6. Superposition of Waves

Important Formulae and Shortcut Methods

1. The velocity 'V' of a wave of frequency 'n', wavelength 'λ' and period 'T' is given by

$$v = n\lambda = \frac{\lambda}{T}$$

2. The phase difference '$\Delta\phi$' at a given instant of time, corresponding to the separation ΔX along the direction of propagation of the wave is given by

$$\Delta\phi = \frac{2\pi(\Delta x)}{\lambda}$$

3. Simple harmonic progressive wave traveling along positive x-direction can be represented by equations.

$$y = A\sin\left(\omega t - \frac{2\pi x}{\lambda}\right) \quad \ldots a$$

$$y = A\sin 2\pi\left(nt - \frac{x}{\lambda}\right) \quad \ldots b$$

$$y = A\sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right) \quad \ldots c$$

$$y = A\sin\frac{2\pi}{\lambda}(vt - x) \quad \ldots d$$

where 'y' is the displacement of a particle at a distance 'x' from the origin after t seconds. 'A' is the amplitude, 'n' is the frequency, 'λ' is the wavelength and 'v' is the velocity.

4. A simple harmonic progressive wave traveling along the negative 'x' direction is given by

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

where, A = amplitude, T = period, λ = wavelength, x = distance of the particle from the origin at the instant of time 't'.

5. Angular velocity 'ω' : $\omega = \frac{2\pi}{T} = 2\pi n$

6. **Beats :** When two sound waves of almost equal frequencies n_1 and n_2 superimpose, beats are produced.
Frequency of beats = $n_1 \sim n_2$ and
In addition to the two original notes, a third note of frequency = $n_1 \sim n_2$ is heard. It is called **difference tone** summation tone of frequency $n_1 + n_2$ which is very feeble is also heard.

7. If a prong of a tuning fork is loaded with some material like wax, the frequency of the fork decreases. On the other hand, if the prongs are filed, the frequency of the fork increases.

8. **Doppler effect :** If there is relative motion between the source of sound and the observer, the frequency or the pitch of the sound appears to be changed. This is known as Doppler effect. When the two source and observer are approaching each other, the pitch appears to be raised and when they recede from each other, the pitch appears to be lowered.

$$n_a = n\left(\frac{v \pm v_0}{v \mp v_s}\right)$$

9. Velocity of sound in an elastic medium is given by $v = \sqrt{\frac{E}{\rho}}$ (Newton formula)

where, E = modulus of elasticity of medium, ρ = density of medium

(a) For gases : $E = \gamma p$, where $\gamma = \frac{C_p}{C_v}$, p = pressure $\therefore v = \sqrt{\frac{\gamma p}{\rho}}$ (Laplace's correction)

(b) For solids : E = Y, the Young's modulus of solid $\therefore v = \sqrt{\frac{Y}{\rho}}$

(c) For liquids : E = B, the bulk or volume modulus of the liquid $\therefore v = \sqrt{\frac{B}{\rho}}$

10. Velocity of sound in a gas is independent of the pressure but is directly proportional to the square root of the absolute temperature, i.e., $v \propto \sqrt{T}$

$$\therefore \quad \frac{v}{v_0} = \sqrt{\frac{T}{T_0}} = \sqrt{\frac{t+273}{273}} \quad \text{where, t is the temperature in °C.}$$

$$v_0 = v\left(1 - \frac{\alpha t}{2}\right) \quad \text{.... where } \alpha = \frac{1}{273}$$

11. Velocity of sound is inversely proportional to the square root of the density of the gas, pressure being constant.

$$\therefore \quad \frac{v_1}{v_2} = \sqrt{\frac{\rho_2}{\rho_1}}$$

Note : Density of moist air is less than that of dry air.

12. Velocity of sound is inversely proportional to the square root of the molecular weight of the gas.

$$\frac{v_1}{v_2} = \sqrt{\frac{M_2}{M_1}}$$

➤ Sound waves can be refracted, diffracted but cannot be polarised. Due to large wavelength, sound waves required large reflecting surfaces.

➤ Speed of sound = $\sqrt{\frac{\gamma}{3}} \times$ r.m.s. speed of molecules of air

➤ The frequency of notes produced by the organ pipe varies
(i) directly as $\sqrt{\gamma}$, where 'γ' is the thermodynamic constant.
(ii) directly as $\sqrt{T}$, where 'T' is absolute temperature of the gas.
(iii) inversely as $\sqrt{\rho}$, where 'ρ' is the density of the gas.
(iv) inversely as length of the tube.

