac{\lambda}{4}$

For $n = 1,2, \dots$

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

$f_0 = 2$kHz (1st harmonic)

$f_1 = 6$ kHz (2nd harmonic or 1st overtone)

$f_2 = 10$ kHz (3rd harmonic or 2nd overtone)

229 **(c)**

$y_2 = 5[\sin 3\pi t + \sqrt{3} \cos 3\pi t]$

$= 5\sqrt{1+3} \sin\left(3\pi t + \frac{\pi}{3}\right)$

$= 10 \sin\left(3\pi t + \frac{\pi}{3}\right)$

So, $A_1 = 10$ and $A_2 = 10$

230 **(b)**

$2\left(\frac{v_1}{2l_1}\right) = \frac{v_2}{4l_2}$

$\therefore \frac{\sqrt{T/\mu}}{l_1} = \frac{320}{4l_2}$

(μ=mass per unit length of wire)

$Or\ \frac{\sqrt{50/\mu}}{0.5} = \frac{320}{4 \times 0.8}$

Solving we get μ=0.02 kg/m=20 g/m

$\therefore$ Mass of string=20 g/m ×0.5 m=10 g

231 **(b)**

$y(x,t) = f(x - vt)$

$y = (x, 0) = \frac{4 \times 10^{-3}}{8 - x^2}$

For a travelling wave in the x- direction

$y(x,t) = \frac{4 \times 10^{-3}}{8 - (x - 5t)^2}$

232 **(c)**

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 $\lambda/2$

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

$y_{\text{reflected}} = -a\cos(\omega t + kx)$

233 **(d)**

Time of fall $= \sqrt{\frac{2h}{g}} = \sqrt{\frac{2\times10}{1000}} = \frac{1}{\sqrt{50}}$

In this time number of oscillations are eight.

So time for 1 oscillation $= \frac{1}{8\sqrt{50}}$

Frequency $= 8\sqrt{50}\ Hz = 56\ Hz$

234 **(b)**

If one of the natural frequencies of the string matches with the source frequency, then resonance condition will arise and the string will vibrate with source frequency

235 **(c)**

Suppose at an instant t, the x-coordinate of a point with refrence to moving frame is x_0. Since, at this moment, origin of moving frame is at distance vt from origin of the fixed reference frame, therefore, putting this value of x in the given equation, we get

$y = a\cos[\omega t - k(vt + x_0)]$

$y = a\cos[(\omega - kv)\,t - x_0)]$

Hence, option (c) is correct

236 **(c)**

At $t = 2s$

$$y = \frac{1}{[1 + (x-1)^2]}$$

or $x - vt = x - 1 \Rightarrow 1 = vt$

$\Rightarrow 1 = v \times 2$

$\Rightarrow v = 0.5$ m/s

237 **(c)**

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

$$\frac{\pi}{4} = \frac{2\pi}{\lambda} \times \frac{1.25}{100}$$

On solving, we get

$$\lambda = \frac{1}{10}\,\text{m/s}$$

$$u = n\lambda = 1000 \times \frac{1}{10} = 100 \text{ m/s}$$

238 **(a)**

For minimum,

$$\Delta x = (2n-1)\,\frac{\lambda}{2}$$

The maximum possible path difference = difference between the source = $3m$

For no minimum

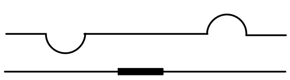
$$\frac{\lambda}{2} > 3 \ \ \Rightarrow \lambda > 6$$

$$f = \frac{V}{\lambda} < \frac{330}{6} = 55$$

If $f < 55$ Hz, no minimum will occur

239 **(b)**

After 2 s, tubes will overlap each other. According to superposition principle, the string will not have any distortion and will be straight. Hence, there will be no PE. The total energy will be kinetic



240 **(b)**

Path difference $= (2l - l) = \lambda/2$ (for minimum)

$\lambda = 2l$

241 **(c)**

Velocity of wave on string $= \sqrt{T/\mu} = 8$ m/s

The pulse gets inverted after reflection from the fixed end, so for constructive interference to take place between successive pulse, the first pulse has to undergo two reflections from fixed end

So, $\Delta t = \frac{2\times0.4+2\times0.4}{8} = 0.2$ s

242 **(b)**

Let the speed of wave be v, for crossing one wave crests to the other while travelling in the same direction, the surfing speed has to be greater than speed of the wave, i.e., $v >$ 15 m/s

Let wavelength of wave be λ m

While surfing in the same direction

$\lambda = (15 - v) \times 0.8$

While surfing in the direction opposite to the wave motion

$\lambda = (15 + v) \times 0.6$

$(15 - v)0.8 = (15 + v)0.6$

$v = 15/7$ m/s $= 2.143$ m/s

So, $\lambda = (15 - 2.143) \times 0.8 = 10.3$ m

243 **(b)**

After 2 s, the two pulses will nullify each other. As string now becomes string, there will be no deformation in the string. In such a situation, the string will not have potential energy at any point. The whole energy will be kinetic

244 **(b)**

$$n_1 = \frac{\omega_1}{2\pi} = \frac{400\pi}{2\pi} = 200 \text{ Hz}$$

$$n_2 = \frac{\omega_2}{2\pi} = \frac{404\pi}{2\pi} = 202 \text{ Hz}$$

Therefore, the number of beats $n = n_2 - n_1 =$ 2 Hz

Again $A_1 = 4$ and $A_2 = 3$

$$\frac{I_{\max}}{I_{\min}} = \frac{(A_1 + A_2)^2}{(A_1 - A_2)^2} = \left(\frac{4+3}{4-3}\right)^2 = \frac{49}{1}$$

This is alternative (b) is correct

245 **(a)**

$$f_0 = \frac{5}{2l}\sqrt{\frac{9\text{g}}{\mu}} = \frac{2}{2l}\sqrt{\frac{M\text{g}}{\mu}}$$

$\therefore M = 25$ kg

246 **(a)**

$V(x) = k|x|^3$

$$\therefore [k] = \frac{[V]}{[x]^3} = \frac{\text{ML}^2\text{T}^{-2}}{\text{L}^3} = \text{ML}^{-1}\text{T}^{-2}$$

Now time period on T and

$(\text{mass})^x\ (\text{amplitude})^y (k)^2$

$\therefore [\text{M}^0\text{L}^0\text{T}] = [\text{M}]^x[\text{L}]^y[\text{ML}^{-1}\text{T}^{-2}]^z$

$= [\text{M}^{x-y}\text{L}^{y-x}\text{T}^{-2z}]$

Equation the powers, we get

$-2z = 1$ or $z = -1/2$

$y - z = 0 \quad y = z = -1/2$

Hence $T \propto (\text{amplitude})^{-1/2}$

or $T \propto \frac{1}{\sqrt{a}}$

247 **(c)**

Let v be the speed of sound, u be the speed of train

Then, $v_s = v_o = u$

and $f' = f\left(\frac{v + v\cos\theta}{v + u\cos\theta}\right) = f$

248 **(d)**

$$\frac{v}{4l_1} = 3\left(\frac{v}{2l_2}\right) \Rightarrow \frac{l_1}{l_2} = \frac{1}{6}$$

249 **(c)**

Since source and both the observers are stationary, therefore no change will be observed by the two observers. It means both the observers will receive waves with natural frequency, which is equal to n

250 **(b)**

$l_1 + e = \lambda/4$ or $3l_1 + 3e = 3\lambda/4$

Again $l_2 + e = \frac{3\lambda}{4}$

$\therefore 3l_1 + 3e = l_2 + e$

or $2e = l_2 - 3l_1$

or $e = \frac{1}{2}(l_2 - 3l_1) = \frac{1}{2}(32 - 3 \times 10) = 1$ cm

251 **(c)**

Given $\frac{v}{4l_1} = \frac{3v}{2l_2} \Rightarrow \frac{l_1}{l_2} = \frac{1}{6}$

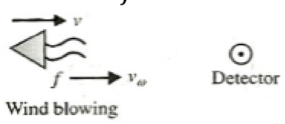
252 **(a)**

At any instant t, the wave equation will express the variation of y with x which is equal to the shape of the string at an instant t

253 **(c)**

$$\lambda' = \frac{\text{Wave speed relative to listener}}{f}$$

$$\Rightarrow \lambda' = \frac{v + v_\omega}{f} = \frac{v + v_\omega}{v}\lambda$$



254 **(c)**

For the wave $y = A\sin(\omega t - kx)$, $v_0 = A\omega$

Where A is, the maximum displacement

For the given condition

$$\frac{A}{2} = A\sin(\omega t - kx)$$

$$\sin(\omega t - kx) = \frac{1}{2}$$

And $\frac{\partial y}{\partial t} = A\omega\cos(\omega t - kx) = A\omega\frac{\sqrt{3}}{2} = \frac{\sqrt{3}v_0}{2}$

255 **(a)**

With reflection in tension, frequency of vibrating string will increase. Since number of beats are decreasing. Therefore, frequency of vibrating string or third harmonic frequency of closed pipe should be less than the frequency of tuning fork by 4.

$\therefore$ frequency of tuning fork

= Third harmonic frequency of closed pipe+4

$$= 3\left(\frac{v}{4l}\right) + 4 = 3\left(\frac{340}{4 \times 0.75}\right) + 4 = 344\ Hz$$

256 **(c)**

The frequency of reflected sound heard by the driver

$$n' = n\left(\frac{v - (-v_O)}{v - v_S}\right) = n\left(\frac{v + v_O}{v - v_S}\right)$$

$$= 124\left[\frac{330 + (72 \times 5/18)}{330 - (72 \times 5/18)}\right] = 140\ vibration/sec$$

257 **(c)**

The decibel scale is logarithmic $dB = 10\log(I/I_0)$. Each increase in intensity by a power of ten increases the decibel reading by 10 units. Hence, to increase the decibel reading by 20, there should be an increase in the intensity of $10 \times 10 = 100$

258 **(c)**

Node means a point at which medium particles do not displace from its mean position and antinode mean a point at which particles oscillate with maximum possible amplitude. Nodes and antinodes are obtained for both types of stationary waves, transverse and longitudinal. Hence, options (a) and (b) both are wrong. To obtain a stationery wave, two waves travelling in opposite directions, having same amplitude, same frequency are required. They must have same nature, means either both of the waves should be longitudinal or both of them should be transverse. Hence, option (c) is correct

259 **(c)**

We start with a general form for a rightward moving wave,

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

The amplitude given is $A = 0.2$ cm $= 0.02$m

The wavelength is given as,
$\lambda = 1.0$ m
Wave number $= k = 2\pi/\lambda = 2\pi \text{ m}^{-1}$
Angular frequency,
$\omega = vk = 10\pi$ rad/s
$y(x,t) = (0.02)\sin[2\pi(x - 5.0\,t) + \phi]$
We are told that for $x = 0, t = 0$,
$y = 0$ and $\frac{\partial y}{\partial t} < 0$
i.e., $0.02 \sin\phi = 0$ (as $y = 0$)
and $-0.2\pi\cos\phi < 0$
from these conditions, we may conclude that
$\phi = 2n\pi$ where $n = 0,2,4,6 \ldots\ldots$
Therefore
$y(x,t) = (0.02\text{ m})\sin[(2\pi\text{m}^{-1})x - (10\pi\text{ s}^{-1})t]$ m

260 **(d)**

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

$$\frac{n_2}{n_1} = \frac{l_1}{l_2}\sqrt{\frac{T_2}{T_1}}$$

$$= \frac{l_1}{\left[l_1 - \frac{40}{100}l_1\right]}\sqrt{\left(\frac{T_1 + \frac{44}{100}T_1}{T_1}\right)}$$

$$= \frac{100}{60} \times \frac{12}{10} = 2:1$$

261 **(a)**
In both cases, the 'applied frequency' is same. So, the frequency of vibration has to be same. However, the mode of vibration of the string be different

262 **(d)**
$\frac{f_1}{f_2} = \frac{101}{100}$
$f_1 - f_2 = 5$
$\frac{101}{100}f_2 - f_2 = 5$ or $f_2 = 500$ Hz
and $f_1 = f_2 + 5 = 505$ Hz

263 **(a)**
$V_P(\max) = \left(\frac{dy}{dt}\right)_{\max} = 50$ units
$V_\omega = \frac{\omega}{k} = \frac{100}{25} = 4$ units
$\frac{V_P(\max)}{V_\omega} = 12.5$

264 **(d)**
$v_B - v_A + \frac{3}{100}v_A$
$v_C = v_A - \frac{2}{100}v_A$
$v_B - v_C = 8$
$\frac{3}{100}v_A + \frac{2}{100}v_A = 8$
or $v_A \times \frac{5}{100} = 8$ or $v_A = 160$ Hz

265 **(c)**
The brass rod is open at both ends
So the longitudinal waves will have a fundamental frequency $f_0 = \frac{v}{2l}$
$v = (3000)(2)\left(\frac{40}{100}\right)$
$v = 2400$ m/s

266 **(a)**
String 1 is heavy so it can easily pull up the lighter string 2, while string 2 being lighter would not be able to displace the point

267 **(d)**
Maximum particle velocity $= \omega A$
Wave velocity $= \frac{\omega}{K}$
Therefore, the required ratio
$= \frac{\omega A}{\omega/K}$
$= AK$
$= 60 \times 10^{-6} \times 6$
$= 3.6 \times 10^{-4}$

268 **(b)**
When the cylinder is given a small push downwards, say x, then two forces start acting on the cylinder trying to bring it to its mean position.
Restoring force $= -$(uptrust+ spring force)
$= -[\rho Axg + kx]$
$= -[\rho Ag + k]x$

$$M\omega^2 = \rho Ag + k \Rightarrow \omega = \left[\frac{\rho Ag + k}{M}\right]^{1/2}$$

$$\Rightarrow v = \frac{1}{2\pi}\left[\frac{\rho Ag + k}{M}\right]^{1/2}$$

269 **(b)**

$$y(x,t) = \frac{6}{(x-2t)^2}$$

$$\Rightarrow v_p = \frac{\partial y}{\partial t} = \frac{24}{(x-2t)^3}$$

$$v_p[x = 2, t = 2] = \frac{24}{-2^3} = -3 \text{ m/s}$$

270 **(d)**
Assume $1/\sqrt{a} = A\cos\theta$ (i)
$\frac{1}{\sqrt{b}} = A\sin\theta$ (ii)
On simplifying, we get $y = A\sin(\omega t + \theta)$
Squaring and adding Eqs. (i) and (ii) $A = \sqrt{\frac{a+b}{ab}}$

271 **(a)**
Length of air column in resonance is odd integer

multiple of
$\frac{\lambda}{4}$
And prongs of tuning fork are kept in a vertical plane.

272 **(b)**
When a stationery wave is established in a medium then maximum deformation of the medium is produced at nodes. Hence, maximum pressure change takes place at nodes and at antinodes, no pressure change takes place. Therefore, option (a) is wrong.

$$v = \sqrt{\frac{\text{Elasticity}}{\text{Density}}}$$

Since, elasticity and density both are the characteristic property of the medium, therefore, velocity of a longitudinal wave in a medium is its physical characteristic. So, option (b) is correct
Due to propagation of longitudinal wave in a medium pressure change

$$\Delta P = \frac{\gamma P u}{v}$$

Where u is the velocity of medium particles
Pressure change will be maximum possible when medium particles have maximum possible velocity, which is equal to $a\omega = 2\pi na$
Hence, $\Delta P = \gamma P \frac{2\pi na}{v}$
But $\gamma P = \rho v^2$
$\therefore \Delta P = 2\pi\, na\rho v$
So, option (c) and therefore option (d) is also wrong

273 **(d)**
Probable frequency of A is 390 Hz and 378 Hz and after loading the beats are decreasing from 6 to 4 so the original frequency of A will 390 Hz

274 **(b)**
$y(x, t = 0) = \frac{6}{x^2}$ then $y(x, t) = \frac{6}{(x-2t)^2}$

$$\frac{\partial y}{\partial t} = \frac{24}{(x-2t)^3} \text{ at } x = 2, t = 2$$

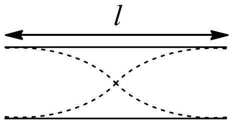
$$V_y = \frac{24}{(-2)^3} = -3 \text{ m/s}$$

275 **(b)**
Substituting $x = 0$, we have given wave $y = A \sin \omega t$ at $x = 0$ other should have $y = -A \sin \omega t$ equation so displacement may be zero at all the time. Hence, option (b) is correct

276 **(a)**
For both ends open, fundamental frequency

$$\frac{2\lambda_1}{4} = l \Rightarrow \lambda_1 = 2l$$

$$\therefore v_1 = \frac{c}{\lambda_1} = \frac{c}{2l} \quad \text{(i)}$$



For one end closed the third harmonic

$$\frac{3\lambda_2}{4} = l \Rightarrow \lambda_2 = \frac{4l}{3}$$

$$v_2 = \frac{c}{\lambda_2} = \frac{3c}{4l} \quad \text{(ii)}$$

Given $v_2 - v_1 = 100$
From Eqs. (i) and (ii)

$$\frac{v_2}{v_1} = \frac{3/4}{1/2} = \frac{3}{2}$$

On solving, we get $v_1 = 200$ Hz

277 **(d)**
When the source approaches the observer,

$$f_1 = f\left(\frac{v}{v - v_s}\right) = f\left(1 - \frac{v_s}{v}\right)^{-1} \approx f\left(1 + \frac{v_s}{v}\right)$$

Or $\left(\frac{f_1 - f}{f}\right) \times 100 = \frac{v_s}{v} \times 100 = 10 \quad$ (i)
In the second case, when the source recedes from the observer

$$f_2 = f\left(\frac{v}{v + v_s}\right) = f\left(1 + \frac{v_s}{v}\right)^{-1} = f\left(1 - \frac{v_s}{v}\right)$$

$\therefore \left(\frac{f_2 - f}{f}\right) \times 100 = -\frac{v_s}{v} \times 100 = -10$ [from Eq.(i)]
In the first case, observed frequency increases by 10% while in the second case, observed frequency decreases by 10%

278 **(b)**
Let Δlbe the end correction. Given that,
Fundamental tone for a length 0.1m=first overtone for the length 0.35m

$$\therefore \frac{v}{4(0.1 + \Delta l)} = \frac{3v}{4(0.35 + \Delta l)}$$

Solving this equations we get Δl=0.025m=2.5 cm

279 **(c)**
Let relative velocity be v and the speed of sound be v_0Then,

$$f_1 = \frac{v_0 - (-v)}{v_0} \times f_0 = \frac{v_0 + v}{v_0} f_0$$

$$f_2 = \frac{v_0}{v_0 - v} \times f_0$$

$$f_3 = \frac{v_0 + v/2}{v_0 - v/2} \times f_0$$

It is clear from above that $f_1 \neq f_2 \neq f_3, f_3 > f_0$ and we can prove that $f_2 > f_3 > f_1$

280 **(b)**

$$\frac{\lambda}{2} = 46 - 16 \Rightarrow \frac{\lambda}{2} = 30 \text{ cm}$$

or $\lambda = 60$ cm

$$\therefore v = \lambda f = \frac{60}{100} \times 500 = 300 \text{ m/s}$$

281 **(a)**

The frequency of oscillation of the standing wave is same as that of either of the component waves

282 **(c)**

Given $v_c = v_o$(both first overtone)

Or

$$3\left(\frac{v_c}{4L}\right) = 2\left(\frac{v_o}{2l_o}\right)$$

$$\therefore l_o = \frac{4}{3}\left(\frac{v_o}{v_c}\right)L = \frac{4}{3}\sqrt{\frac{\rho_1}{\rho_2}}L$$

$$\left(as\ v \propto \frac{1}{\sqrt{\rho}}\right)$$

Therefore correct option is (c).