13. $y = y_1 + y_2 = A$

$$\left[\sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right) + \sin 2\pi\left(\frac{t}{T} + \frac{x}{\lambda}\right)\right] = 2A\cos\left(\frac{2\pi x}{\lambda}\right)\sin\left(\frac{2\pi t}{T}\right) = R\sin\left(\frac{2\pi t}{T}\right)$$

At a node : R = 0 At an antinode : $|R| = R_{max} = 2A$

Distance between a node and an adjacent antinode = $\frac{\lambda}{4}$

Distance between adjacent nodes or antinodes = $\frac{\lambda}{2}$

14. Bounded string : All harmonics (2n, 3n, 4n, 5n, ...) present as overtones.

Fundamental mode : $n = \frac{1}{2L}\sqrt{\frac{T}{m}} = \frac{1}{2Lr}\sqrt{\frac{T}{\pi\rho}}$ (ρ = mass density of string/wire)

pth overtone = (p + 1) th harmonic : $n_p = (p+1)n = \frac{(p+1)}{2L}\sqrt{\frac{T}{m}}$

15. Stopped air column (in a pipe closed at one end) : Only odd harmonics (3n, 5n, 7n, ...) present as overtones.

Fundamental mode : $\lambda = 4L,\ n = \frac{v}{4L} = \frac{v}{4(\ell + e)}$ (e = 0.3d)

pth overtone = (2p + 1)th harmonic : $\lambda p = \frac{2L}{(2p+1)}$, $n_p = (2p+1)n = \frac{(2p+1)v}{4L}$

For the first two resonances with a tuning fork of frequency n : $v = 2n(\ell_1 - \ell)$, $e = \frac{1}{2}(\ell_1 - 3\ell)$

16. Two stopped pipes of same diameter : End correction, $e = \frac{n_1\ell_1 - n_2\ell_2}{n_2 - n_1}$

17. Open air column (in a pipe open at both ends) : All harmonics (2n, 3n, 4n, 5n, ...) present as overtones.

Fundamental mode : $\lambda = 2L,\ n = \frac{v}{2L} = \frac{v}{2(\ell + e)}$ (e = 0.6d)

pth overtone = (p + 1)th harmonic : $\lambda_p = \frac{2L}{(p+1)}$, $n_p = (p+1)n = \frac{(p+1)v}{2L}$

For same L, $n_{open} = 2n_{closed}$

For same n($n_{open} = n_{closed}$), $L_{open} = 2L_{colosed}$

18. Two open pipes of same diameter : End correction, $e = \frac{n_1\ell_1 - n_2\ell_2}{2(n_2 - n_1)}$

19. Sonometer (fundamental mode) :

$n = \frac{1}{2L}\sqrt{\frac{T}{m}} = \frac{1}{2Lr}\sqrt{\frac{T}{\pi\rho}}$ (ρ = mass density of string/wire)

$$\frac{n_{\text{load in air}}}{n_{\text{load immersed in water}}} = \sqrt{\frac{\rho_{load}}{\rho_{load} - \rho_{water}}} = \sqrt{\frac{S_{load}}{S_{load} - 1}}$$

(ρ and s ≡ mas density and relative density of load)

20. Melde's experiment : p^{th} harmonic (p loops formed)

Frequency of tuning fork, $N = n' = \frac{p}{2L}\sqrt{\frac{T}{m}}$ (perpendicular position)

$N = 2n = \frac{p}{L}\sqrt{\frac{T}{m}}$ (parallel position)

➤ Two identical waves moving in opposite directions along the string will still produce standing waves even if their amplitudes are unequal. This is the case when an incident travelling wave is only partially reflected from a boundary, the resulting superposition of two waves having different amplitudes and travelling in opposite directions gives a standing wave pattern of waves whose envelop is shown in figure.

The standing wave ratio (SWR) is defined as $\frac{A_{max}}{A_{min}} = \frac{A_i + A_r}{A_i - A_r}$

- If the two emitted waves from sources S_1 and S_2 already have a phase difference of 'π' the conditions for maximas and minimas are interchanged i.e. path difference.

  $\Delta x = \frac{\lambda}{2}, \frac{3\lambda}{2}, \ldots\ldots$ (for constructive interference)

  $\Delta x = \lambda, 2\lambda, \ldots\ldots$ (for destructive interference)

- Most of the problems of interference can be solved by calculating the path difference Δx and then by putting $\Delta x = 0, \lambda, 2\lambda, \ldots\ldots$ (constructive interference)

  $\Delta x = \frac{\lambda}{2}, \frac{3\lambda}{2}, \ldots\ldots$ (destructive interference) provided waves from S_1 and S_2 are in phase.

Multiple Choice Questions

MHT–CET 2004

1. The phase difference between two points is π/3. If the frequency of wave is 50 Hz, then what is the distance between two points? (Given, $v = 330\ ms^{-1}$)
(A) 2.2 m (B) 1.1 m (C) 0.6 m (D) 1.7 m

MHT–CET 2004

2. What is the phase difference between two successive crests in the wave?
(A) π (B) π/2 (C) 2π (D) 4π

3. In Melde's experiment, the string vibrates in 4 loops when a 50 g weight is placed in the pan of weight 15 g. To make the string to vibrates in 6 loops the weight that has to be removed from the pan is
(A) 0.0007 kg-wt (B) 0.0021 kg-wt (C) 0.036 kg-wt (D) 0.0029 kg-wt