283 **(d)**

The equation of stationary wave for open organ pipe can be written as

$$y = 2A\cos\left(\frac{2\pi x}{\lambda}\right)\sin\left(\frac{2\pi f t}{v}\right)$$

where $x = 0$ is the open end from where the wave gets reflected.

Amplitude of stationary wave is

$$A_S = 2A\cos\left(\frac{2\pi x}{\lambda}\right)$$

For $x = 0.1$ m,

$$A_S = 2 \times 0.002 \cos\left[\frac{2\pi \times 0.1}{0.4}\right] = 0$$

284 **(b)**

$$v' = \frac{v}{v + v_,}v$$

Or $\frac{6}{7}v = \frac{330}{330+v_,}v$

Or $6 \times 330 + 6v_, = 7 \times 330$

Or $6v_, = 330$ or $v_, = 55$ m/s

285 **(b)**

For fundamental mode

$(\lambda/2) = 100$ cm or $\lambda = 200$ cm

As $n = 330$ Hz, Hence

$$V = n\lambda = 330 \times \frac{200}{100} = 660 \text{ m/s}$$

286 **(b)**

Time recorded in summer is more accurate. The velocity of sound is directly proportional to the square root of absolute temperature. Hence, the sound of the gun fired at the starting point will reach the finishing point quicker in summer than in winter. The lapse of time due to the time taken by the sound in reaching the finish point will be less in summer and hence the time recorded will be more accurate in summer than in winter

287 **(a)**

$$f(E) = 1.5 \times 400 = 600 \text{ Hz} = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

$$= \frac{1}{2 \times 0.25}\sqrt{\frac{90}{\mu}}$$

$$\mu = \frac{90}{(0.5)^2 \times (600)^2} = 1 \text{ g/m}$$

288 **(b)**

$$y = 4\cos^2\left(\frac{t}{2}\right)\sin(1000t)$$

$$= 2\left(2\cos^2\frac{t}{2}\sin 1000t\right)$$

$$= 2[\cos t + 1]\sin 1000t$$

$$= 2\cos t \sin 1000t + 2\sin 1000t$$

$$= \sin 1001t + \sin 999t + 2\sin 1000t$$

289 **(a)**

Effective gravity $= \text{g}\cos\alpha$

$$\therefore T = 2\pi\sqrt{\frac{L}{\text{g}\cos\alpha}}$$

290 **(d)**

No Doppler effect, because velocity is perpendicular to line joining vehicle and observer

291 **(a)**

$\frac{\sqrt{T}}{l}$ = constant; tension decreases by a factor $(8-1)/8$,

Length decreases by a factor square root of this, i.e., $\sqrt{7/8} = 0.93$

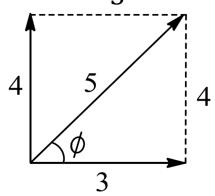
292 **(a)**

$$\frac{v_A}{v_B} = \frac{D_B}{D_A} = \frac{1}{2}$$

293 **(a)**

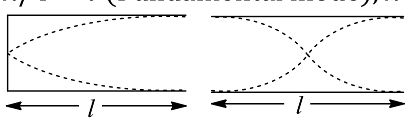
$$a = \sqrt{3^2 + 4^2} = \sqrt{9 + 16} = \sqrt{25} = 5 \text{ cm}$$

$$\tan\phi = \frac{4}{3} \text{ or } \phi = \tan^{-1}\left(\frac{4}{3}\right)$$



294 **(a)**

$\lambda/4 = l$ (Fundamental mode), $\lambda = 4l, c = v\lambda$



$$\therefore v = \frac{c}{\lambda} = \frac{c}{4l} = 512 \text{ Hz}$$

Given, $\lambda'/2 = l$

Fundamental mode,

$\therefore\ \lambda' = 2l$ but $c = v'\lambda'$

$\therefore\ v' = \frac{c}{\lambda'} = \frac{c}{2l} = 2\left(\frac{c}{4l}\right)$

$= 2 \times 512 = 1024$ Hz

295 **(a)**

Length of open organ pipe $l = 2\ m$

When it is dipped in water, it becomes closed at one end. Let l_1 be the length of air column of pipe immersed, then frequency of first overtone of pipe $= \frac{3v}{4l_1}$

Given $\frac{3v}{4l_1} = 170$

$l_1 = \frac{3v}{4 \times 170}$

$= \frac{3 \times 340}{4 \times 170} = 1.5$ m

Length immersed

$x = l - l_1$

$= 2 - 1.5 = 0.5$ m

296 **(d)**

$v = 960$ m/s; $\quad n = \frac{3600}{60}$ Hz

So $\lambda = \frac{v}{n} = \frac{960}{60} = 16$ m

297 **(c)**

$P = \frac{1}{2}\mu\omega^2 A^2 v$ where $v = \sqrt{\frac{T}{\mu}}$

298 **(b)**

Given $\omega = 3\pi$

$f = \frac{\omega}{2\pi} = 1.5$

Also $\Delta x = 1.0$ cm

Given, $\phi = \frac{2\pi}{\lambda}\Delta x \ \Rightarrow \frac{\pi}{8} = \frac{2\pi}{\lambda} \times 1$

$\lambda = 16$ cm

$v = f\lambda = 16 \times 1.5 = 24$ cm/s

299 **(d)**

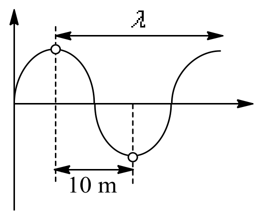
$y(x,t) = \frac{a}{(x \pm vt)^2 + b}$

Is another form of progressive wave equation propagating with a speed v

Negative sign to be taken for propagation along $+x$-axis and positive sign to be taken to propagation along $-x$-axis

300 **(b)**

Frequency of wave $= 1/4$ Hz



Wavelength of wave, $\lambda = 2 \times 10 = 20$ m

Velocity of wave $f\lambda = 5$ m/s

301 **(a)**

$l_1 + \varepsilon = \frac{v}{4f_0}$

$l_2 + \varepsilon = \frac{3v}{4f_0}$

$l_3 + \varepsilon = \frac{5v}{4f_0}$

On solving, we get $l_3 = 2l_2 - l_1$

302 **(c)**

$V = \frac{1}{Dl}\sqrt{\frac{T}{\pi d}}$ or $v \propto \frac{1}{D}$

Now ,$\left(\frac{v'}{v} - 1\right) \times 100 = \left(\frac{30}{31} - 1\right) \times 100$

$= -\frac{100}{31} = -3.2$

304 **(a,b,c,d)**

$v_p = v \times \partial y/\partial x$ for $y = A\sin(\omega t - kx)$,

we have

$v_p = kv \times A\cos(\omega t - kx) = \omega A\cos(\omega t - kx)$

i.e., it is varying

Also, $v_p \propto \omega$ and $v_p \propto A$

305 **(b,c)**

$\mathrm{KE}_{\max} = \frac{1}{2}kA^2 = \frac{1}{2} \times 2 \times 10^6 \times (0.01)^2 = 100$ J

$U_{\max} = \mathrm{TE} = 160$ J

306 **(a,b,d)**

Fundamental frequency:

$v = \frac{320}{4 \times 1}$ Hz $= 80$ Hz

Now only odd harmonic are present

307 **(a,b,d)**

If P divides AB in ratio 1:4, then the fundamental frequency corresponds to 5 loops, one loop in AP and 4 loops in PB which corresponds to 5^{th} harmonic of 1 kHz. Hence fundamental = 5 kHz

If P be taken at midpoint, the third harmonic will have three loops in each half of the wire AB. Hence total number of nodes (including A and B) will be $5 + 2 = 7$.

If P divides AB in the ratio 1:2, the fundamental will have three loops, corresponding to the frequency of 3 kHz. For this string to vibrate with the fundamental of 1 kHz, the tension must be $(T/9)$

The wire AB will be symmetry, vibrate with the same fundamental frequency when P divides AB in the ratio $a{:}\,b$ or in the ratio $b{:}\,a$

308 **(a)**

$$\mu = \frac{\sin i}{\sin r} = \frac{v_{cooler}}{v_{hotter}} = \sqrt{\frac{T_1}{T_2}}$$

$$= \sqrt{\frac{273 + 27}{273 + 127}} = \sqrt{\frac{3}{4}}$$

$$\therefore \sin r = \sqrt{\frac{4}{3}} \times \sin i$$

$$= \sqrt{\frac{4}{3}} \sin 30° = \sqrt{\frac{4}{3}} \times \frac{1}{2} = \frac{1}{\sqrt{3}}$$

$$r = \sin^{-1}(1/\sqrt{3})$$

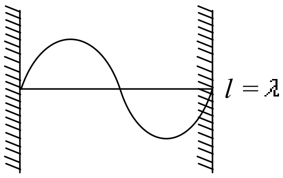
309 **(a,b,d)**

Speed of wave in wire

$$V = \sqrt{\frac{T}{\rho A}} = \sqrt{\frac{Y\Delta l}{l} A \times \frac{1}{\rho A}} = \sqrt{\frac{Y\Delta l}{l\rho}}$$

Minimum frequency; that means fundamental mode

$$f = \frac{V}{\lambda} = \frac{V}{2l} = \frac{1}{2l}\sqrt{\frac{Y\Delta l}{l\rho}} = 35 \text{ Hz}$$



Stress $= Y\dfrac{\Delta l}{l}$

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

$$= 4.41 \times 10^7 \text{ N/m}^2$$

and frequency of first overtone $= 70$ Hz

310 **(a,b,c)**

Standing waves are produced by two similar waves superposing while travelling in opposite directions. This can happen in options (a) and (c)

311 **(b,c)**

Let the equation to the wave be

$$y = A\sin\left[2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right) + \phi\right] \quad \text{(i)}$$

Where A is the amplitude of the wave and ϕ, phase angle. It is given that $y = a$, when $x = 0$ and $t = T/4$ and also that $y = v$ when $x = \lambda/4$ and $t = T/4$

Substituting in (i),

$$y = a = A\sin\left(\frac{\pi}{2} + \phi\right)$$

$$y = v = \frac{2\pi A}{T}\cos\left[2\pi\left(\frac{1}{4} - \frac{1}{4}\right) + \phi\right]$$

$$v = \frac{2\pi A}{T}\cos\phi$$

Putting $\phi = 0, y = a = A$, so that amplitude $A = a$

Also, $v = \frac{2\pi A}{T}[\cos 0] = \frac{2\pi a}{T}$

$$\frac{2\pi}{T} = \frac{v}{a}$$

Hence the equation to the wave is

$$y = a\sin\frac{v}{a}\left[t - \frac{Tx}{\lambda}\right]$$

$$y = a\sin\frac{v}{a}\left[t - \frac{x}{V}\right]$$

Where $V = \frac{\lambda}{T}$ is the velocity of the wave in the gas

312 **(b,d)**

Comparing with $y = a\cos(\omega t - kx)$

$\omega = 500, k = 70$

Speed of wave

$$= \frac{\omega}{k} = \frac{500}{70} = \frac{50}{7} \text{m/s}$$

$k = 70$

$$\frac{2\pi}{\lambda} = 70$$

or $\lambda = \frac{2\pi}{70}$ m $= \frac{2\pi}{70} \times 100$ cm $= \frac{20\pi}{7}$ cm

313 **(a,b,d)**

Statement (a) is correct. Let us write

$y(x,t) = f(vt + x) = f(z)$

Differentiating with respect to time t,we have

$$\frac{\partial y}{\partial t} = \frac{\partial f}{\partial x}\frac{\partial x}{\partial t} = v\frac{\partial f}{\partial x}$$

Differentiating again with respect to time t, we have

$$\frac{\partial^2 y}{dt^2} = v^2\frac{\partial^2 f}{\partial x^2}$$

Similarly, differentiating twice with respect to x, we have

$$\frac{\partial^2 y}{dx^2} = \frac{\partial^2 f}{\partial x^2}$$

Hence $\frac{\partial^2 y}{\partial t^2} = v^2\frac{\partial^2 y}{\partial x^2}$

Which is the standard equation (in differential form) of a travelling wave

Statement (b) is also correct. Because the wave is reflected back into the same medium, the velocity remains unchanged. The wavelength cannot change because frequency cannot change by reflection

Statement (c) is incorrect

The ultrasonic wave bends away from the normal because the speed of the wave (being a sound wave) is greater in water than in air

Statement (d) is correct

The reason is that solids have a much higher modulus of elasticity than gases at NTP

314 **(b,c,d)**

Given,

$$y=\frac{0.8}{(4x+5t)^2+5}=\frac{0.8}{16\left[x+\frac{5}{4}t\right]^2+5} \quad \text{(i)}$$

We know that equation of moving pulse is

$y=f(x+vt)$ (ii)

On comparing Eqs. (i) and (ii), we get

$$v=\frac{5}{4}\text{ m/s}=\frac{2.5}{2}\text{m/s}$$

Wave will travel a distance of 2.5 m in 2 s

315 **(b,c)**

The equation has to be reduced to the form

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

$$=A\sin 314\left(\frac{t}{0.5\text{ s}}-\frac{x}{100\text{m}}\right)$$

$$=A\sin 2\pi\left(\frac{50t}{0.5\text{ s}}-\frac{x50}{100\text{m}}\right)$$

$$=A\sin 2\pi\left(\frac{t}{0.01\text{s}}-\frac{x}{2\text{m}}\right)$$

$$n=\frac{1}{T}=\frac{1}{0.01}=100\text{ Hz}$$

and $\lambda=2$ m

316 **(a,c)**

Let velocity of each observer be u as shown in the figure

$\underset{A}{}\xrightarrow{u}\quad \underset{S}{\bullet}\quad \underset{B}{}\xrightarrow{u}$

Then frequency received by A will be

$$n_1=n_0\left(\frac{v+u}{v}\right)$$

Where n_0 is natural frequency of the source and v is sound propagation velocity. The frequency received by B will be

$$n_2=n_0\left(\frac{v-u}{v}\right)$$

Since $(n_1+n_2)/2=n_0$, therefore, option (a) is correct

317 **(a,b)**

$y(x,0)=f(x)$. So shape of string at $t=0$ is given by $y=f(x)$ as velocity of wave $dx/dt=+a$, is constant, so shape of string does not change, or we can say $(x-at)$ is constant. Thus, the shape of string remains the same

As a is $-$ve and constant, so $dx/dt=-$ve and hence, wave is moving along $-$ve x-direction.

Speed $=-a$ and not a as speed cannot be $-$ve

318 **(a,b,d)**

Mechanical waves can be transverse on a liquid surface and this is possible only because tension.

In solids, $v_{\text{longitudinal}}>v_{\text{transverse}}$

Transverse waves are possible only on the surface of a liquid because they required the property of rigidity. All non-mechanical waves found till now transverse in nature

319 **(a,d)**

When the source are coherent,

$$R^2=a^2+b^2+2ab\cos\phi$$

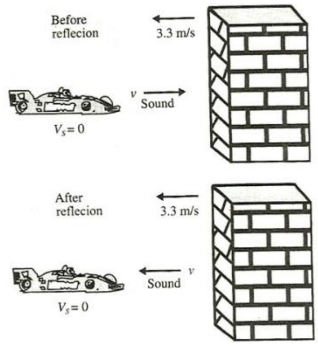
For constructive interference, $\phi=0$

$$I=I_0+I_0+2\sqrt{I_0I_0\cos 0°}=4I_0$$

When the sources are incoherent, intensities just add

$$I=I_0+I_0=2I_0$$

320 **(a,c)**



$$f'=f\left(\frac{v+v_{\text{wall}}}{v-v_{\text{wall}}}\right)$$

$$f'=1000\left(\frac{340+303}{340-3.3}\right)=1020\text{ Hz}$$

$$\frac{f'-f}{f}\times 100=\frac{\Delta f}{f}\times 100=2\%$$

321 **(b,c)**

On reflection from a rigid support the reflected wave suffers an additional phase change of π. When this reflected wave superimposes with incident wave stationery waves are obtained with node at the rigid support and intensity of such stationary waves very periodically with distance

322 **(b,d)**

Force increases linearly therefore, force acting on the particle at $x=\frac{A}{2}$ will be $-$2F. Potential energy $U\propto x^2$ ie,

Potential energy at $x=\frac{A}{2}$ will become4U.

Speed of particle is given by

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

ie, $v \propto \sqrt{A^2 - x^2}$

At $\quad x = -\frac{A}{4}, \sqrt{A^2 - x^2} = \sqrt{\frac{15}{16}A}$

And at $\ x = \frac{A}{2}\ , \sqrt{A^2 - x^2} = \sqrt{\frac{3}{4}A}$

ie, $\sqrt{A^2 - x^2}$ has become $\sqrt{\frac{4}{5}}$ times

Therefore, velocity at $x = \frac{A}{2}$ may be $\pm\sqrt{\frac{4}{5}}v$ or

kinetic energy will become $\frac{4}{5}$ times or 0.8 times.

323 **(c,d)**

$y_A = A\sin[\omega t - k(AC)]$

$y_B = \sin\left[\omega t - \frac{\pi}{2} - k\ (BC)\right]$

For maximum intensity at C

$k(BC - AC) + \frac{\pi}{2} = 2n\pi$

$BC - AC = \left(n\lambda - \frac{\lambda}{4}\right) = 15, 35, 55, 75, \ldots$

324 **(b,c)**

Comparing with the equation

$y = 2A\sin\left(\frac{n\pi x}{L}\right)\cos(\omega t)$, we have

$2A = 2$ mm or $A = 1$ mm

and $\frac{n\pi x}{L} = 6.28x = 22\pi x$

$L = \frac{n}{2}$ m

For $n = 1, L = 0.5$ m

325 **(a,b,c)**

Moving plane is like a moving observer. Therefore, number of waves encountered by moving plane

$f_2 = f\left(\frac{v + v_0}{v}\right) = f\left(\frac{c + v}{c}\right)$

Frequency of reflected wave,

$f_2 = f_1\left(\frac{v}{v - v_s}\right) = f\left(\frac{c + v}{c - v}\right)$

Wavelength of reflected wave,

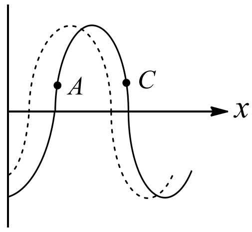
$\lambda_2 = \frac{v}{f_2} = \frac{c}{f_2} = \frac{c}{f}\left(\frac{c - v}{c + v}\right)$

Number of beats heard $= f_2 - f = \frac{2vf}{c-v}$

326 **(b,d)**

Since A is moving upwards, after an elements time interval, the wave will be as shown dotted in figure. It means, the wave is travelling leftwards. Therefore, option (a) is wrong.

Displacement amplitude of the wave maximum possible displacement of medium particles, due to propagation of the wave which is equal to the displacement at B at the instant shown in the figure. Hence, option (b) is correct.



From the figure, it is clear that C is moving downwards at this instant. Hence, option (c) is wrong

The phase difference between two points will be equal to $\pi/2$ if distance between them is equal to $\lambda/4$. Between A and C, the distance is less than $\lambda/2$. It may be equal to $\lambda/4$. Hence phase difference between these two points may be equal to $\pi/2$. Therefore, option (d) is correct

327 **(b,c,d)**

$v \propto \sqrt{T}$

$60\text{ dB} = 10\log\frac{I_1}{I_0}$

$30\text{ dB} = 10\log\frac{I_2}{I_0}$

$30 = 10\log\frac{I_1}{I_2} \Rightarrow \frac{I_1}{I_2} \neq 2$

328 **(d)**

Each end of the string is fixed and forms a node. Distance between two consecutive nodes is $\frac{\lambda}{2} = 40\text{cm}.\ \therefore\ \lambda = 80$ cm.

329 **(a,b,d)**

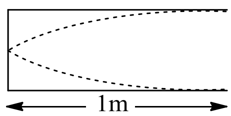
In general we can write for a closed end pipe

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

Where $n = 1, 2, 3, \ldots$

$\therefore v = \frac{c}{4l}, \frac{3c}{4l}, \frac{5c}{4},$

$\ldots = 80, 240, 400, \ldots$



330 **(a,b)**

As the string is rigidly clamped at its two ends, therefore,

$y = 0\ at\ x = 0$. This can be satisfied only by the term

$\sin\frac{n\pi x}{L}$, where m is an integer.

Therefore, option (a) and (b) are correct.

331 **(a,c)**
In first normal mode of vibration

$$n=\frac{v}{4l},l=\frac{v}{4n}=\frac{330\times 100}{4\times 264}=31.25\text{cm}$$

In second normal mode of vibration,

$$n=\frac{3v}{4l},l=\frac{3v}{4n}=3\times 31.25=93.75\text{cm}$$

332 **(c)**
$v=n\lambda=\left(\frac{54}{60}\right)\times 10=9\text{ms}^{-1}$

333 **(a,c)**
Displacement and amplitude both, are added vectorially in superposition principle.

334 **(a,c)**
From superposition principle,
$y=y_1+y_2+y_3$
$=a\sin\omega t+a\sin(\omega t+45°)+a\sin(\omega t+90°)$
$=a\{\sin\omega t+\sin(\omega t+90°)\}+a\sin(\omega t+45°)$
$=2a\sin(\omega t+45°)\cos 45°+a\sin(\omega t+45°)$
$=(\sqrt{2}+1)a\sin(\omega t+45°)=A\sin(\omega t+45°)$
Therefore, resultant motion is simple harmonic of amplitude $A=(\sqrt{2}+1)a$ and which differs in phase by 45° relative to the first
Energy in SHM $\propto$ (amplitude)^2
$\left[E=\frac{1}{2}mA^2\omega^2\right]$
$\therefore\ \frac{E_{\text{resultant}}}{E_{\text{single}}}=\left(\frac{A}{a}\right)^2=(\sqrt{2}+1)^2=(3+2\sqrt{2})$
$\therefore\ E_{\text{resultant}}=(3+2\sqrt{2})E_{\text{single}}$

335 **(a,c,d)**
$\frac{\lambda}{4}=0.1\ \Rightarrow\lambda=0.4$
From graph $\Rightarrow T=0.2$s and amplitude of standing wave is $2A=4$ cm
Equation of the standing wave
$y(x,t)=-2A\cos\left(\frac{2\pi}{0.4}x\right)\sin\left(\frac{2\pi}{0.2}t\right)$ cm
$Y(x=0.05,t=0.05)=-2\sqrt{2}$ cm
$Y(x=0.04,t=0.05)=-2\sqrt{2}\cos 36°$
Speed $=\frac{\lambda}{T}=2$ m/s
$V_y=\frac{dy}{dt}=-2A\times\frac{2\pi}{0.2}\cos\left(\frac{2\pi x}{0.4}\right)\cos\left(\frac{2\pi t}{0.2}\right)$
$V_y\left(x=\frac{1}{15}m,t=0.1\right)=20\pi$ cm/s

336 **(b,c,d)**
When observer P approaches the stationery source at speed v
$n_1=\frac{V+n}{v}\times n_0$ (i)
(V is speed of sound)
When soured S approaches the stationary observer P at speed v,
$n_2=\frac{V}{V-v}\times n_0$ (ii)
Thus $n_2>n_1$ i.e., choice (b) is correct when both S and P approach each other with speed $v/2$
$n_3=\frac{V+(v/2)}{V-(v/2)}n_0$ (iii)
Hence, $n_3>n_0$ and n_3 lies between n_1 and n_2

337 **(c,d)**
$y=y_1+y_2$
$=A\sin(\omega t-kx)+3A\sin(\omega t+kx)$
$=A\sin\omega t\cos kx-A\cos\omega t\sin kx$
$+3A\sin\omega t\cos kx+3A\cos\omega t\sin kx$
$=4A\sin\omega t\cos kx+2A\cos\omega t\sin kx$
$=2A\sin\omega t\cos kx+2A\sin(\omega t+kx)$
It is combination of a stationery and travelling wave
Maximum amplitude $=4A$
Minimum amplitude $=2A$
Distance between points having amplitude $4A$ and $2A$ will be $=\lambda/4=v/4f$

338 **(b,c,d)**
Statement (a) is incorrect
A change in pressure has no effect on the speed of sound. The decrease in the speed of sound at high altitudes is due to fall in temperature
Statement (b) is correct
Standing waves are produced due to superposition of the incident waves and the waves reflected from the fixed ends of the string. Since, the ends are never perfectly rigidly fixed, the amplitude of the reflected wave is always less than that of the incident wave. Consequently, the resultant amplitude at nodes is not exactly zero. Thus, the nodes are not well defined
Statement(c) is also correct
To observer beats, the difference between the two interfering frequencies must be less than about 10-16 Hz. Since, visible light waves have very high frequencies, beats are not observed due to persistence of vision
Statement (d) is also correct. We know that

$f_1 = \frac{f}{1-\frac{u}{v}}$ (i)

And $f_2 = f\left(1+\frac{u}{v}\right)$ (ii)

Expression Eq.(i) may be written as

$f_1 = f\left(1-\frac{u}{v}\right)^{-1}$

Expanding binomially and retaining terms up to order u^2/v^2, we have

$f_1 = v\left(1+\frac{u}{v}+\frac{u^2}{v^2}\right)$ (iii)

Comparing Eqs. (ii) and (iii), we find that $f_1 > f_2$

339 **(a)**

Compare the given equation with the standard equation

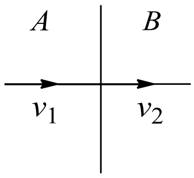
$y = a\sin(\omega t - x)$

$v = 200\ \mathrm{ms}^{-1}$

340 **(b,c)**

Intensity of sound depends on both, the amplitude and the frequency of wave. The practical unit of intensity (*ie* loudness) is decibel.

341 **(a,b,d)**



Frequency does not change on changing the medium

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

As velocity increases, so wavelength increase

As there is no absorption or reflection or reflection of wave, so intensity remain same

342 **(b,c)**

Because in general phase velocity = wave velocity. But in case of complex waves (many waves together) phase velocity ≠ wave velocity.

∴ If two waves have same λ, v; then they have same frequency too

343 **(a,d)**

In both cases (a) and (d) the source and observer are relatively at rest, thus neither of them is approaching or separating from each other. Effectively, it is the medium that moves in each of these cases. The received (apparent) frequency differs from the emitted frequency if and only if the time required for the wave to travel from the source to observer is different for different wave fronts. With a uniform steady motion of the medium, past the observer and source, the transit time from source to observer is the same for all wavefronts. Hence it follows that apparent frequency is equal to the true emitted frequency. Thus there is no Doppler effect. In cases (b) and (c), Doppler effect will be observed as the source and observer have a relative speed and so they and so they will approach or recede from each other

344 **(a,b,c,d)**

If a wave is incident normally on a surface then it gets reflected back to its original path. The incident wave is travelling along negative x-direction and reflected wave is travelling along positive x-direction. Hence, the wave is incident normally on the surface. Therefore, option (a) is correct

The equation of the reflected wave will be

$y' = a'\sin(ct - bx + \phi)$only when the reflecting surface is $x = 0$ plane, i.e., $y - z$ plane

Hence, option (b) is correct

Since, ϕ is equal to zero, it means, no phase change takes place at the reflecting surface. It is possible only when the reflection surface is boundary of a rarer medium. It means wave is travelling in a denser medium relative to the other medium. Hence, option (c) is also correct

If the reflecting surface is perfectly elastic then whole of the incident energy gets reflected back. In that case a' will be equal to a. But if a part of wave is refracted into the other medium, then amplitude of oscillations for the reflected wave will be less than that for incident wave. It implies that a' can never be greater than a.Hence, option (d) is also correct

345 **(a,c)**

If a string of length l has cross-sectional area A, density of its material ρ then its oscillation energy is given by

$E = \pi^2 A\rho a_0^2 l f^2$

Where f is frequency of transverse stationary wave formed in the string

But $f = \frac{v}{\lambda} = \frac{1}{\lambda}\sqrt{\frac{T}{m}}$

Where λ is wavelength, T is tension in the string and $m = A\rho$

Since, string has a fixed length, therefore, wavelength of a tone excited in the string is constant. Hence, energy $E \propto T$. Therefore, option (a) is correct:

If the frequency of fundamental tone is f_0, then frequency of nth overtone will be equal to $(n+1)f_0$

Hence, oscillation energy of the string will be equal to

$E_n = \pi^2 A\rho a_0^2 l f_0^2 (n+1)^2$

Since, E_n is not directly proportional to n^2, therefore, option (b) is wrong

Since every particle of the string performs SHM, therefore, r.m.s. speed of a particle

$= 1/\sqrt{2} \times$ its maximum speed

Hence, average KE is half of maximum KE. But maximum KE. But maximum KE is equal to oscillation energy of the string. Therefore option (c) is correct

346 **(a,d)**

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

For equilibrium $Mg = mg\sin 30 = T$

$M = m/2$

$$100 = \sqrt{\frac{Mg}{9.8\times 10^{-3}}} = \sqrt{\frac{M(9.8)}{9.8\times 10^{-3}}}$$

$100 = \sqrt{M(1000)}$

$M = 10\text{kg}$ and $m - 20$ kg

347 **(a,c)**

For a transverse sinusoidal wave travelling on a string, the maximum velocity is $a\omega$. Also, the maximum velocity is

$$\frac{v}{10} = \frac{10}{10} = 1 \text{ m/s}$$

$\therefore\ a\omega = 1 \Rightarrow 10^{-3} \times 2\pi f = 1$

$$\Rightarrow f = \frac{1}{2\pi \times 10^{-3}} = \frac{10^3}{2\pi}\text{Hz}$$

The velocity $v = f\lambda$

$$\therefore\ \lambda = \frac{v}{f} = \frac{10}{10^3/2\pi} = 2\pi \times 10^{-2}\text{m}$$

348 **(a,b,c)**

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

349 **(a,c,d)**

$y = f(x - vt)$

Particle velocity,

$$v_P = \frac{dy}{dt} = -vf'(x - vt)$$

To find velocity of wave

$$\frac{d}{dt}(x - vt) = 0$$

$$\frac{dx}{dt} = v$$

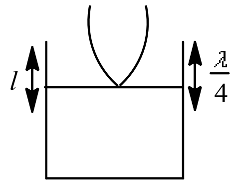
350 **(a,c)**

$$\frac{\partial^2 y}{\partial x^2} = (\text{constant})\frac{\partial^2 y}{\partial t^2}$$

351 **(a,b,d)**

$$\iota < \frac{\lambda}{4}$$

Further, larger the length of air column, feebler is the intensity.



352 **(a,b,c)**

Number of waves striking the surface per second (for the frequency of the waves reaching surface of the moving target)$n' = \frac{(c+v)}{\lambda} = \frac{v(c+v)}{c}$

Now these waves are reflected by the moving target

(Which now act as a source). Therefore apparent frequency or reflected sound

$$n" = \left(\frac{c}{c-v}\right)n' = v\left(\frac{c+v}{c-v}\right)$$

The wavelength of reflected wave

$$= \frac{c}{n"} = \frac{c(c-v)}{v(c+v)}$$

The number of beats heard by stationary listener

$$= n" - v = v\left(\frac{c+v}{c-v}\right) - v = \frac{2vv}{(c-v)}$$

Hence option (a) (b) and (c) are correct

353 **(b,d)**

$T_1$and T_2 are the higher and lowest tensions initially. Now, frequency $\propto \sqrt{\text{tension}}$. Therefore, frequency produced in wire with tension $T_1$is higher and that with tension T_2 is lower. If we lower the tension T_2 then beat frequency will increase. Therefore, the tension T_1 is decreased. If tension has to be increased then tension T_2 should be increased

354 **(a,b,c)**

A travelling wave is of the form F$(ax \pm bt)$. Therefore, choice (a), (b),(c) are correct.

355 **(b,c)**

Due to the clamping of the square plate at the edges, its displacements along the x-and y-axes will individually be zero at the edges. Only the choices (b) and (c) predict these displacements correctly. This is because $\sin 0 = 0$

356 **(b,c)**

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

Change in temperature affects the velocity of sound in air but as long as temperature remains same change in pressure has no effect

$$v = \sqrt{\frac{B}{P}}$$

Bilk modulus of water is very high, so velocity of sound in water is higher than that in air

357 **(b,d)**

At open end phase of pressure wave charge by π so compression returns as rarefraction. While at closed end phase of pressure wave does not change so compression return as compression

358 **(b,c)**

In the given equation as x is positive, therefore, the wave is traveling along negative direction of x- axis

$$\frac{2\pi}{\lambda} = 10\pi, \lambda = \frac{2\pi}{10\pi} = 0.2\text{m}$$

$$\frac{2\pi}{T} = 15\pi, T = \frac{2\pi}{15\pi} = \frac{2}{15}\text{s}$$

$$v = \frac{\lambda}{T} = \frac{0.2}{2/15} = 1.5\text{ms}^{-1}$$

359 **(b,c)**

When two waves having same frequency superimpose under given conditions the frequency of the resultant wave is the same as that of component waves. From the theory of interference of waves it can be easily understood. The amplitude of resultant wave for the given situation is given by

$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\delta}$ where δ is the phase difference between the waves, so A can be anything between $A_1 - A_2$ to $A_1 + A_2$ depending upon the value of δ

360 **(a,c,d)**

If intensity at a point is I, then energy density at that point is $E = I/v$, where v is wave propagation velocity

It means that $E \propto I$. Hence, the graph between E and I will be a straight line passing through the origin. Therefore, (a) is correct and (b) is wrong.

Intensity is given by

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

Hence, $E = 2\pi^2 n^2 a^2 \rho$

It means that $E \propto n^2$

Hence, the graph between E and n will be a parabola passing through origin, having increasing slope and symmetric about E- axis. Hence, option (d) is correct.