4. The harmonics which are present in a pipe, open at one end are
(A) odd harmonics (B) even harmonics
(C) even as well as odd harmonics (D) None of the above

MHT-CET 2005

5. If the length of an open organ pipe is 33.3 cm, then the frequency of fifth overtone is ($v_{sound} = 333\ ms^{-1}$)
(A) 3000 Hz (B) 1500 Hz (C) 2500 Hz (D) 1250 Hz

6. Tuning fork A of frequency 305 Hz produces 5 beats s^{-1} with another tuning fork B. After filing tuning fork B, it produces 3 beats s^{-1} with A. The frequency of B before filing was
(A) 300 Hz (B) 313 Hz (C) 310 Hz (D) 308 Hz

7. Wavelength of wave is a distance between two particles which are differing in phase by
(A) π (B) 2π (C) $\frac{2\pi}{3}$ (D) $\frac{\pi}{3}$

8. The displacement of a particle performing simple harmonic motion is given by, $x = 8 \sin \omega t + 6 \cos \omega t$, where distance is in cm and time is in sec. The amplitude of motion is
(A) 10 cm (B) 2 cm (C) 14 cm (D) 3.5 cm

MHT–CET 2006

9. A note has a frequency 128 Hz. The frequency of a note two octaves higher than it is
(A) 256 Hz (B) 64 Hz (C) 32 Hz (D) 512 Hz

10. At a certain instant a stationary transverse wave is found to have maximum kinetic energy. The appearance of string at that instant is

(A) sinusoidal shape with amplitude $\frac{A}{3}$ (B) sinusoidal shape with amplitude $\frac{A}{2}$

(C) sinusoidal shape with amplitude A (D) straight line

11. A note has a frequency 128 Hz. The frequency of a note two octaves higher than it is

(A) 256 Hz (B) 64 Hz (C) 32 Hz (D) 512 Hz

MHT-CET 2007

12. A standing wave having 3 nodes and 2 antinodes is formed between two atoms having a distance 1.21 Å between them. The wavelength of the standing wave is

(A) 1.21 Å (B) 1.42 Å (C) 6.05 Å (D) 3.63 Å

13. A pulse of a wave train travels along a stretched string and reaches the fixed end of the string. It will be reflected with

(A) a phase change of 180° with velocity reversed

(B) the same phase as the incident pulse with no reversal of velocity

(C) a phase change of 180° with no reversal of velocity

(D) the same phase as the incident pulse but with velocity reversed

14. The displacement equation of a simple harmonic oscillator is given by

$y = A \sin \omega t - B \cos \omega t$ The amplitude of the oscillator will be

(A) A - B (B) A + B (C) $\sqrt{A^2 + B^2}$ (D) $(A^2 + B^2)$

MHT–CET 2008

15. The angle between particle velocity and wave velocity in a transverse wave is

(A) zero (B) $\pi/4$ (C) $\pi/2$ (D) π

MHT-CET 2009

16. Fundamental frequency of pipe is 100 Hz and other two frequencies are 300 Hz and 500 Hz, then

(A) pipe is open at both the ends

(B) pipe is closed at both the ends

(C) one end is open and another end is closed

(D) None of the above

17. In a resonance pipe the first and second resonances are obtained at depths 22.7 cm and 70.2 cm respectively. What will be the end correction?

(A) 1.05 cm (B) 115.5 cm (C) 92.5 cm (D) 113.5 cm

MHT–CET 2010

18. In sine wave, minimum distance between 2 particles always having same speed is

(A) (B) $\frac{\lambda}{4}$ (C) $\frac{\lambda}{3}$ (D) λ

19. The equation of a simple harmonic progressive wave is given by y = A sin (100 πt-3x). Find the distance between 2 particles having a phase difference of $\frac{\pi}{3}$.

(A) $\frac{\pi}{9}$m (B) $\frac{\pi}{18}$m (C) $\frac{\pi}{6}$m (D) $\frac{\pi}{3}$m

20. Two Cu wires of radii R_1 and R_2 are such that ($R_1 > R_2$). Then which of the following is true?
(A) Transverse wave travels faster in thicker wire
(B) Transverse wave travels faster in thinner wire
(C) Travels with the same speed in both the wire
(D) Does not travel

21. n_1 is the frequency of the pipe closed at one end and n_2 is the frequency of the pipe open at both ends. If both are joined end to end, find the fundamental frequency of closed pipe so formed

(A) $\frac{n_1n_2}{n_2+2n_1}$ (B) $\frac{n_1n_2}{2n_2+n_1}$ (C) $\frac{n_1+2n_2}{n_2n_1}$ (D) $\frac{2n_1+n_2}{n_2n_1}$

22. In the fundamental mode, time taken by the wave to reach the closed end of the air filled pipe is 0.01 s. The fundamental frequency is
(A) 25 (B) 12.5 (C) 20 (D) 15

MHT-CET 2011

23. In a resonance tube the first resonance with a tuning fork occurs at 16 cm and second at 49 cm. If the velocity of sound is 330 m/s, the frequency of tuning fork is
(A) 500 (B) 300 (C) 330 (D) 165