Particle maximum velocity is

$u_0 = a\omega = 2\pi\, na$

$\Rightarrow \pi na = \frac{u_0}{2}$

Hence, $E = \frac{1}{2}\rho u_0^2$

It means that graph between E and u_0 will be a parabola, have increasing slope and will be symmetric about E-axis. Hence, option (c) is also correct

361 **(a,b,c,d)**

The statement (a) is supported by water waves. An elastic medium is required for mechanical waves only. So, option (d) is also correct

The other two options (b) and (c) are also correct

362 **(b,d)**

A travelling wave is characterized by wave functions of the type $y = f(vt + x)$ or $y = f(vt - x)$. The function $y = a\sin(bx + ct)$ represents a wave travelling in the negative x-direction and the function $y = a\sin(bx - ct)$ a wave in positive x-directive. Hence, the correct choice are (b) and (d)

363 **(b,c)**

This is the case of sustained interference in which position of maxima and minima remains fixed all over the screen

$$\frac{I_{\min}}{I_{\max}} = \left(\frac{a_1 - a_2}{a_1 + a_2}\right)^2$$

And both waves must have been travelling in the same direction with a constant phase difference (condition for coherence)

364 **(b,d)**

For a travelling wave on a string, oscillation energy of an elemental length does not remain constant as the force exerted by neighbouring elements, i.e., tension is doing work on any element of string. Oscillation energy takes periodically. Oscillation energy of different elements of same length are not the same, it can be easily shown by taking two elements of same length on string

365 **(a,c,d)**

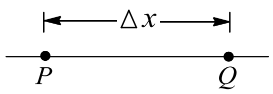
$y = y_1 + y_2$
$y = 4[\sin(3x - 2t) + \sin(3x + 2t)]$
$y = 4[2\sin(3x)\cos(2t)$
$y = 8\sin(3x)\cos(2t)$
$y = R\cos(2t)$
R =Resultant Amplitude $= 8\sin(3x)$
$R = 8\sin[3(2.3)]$
$R = 8\sin(6.9)$
$R = 4.63$ cm
Nodes are formed at points of zero intensity, i.e.,
$I_R = R^2 = 0$
$\sin^2(3x) = 0$
$\sin(3x) = 0$
$3x = 0, \pi, 2\pi, 3\pi, 4\pi, \ldots$
$x = 0, \frac{\pi}{3}, \frac{2\pi}{3}, \pi\frac{4\pi}{3}, \ldots$
Antinodes are formed in between

366 **(c,d)**

For a closed tube
$f_n = \frac{nv}{4L}$
$L = 1.1$ m, $v = 330$ m/s
$f_n = \frac{n \times 330}{4 \times 1.1} = 500$ Hz $\quad n = 6.66$
Highest frequency,
$f_h = \frac{6 \times 330}{4 \times 1.1} = 450$ Hz
Lowest frequency,
$f_1 = \frac{1 \times 330}{4.4} = 75$ Hz

367 **(b,c,d)**

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



$= \frac{\lambda}{2\pi}\pi = \frac{\lambda}{2}$
Let for P: $y_1 = A\sin\omega t$, then
For Q: $y_2 = A\sin(\omega t - \pi) = -A\sin\omega\, t$
We see that $y_1 = -y_2$
and $|y_1| = |y_2|$
Frequency of both particles should be same because the same wave passes through them

368 **(a)**

Compare the given equation

$y = 20\sin\left(\frac{\pi}{4}x + \frac{\pi t}{2}\right)$

With the standerd from

$y = a\sin\left(\frac{2\pi}{\lambda}x + \frac{2\pi t}{T}\right)$, we get

$a = 20$

$\frac{2\pi}{\lambda} = \frac{\pi}{4}, \lambda = 8$

$\frac{2\pi}{T} = \frac{\pi}{2}, T = 4,$

$n = \frac{1}{T} = \frac{1}{4} = 0.25$

369 **(a,b,d)**

Due to propagation of a wave the energy density at a point is given by
$E = I/v$
Where I is intensity at that point and v is wave propagation velocity.
It means energy density E is directly proportional to intensity I. If power emitted by a point source is P then intensity at a distance r from it is equal to
$I = \frac{P}{4\pi r^2}$ or $I \propto \frac{1}{r^2}$
Hence, the shape of the curve between I and r will also be same as that given in figure of the question.
Hence, option (a) is correct.
If the source is a plane sound source then intensity at every point in front of the source will be same if damping does not take place. But if damping takes place then the amplitude of oscillation of medium particles decreases with distance. Hence, the intensity decreases with the distance from the source. In that case, the curve between I and r may have the same shape as shown in the figure given in the question. Hence, option (b) is also correct.
If the source is a plane source, intensity at every point of the source will be the same. But of power of the source is decreasing with time then intensity will also decrease with time. But at an instant, intensity at every point in front of source will be same. Therefore, the energy density at every point in front of source will also be same, through it will decrease with time. Hence, option (c) wrong.
Intensity, $I = 2\pi^2 n^2 a^2 \rho v$
Since, intensity $I \propto \rho$(density of medium) and density I is decreasing with distance, therefore, the density ρ also decreases with distance from

the source. Hence, option (d) is also correct

370 **(a,b)**

Change of medium and change of temperature do effect the velocity of sound. Change in wavelength does not further, there is no effect of change in pressure on velocity of sound, provided temperature remains constant.

371 **(b,c)**

When the shift in star light is towards red end, wavelength increase and the apparent frequency is less than the actual. The star must be receding away from the earth.

372 **(a,b)**

In case of a stationery wave, all the particles lying between two consecutive nodes, oscillate in the same phase

Since all the particles of given string are oscillating in the same phase, therefore, all particles of the string lie between two consecutive nodes. Hence, the string is oscillating in the single loop. It means, it is oscillating in its fundamental tone. Hence (a) is correct

Interference is a phenomenon of obtaining constant intensity at a fixed position but the intensity varies with position of the point of observation. Hence, intensity should vary from point to point. Hence, to observe interference, two source having same frequency must be placed some distance apart. Hence option (b) is correct

Beats is a phenomenon of obtaining an intensity which varies with time. To obtain beats, two sources having different frequencies are required. Therefore, option (c) is wrong

373 **(a,b,c)**

Comparing the given equation of travelling wave with

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

Amplitude $= a$, angular frequency $\omega = b$ and $\frac{2\pi}{\lambda} = c$ or wavelength $\lambda = 2\pi/c$

$\frac{a}{\lambda} = \frac{ac}{2\pi}$

Therefore, option (a) is correct

Velocity oscillation amplitude of medium particles is $a\omega = ab$

Wave propagation velocity $v = \omega\lambda/2\pi = b/c$

$\frac{a\omega}{v} = ac$

Hence, option (b) is also correct.

Relative deformation or strain produced in the medium is $\varepsilon = u/v$, where u is particle's velocity and v is wave velocity. Since v is property of the medium, therefore, ε is directly proportional to velocity of the medium particles (u).

ε will be maximum possible when u is maximum.

Hence, option (c) is also correct

374 **(c,d)**

Since the first wave and the third wave moving in the same direction have the phase angles ϕ and $(\phi + \pi)$, they superpose with opposite phase at every point of the vibrating medium and thus cancel out each other, in displacement, velocity, and acceleration. They in effect, destroy each other out. Hence we are left with only the second wave which progresses as a simple harmonic wave of amplitude A. The velocity of this wave is the same as if it were moving alone

375 **(b,c)**

$y = A\sin(10\pi x = 15\pi t + \pi/3)$

The standard equation of a wave travelling in X-direction is

$y = A\sin\left[\frac{2\pi}{\lambda}(vt + x) + (\phi)\right]$

$\Rightarrow y = A\sin\left[\frac{2\pi v}{\lambda}t + \frac{2\pi}{\lambda}x + \phi\right]$

Comparing it with the given equation we find

$\frac{2\pi v}{\lambda} = 15\pi$

and $\frac{2\pi}{\lambda} = 10\pi$

$\lambda = \frac{1}{5} = 0.2$ m

$\therefore v = \frac{15\pi}{2\pi} \times \frac{1}{5} = 1.5$ m/s

377 **(a,b,c,d)**

It is given that $y(x,t) = 0.02\cos(50\pi t +$ $\pi/2)\cos(10\pi x)$

$\cong A\cos\left(\omega t + \frac{\pi}{2}\right)\cos kx$

Node occurs when $kx = \frac{\pi}{2}, \frac{3\pi}{2}$, etc

$\Rightarrow 10\pi x = \frac{\pi}{2}, \frac{3\pi}{2}$

$\Rightarrow x = 0.05$ m, 0.15 m   option(a)

Antinode occurs when $kx = \pi, 2\pi, 3\pi$ etc

$\Rightarrow 10\pi x = \pi, 2\pi, 3\pi$ etc

$\Rightarrow x = 0.1$ m, 0.02 m, 0.3 m option (b)

Speed of the wave is given by

$v = \frac{\omega}{k} = \frac{50\pi}{10\pi} = 5$ m/s   option (c)

Wavelength is given by

$\lambda = \frac{2\pi}{k} = \frac{2\pi}{10\pi} = \left(\frac{1}{5}\right)$ m $= 0.2$ m   option (d)

378 **(a,b,d)**

Given wave is $y = A\cos\frac{\pi}{2}[kx - \omega t - \alpha]$
Here wave number, $k \times \frac{\pi}{2} = \frac{2\pi}{\lambda}$ giving $\lambda = \frac{4}{k}$
Here $k = 0.005\ \text{cm}^{-1}$. Hence
$\lambda = \dfrac{4}{0.005}\text{cm} = 8\text{m}$
Maximum velocity $V_m = A \times$ angular velocity
Here angular velocity
$= \dfrac{\pi\omega}{2} = \dfrac{3.14 \times 8}{2} = 12.56\ \text{rad/d}$
Hence $V_m = 0.6 \times 12.56\ \text{m/s} = 7.53\ \text{m/s}$
Also, to produce stationery waves, the two waves should travel in opposite directions and have same frequency. The wave given by $y = A\cos\frac{\pi}{2}(kx + \omega t - \alpha)$ fulfils this condition

379 **(a,c,d)**
Fundamental frequency of closed pipe $n = \frac{v}{4l}$
Where $v = \sqrt{\frac{\gamma RT}{M}} \Rightarrow v \propto \frac{1}{\sqrt{M}}$
$\because M_{H_2} < M_{air} \Rightarrow v_{H_2} > v_{air}$
Hence fundamental frequency with H_2 will be more as compared to air. So option (a) is correct.
Also $n \propto \frac{1}{l}$, hence if l decreases n increases so option (c) is correct.
It is well known that $(n)_{\text{Open}} = 2(n)_{\text{Closed}}$ hence option (d) is correct

380 **(a,b,c)**
Wavelength of a wave is a property of source and medium both. So, wavelength can change if either frequency or speed of wave or both change. Here, medium property (like tension in string) can change freq. may change which causes the change in the speed of wave, or source which causes the change in the speed of wave, or source frequency may change

381 **(b,c)**
As time increases, the source and detector are relatively approaching each other up to $t = t_0$, where t_0 is the instant when the source and detector are located perpendicular to direction of motion
$v_0 \times t_0 = \dfrac{d\cot\theta_0}{2}$
$t_0 = \dfrac{d\cot\theta_0}{2v_0}$
For $t < t_0$
$f_{\text{ap}} > f_0$
For $t > t_0$,
$f_{\text{ap}} < f_0$

382 **(a,c)**
$v_{\max} = a\omega = a(2\pi f)$
Given that $a(2\pi f) = \frac{v}{10} = \frac{10}{10} = 1$
$f = \dfrac{1}{2\pi a} = \dfrac{10^3}{2\pi}\text{Hz}$
As $v = f\lambda$
or $\lambda = \frac{v}{f} = \frac{10}{10^3/2\pi} = 2\pi \times 10^{-2}\text{m}$

383 **(c,d)**
$t = 0, \dfrac{1}{(f_1 - f_2)}, \dfrac{2}{(f_1 - f_2)}, \dfrac{3}{(f_1 - f_2)}, \dots$
Are times at which maxima are obtained
$t = \dfrac{\frac{1}{2}}{(f_1 - f_2)}, \dfrac{\frac{3}{2}}{(f_1 - f_2)}, \dfrac{\frac{5}{2}}{(f_1 - f_2)}, \dots$
Are times at which minima are obtained

384 **(a,d)**
a. New wave $= y_1\hat{j} + z_1\hat{k}$
$= (a\hat{j} + a\hat{k})\sin\omega\left(\dfrac{t - x}{v}\right)$
Amplitude $= |a\hat{j} + a\hat{k}| = a\sqrt{2}$
(i) and (ii) are travelling in opposite directions, so they will form stationary waves.

Similarly (iii) and (iv) will make the stationery wave

385 **(b,c,d)**
$y = 4\sin\left[\dfrac{\pi}{16}(16t + x)\right]$
Compared with $y = a\sin\left[\frac{2\pi}{\lambda}(vt + x)\right]$
Also $\Delta\phi = \frac{2\pi}{\lambda}\Delta x = \frac{2\pi}{\lambda}(v\,\Delta t)$

386 **(a,b,d)**
A stationery wave is characterized by a function of type $y = f(t)g(x)$. Hence, choices (a) and (b) represent a stationery wave. Choice (d) is superposition of two oppositely travelling waves of the same amplitude and same frequency, which gives rise to a stationery wave. Hence choice (d) also represents a stationery wave

387 **(b,c,d)**
$y(x,t) = \dfrac{0.8}{16\left[\left(x + \frac{5}{4}t\right)^2 + \frac{5}{16}\right]}$
$y(x,t) = \dfrac{0.05}{\left(x + \frac{5}{4}t\right)^2 + \frac{5}{16}}$
Where wave velocity = 5/4 m/s
Distance travelled by the wave this velocity in 2 s in
5/4(2)=2.5 m
$y(x,t)$ will be maximum when $4x + 5t = 0$

$y_{\max} = \frac{0.8}{5} = 0.16$ m

388 **(a,b,d)**

It is a known fact as well as experimentally and analytically verified that wave speed depends on the properties of the medium and is same for the entire wave.

The particle velocity is given by

$v_P = \frac{\partial y}{\partial t} = -A\omega\cos(kx - \omega t)$

Where symbols have their usual meanings. It is clear from above expression that v_P depends upon amplitude and frequency of wave which are wave properties and are having different values for different particles at a particular instant

389 **(a,b,c,d)**

Factual

390 **(b,c,d)**

When the vibrating tuning fork is brought in contact with the table, the vibrations of the tuning fork are being transmitted to the surface of table whole surface area is very large as compared to the surface area of tuning fork and hence sound becomes louder and due to the energy transmitted over the table, the sound dies sooner

391 **(a,b,c)**

$y = A\sin(7.5\pi x - 3000\pi t)$

$k = \frac{2\pi}{\lambda} = 7.5\pi \Rightarrow \lambda = \frac{2}{7.5}$ m

$\omega = 2\pi f = 3000\pi \Rightarrow f = 1500$Hz

$v = \frac{2}{7.5} \times 1500 = 400$ m/s

Density

$\rho = B/v^2 = 1.6 \times 10^5/(400)^2 = 1$ kg/m^3

$(\Delta\rho)_{\max} = BAk$

The maximum amplitude of the wave is

$A = \frac{(\Delta\rho)_{\max}}{BK} = \frac{30}{1.6 \times 10^5 \times 7.5\pi}$

$= \frac{10 \times 10^{-5}}{4\pi} = \frac{10^{-4}}{4\pi}$ m

Intensity of wave at a distance 5 m from the source is

$I = \frac{(\Delta\rho)^2_{\max}}{2\rho v} = \frac{30^2}{2 \times 1 \times 400} = 1.125$ W/m^2

392 **(a,c)**

The wavelength possible in an air column in a pipe which has one closed end is

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

So, $c = v\lambda \Rightarrow 330 = 264 \times \frac{4l}{2n+1}$

As it is in resonance with a vibrating tuning fork of frequency 264 Hz

$l = \frac{330 \times (2n+1)}{264 \times 4}$

For $n = 0, l = 0.315$ m $= 31.25$ cm

For $n = 1, l = 0.9375$ m $= 93.75$ cm

393 **(a,c,d)**

A is the rigid boundary, displacement is zero but pressure variation is maximum, i.e., reflected pressure wave is non- inverted w.r.t. the incident pressure wave. At the free end, reflected and incident pressure waves are out of phase by π

394 **(a, b, c, d)**

$y = 10^{-4}\sin(60t + 2x)$. Comparing the given equation with the standard wave equation travelling in negative x-direction,

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

We get amplitude $a = 10^{-4}$m

Also, $\omega = 60$

$\therefore\ 2\pi f = 60 \Rightarrow f = \frac{30}{\pi}$Hz

Also, $k = 2$

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

We know that

$v = f\lambda = \frac{30}{\pi} \times \pi = 30$ m/s

395 **(a,b,c,d)**

$y = 10^{-4}\sin(60t + 2x)$

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

Now, $k = 2, 2\pi/\lambda = 2$ or $\lambda = \pi$ metre

Again $\omega = 60$

or $23\pi f = 60$ or $f = \frac{60}{2\pi}$ or $v = \frac{30}{\pi}$ Hz

Again, $v = \frac{\omega}{k} = \frac{60}{2}$ m/s $= 30$ m/s

396 **(a,b,c)**

Pressure amplitude

$P = \frac{2\pi a E}{\lambda}$

Where E is the coefficient of elasticity. We have,

$E = v^2\rho \left\{\because v = \sqrt{\frac{E}{\rho}}\right\}$

$\therefore P_0 = \frac{2\pi a v^2\rho}{\lambda} = \frac{2\pi a v^2\rho}{\left(\frac{v}{f}\right)}$

$\Rightarrow P_0 = 2\pi\, a v f \rho = 13.8$ N/m^2

Energy density is $2\pi^2 a^2 f^2 \rho = 6.4 \times 10^{-4} J/m^3$

Energy flux is $2\pi^2 a^2 d^2 \rho v = 0.22\, J/(m^2/s)$

397 **(b,c,d)**

Frequency is the property of source while velocity is the property of medium and wavelength is the property of both medium and source. So,

wavelength and velocity of wave change as the medium change, while frequency remains same. On the boundary some absorption can be there, as a result the amplitude (and hence intensity) can decrease as the medium changes.
Amplitude will either decrease or remain the same but it can never increase due to change in medium (assuming no external source is providing energy)

398 **(b,c)**
At any point on line AB, the phase difference between two waves is zero and hence waves will interfere constructively
Along CD, the phase difference changes and waves interfere constructively and destructively and, hence sound will be loud, faint and so on

399 **(a,b,c,d)**
For a point source
$I \propto \frac{1}{r^2}$
For a line source
$I \propto \frac{1}{r}$
For a plane wave, intensity remains same because there is no spreading of wave

400 **(b, d)**
$\Delta\phi = \frac{2\pi x_1}{\lambda} - \omega t + \frac{\pi}{4} - 2\pi \frac{x_2}{\lambda} + \omega t - \frac{\pi}{6}$
$= \frac{2\pi}{\lambda}(x_1 - x_2) + \frac{\pi}{12}$
Two constructive interference
$\frac{2\pi}{\lambda}(x_1 - x_2) + \frac{\pi}{12} = 2n\pi \quad n = 0, 1, 2, \dots$
For destructive interference
$\frac{2\pi}{\lambda}(x_1 - x_2) + \frac{\pi}{12} = (2n-1)\pi$

401 **(a,c,d)**
For a plane wave, intensity (energy crossing per unit area per unit time) is constant at all point. But for a spherical wave, intensity at a distance r from a point source of power (P), is given by
$I = \frac{P}{4\pi r^2} \Rightarrow I \propto \frac{1}{r^2}$
But the total intensity of the spherical wave over the spherical surface centred at the source remains constant at all times

402 **(b,d)**
Since $T_1 > T_2, v_1 > v_2$
Now, $v_1 - v_2 = 6$
Beat frequency would remains the same even if $v_2 - v_1 = 6$
To decrease v_1, T_1 needs to be decreased. To increase v_2, T_2 needs to be increased

403 **(b)**
Velocity of wave $= \frac{\text{Distance travelled by wave } (\lambda)}{\text{Time period } (T)}$

Wavelength is also defined as the distance between two nearest points in phase

404 **(d)**
For a given velocity $v_{\max}$ depends on the frequency of the wave

405 **(b)**
Transverse waves travel in the form of crest and troughs involving change in shape of the medium. As liquids and gases do not posses the rigidity therefore transverse waves cannot be produced in liquid and gases. Also light wave is one example of transverse wave.

406 **(d)**
In standing waves the medium particles are oscillating and hence are not at rest, through few particles present at the location of node remain at rest

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

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

408 **(b)**
In a transverse vibration, the mean distance between the successive vibrating particles remains constant. Only crests and troughs are formed

409 **(a)**
Equations show that the phase difference between two waves $\phi = \pi/2$

$\therefore$ From $R = \sqrt{a^2 + b^2 + 2ab \cos\pi/2}$

$= \sqrt{a^2 + a^2 + 2a^2 \cos 90°}$

$= \sqrt{2a^2} = a\sqrt{2}$

Both the assertion and reason are true and reason is correct explanation of the assertion.

410 **(a)**
Since the wavefronts are plane, the amount of energy passing per unit time per unit area remains same

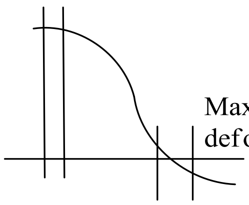
411 **(e)**
Since transverse wave can propagate through medium which posses elasticity of shape. Air posses only volume elasticity therefore transverse wave cannot propagate through air

412 **(b)**
Velocity of sound is given by

$$V = \sqrt{\frac{E}{\rho}}$$

As the elasticity of solid is larger than that of gases, hence it is obvious that velocity of sound is greater in solids than in gases

413 **(d)**



For a travelling wave,

$$y = A\sin(\omega t \pm kx + \theta)$$

at a given position (x):

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

thus, a particle perform SHM

At extreme position deformation w.r.t. mean position is minimum, therefore its deformation potential energy is minimum

414 **(c)**
Velocity of source is equal to velocity of observer

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

$$f' = f_0\ (\because V_0 = V_s)$$

415 **(b)**

As $\lambda_v < \lambda_r$

$\therefore$ Violet shift means apparent wavelength of light form a star decreases. Obviously, apparent frequency increases. This would happen when the star is approaching the earth. Thus the Reason, though correct, is not a correct explanation of Assertion

416 **(a)**
The tuning fork does produce harmonics, but the intensities of the harmonics are too weak to be effective, due to its special distribution of mass and the use of prongs

417 **(d)**

$$L(\text{in dB}) = 10\log_{10}\frac{I}{I_0}$$

$$\Rightarrow I = I_0 10^{\frac{L}{10}}$$

$$\therefore \frac{I_{80}}{I_{40}} = \frac{10^8}{10^4} = 10^4$$

418 **(c)**
The resultant amplitude of two waves is given by

$$A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\theta}$$

Here $a_1 = a_2 = A = a$ or $\frac{1}{2} = 1 + \cos\theta$

or $\cos\theta = \frac{1}{2}$ or $\theta = 120°$

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

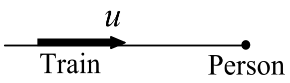
421 **(a)**
Sound waves require material medium to travel. As there is no atmosphere (vacuum) on the surface of moon, therefore of sound waves cannot reach from one person to another

422 **(c)**
$P_{av} = \frac{\rho v \omega^2 A^2}{2}$ when medium changes v, ρ and A can change but frequency remains same

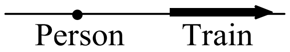
423 **(a)**
The fundamental frequency of an organ pipe is

$n = V/(2l)$. As temperature increases, both V and l increases but V increases more rapidly than l. Hence fundamental frequency increases as the temperature increases

424 **(d)**



$$f = f_0\left[\frac{c+o}{c-u}\right]$$



$$f = f_0\left[\frac{c}{c+u}\right]$$

So, when the train is approaching, frequency has constant value given by

$$f_0\left[\frac{c}{c-u}\right]$$

425 **(a)**

A node is a place of zero amplitude and an antinode is a place of maximum amplitude

426 **(d)**

The frequency of the plucked string will be same as the wave it produce in air the speeds of the waves depend on the media in which they are propagating

427 **(c)**

The principle of superposition does not state that the frequencies of the oscillation should be nearly equal. For beats to be heard the condition is that difference in frequencies of the two oscillations should not be more than 10 times per seconds for a normal human ear to recognise it. Hence we cannot hear beats in the case of two tuning forks vibrating at frequencies 256 Hz and 512 Hz respectively

429 **(c)**

The person will hear the loud sound at nodes than at antinodes. We know that at anti-nodes the displacement is maximum and pressure change is minimum while at nodes the displacement is zero and pressure change is maximum. The sound is heard due to vibration of pressure.

Also in stationary waves particles in two different segment vibrates in opposite phase

430 **(a)**

A potential energy of the elements is the work done to stretch it form dx to dl

$$dU = F(dl - dx)$$

$$= F\left(\sqrt{(dx)^2 + (dx)^2} - dx\right)$$

$$= F\,dx\left[\left(1+\frac{dy}{dx}\right)^{\frac{1}{2}} - 1\right]$$

$$= \frac{1}{2}Fdx\left(\frac{\partial y}{\partial x}\right)^2$$

Assuming that the disturbance is small

431 **(d)**

$$P = \frac{\omega^2 A^2 F}{2V}$$

But $V = \sqrt{\frac{F}{\mu}}$

$$\Rightarrow P = \frac{\omega^2 A^2 F}{2\sqrt{F}/\sqrt{\mu}} = \omega^2 A^2\sqrt{\mu F}$$

$$P \propto \sqrt{F}$$

432 **(d)**

Each wave continues to move onwards in its respective direction in interference

433 **(c)**

If a closed pipe of length L is in resonance with a tuning fork of frequency v, then

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

An open pipe of some length l produces vibrations of

Frequency $\frac{v}{2L}$. Obviously, it cannot be in reasonance

With the be given tuning fork of frequency $\mathrm{v}\left(=\frac{v}{4l}\right)$.

434 **(c)**

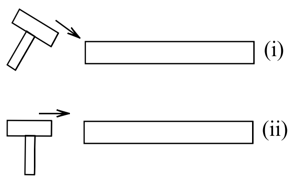
It is clear fact that sounds has greater speed in solid then in air. Hence, when ear is placed on the rails the sound of train coming from some distance is heard Hence, Assertion is true and Reason is false.

435 **(d)**
Amplitude of a progressive longitudinal wave is the same at all points of a medium, assuming there is no attenuation. It is the instantaneous displacement of a particle from the mean position that differs and depends upon the phase angle of the wave

436 **(b)**
The Assertion is true, and the Reason is also true. But the Reason given is no explanation for the Assertion.

437 **(c)**
Speed of light is greater than that of sound, hence flash of lightening is seen before the sound of thunder

438 **(a)**
In the first case the waves produced are transverse and in the second case the waves generated are longitudinal



439 **(d)**
When moisture is present in air, the density of air decreases. It is because the density of water vapours is less than that of dry air. The velocity of sound is inversely proportional to the square root of density, hence sound travel faster in moist air than in the dry air. Therefore, on a rainy day sound travels faster than on a dry day

440 **(a)**
A compression is a region of medium in which particles come closer means distance between the particles become less than the normal distance between them. Thus there is a temporary decrease in volume and a consequent increase in density of medium.

Similarly, in rarefaction particles get farther apart and a consequent decrease in density

441 **(d)**

$$SL_f = 10\log\frac{2I}{I_0}$$

Where I is the intensity at point P due to one person

$$60\text{ dB} = SL = 10\log\frac{I}{I_0}$$

$$\Rightarrow SL_f = 10\log 2 + 10\log\frac{I}{I_0} = 63.01\text{ dB}$$

442 **(c)**
Both statements are true. The wavelength of a wave from a source moving towards or away from an observer changes due to the motion of the source. Similarly, for an observer moving towards or away from a source, it is the frequency (number of waves passing him per second) that is affected by his motion

443 **(a)**
According to Newton, speed of sound in gases,

$$V=\sqrt{\frac{K_{iso}}{p}} = \sqrt{\frac{p}{p}}$$

Laplace pointed out that since the changes taking place in the gases due to the propagation of sound cannot be isothermal but are adiabatic in nature, he corrected the Newton's formula accordingly ie,

$$V=\sqrt{\frac{K_{adia}}{p}} = \sqrt{\frac{\gamma p}{p}}$$

444 **(a)**
Since the initial phase difference between the two waves coming from different violins changes, therefore, the waves produced by two different violins does not interfere because two waves interfere only when the phase difference between them remain constant throughout

445 **(e)**
Speed of sound is independent of pressure because $v = \sqrt{\frac{\gamma P}{\rho}}$. At constant temperature, if P changes then ρ also changes in such a way that the ratio $\frac{P}{\rho}$ remains constant hence there is no effect of the pressure change on the speed of sound

446 **(b)**

Sound produced by an open organ pipe is richer because it contains all harmonics and frequency of fundamental note in an open organ pipe is twice the fundamental frequency in a closed organ pipe of same length.

Reason is also correct, but it is not explaining the assertion

447 **(a)**

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

448 **(a)**

$\lambda = \frac{v}{n} = \frac{350}{500} = 0.7 \text{ m}$

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

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

$\therefore x = \frac{0.7}{2\pi} \times \left[\frac{60\pi}{180}\right] = 0.12\text{m} = 12\text{cm}$

449 **(a)**

The fundamental frequency of an organ pipe is $n = V/2l$. As temperature increases, both V and l increases but V increases more rapidly than l. Hence fundamental frequency increases as the temperature increases

451 **(c)**

Intensity of sound at any point is dependent upon frequency as well as amplitude. As due to Doppler effect the apparent frequency changes, so intensity as perceived by the listener also changes. When listener is moving, wavelength remains the same

452 **(a)**

Two waves moving in uniform string with uniform tension shall have same speed and may be moving in opposite directions

453 **(c)**

The correct formula for velocity of sound in a gas is $v = \sqrt{\frac{\gamma p}{\rho}}$

For monoatomic gas, $\gamma = 1.67$;

For diatomic gas$\gamma = 1.40$.

$\therefore$ v is larger in case of monoatomic gas compared to its value in diatomic gas.

454 **(b)**

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

455 **(a)**

When $b = a$, then from

$R = \sqrt{a^2 + b^2 + 2ab\cos\phi}$

$a^2 = a^2 + a^2 + 2a\,a\,\cos\phi = 2a^2(1 + \cos\phi)$

$1 + \cos\phi = \frac{1}{2}$

$\cos\phi = \frac{1}{2} - 1 = \frac{1}{2}, \phi = 120°$

The assertion and reason, both are true and reason is correct explanation of the assertion.

456 **(d)**

Changes of pressure and density occur at nodal points only for a longitudinal standing wave

457 **(c)**

Principle of superposition holds true only when the vectors are linear functions of variable and its derivatives

458 **(b)**

In stationery wave, total energy associated with it is twice the energy of each of incidence and reflected wave.

Large amount of energy are stored equally in standing waves and become trapped with the waves. Hence, there is no transmission of energy through the waves.

459 **(d)**

In a closed organ pipe $l_2 = 3l_1$

$l_2 = 3 \times 60 = 180$ cm

i.e., statement 1 is false and statement 2 is true

461 **(d)**
At node $v = 0$, at antinode tension perpendikcular to velocity therefore, at these points power $= 0, (P = \vec{F}.\vec{V})$ At other points $P \neq 0$

462 **(b)**
As tension is increased to 4 times, the wave speed (of component waves) increases by a factor of 2 and hence the wavelength

The spacing between two consecutive nodes in standing waves is equal to half of wavelength of component waves. Let λ be the wavelength of component waves before increasing the tension, then $\Delta x = \lambda/2$

After increasing the tension in string $\Delta x'$ (spacing between different nodes)

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

So, spacing between the node and antinode is

$$\frac{\Delta x'}{2} = \Delta x$$

463 **(a)**
Let v be the frequency of fork.

$n_1 - n = 4$

And $n - n_2 = 4$ ....(i)

$\therefore n_1 - n_2 = 8$ ...(ii)

Also, $\frac{n_1}{n_2} = \frac{l_2}{l_1} = \frac{50}{49}$

$$\therefore n_1 = \frac{50}{49} n_2$$

From (ii), $\frac{50}{49} n_2 - n_2 = 8, \frac{1}{49} n_2 = 8$

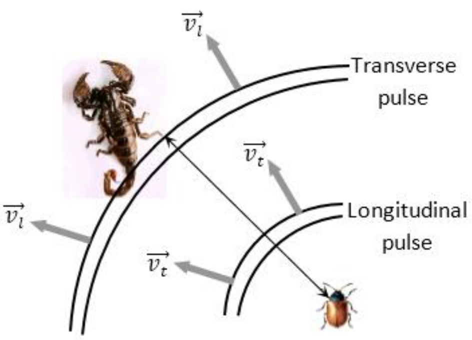
$n_2 = 49 \times 8 = 392.$

From (i), $n = 4 + n_2 = 4 + 392 = 396$ Hz

Choice (a) is correct.

464 **(c)**
Superposition principle is valid for other frequencies also, like standing wave or interference phenomena

465 **(a)**
A beetle motion sends fast longitudinal pulses and slower transverse waves along the sends surface. The send scorpion first intercept the longitudinal pulses and learns the direction of the beetle; it is in the direction of which ever leg is disturbed earliest by the pulses. The scorpion then senses the time interval (Δt) between that first interception and the interception of slower transverse waves and uses it to determine the distance of the beetle. The distance is given by $\Delta t = \frac{d}{v_t} - \frac{d}{v_l}$



466 **(a)**
We have

$$V = \sqrt{\frac{E}{\rho}}$$

Through ρ is large for solid, the coefficient of elasticity E is much larger as compared to liquid and gases, i.e., V is more

467 **(c)**
The velocity of sound in a gas is directly proportional to the square root of its absolute temperature $v = \sqrt{\gamma RT/M}$. Since temperature of a

hot day is more than that of a cold winter day, therefore sound travel faster on a hot summer day than on a cold winter day

468 **(a)**
Number of beats $s^{-1} m = n_1 - n_2$

$= \frac{v}{\lambda_1} - \frac{v}{\lambda_2} = v\left[\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right]$

$= 336.6\left[\frac{1}{1} - \frac{1}{1.01}\right] = 3$

469 **(d)**
The speed of sound in gaseous medium is given by

$v = \sqrt{\frac{\gamma p}{\rho}}$ ...(i)

At constant temperature

$pV = \text{constant}$ ...(ii)

If V is the volume of one mole of a gas, then density of gas

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

Where M is the molecular weight of the gas.

∴ Eq. (ii) becomes

$\frac{pM}{\rho} = \text{constant}$

or $\frac{p}{\rho} = \text{constant}$ as M is a constant

Therefore, from Eq. (i), we have

$v = \text{constant} \times \sqrt{\gamma}$

Thus, change in air pressure does not effect the speed of sound.

Reason is clear from Eq. (i)

470 **(d)**
Every small segment is acted upon by forces from both sides of it hence energy is not conserved, rather it is transmitted by the element

471 **(c)**
The equation of stationary waves is

$y = 20 \sin \frac{\pi x}{4} \cos \omega t$

Compare with $y = 2a \sin Kx \cos \omega t$

$K = \frac{\pi}{4}$ $As\ \lambda = \frac{2\pi}{K}$

$\therefore \lambda = \frac{2\pi}{\pi/4} = 8\text{m}$

Distance between two consecutive antinodes

$= \frac{\lambda}{2} = \frac{8}{2} = 4\text{m}$

Assertion is true. The data is sufficient.

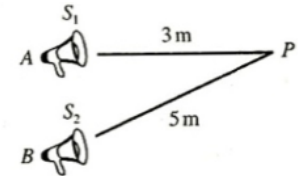
Reason is false.