24. If the temperature increases, then what happens to the frequency of the sound produced by the organ pipe?
(A) increases (B) decreases (C) unchanged (D) not definite

25. For the stationary wave, y = 4 sin$\left(\frac{\pi x}{15}\right)$cos (96 πt), the distance between a node and the next antinode is
(A) 7.5 (B) 15 (C) 22.5 (D) 30

26. The equation of sound wave is y = 0.0015 sin (62.4x + 316 t). Find the wavelength of this wave
(A) 0.2 unit (B) 0.1 unit (C) 0.3 unit (D) None of these

MHT–CET 2013

27. A source of unknown frequency gives 4 beats s^{-1} when sounded with a source of known frequency 250 Hz. The second harmonic of the source of unknown frequency gives five beats per second when sounded with a source of frequency 513 Hz. The unknown frequency is
(A) 254 HZ (B) 246 Hz (C) 240 Hz (D) 260 Hz

28. A wave travelling in the positive X-direction having maximum displacement along Y-direction as 1 m, wavelength 2π m and frequency of $\frac{1}{\pi}$Hz is represented by

(A) y = sin(x - 2t) (B) y = sin(2πx - 2πt)
(C) y = sin (10πx - 20πt) (D) y = sin(2πx + 2πt)

29. If we study the vibration of a pipe open at both ends, then the following statements is not true.
(A) Open end will be antinode
(B) Odd harmonics of the fundamental frequency will be generated
(C) All harmonics of the fundamental frequency will be generated
(D) Pressure change will be maximum at both ends

MHT–CET 2014

30. When a wave travels in a medium, displacement of a particle is given by $y = a \sin 2\pi (bt - cx)$ where 'a', 'b', 'c' are constants. The maximum particle velocity will be twice the wave velocity if

(A) $b = ac$ (B) $b = \frac{1}{ac}$ (C) $c = \pi a$ (D) $c = \frac{1}{\pi a}$

MHT–CET 2015

31. The equation of the progressive wave is $y = a \sin 2\pi\left(nt - \frac{x}{5}\right)$. The ratio of maximum particle velocity to wave velocity is

(A) $\frac{\pi a}{5}$ (B) $\frac{2\pi a}{5}$ (C) $\frac{3\pi a}{5}$ (D) $\frac{4\pi a}{5}$

MHT-CET 2015

32. In sonometer experiment, the bridges are separated by a fixed distance. The wire which is slightly elastic, emits a tone of frequency 'n' when held by tension 'T'. If the tension is increased to '4T', the tone emitted by the wire will be of frequency
(A) n (B) 2n
(C) Slightly greater than 2n (D) Slightly less than 2n

33. An open and closed organ pipe have the same length. The ratio of 'p'th mode of frequency of vibration of air in two pipes is

(A) $p(2p+1)$ (B) $\frac{2p}{2p-1}$ (C) p (D) 1

34. In a pipe open at both ends, 'n_1' and 'n_2' be the frequencies corresponding to vibrating lengths 'ℓ_1' and 'ℓ_2' respectively. The end correction is

(A) $\frac{n_1\ell_2 - n_2\ell_1}{2(n_1 - n_2)}$ (B) $\frac{n_2\ell_2 - n_1\ell_1}{2(n_2 - n_1)}$ (C) $\frac{n_2\ell_2 - n_1\ell_1}{2(n_1 - n_2)}$ (D) $\frac{n_1\ell_1 - n_2\ell_2}{(n_1 - n_2)}$

35. The length and diameter of a metal wire is doubled The fundamental frequency of vibration will change from 'n' to (Tension being kept constant and material of both the wires is same)

(A) $\frac{n}{4}$ (B) $\frac{n}{8}$ (C) $\frac{n}{12}$ (D) $\frac{n}{16}$

MHT-CET 2016

36. Wire having tension 225 N produces six beats per second when it is tuned with a fork. When tension changes to 256 N, it is tuned with the same fork, the number of beats remain unchanged. The frequency of the fork will be
(A) 186 Hz (B) 225 Hz (C) 256 Hz (D) 280 Hz

37. Two strings A and B of same material are stretched by same tension. The radius of the string A is double the radius of string B. Transverse wave travels on string A with speed 'V_A' and on string B with speed 'V_B'. The ratio $\frac{V_A}{V_B}$ is

(A) $\frac{1}{4}$ (B) $\frac{1}{2}$ (C) 2 (D) 4

38. When open pipe is closed from one end then third overtone of closed pipe is higher in frequency by 150 Hz than second overtone of open pipe. The fundamental frequency of open end pipe will be

(A) 75 Hz (B) 150 Hz (C) 225 Hz (D) 300 Hz

39. If the end correction of an open pipe is 0.8 cm then the inner radius of that pipe will be

(A) $\frac{1}{3}$ cm (B) $\frac{2}{3}$ cm (C) $\frac{3}{2}$ cm (D) 0.2 cm

40. A progressive wave is represented by $y = 12 \sin (5t - 4x)$ cm. On this wave, how far away are the two points having phase difference of 90° ?