472 **(b)**
When the string is resonating in 1st harmonic or fundamental tone, all the particles of the string are vibrating in phase. When the string is resonating in even harmonic the particles near the ends of the sting are vibrating out of phase as even number of loops are there, while reverse is the case for odd harmonics. In all modes all the particles of the string are crossing mean position or extreme position simultaneously twice in one cycle

473 **(a)**
As it is clear from the equation that speed of each wave is same and equal to 2 m/s.
From the graphs it is clear that wavelength is maximum for graph in **p.** and the least for **r.** As wavelength is the property of both source and medium and here medium is the same, so we can conclude that the relation among three wavelength, is determined by source property, i.e., frequency. From equation it is clear that frequency is maximum for y_3 and least for y_1.
From $\lambda = v/f$, we can conclude that wavelength is maximum for the wave having least frequency

474 **(c)**
Power transferred in a string wave a given by
$P = \mu v A^2 \omega^2 \cos^2(\omega t - kx)$
and $P_{\text{av}} = \frac{\mu v A^2 \omega^2}{2}$

475 **(a)**
Intensity at a distance r from a source of power output P is given by
$I = \frac{P}{4\pi r^2}$



$I_1 = \dfrac{0.96\pi \text{mW}}{4\pi(3)^2} = \dfrac{1}{40}\text{mW} = 25\ \mu\text{W/m}^2$

$I_1 = \dfrac{9\pi \text{mW}}{40\pi(5)^2} = \dfrac{9}{1000}\text{mW} = 9\mu\text{W/m}^2$

For incoherent source,

$I_R = I_1 + I_2 = (25+9) = 34\ \mu\text{W/m}^2$

For coherent source, $\Delta = 0$

$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}$

$\left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = (5+3)^2 = 64\mu\ \text{W/m}^2$

For $\delta = \pm\pi, I_R = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$

$= (5-3)^2 = 4\mu\ \text{W/m}^2$

If the speaker S_2 is witches off, $I_R = I_1 = 25\ \mu\ \text{W/m}^2$

476 **(a)**

(A) $\dfrac{\lambda}{4} = L, \lambda = 4L,$

Sound waves are longitudinal waves

(B) $\dfrac{\lambda}{2} = L, \lambda = 2L$

Sound waves are longitudinal waves

(C) $\dfrac{\lambda}{2} = L, \lambda = 2L$

String waves are transverse waves

(D) $\lambda = L$

String waves are transverse waves

477 **(a)**

In string $V = \sqrt{T/\mu} = 320$ m/s

Open pipe and string fixed at both ends

$f = \dfrac{nv}{2L} = 320, 640, 960, \ldots$

Closed pipe and string free end

$f = (2n-1)\dfrac{v}{4L} = 160{,}480{,}800, \ldots$

478 **(d)**

Use $x = 0; t = 0$ for y and particle velocity $\frac{\partial y}{\partial x}$.

Like for

i., $y = 0$ at $x = 0$ and $t = 0. \frac{\partial y}{\partial t} > 0$, i.e., positive therefore it matches with (c)

479 **(a)**

1. $y = 4\sin(5x - 4t) + 3\cos(4t - 5x + \pi/6)$ is super position of two coherent waves, so their equivalent will be an another travelling wave

2. $y = 10\cos\left(t - \frac{x}{330}\right)\sin(100)\left(t - \frac{x}{330}\right)$

Let us check at any point, say at $x = 0$

$y = (10\cos t)\sin(100t)$

at any amplitude is changing sinusoidally, so this is equation of beats

3. $y = 10\sin(2\pi x - 120t) + 10\cos(120t + 2\pi x)$

=superposition of two coherent waves travelling in opposite direction

4. $y = 10\sin(2\pi x - 120t) + 8\cos(118 - 59/30\pi x)$= superposition of two waves whole frequencies are slightly different ($\omega_1 = 120; \omega_2 = 118$) ⇒ equation of beats

480 **(c)**

Bass strings have low fundamental frequency and larger wavelength. For having low frequency the string has to be long according to expression, $f \propto v/L$. For low f, v should be low, i.e., string should be thick. For treble strings also, the same explanation holds true

481 **(b)**

i. While passing through mean position the deformation is maximum ⇒KE maximum and PE maximum

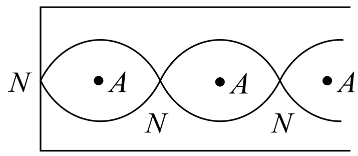
ii. Minimum speed and minimum deformation ⇒KE minimum and PE minimum

iii. Speed is maximum and minimum deformation maximum⇒KE maximum and PE minimum

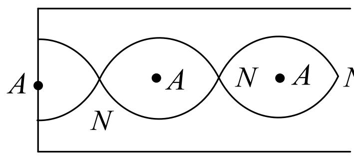
iv. Speed minimum and deformation maximum⇒ KE minimum and PE maximum

482 **(c)**

Second overtone is shown in figure



Displacement wave



Pressure wave

Distance between nearest node and antinode is 2/5

483 **(b)**

If we change the speed of hand, then particle speed changes. If the amount by which hand movement changes, then amplitude of pulse changes. If time in which hand comes to its original position changes, the width of pulse changes

484 **(b)**

The loudness that we sense is related to the intensity of the sound though it is not directly proportional.

A sound of high pitch is said to be shrill and its frequency is high. A sound of low pitch is said to be grave and its frequency is low.

The quality of sound is given by waveform.

485 **(a)**

Wavelength of wave in medium changes when there is relative motion between medium and source. Frequency observed by observer is different from source frequency only if there is relative motion between observer and source. Speed of sound w.r.t. medium will not change until temperature of medium changes

486 **(b)**

To solve this question the only concept required is that sound is a mechanical wave and requires some medium for its propagation while light can travel through vacuum also

487 **(c)**

Number of loops (of length $\lambda/2$) will be even or odd and node of antinode will respectively be formed at the middle

Phase difference between two particles in same loop will be zero and that between two particles in adjacent loops will be π

Number of loops will not be integral. Hence neither a node nor an antinode will be formed in the middle

Phase difference between two particle in same loop will be zero and that between two particles in adjacent loops will be π

488 **(b)**

$v_1 = 1310$ Hz, $\quad v_2 = 1834$ Hz, $v_3 = 2358$ Hz

$\frac{v_2}{v_1} = \frac{7}{5}; \; \frac{v_3}{v_1} = \frac{9}{5}$

$v_1 : v_2 : v_3 = 5 : 7 : 9$

(This corresponds to a pipe closed at one end)

Fundamental frequency

$$n_0 = \frac{2358}{9} = 262 \text{ Hz}$$

Frequency of the first overtone

$n_1 = 3n_0 = 786$ Hz

Frequency of the fifth overtone

$= 5n_0 = 1310$ Hz

For fundamental frequency

$\lambda_0/4 = l$

$\lambda_0 = 4l$

$$n_0 = \frac{v}{4l} \Rightarrow l = \frac{v}{4n_0} = \frac{340}{4 \times 262}$$

$= 32.4 \times 10^{-2}$ m

Length of the pipe $= 32.4$ cm

489 **(a)**

Pressure amplitude is given by

$$P_0 = \rho\omega v A_0 = 1.29 \times 2\pi \times 10^3 \times 340 \times (0.01 \times 10^{-3})$$

$= 27.55$ N/m^2

Intensity is given by

$$I = \frac{1}{2}\rho\omega^2 A^2 v = \frac{1}{2} \times 1.29 \times (2\pi \times 10^3)^2 \times (10^{-5})^2(340)$$

$= 0.865$ W/m^2

Power, $P = IA = (0.865)\pi(0.1)^2 = 0.027$ W $= 2.7 \times 10^{-2}$W

Intensity at $r = 10$ m is $I = \frac{P_{av}}{A} = \frac{2.7\times10^{-2}}{4\pi\times10^2}$

$= 2.15 \times 10^{-5}$W/m^2

490 **(d)**

Velocity of wave on a string is given by $v = \sqrt{T/\mu}$.

Frequency is the property of source. Wavelength $= v/f$

491 **(a)**

Power $\propto f^2A^2$

492 **(a)**

Hence $\omega_1 = 100\pi$ and $\omega_2 = 92\pi$, Hence

$v_1 - \frac{100\pi}{2\pi} = 50$ Hz and

$$v_2 = \frac{92\pi}{2\pi} = 46\text{Hz}$$

$\therefore$ Number of beats per second $= v_1 - v_2 = 50 - 46 = 4$

493 **(b)**

The wave is travelling along positive x-axis

$\therefore y = A\sin[kx - \omega t + \phi]$

At $x = 0, y = A\sin[-\omega t + \phi]$

Also, at $t = 0, y = A\sin\phi = A/2$,

$\sin\phi = 1/2$

$\Rightarrow \phi = (\pi/6), (5/6), \dots$ (i) and at $t = 0.05$ s, $y = A\sin\left(\frac{-\omega}{20} + \phi\right) = 0$

or $\frac{-\omega}{20} + \phi = 0, \pi, 2\pi, \ldots\ldots$ (ii)

For $t = 0.05$ s and $x = 1$ m,

$y = A\sin\left(k - \frac{\omega}{20} + \phi\right) = 0$

Since, $\lambda = 2$ m

$\therefore\ \pi - \frac{\omega}{20} + \phi = 0, \pi, 2\pi \ldots\ldots$ (iii)

From Eqs.(i), (ii) and (iii), we get

$\phi = \pi/6$

$\phi - \frac{\omega}{20} = 0$

$\omega = \frac{10\pi}{3}$

$\therefore\ f = \frac{\omega}{2\pi} = \frac{5}{3}$ Hz

Velocity of wave is

$V = \lambda f = (2)(5/3) = 10/3$ m/s

Maximum velocity of the particle is

$V_{\max} = \omega A = (10\pi/3)(10 \times 10^{-3}) = \pi/30$ m/s

Tension in the string is

$T = \mu V^2 = (0.25)(10/3)^2 = 25/9$ N

The equation of the wave is

$y = 10\sin[\pi x - (10/3)\pi t + (\pi/6)]$

494 **(c)**

Mass per unit length of the string is

$\mu = Ad = (0.80\text{ mm}^2) \times (12.5\text{ g/cm}^3)$

$= (0.80 \times 10^{-6}\text{m}^2) \times (12.5 \times 10^3\text{kg/m}^3)$

$= 0.01$ kg/m

Speed of transverse waves produced in the string

$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{64}{0.01\text{ kg/m}}} = 80$ m/s

The amplitude of the source is $a = 1.0$ cm and the frequency is $f = 20$ Hz. The angular frequency is $\omega = 2\pi f = 40\pi$/s

Also at $t = 0$, the displacement is equal to its amplitude, i.e., at $t = 0, y = a$. The equation of motion of the source is, therefore

$y = (1.0\text{ cm})\cos[(40\pi\text{s}^{-1})t]$ (i)

The equation of the wave travelling on the string along the positive X-axis is obtained by replacing t by $[t - (x/v)]$ in Eq. (i). It is, therefore,

$y = (1.0\text{ cm})\cos[(40\pi\text{s}^{-1})\{t - (x/v)\}]$

$= (1.0\text{ cm})\cos[(40\pi\text{s}^{-1})t - \{(\pi/2)\text{ m}^{-1}\}x]$ (ii)

The displacement of the particle at $x = 50$ cm at time $t = 0.05$ s is obtained from Eq. (ii).

$y = (1.0\text{ cm})\cos[(40\pi\text{ s}^{-1})(0.05\text{ s})$

$-\{(\pi/2)\text{m}^{-1}\}(0.5\text{ m})]$

$= (1.0\text{ cm})\cos[2\pi - (\pi/4)]$

$= 1.0\text{ cm}/\sqrt{2} = 0.71$ cm

The velocity of the particle at position x at time t is also obtained from Eq. (ii)

$V = \frac{\partial y}{\partial t} = -(1.0\text{ cm})(40\pi\text{ s}^{-1})\sin[(40\pi\text{ s}^{-1})t$

$-\{(\pi/2)\text{m}^{-1}\}x]$

$= -\left(40\pi\frac{\text{cm}}{\text{s}}\right)\sin\left(2\pi - \frac{\pi}{4}\right)$

$= -\frac{40\pi}{\sqrt{2}}\text{cm/s} = -89$ cm/s

495 **(d)**

$\lambda = 2\,(4.5 - 2.5) = 4$ cm; $v = n\lambda$

$\Rightarrow n = \frac{40}{4} = 10$ Hz

$\phi = \frac{2\pi}{\lambda}\Delta x = \frac{5\pi}{4}\text{rad} \Rightarrow \phi = \frac{2\pi}{T}\Delta t$

$\Delta t = \frac{\phi}{2\pi n} = \frac{\pi/3}{2\pi 10} = \frac{1}{60}$ s

Velocity of p should be maximum, as it is mean position

$v_p = \omega A = 2\pi f A = 2\pi \times 10 \times \frac{2}{100}$

$= 1.26$ m/s

This velocity should be –ve, because slope at p is +ve

496 **(c)**

Since, the wave is a plane travelling wave, intensity at every point will be the same.

Since, initial phase of particle at x=0 is zero and the wave is travelling along positive x-direction equation of the wave will be of the form

$\delta = a\sin\omega\left(t - \frac{x}{v}\right)$ (i)

Let intensity of the wave be I, then space density of oscillation energy of medium particles will be equal to

$E = \frac{I}{v}$

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

Therefore $E = 2\pi^2 n^2 a^2 \rho = 0.16\pi^2$ J/m^3

$a^2 n^2 = 4 \times 10^{-4}$

or $an = 0.02$ (ii)

Shear strain of the medium is

$\phi = \frac{d}{dx}\delta$

Differentiating Eq. (i),

$\phi = -\frac{a\omega}{v}\cos\omega\left(t - \frac{x}{v}\right)$

Modulus of share strain f will be maximum when

$\cos\omega\left(t - \frac{x}{v}\right) = \pm 1$

$\therefore$ Maximum shear strain $8\pi \times 10^{-5}$

$\phi_0 = \frac{a\omega}{v}$

But it is equal to

$$\frac{a\omega}{v} = 8\pi \times 10^{-5}$$

Where

$\omega = 2\pi n$

$an = 4v \times 10^{-5}$ (iii)

Solving Eqs. (ii) and (iii), $v = 500$ m/s

Since, the wave is travelling along positive x-direction, therefore, phase difference between particles at point (1 m, 1 m, 1 m) and (2 m, 2 m, 2 m) is due to difference between their x coordinates only

The phase difference is given by

$$\Delta\theta = 2\pi \frac{\Delta x}{\lambda}$$

$\Delta x = (x_2 - x_1) = (2-1)\text{m} = 1$ m

$$\lambda = \frac{2\pi \Delta x}{\Delta\theta} = 2.5 \text{ m}$$

But $v = n\lambda$, therefore,

$$n = \frac{v}{\lambda} = 200 \text{ Hz}$$

Substituting $n = 200$ Hz in Eq.(ii),

$a = 1 \times 10^{-4}$m

Angular frequency, $\omega = 2\pi n = 400\pi$ rad/s.

Substituing all these values in Eq.(i),

$\delta = 10^{-4} \sin \pi(400t - 0.8x)$ m

Since, due to propagation of the wave, shear strain is produced in the medium, the wave is a plane transverse wave

497 **(a)**

The equation of wave moving in negative x-direction, assuming origin of position at $x = 2$ and origin of time (i.e., initial time) at $t = 1$ s

$y = 0.1 \sin(4\pi t + 8x)$

Shifting the origin of position to left by 2 m, to $x = 0$. Also shifting the origin of time backwards by 1 s, that is to $t = 0$ s

$y = 0.1[4\pi(t-1) + 8(x-2)]$

498 **(b)**

$$v_1 = \sqrt{\frac{F}{\mu}}$$

$$v_2 = \sqrt{\frac{F}{4\mu}} = \frac{1}{2}\sqrt{\frac{F}{\mu}}$$

$$v_3 = \sqrt{\frac{F}{9\mu}} = \frac{1}{3}\sqrt{\frac{F}{\mu}}$$

$$v_4 = \sqrt{\frac{F}{16\mu}} = \frac{1}{4}\sqrt{\frac{F}{\mu}}$$

Total time taken

$$= \frac{L}{v_1} + \frac{L}{v_2} + \frac{L}{v_3} + \frac{L}{v_4} = \frac{10L}{\sqrt{F/\mu}}$$

499 **(a)**

Frequency $= \frac{1}{\text{Time period}} = \frac{1}{0.4} = 2.5$Hz

Amplitude $= \frac{1}{2} \times 0.3 \text{ m} = 0.15$ m

Wave speed $= f\lambda = 2.5 \times 0.8 \text{ m} = 2$ m/s

500 **(b)**

$\omega = 2\pi f = 6\pi$ rad/s

and $k = \frac{\omega}{v} = \frac{6\pi}{15} = 1.26$

$y = 0.1 \cos(1.26\, x - 18.8t)$

At point 2.5 m from child and equation of displacement

$y = 0.1 \cos(3.15 - 18.8t)$

$= -0.1 \cos(18.8)t$

At $\lambda = 5$, time taken to reach 2.5 m $= T/2$

$$\Delta\phi = \frac{2\pi \Delta t}{T} = \pi$$

501 **(b)**

$$v = \sqrt{\frac{T}{\mu}} = 20 \text{ m/s}$$

$$\lambda = \frac{v}{f} = \frac{20}{100} = 0.2 \text{ m} = 20 \text{ cm}$$

and $k = \frac{2\pi}{\lambda} = 10\pi, \omega = 2\pi f = 200\pi$

So $y = -0.02 \cos(10\pi x - 200\,\pi t)$

$-$ve sign is because at $t = 0$ and $x = 0, y$ is $-$ve

Wave velocity is constant for a medium but particle velocity keeps changing

as $v = y' = 4\pi \sin(10\pi x - 200\pi t)$

$$\frac{d^2y}{dt^2} = -0.02\, x(200\pi)^2 \cos(10\pi x - 200\pi t)$$

For $a_{\max} = -a\omega^2 = -7888$ m/s^2

$|a_{\max}| = 7888$ m/s^2

As frequency doubles, λ becomes half, speed of wave remains same

502 **(c)**

Time taken to reach other end is independent of frequency and amplitude $v = \sqrt{\frac{T}{m}}$