(A) $\frac{\pi}{2}$ cm (B) $\frac{\pi}{4}$ cm (C) $\frac{\pi}{8}$ cm (D) $\frac{\pi}{16}$ cm

MHT–CET 2017

41. The equation of the progressive wave is $Y = 3\sin\left[\pi\left(\frac{t}{3}-\frac{x}{5}\right)+\frac{\pi}{4}\right]$ where x and Y are in metre and time in second. Which of the following is correct?

(A) velocity V = 1.5 m/s (B) amplitude A = 3 cm
(C) frequency F = 0.2 Hz (D) wavelength λ = 10 m

42. The closed and open organ pipes have same length. When they are vibrating simultaneously in first overtone, produce three beats. The length of open pipe is made $\frac{1}{3}^{rd}$ and closed pipe is made three times the original, the number of beats produced will be

(A) 8 (B) 14 (C) 17 (D) 20

43. Two uniform wires of the same material are vibrating under the same tension. If the first overtone of the first wire is equal to the second overtone of the second wire and radius of the first wire is twice the radius of the second wire then the ratio of the lengths of the first wire to second wire is

(A) $\frac{1}{3}$ (B) $\frac{1}{4}$ (C) $\frac{1}{5}$ (D) $\frac{1}{6}$

44. In sonometer experiment, the string of length 'L' under tension vibrates in second overtone between two bridges. The amplitude of vibration is maximum at

(A) $\frac{L}{3}, \frac{2L}{3}, \frac{5L}{6}$ (B) $\frac{L}{8}, \frac{L}{4}, \frac{L}{2}$ (C) $\frac{L}{2}, \frac{L}{4}, \frac{L}{6}$ (D) $\frac{L}{6}, \frac{L}{2}, \frac{5L}{6}$

45. The fundamental frequency of an air column in a pipe closed at one end is 100 Hz. If the same pipe is open at both the ends, the frequencies produced in Hz are

(A) 100, 200, 300, 400, … (B) 100, 300, 500, 700, …
(C) 200, 300, 400, 500, … (D) 200, 400, 600, 800, …

MHT-CET 2018

46. A string is vibrating in its fifth overtone between two rigid supports 2.4 m apart. The distance between successive node and antinode is
(A) 0.1 m (B) 0.2 m (C) 0.6 m (D) 0.8 m

47. 'n' number of waves are produced on a string in 0.5 second. Now the tension in the string is doubled (Assume length and radius constant), the number of waves produced in 0.5 second for the same harmonic will be
(A) n (B) $\sqrt{2}$ n (C) $\frac{n}{\sqrt{2}}$ (D) $\frac{n}{\sqrt{5}}$

48. A pipe closed at one end has length 83 cm. The number of possible natural oscillations of air column whose frequencies lie below 1000 Hz are (velocity of sound in air = 332 m/s)
(A) 3 (B) 4 (C) 5 (D) 6

49. When source of sound moves towards a stationary observer, the wavelength of sound received by him
(A) decreases while frequency increases
(B) remains the same whereas frequency increases
(C) increases and frequency also increases
(D) decreases while frequency remains the same

MHT–CET 2019

50. A transverse wave is propagating on the string. The linear density of a vibrating string is 10^{-3} kg/m. The equation of the wave is $Y = 0.05 \sin(x + 15t)$ where x and Y are the metre and time in second. The tension in the string is
(A) 0.250 N (B) 0.325 N (C) 0.2 N (D) 0.225 N

51. The equation of simple harmonic progressive wave is given by $Y = a \sin 2\pi(bt - cx)$
The maximum particle velocity will be twice the wave velocity if
(A) $c = \frac{1}{\pi a}$ (B) $c = 2\pi a$ (C) $c = \frac{1}{2\pi a}$ (D) $c = \pi a$

52. For formation of beats, two sound notes must have
(A) different amplitudes and different frequencies
(B) nearly equal frequencies and equal amplitudes
(C) exactly equal frequencies only
(D) exactly equal amplitudes only

53. A simple harmonic progressive wave travelling through a medium is represented by $y = a \sin 2\pi\left(nt - \frac{x}{\lambda}\right)$. If the maximum velocity of particle of medium is 'P' times the wave velocity, then the wavelength 'λ' of the wave is given by
(A) $\frac{\pi a}{2P}$ (B) $P\pi a$ (C) $\frac{2\pi a}{P}$ (D) $\frac{\pi a}{P}$

54. A set of 25 tuning forks is arranged in order of decreasing frequencies. Each fork, produces 3 beats with succeeding one. If the first fork is octave of last, then the frequency of 1st and 15th fork in Hz is
(A) 144, 99 (B) 72, 99 (C) 144, 102 (D) 72, 102

55. The displacement of a particle from its mean position (in m) is given by $y = 0.4 \sin(5\pi t + 2.5\pi) \cos(5\pi t + 2.5\pi)$. The motion of the particle is
(A) non–periodic
(B) periodic but not S.H.M.
(C) S.H.M. with period 0.2 s
(D) S.H.M. with period 0.1 s