As m increases, velocity decreases

So time taken will be more or will increase

As T increases, velocity also increases

So time taken will be or it will decreases

503 **(c)**

Let general wave equation is $y = A\sin(\omega t - kx + \phi)$

$$v = \frac{dy}{dt} = A\omega\cos(\omega t - kx + \phi)$$

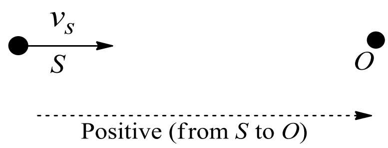
For curve (1), $x = 0$

At $t = 0, x = 0$, we have $y = 0$
$\Rightarrow 0 = A\sin[\phi] \Rightarrow \sin\phi = 0$
$\Rightarrow \phi = 0$ or π
Here $\phi = \pi$(because velocity is negative)
For curve (2), $x = 7$ cm
At $t = 0, x = 7$ cm, $y = -1$
$-1 = \sin(-k \times 7 + \pi)$
$\Rightarrow \sin(-7k + \pi) = -1/2$
$\Rightarrow -7k + \pi = 2n\pi + \frac{7\pi}{6}$ or $2n\pi + \frac{11\pi}{6}$
Here $\Rightarrow -7k + \pi = 2n\pi + \frac{11\pi}{6}$
(because at $t = 0$, velocity is positive)
$\Rightarrow -7\left(\frac{2\pi}{\lambda}\right) = 2n\pi + \frac{5\pi}{6}$
$\Rightarrow \lambda = \frac{-14\pi}{\frac{5\pi}{6} + 2n\pi}$
$\Rightarrow \lambda = \frac{-84}{12n + 5}$
For $n = 1, \lambda = 12$cm
For $n = -2, \lambda = \frac{84}{19}$ cm (not possible)
Because $\lambda > 7$ cm
$v = f\lambda = 100 \times \frac{12}{100} = 12$ m/s

504 **(d)**
From the graph it is clear
Wave velocity $v = \frac{(8-3)}{0.006}$
$v = \frac{5 \times 10^3}{6}$ m/s
And wave velocity $v = f\lambda$
$\frac{5 \times 10^3}{6} = f(9 - 1) \Rightarrow f = \frac{5 \times 10^3}{6 \times 8} = 104\ \mathrm{s^{-1}}$
Alternate Method
Let $y = 4\sin(\omega t - kx + \phi)$
For curve (1):
$-\frac{1}{\sqrt{2}} = 1\sin(\omega \times 0.002 + \phi)$
$\Rightarrow \sin(0.002\,\omega + \phi) = -\frac{1}{\sqrt{2}}$
$\Rightarrow 0.002\omega + \phi = \frac{5\pi}{4}$ or $\frac{7\pi}{4}$
But as the velocity is downward
So, $0.02\omega + \phi = \frac{5\pi}{4}$ (i)
For curve (2):
$1 = 1\sin(\omega \times 0.008 + \phi)$
$\Rightarrow 0.008\omega + \phi = 2\pi + \frac{\pi}{2}$ (ii)
From Eqs. (i) and (ii)
$6\omega = 1250\pi$
$\Rightarrow f = \frac{1250\pi}{12\pi} = 104$Hz
$v = f\lambda = \frac{1250}{12} \times 8 = \frac{2500}{3}$ m/s

505 **(d)**
a. At P: Slope of tangent
$= \frac{dy}{dx} = \tan 60° = \sqrt{3}$
Particle velocity
$v_p = -v\frac{dy}{dx} \Rightarrow 20\sqrt{3} = -v\sqrt{3}$
$\Rightarrow |v| = 20$ cm/s $= \frac{1}{5}$ m/s
Hence the wave is travelling in negative x-direction with velocity 20 cm/s
b. From graph, amplitude $A = 4 \times 10^{-3}$m
Wave length $\lambda = (5.5 - 1.5) = 4 \times 10^{-2}$m
Wave number
$K = \frac{2\pi}{\lambda} = \frac{2\pi}{4 \times 10^{-2}} = 50\pi\mathrm{m^{-1}}$
Angular frequency $\omega = kv$
$= 50\pi \times \frac{1}{5} = 10\pi$
Hence equation can be written as
$y = A\sin(\omega t + kx + \phi)$
$y = (4 \times 10^{-3})\sin(10\pi t + 50\pi x + \phi)$ (i)
At $t = 0, x = 0$
$2\sqrt{2} \times 10^{-3} = 4 \times 10^{-3}\sin(\phi)$
$\Rightarrow \sin\phi = \frac{1}{\sqrt{2}}, \phi = \frac{\pi}{4}, \frac{3\pi}{4}$
Particle is moving up at $t = 0, x = 0$
Hence, $\phi = \frac{\pi}{4}$
Hence equation is
$y = (4 \times 10^{-3})\sin\left(10\pi t + 50\pi x + \frac{\pi}{4}\right)$

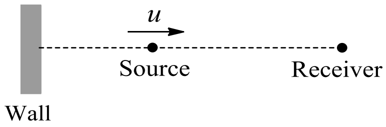
506 **(a)**
In front of train: Velocity of observer is $V_0 = 0$ m/s. Velocity of source is $V_S = +30$ m/s. The direction from S to O is considered to be the positive direction



Hence, the apparent frequency is
$f' = f\left(\frac{c - V_0}{c - V_S}\right) = f\left(\frac{c - 0}{c - 30}\right)$
$\Rightarrow f' = \frac{500 \times 345}{345 - 30} = 547.62$ Hz

507 **(a)**
Since source moves away from the wall, it means that its velocity is toward the receiver as shown in the figure. Hence, frequency of direct sound received by it is greater than natural frequency of

the source



Frequency of direct waves

$n_d = n_0 \left(\frac{v}{v-u}\right) = 660$ Hz

Frequency of reflected sound is equal to frequency received by the wall. Since source is moving away from the wall, therefore, frequency received by the wall is less than natural frequency of the source which is equal to

$n_0 \left(\frac{v}{v+u}\right)$

Therefore, the frequency of reflected sound is

$n_r = n_0 \left(\frac{v}{v+u}\right) = 550$ Hz

Hence, the beat frequency recorded by the receiver is

$n_r - n_d = 110$ Hz

Since the receiver is stationary, therefore, velocity of both direct and reflected sound relative to the receiver is equal to u. Hence, wavelength of direct waves is

$\frac{v}{n_d} = 0.5 \text{ m} = 50 \text{ cm}$

and wavelength of reflected waves is

$\frac{v}{n_r} = 0.6 \text{ m} = 60 \text{ cm}$

508 **(b)**

Source frequency $n_0 = 1700$ Hz. Source (coinciding with observer at $t = 0$) moves away with uniform acceleration ω. Consider the wave which is received by the observer at instant $t = \tau$. It will have left the source at an earlier instant of time, say $t(< \tau)$, when the distance of source was r(say). If u be velocity of source at6 instant t, then $r = (1/2)\omega t^2$ and $u = \omega t$. We then have the relation between τ and t,

$$\tau = t + \frac{r}{V} = t + \frac{\omega t^2}{2V}$$

This is a quadratic equation in t, giving the solution

$$\omega t = \frac{-2V + \sqrt{4V^2 + 8V\omega\tau}}{2}$$

$$u = \omega t = V\left[\sqrt{1 + \frac{2\omega\tau}{V}} - 1\right]$$

$$= 340 \times \left[\sqrt{1 + \frac{2 \times 10 \times 10}{340}} - 1\right]$$

$$= 340\left[\sqrt{\frac{27}{17}} - 1\right]$$

Then apparent frequency is given by

$$n_a = \left(\frac{V}{V+u}\right) n_0$$

Putting values $V = 340 \text{m/s}, \tau = 10 \text{s}, \omega = 10 \text{ m/s}^2$, we have

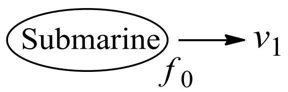
$$n_a = \left(\frac{340}{340+u}\right) 1700$$

$$= 1700 \times \sqrt{\frac{17}{27}} = 1.35 \text{ kHz}$$

509 **(c)**

Since the source is moving on a small circle in a plane perpendicular to the direction of the wave moving towards the observer located on the axis of the circle, there would be no change in the observed frequency which will be the same as the real frequency i.e., 500 Hz

510 **(b)**



$$f' = f_0\left(\frac{v+v_1}{v-v_1}\right), v = 1050$$

$$f' = \frac{110 f_0}{100}$$

Solve to get : $v_1 = 50$ m/s

511 **(c)**

In the propagation of sound waves, let pressure amplitude be Δp_0 and displacement amplitude be A. Then,

$\Delta p_0 = BAK$

Where symbols have their usual meanings. We have

$$SL = 10 \log \frac{I}{I_0}$$

$$\Rightarrow 40 = 10 \log \frac{I}{10^{-12}}$$

$$\Rightarrow I = 10^{-8} \text{W/m}^2$$

$$I = \frac{\Delta p_0^2}{2\rho v}$$

$$\Rightarrow \Delta p_0 = \sqrt{I \times 2\rho v}$$

$$= \sqrt{10^{-8} \times 2 \times \frac{15}{11} \times 330 \text{ N/m}^2}$$

$$= 3 \times 10^{-3} \text{ N/m}^2$$

512 **(c)**

$$I = \frac{P}{A}$$

So, $I_1 = \frac{P}{A_1}$ and $I_1 = I_2 = \frac{P}{A_1}$

513 **(d)**

The force exerted on inner ear is same as that of the force exerted on eardrum, due to negligible mass of ossicles

$$P_{\max} = \frac{\mathrm{F}_{\max}}{\text{area of stirrup}}$$

$$= \frac{P_{\max \text{ on eardrum}} \times A_{\text{eardurm}}}{A_{\text{stirrup}}}$$

Pressure amplitude is given by

$$\Delta P_0 = P_{\max} - P_{\text{normal value}}$$

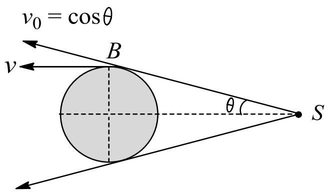
$$= \frac{(P_0 + (\Delta P_0)_{\text{on eardrum}}) \times A_{\text{eardrum}}}{A_{\text{stirrup}}} - \frac{P_0 \times A_{\text{eardurm}}}{A_{\text{stirrup}}}$$

$$= \frac{(\Delta P_0)_{\text{on eardrum}} \times A_{\text{eardru}}}{A_{\text{stirrup}}}$$

$$= \frac{4 \times 10^{-2} \times 50 \times 10^{-6}}{5 \times 10^{-6}} = 0.4 \text{ Pa}$$

514 **(d)**

The location of detector at required instant is shown in Fig.



We have, $v_0 = R\omega$ [speed of detector]

$$f_{\text{ap}} = \frac{v - v_0 \cos\theta}{v} \times f$$

$$\cos\theta = \frac{2R}{\sqrt{5}R}$$

$$f_{\text{ap}} = \frac{v - \omega R \times \frac{2}{\sqrt{5}}}{v} \times f$$

515 **(c)**

The frequency heard directly from source is given by

$$f_1 = \left(\frac{v}{v - v_s}\right) f$$

Here $v = 340$ m/s, $v_s = 2$ m/s, $f = 512$

$$f_1 = \frac{340}{338} \times 512 = 515 \text{ Hz}$$

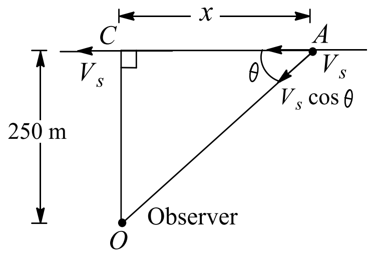
The frequency of the wave reflected from wall will be same (no relative motion between wall and listener, so no change in frequency). Hence no beats are observed

516 **(d)**

Let the source be moving along the straight line AC and observer be located at O, as shown. Let the velocity of sound in air be v. The velocity of source is ηv

Let the sound wave received by the observer at the moment when the source is closest to the observer (at C) be emitted by the source when it was at point A

Therefore, by the time source travels from A to C, the sound wave travels from A to O. If this time interval is $t, AC = \eta vt$ and $AO = vt$. Velocity of approach of source when it is at A,



$$v_s = (\eta v)\cos\theta = (v)\left(\frac{AC}{AO}\right) = \eta v\left(\frac{\eta vt}{vt}\right) = \eta^2 v$$

When the sound wave emitted by the source at A reaches the stationary observer at O, it will receive the frequency

$$f = f_0\left(\frac{v}{v - v_s}\right) = f_0\left(\frac{v}{v - n^2 v}\right)$$

$$= \frac{f_0}{1 - \eta^2} = \frac{1800}{1 - (0.8)^2} = 5000 \text{ Hz}$$

517 **(a)**

A minimum frequency =fundamental frequency

$$f = f_0$$

$$f_0 = \frac{1}{2l}\sqrt{\frac{T}{m}} = \frac{1}{2 \times 0.5}\sqrt{\frac{400}{5 \times 10^{-3} \times 2}} = 200 \text{ Hz}$$

518 **(a)**

Let c be the speed of sound and f_1, f_2 be the frequency of tuning forks

$$f_1 = \frac{c}{4l_1} = \frac{c}{4 \times 32} = \frac{c}{128}$$

$$f_2 = \frac{c}{2l_2} = \frac{c}{2 \times 66} = \frac{c}{132}$$

Now $|f_1 - f_2| = 8$

As $f_1 > f_2$ we have $|f_1 - f_2| = 8$

$$\frac{c}{128} - \frac{c}{132} = 8$$

$$c = \frac{128 \times 132 \times 8}{4} = 33792 \text{ cm/s}$$

$$f_1 = \frac{c}{128} = 264 \text{ Hz}$$

$f_2 = \frac{c}{132} = 256 \text{ Hz}$

519 **(b)**

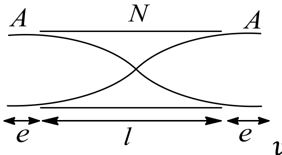
When an air column in a tube vibrates, the antinodes at the open end(s) are located at a small distance outside the open end. This small distance is called as end correction.

Approximate end correction $= 0.3\,d$

Where d is the diameter of the tube

In case of a tube open at both ends, the effective length of the tube that should be taken in calculation will now be l

$\Rightarrow l' = l + 2e$ where $e = 0.3d$



$v = \frac{c}{2l}$

$\Rightarrow 320 = \frac{320}{2(l + 2e)}$

$l + 2e = 0.5$

$0.48 + 2(0.3d) = 0.5$

$\Rightarrow d = 1/30 \text{ m} = 3.33 \text{ cm}$

520 **(d)**

Pipe is closed from one end:

An air column in a pipe closed from one end oscillates only harmonics [1st harmonic (fundamental mode), 3rd harmonic (1st overtone), 5th harmonic (2nd overtone), 7th harmonic (3rd overtone) etc.]

Fundamental frequency $= \frac{V}{4l} = \frac{340}{4 \times \frac{45}{100}} = 100 \text{ Hz}$

Other modes of oscillation are

3rd harmonic frequency $= 3 \times 100 = 300$ Hz

5th harmonic frequency $= 5 \times 100 = 500$ Hz

7th harmonic frequency $= 7 \times 100 = 700$ Hz

9th harmonic frequency $= 9 \times 100 = 900$ Hz

11th harmonic frequency$= 11 \times 100 = 1100$ Hz

13th harmonic frequency $= 13 \times 100 = 1300$ Hz

Only those natural oscillations are to be counted whose frequencies lie below $f_0 = 1250$ Hz, the harmonics till 11th harmonic are to be counted

Since, the number of possible natural oscillations $=$ 1(1st harmonic)+1(3rd harmonic)+1 (5th harmonic)+1(7th harmonic)+ 1(9th harmonic)+1(11th harmonic)= 6

Second Method

All the frequencies possible are integral multiple of fundamental frequency which is 100 Hz. Using the fact that integer which is multiplied by fundamental frequency is the number of harmonic itself you get, highest predicted= $[12.50/100]$ where $[x]$ represents greatest integer less than or equal to $x = [12.5] = 12$

Now for closed pipe, only odd harmonic are possible, highest harmonic possible =11th. The possible harmonic are 1, 3, 5, 7, 9, 11 which are six in number

521 **(d)**

For largest mass, $P = 1$

$n = \frac{P}{2L}\sqrt{\frac{T}{\mu}}$

$700 = \frac{p}{2L}\sqrt{\frac{T}{\mu}}$

$m = 2 \times 10^{-3}\text{kg/m}, L = 1\text{m}$

$T = [(700)^2 \times 4 \times 1 \times 2 \times 10^{-3}] = 3920 \text{ N}$

Largest mass to be hang, $M_{\max} = 3920/9.8 = 400 \text{ kg}$

522 **(c)**

Fundamental frequency

$n_{\text{Ne}} = \frac{1}{2L}\sqrt{\frac{\gamma RT}{M_{\text{Ne}}}}$

$n_{\text{Ne}} = 300\text{Hz}, M_{\text{Ne}} = 20 \times 10^{-3}\text{kg}$

$\gamma = \frac{5}{3}, R = \frac{20}{3}\text{J/mol K}$

$T = 270 \text{ K}$

$L = \frac{1}{2 \times 300}\sqrt{\frac{\frac{5}{3} \times \frac{25}{3} \times 270}{20 \times 10^{-3}}}$

$= \frac{250\sqrt{3}}{2 \times 300} = \frac{5\sqrt{3}}{12}\text{m}$

523 **(a)**

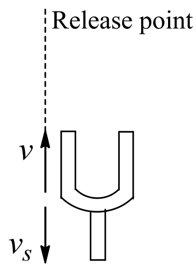
Speed sound in air at 59°C $= 2n(l_2 - l_1)$

$= 2 \times 500(49.2 - 16) \times 10^{-2}$

$= 332 \text{ m/s}$

524 **(b)**

Let t' be the time at which the tuning fork emits a sound wave which reaches the release point at $(t - t')$



The apparent frequency received at the release point

$v' = \frac{v_0 v}{v + v_s}$

$V' = 475 \text{ Hz};\ v_0 = 500 \text{ Hz},\ y = 340 \text{ m/s}$

$$475 = \frac{500 \times 340}{340 + v_s} \Rightarrow v_s = 17.9 \text{ m/s}$$

525 **(c)**

Velocity of sound at

$107°\text{C} = 2n(l_2 - l_1)$

$= 2 \times 500(58.5 - 19) \times 10^{-2}$

$= 395$ m/s

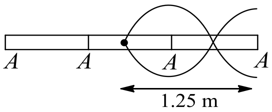
526 **(b)**

Velocity of the longitudinal waves in the rod

$v = \sqrt{Y/d} = \sqrt{2 \times 10^{11}/8000} = 5000$ m/s

The wavelength of the wave for the mode of vibration in which 2 antinode occur is

$$\lambda = \frac{1.25}{(3/4)} = \frac{5}{3} \text{m}$$



Hence frequency of vibration

$$n = \frac{V}{\lambda} = \frac{5000}{5/3} \text{Hz} = 3000 \text{ Hz}$$

527 **(c)**

The given longitudinal standing wave is

$y = a \cos kx \cos \omega t$ (i)