56. A simple harmonic progressive wave is represented as $y = 0.03 \sin \pi (2t - 0.01x)$ m. At a given instant of time, the phase difference between two particles 25 m apart is
(A) $\frac{\pi}{2}$ rad (B) $\frac{\pi}{4}$ rad (C) $\frac{\pi}{8}$ rad (D) π rad

57. Two open pipes of different lengths and of same diameter in which the air column vibrates with fundamental frequencies 'n_1' and 'n_2' respectively. When both pipes are joined to form a single pipe, its fundamental frequency will be
(A) $\frac{n_1 n_2}{2n_2 + n_1}$ (B) $\frac{n_1 n_2}{n_1 + n_2}$ (C) $\frac{n_1 + n_2}{n_1 n_2}$ (D) $\frac{2n_2 + n_1}{n_1 n_2}$

58. In fundamental mode, the time required for the sound wave to reach upto the closed end of a pipe filled with air is 't' second. The frequency of vibration of air column is
(A) $(2t)^{-1}$ (B) $2(t)^{-1}$ (C) $(4t)^{-1}$ (D) $4(t)^{-1}$

59. A stretched string fixed at both ends has 'm' nodes, then the length of the string will be
(A) $(m-2)\frac{\lambda}{2}$ (B) $\frac{(m+1)\lambda}{2}$ (C) $(m-1)\frac{\lambda}{2}$ (D) $\frac{m\lambda}{2}$

60. A stretched wire of length 260 cm is set into vibrations. It is divided into three segments whose frequencies are in the ratio 2 : 3 : 4 Their lengths must be
(A) 120 cm, 80 cm, 60 cm (B) 80cm, 60cm, 120cm
(C) 120 cm, 60 cm, 80 cm (D) 60cm, 80cm, 120cm

61. Find the wrong statement from the following about the equation of stationary wave given by $Y = 0.04 \cos(\pi x) \sin(50\pi t)$ m where t is in second. Then for the stationary wave
(A) Velocity = 50 m/s (B) Time period = 0.02 s
(C) Amplitude = 0.02 m (D) Wavelength = 2 m

62. The fundamental frequency of sonometer wire increases by 9 Hz. If its tension is increased by 69%, keeping the length constant. The frequency of the wire is
(A) 30 Hz (B) 36 Hz (C) 42 Hz (D) 24 Hz

63. A pipe open at both end and a pipe closed at one end have same length. The ratio of frequencies of their pth overtone is
(A) $\frac{p+1}{2p+1}$ (B) $\frac{p+1}{2p}$ (C) $\frac{2(p+1)}{2p+1}$ (D) $\frac{p}{2p+1}$

64. A sonometer wire is in unison with a tuning fork, when it is stretched by weight 'W' and the corresponding resonating length is 'L_1' If the weight is reduced to $\left(\frac{W}{4}\right)$, the corresponding resonating length becomes 'L_2'. The ratio $\left(\frac{L_1}{L_2}\right)$ is
(A) 4 : 1 (B) 1 : 4 (C) 2 : 1 (D) 1 : 2

65. If a resonance tube is immersed in water of density (ρ_w) and then in liquid of density (ρ_L) $\rho_L > \rho_W$, then its frequency in liquid will
(A) increase (B) decrease
(C) remain the same (D) depend on density of liquid

66. A sonometer wire is vibrating in third overtone. There are
(A) 4 nodes and 5 antinodes (B) 4 nodes and 4 antinodes
(C) 5 nodes and 4 antinodes (D) 5 nodes and 5 antinodes

67. An open pipe is suddenly closed so that the second overtone of the closed pipe is observed to be higher in frequency by 100 Hz than the first overtone of the original pipe. The fundamental frequency of the open end pipe will be
(A) 200 Hz (B) 50 Hz (C) 100 Hz (D) 300 Hz

68. A wire of length 'L' having tension 'T' and radius 'r' vibrates with natural frequency 'N'. Another wire of the same metal with length '2L' having tension '2T' and radius '2r' will vibrate with natural frequency
(A) $2\sqrt{2}N$ (B) $N/2\sqrt{2}$ (C) 2N (D) N

69. The end correction for a pipe closed at one end is 'e_1' and for an open pipe it is 'e_2'. The ratio $\frac{e_1}{e_2}$ is
(A) 2 : 1 (B) 4 : 1 (C) 1 : 4 (D) 1 : 2

70. A standing wave having 5 nodes and 4 antinodes is formed on the string stretched between two rigid supports separated by a distance 100 cm. What is the length of each loop of the standing wave?
(A) 25 cm (B) 20 cm (C) 50 cm (D) 40 cm

71. A closed and open organ pipe of same length produce 2 beats when they are set into vibrations simultaneously in their fundamental mode. The length of the open organ pipe is now halved and that of the closed pipe is doubled. The number of beats produced will be
(A) 7 (B) 8 (C) 5 (D) 9