The nodes of this wave are located where $\cos kx = 0$ (i.e., at the values

$$x = \frac{\lambda}{4}, \frac{3\lambda}{4}, \ldots$$

and the antinodes are located where $\cos kx = \pm 1$ (i.e.,) at using the values

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

At the nodes, the space density of kinetic energy (kinetic energy per unit vanishes for the nodes i.e.,

$$x = \frac{\lambda}{4}, \frac{3\lambda}{4} \text{ etc}$$

Also, y is maximum at $t = 0$, as we see from Eq. (i). Hence potential energy must be maximum at $t = 0$. Hence the time factor in potential energy density must enter as $\cos^2 \omega t$. Also, the sum kinetic and potential energy densities must always be constant for a given x as it represents total energy at that point

Hence the potential energy density is

$$E_P = \frac{\rho a^2 \omega^2}{2} \sin^2 kx \cos^2 \omega t \quad \text{(ii)}$$

and the kinetic energy density is

$$E_K = \frac{\rho a^2 \omega^2}{2} \cos^2 kx \sin^2 \omega t \quad \text{(iii)}$$

528 **(d)**

$$\mu = \frac{1.2}{2} = 0.6 \text{ kg/m}$$

$n = 5$ Hz

$\lambda = 2l = 4$m

$V = n\lambda = 5 \times 4 = 20$ m/s

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

$T = 20^2 \times 0.6 = 240$ N

$$\left(\frac{\partial y}{\partial t}\right)_{\max} = 3.14 \text{ m/s}$$

$(2A)\omega = 3.14$

Amplitude $2A = \frac{3.14}{2 \times (3.14) \times 5} = 0.1$ m

Equation of standing wave is

$$y = (0.1) \sin\left(\frac{\pi}{2}\right) x \sin(10\pi)t$$

529 **(a)**

$$\xi = (0.1 \text{ mm}) \cos \frac{2\pi}{0.8}(y + 1 \text{ cm}) \cos(400t)$$

End correction is 1 cm, so at $y = -1$ cm

$$\xi = (0.1 \text{ mm}) \cos \frac{2\pi}{0.8}(-1 \text{ cm} + 1 \text{ cm}) =$$

$= (0.1 \text{ mm}) \cos(0) =$ Antinode

So upper end is open

At lower end $y = 99$ cm $= 0.99$ m

$$\xi = (0.1 \text{ mm}) \cos \frac{2\pi}{0.8}(0.99 + 0.1)$$

$$= 0.01 \cos \frac{5\pi}{2} = 0 \Rightarrow \text{Node}$$

So tube is open closed

530 **(a)**

Actual frequency emitted by source does not depend upon the velocity of source but frequency heard may change due to relive motion between the observer and the source

531 **(a)**

$y_1 = A \cos(0.5\pi x - 100\pi t)$

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

For the first wave angular frequency is $\omega_1 = 100\pi, f_{14} = 50$ Hz

For the second wave angular frequency is $\omega_2 = 92\pi, f_2 = 46$ Hz

Frequency at which the amplitude of resultant wave varies

$$f_A = \frac{f_1 - f_2}{2} = \frac{50 - 46}{2} = 2$$

Time interval between this is maximum

$$\Delta t = \frac{1}{2f_A}$$

$$\Delta t = \frac{1}{4}$$

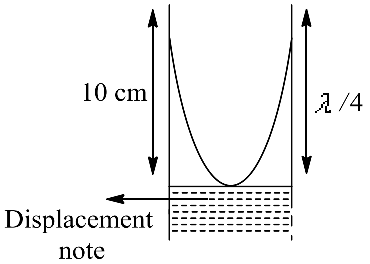
Therefore, the number of time intensity is maximum in time 1 s is 4

532 **(b)**

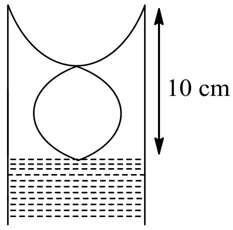
Frequency of source = 680 Hz
Velocity of sound = 340 m/s
Wave length $= \lambda - v/f = 340/680\text{m} = 1/2\text{m}$
Let the person is at distance D when he observes first minimum intensity
Hence the path difference between two source $= \lambda/2$
Path difference at that point
$\sqrt{D^2+d^2} - D = \frac{\lambda}{2}$
$d = 3$
$\sqrt{9^2+D^2} - D = \frac{\lambda}{2}$
$D = \left(1+\frac{9}{D^2}\right)^{1/2} - D = \frac{\lambda}{2}$
Using Binomial thermo
$D = 18$ m
Hence option (b) closest for second minimum

533 **(c)**
$y = y_1 + y_2 = (12\sin 5x)\cos 4t$
Maximum value of y-positions in SHM of an element of the string that is located at an antinode $= \pm 12$ cm $(\sin 5x = \pm 1)$
For the position nodes amplitude should be zero
So, $\sin 5x = 0 \Rightarrow 5x = n\pi$
$x = \frac{n\pi}{5}$
Where $n = 0,1,2,3,\ldots$
Value of amplitude at $x = 1.8$ cm
$A = 12\sin(5\times 1.8) = 4.9$ cm
At any instant say $t = 0$, instantaneous velocity of points on the string is zero for all points as at extreme position velocities of particles are zero

534 **(b)**
Displacement node corresponds to pressure antinode
$L = \frac{\lambda_0}{4}$
$\lambda_0 = 4L = 40$ cm (First harmonic)



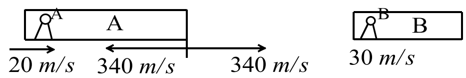
$v = \lambda f$
$f = \frac{v}{\lambda} = \frac{344}{40\times 10^{-2}} = 860$ Hz



For the second resonance
$\frac{3\lambda_0}{4} = L$
$L = 30$ cm
For the third resonance $5\lambda_0/4 = L$
$L = 50$ cm
Also, $v = v/\lambda$
3rd harmonic is 2nd overtone
Hence, frequency for 2nd overtone
$= \frac{5v}{4L} = 4300$ Hz

535 **(c)**
In one second number of maximas is called the beat frequency. Hence,
$f_0 = f_1 - f_2$
$= \frac{100\pi}{2\pi}$ or $\frac{92\pi}{2\pi}$
$= 4\ Hz$

536 **(b)**
$V_{SA} = 340 + 20 = 360 m/s$
$V_{SB} = 340 - 30 = 310 m/s$



537 **(2)**
Given that
$x = 40\cos(50\pi t - 0.02\pi y)$
∴ particle velocity
$v_p = \frac{dx}{dt} = (40\times 50\pi)\{-\sin(50\pi t - 0.02\pi y)\}$
Putting $x = 25$ and $t = \frac{1}{200}$ s,
$v_p = -(2000\pi \text{ cm}$
$/\text{s})\sin\left[50\pi\left(\frac{1}{200}\right) - 0.02\pi(25)\right]$
$= 10\pi\sqrt{2}$ m/s

538 **(1)**
Since frequencies are in odd number ratio, the pipe has to be a closed pipe
Ratio of 3 frequencies = 425: 595: 765
= 5: 7: 9
So fundamental frequency $= f = \frac{425}{5} = 85$ Hz
For fundamental frequency
$l = \frac{v}{4f} = \frac{340}{4\times 85} = 1$ m

539 **(8)**
The observer will hear a sound of the source

moving away from him and another sound after reflection from the wall. The apparent frequencies of these sounds are

$$f_1 = \left(\frac{v}{v+u}\right) f, f_2 = \left(\frac{v}{v-u}\right) f$$

Number of beats $= f_2 - f_1$

$$\left(\frac{v}{v-u} - \frac{v}{v+u}\right) f = \frac{2uvf}{v^2 - u^2} \approx \frac{2uf}{v} = 8$$

540 **(6)**

Loudness due to $S_1 = I_1 = ka^2$ where a is the amplitude and loudness due to S_1 and S_2 both $= I_2 = k(2a)^2 = 4I_1$

$n = 10 \log_{10}(4I_1/I_1) = 10 \log_{10}(4) = 10(0.6) = 6$

541 **(3)**

We know that $\beta = 10 \log_{10} \frac{I}{I_0}$

According to the problems $\beta_A = 10 \log_{10} \frac{I}{I_0}$

$$\beta_B = 10 \log_{10} \left(\frac{2I}{I_0}\right)$$

$$\beta_B - \beta_A = 10 \log \left(\frac{2I}{I}\right) = 10 \times 0.3010 = 3 \text{ dB}$$

542 **(2)**

$f = 500$ Hz, $v = 300 \text{ ms}^{-1}$

$$\lambda = \frac{v}{f} = \frac{300}{500} = \frac{3}{5} \text{m}$$

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

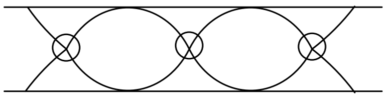
$$l = \frac{(2n-1) \times 300}{4 \times 5} \leq 1 \text{ m}$$

$n \leq 23/6 = 3.83$

Since only odd harmonics are possible there will be only two resonant lengths

543 **(3)**

We have to find the number of pressure antinodes (displacement nodes), which is 3 (from the diagram)



544 **(5)**

$L = 40$ cm, mass $=10$ g

mass per unit length

$$\mu = \frac{10}{40} = \frac{1}{4} (\text{g/cm})$$

Spring constant $k = 160$ N/m

Deflection, $x = 1 \text{ cm} = 0.1 \text{ m}$

Tension in the string:

$T = kx = 160 \times 0.01 = 1.6$ N

$= 16 \times 10^4$ dyne

Wave velocity is given by

$$v = \sqrt{\left(\frac{T}{\mu}\right)} = \sqrt{\left(\frac{(16 \times 10^4)}{\frac{1}{4}}\right)} = 800 \text{ cm/s}$$

Time taken by the pulse to reach the spring

$$t = \frac{40}{800} = \frac{1}{20} = 0.05 \text{ s} = 5 \times 10^{-2} \text{ s}$$

545 **(3)**

Time period

$T = 4 \times 5 \text{ ms} = 20 \times 10^{-3} = 2 \times 10^{-2}$s

Frequency, $f = \frac{1}{T} = \frac{1}{(2\times10^{-2})} = 50$Hz

$\lambda = 2 \times 3 \text{ cm} = 6 \text{ cm}$

Wave speed : $v = \lambda f = 0.06 \times 50 = 3$ m/s

546 **(2)**

Velocity of the wave

$$V = \sqrt{\left(\frac{T}{\mu}\right)} = \sqrt{\frac{(16 \times 10^5)}{0.4}} = 2000 \text{ cm/s}$$

Time taken to reach to the other end $= \frac{20}{200} = 0.01$ s

Time taken to see the pulse again in the original position

$= 0.01 \times 2 = 0.02$ s

547 **(3)**

$$f_1 = 900 \left(\frac{300}{300 + V_1}\right)$$

Or $f_1 = 900 \left[1 + \frac{V_1}{300}\right]^{-1} = 900 - 3V_1$

Likewise, $f_2 = 900 - 3V_2$

Given $f_2 - f_1 = 9$

$3(V_1 - V_2) = 9 \Rightarrow V_1 - V_2 = 3$ m/s

548 **(4)**

$$y = \frac{0.8}{(3x^2 + 24xt + 48t^2 + 4)}$$

$$= \frac{0.8}{3[x^2 + 8xt + 16t^2] + 4}$$

$$= \frac{0.8}{3(x + 4t)^2 + 4}$$

$\therefore x + 4t = x + vt \quad \therefore v = 4$ m/s

549 **(4)**

The linear mass density is

$$\mu = \frac{5 \times 10^{-3}\text{kg}}{50 \times 10^{-3}\text{m}} = 1.0 \times 10^{-2} \frac{\text{kg}}{\text{m}}$$

The wave speed is $v = \sqrt{F/\mu}$

Thus, the tension is $F = \mu v^2$

$$= \left(1.0 \times 10^{-2} \frac{\text{kg}}{\text{m}}\right) \times 6400 \frac{\text{m}^2}{\text{s}^2} = 64 \text{ N}$$

The Young's modulus is given $Y = \frac{F/A}{\Delta L/L}$

The extension is, therefore

$$\Delta L=\frac{FL}{AY}=\frac{64\times0.50}{(1.0\times10^{-6})\times(8\times10^{11})}=0.04\text{ mm}$$

550 **(2)**

$v=40$ cm/s

As velocity of a wave is constant, location of maximum after 5 s given by $40\times5=200$cm along the negative x-axis at $x=-2$ m

551 **(4)**

Here $I_1=1.0\times10^{-8}\text{W/m}^2$

$r_1=5.0\text{ m}, I_2=?, r_2=25\text{ m}$

We know that $I\propto\left(\frac{1}{r^2}\right)$

$I_1r_1^2=I_2\,r_2^2$

$$I_2=\frac{I_1r_1^2}{r_2^2}=\frac{1.0\times10^{-8}\times25}{625}=4.0\times10^{-10}\text{W/m}^2$$

552 **(7)**

$f_0-f_c=2$

$$V\left[\frac{1}{2L}-\frac{1}{4L}\right]=2\text{ or }\frac{V}{L}=8$$

In the second case,

$$f_0'-f_c'=\frac{V}{L}-\frac{V}{8L}=\frac{7V}{8L}=\frac{7}{8}(8)=7$$

553 **(4)**

$\mu=19.2\times10^{-3}\text{kg/m}$

From the free body diagram

$T-4\text{g}-4a=0$

$T=4\,(a+\text{g})=4(2+10)=48$ N

Wave speed:

$$v=\sqrt{\frac{T}{\mu}}=\sqrt{\frac{48}{19.2\times10^{-3}}}=50\text{m/s}$$

So, $n=4$

554 **(1)**

Intensity is given by $I=\frac{p_0^2}{2\rho v}$

Here v and ρ are same for both. And also given that I is same for both. So pressure amplitude is also same for both

555 **(2)**

$l=15.0\text{ m}, v=12\text{ ms}^{-1}$

Since there are 6 nodes, with the ends as nodes there will be five half wavelength in the string

So, $\frac{5\lambda}{2}=l=15\Rightarrow\lambda=6.0$ m

Using $f=\frac{v}{\lambda}=\frac{12}{6}=2.0$ Hz

556 **(2)**

$a_{\text{max}}=\omega^2A=\text{g}$

$$\omega=\frac{2\pi v}{\lambda}, v=\sqrt{\frac{F}{\mu}}$$

$$A_{\text{min}}=\frac{\text{g}\lambda^2\mu}{4\pi^2F}=\frac{\lambda^2\mu}{4F}=2\times10^{-3}\text{m}=2\text{ mm}$$

557 **(3)**

$f\propto\sqrt{T}$ for strings

On increasing the tension by 1%

$f'=\sqrt{101T}$

$$\frac{f'}{f}=\frac{\sqrt{1.01T}}{\sqrt{T}}=(1+0.01)^{\frac{1}{2}}=1+\frac{1}{200}$$

Beat frequency, $f'-f=f\left(\frac{f'}{f}-1\right)=1$

Number of beats in 3 s $=1\times30=30$

558 **(4)**

$$f\propto\frac{(T/\mu)^{1/2}}{L}$$

Where μ =mass per unit length $=\rho a=\rho(\pi r^2)$

So, $f\propto\frac{(T/\rho)^{1/2}}{rL}$

$$\frac{f_2}{f_1}=\left(\frac{T_2}{T_1}\right)^{1/2}\left(\frac{\rho_1}{\rho_2}\right)^{1/2}\left(\frac{r_1L_1}{r_2L_2}\right)$$

$$=\left(\frac{1}{\sqrt{2}}\right)(\sqrt{2})(4)=4$$

559 **(9)**

$$n\left(\frac{4}{4L_c}\right)=m\left(\frac{V}{2L_0}\right)\quad\text{(i)}$$

Also $3\left(\frac{V}{4L_c}\right)=2\left(\frac{V}{2L_0}\right)$ (ii)

From Eq. (ii) $\frac{L_c}{L_0}=\frac{3}{4}$

From Eq.(i) $\frac{n}{m}=2\left(\frac{L_c}{L_0}\right)=\frac{6}{4}=\frac{3}{2}=\frac{9}{6}$

$n=9$ if $m=6$

560 **(3)**

The pattern corresponds to

$$l=\frac{5\lambda}{4}=2.0\text{ m}\quad\lambda=\frac{8}{5}\text{m}$$

With speed $v=5.0\text{ ms}^{-1}$

$$f=\frac{v}{\lambda}=\frac{5\times5}{8}=3.1\text{ Hz}$$

561 **(7)**

Intensity from a point source varies with distance as

$$I\propto\frac{1}{r^2}$$

Let at distance $r_1=10$ m, intensity is I_1,

Then given 20= $10\log\frac{I_1}{I_0}$ (i)

Let for $r=r_2$, sound level be zero. Then intensity at that point should be $I_2=I_0$

and $\frac{I_1}{I_2}=\left(\frac{r_2}{r_1}\right)^2\Rightarrow\frac{I_1}{I_0}=\left(\frac{r_2}{r_1}\right)^2$ (ii)

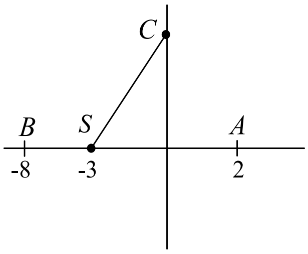
From Eqs. (i) and (ii), we get

$$20=10\log\left(\frac{r_2}{r_1}\right)^2\Rightarrow20=20\log\left(\frac{r_2}{r_1}\right)$$

$$\Rightarrow\frac{r_2}{r_1}=10\Rightarrow r_2=10r_1=7\text{ m}$$

562 **(4)**

Source should be located midway $x = -8$ m and $x = 2$ m. That is at $x = -3$ m. For the same wavefront to reach at $C, SC = SA = SB$



$5 = \sqrt{3^2 + y^2} \Rightarrow y = 4$ m