72. An organ pipe open at both ends vibrate with frequency 'n' which is its xth overtone. When one end of the pipe is closed, it vibrates with frequency 'N' which is its yth overtone then N is

(A) $\frac{(2x+1)n}{2(y+1)}$ (B) $\frac{(y+1)}{(2x+1)n}$ (C) $\frac{(2y+1)n}{2(x+1)}$ (D) $\frac{(y+1)n}{2(2x+1)}$

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73. In resonance tube experiment, the first and second resonating length of air column is 0.2 m and 0.62 m respectively. The inner diameter of the tube is
(A) 3.33 cm (B) 0.2 cm (C) 0.4 cm (D) 0.33 cm

74. In sonometer experiment, the string of length 'L' under tension vibrates in second overtone between the two bridges. The amplitude of vibration is maximum at
(A) $\frac{L}{6}, \frac{L}{2}, \frac{5L}{6}$ (B) $\frac{L}{3}, \frac{2L}{3}, \frac{5L}{6}$ (C) $\frac{L}{2}, \frac{L}{4}, \frac{L}{6}$ (D) $\frac{L}{8}, \frac{L}{4}, \frac{L}{2}$

75. A sonometer wire is vibrating in third overtone. There are
(A) 4 nodes and 5 antinodes. (B) 3 nodes and 4 antinodes.
(C) 5 nodes and 4 antinodes. (D) 4 nodes and 3 antinodes

76. Length of an organ pipe open at both ends is 34 cm. If velocity of sound is 340 m/s, then the frequency of 2^{nd} overtone is
(A) 1000 Hz (B) 2000 Hz (C) 2400 Hz (D) 1500 Hz

77. The third overtone of a closed pipe is in unison with the second overtone of an open pipe. Hence the ratio of the length of the closed pipe to that of the open pipe is
(A) 3 : 2 (B) 1 : 2 (C) 7 : 6 (D) 6 : 7

78. Two identical wires of same length are vibrating in unison with a tuning fork, under same tension. The length of one wire is decreased by 1 cm and it produces 3 beats per second with the tuning fork. The length of other wire is increased by 1 cm and it produces 2 beats per second with the tuning fork. If the original length of wire is 67 cm, the frequency of the tuning fork is
(A) 166 Hz (B) 167 Hz (C) 165 Hz (D) 168 Hz

79. The wave described by $y = 0.35 \sin(2\pi t - 10\pi x)$, where x and y are in metre and t in second, is a wave travelling along the
(A) negative x-direction with amplitude 0.35 m and wavelength $\lambda = 0.5$ m
(B) positive x-direction with frequency 1 Hz and wavelength $\lambda = 0.2$ m
(C) positive x-direction with frequency 1 Hz and amplitude 3.5 m
(D) negative x-direction with frequency π Hz and wavelength $\lambda = 0.5$ m

80. A wire of density 9000 kg/m^3 and Young's modulus 9×10^{10} N/m^2 is stretched between two clamps 1m apart and subjected to an extension 4.9×10^{-4}m. The lowest frequency of transverse vibrations set up in the wire is
(A) 20 Hz (B) 25 Hz (C) 35 Hz (D) 30 Hz

81. When a sonometer wire vibrates in the third overtone, there are
(A) 6 nodes and 5 antinodes. (B) 5 nodes and 4 antinodes.
(C) 4 nodes and 5 antinodes. (D) 4 nodes and 3 antinodes.

82. A simple harmonic porogressive wave is givne by $Y = Y_0 \sin 2\pi\left(nt - \frac{x}{\lambda}\right)$. If the wave velcoity is $\left(\frac{1}{8}\right)^{th}$ of the maximum particle velocity, then the wavelengh is
(A) $\pi Y_0/2$ (B) $\pi Y_0/16$ (C) $\pi Y_0/8$ (D) $\pi Y_0/4$

83. The lengths of a given open end pipe and a closed end pipe are 'L_o' and 'L_c' respectively. If both the pipes emit same fundamental notes, then the ratio L_o:L_c is
(A) 1 : 2 (B) $1 : \sqrt{2}$ (C) $\sqrt{2} : 1$ (D) 2 : 1

84. For a certain organ pipe, three successive resonant frequencies are heard as 300 Hz, 420 Hz and 540 Hz. If the speed of sound in air is 360 m/s, then the pipe is a
(A) closed pipe of 1.5 m length. (B) closed pipe of 3 m length.
(C) open pipe of 1.5 m length. (D) open pipe of 3 m length.

85. A resonance tube closed at one end is of height 1.5 m. A tuning fork of frequency 340 Hz is vibrating above the tube. Water is poured in the tube gradually. The minimum height of water for which resonance is obtained is (Neglect end correction. Speed of sound in air = 340 m/s)
(A) 25 cm (B) 125 cm (C) 150 cm (D) 5 cm

86. A transverse wave propagating along the string is $y = 0.3 \sin(x + 20t)$ where x, y are in metre and t in second. The linear density of the string is 1.2×10^{-4} kg/m. The tension in the string is
(A) 0.072 N (B) 0.024 N (C) 0.096 N (D) 0.048 N

87. Two open pipes 'A' and 'B' have same length but their diameters are 5 cm and 2 cm respectively. Their fundamental frequencies n_A and n_B are related as
(A) $n_A = n_B$ (B) $n_A > n_B$ (C) $n_A < n_B$ (D) $n_A = \frac{5}{3} n_B$

88. If the tension in a sonometer wire is increased by a factor of four, the fundamental frequency (n) of vibration will become
(A) 2n (B) 4n (C) $\left(\frac{1}{2}\right)$n (D) $\left(\frac{1}{4}\right)$n

89. 'n' number of waves are produced on a string in 0.5 second. Now the tension in a string is doubled (Keeping radius constant). The number of waves produced in 0.5 second for the same harmonic will be

(A) $\sqrt{2}\,n$ (B) $\frac{\sqrt{2}}{n}$ (C) $\frac{n}{\sqrt{2}}$ (D) n

90. The resonance tube is filled with a liquid of density higher than that of water, then resonating frequency

(A) will not change (B) may increase or decrease.
(C) will decrease. (D) will increase.

91. The two waves are represented by $Y_1 = 10^{-2}\sin\left[50t+\frac{x}{25}+0.3\right]$m and $Y_2 = 10^{-2}\cos\left[50t+\frac{x}{25}\right]$m where x is in metre and time in second. The phase difference between the two waves is nearly

(A) 1.22 rad (B) 1.05 rad (C) 1.15 rad (D) 1.27 rad

92. A stretched string under tension fixed at both ends vibrates in 4th harmonic. The equation of the stationary wave is Y = 3 sin(200πt) cos(0.4x) where x and y are in cm and t in second. The length of the vibrating string is

(A) 4 π (B) 8 π (C) 6 π (D) 10 π

93. The string of length 'ℓ' is vibrating between two bridges. The length of the string for first harmonic will be (λ = wavelength of the wave)

(A) $\frac{3\lambda}{4}$ (B) λ (C) $\frac{\lambda}{2}$ (D) $\frac{\lambda}{4}$

94. A pipe closed at one end produces a fundamental note of frequency 'ν'. It is cut into two pipes of equal length. The fundamental frequencies produced in the two pipes are

(A) $\frac{\nu}{2}, 2\nu$ (B) $\nu, 2\nu$ (C) $2\nu, 4\nu$ (D) $\frac{\nu}{2}, \nu$

95. In Melde's experiment, when wire is stretched by empty pan, four loops are obtained and when six gram weight is added in the pan, the number of loops becomes one. The mass of pan is

(A) 1.2 gram (B) 1.5 gram (C) 0.8 gram (D) 0.4 gram

96. The 4th overtone of a closed organ pipe is in unison with 2nd overtone of an open pipe. The ratio of the length of the open pipe to length of closed pipe is

(A) 3 : 2 (B) 2 : 1 (C) 2 : 3 (D) 1 : 2

97. A wire is under tension of 2 kg wt. and a wave is travelling through it with some speed. The tension in the wire is so increased that the wave travels through it with thrice the initial speed. The increase in tension is

(A) 20 kg wt. (B) 8 kg wt. (C) 16 kg wt. (D) 4 kg wt.

98. A pipe closed at one end has length 0.8 cm. 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 50 N and the speed of sound is 320 m/s, the mass of the string is

(A) 2 gram (B) 8 gram (C) 4 gram (D) 10 gram

99. The 3rd overtone of a closed organ pipe is in unison with 3rd overtone of an open pipe. The ratio of the length of the closed pipe to length of open pipe is

(A) $\frac{6}{5}$ (B) $\frac{4}{3}$ (C) $\frac{7}{9}$ (D) $\frac{7}{8}$

100.A simple harmonic progressive wave is represented as $Y = A \sin 2\pi\left(nt - \frac{\pi}{\lambda}\right)$cm. If the maximum particle velocity is four times the wave velocity, then the wavelength of the wave is

(A) $\frac{\pi A}{2}$ (B) $4\pi A$ (C) $2\pi A$ (D) $\frac{\pi A}{4}$

101.The equation of vibration of a stretched string fixed at both ends and vibrating in 5th harmonic is $Y = 3 \sin(0.4x) \cos(200\pi t)$ where 'x' and 'Y' are in cm and t in second. Length of the string is

(A) $(12.5)\pi$ cm (B) $(10.5)\pi$ cm (C) $(8.5)\pi$ cm (D) $(4.5)\pi$ cm

102.The speed of a wave in a certain medium is 960 m/s. If 900 waves pass over a certain point of the medium in half a minute, the wavelength of the wave is

(A) 16 m (B) 32 m (C) 9 m (D) 18 m

103.A resonance tube completely filled with water has small hole at the bottom. Length of the tube is 0.8 m. A vibrating tuning fork of frequency 500 Hz is held near the open end of tube. Water is slowly removed from the bottom. The maximum number of resonances heard will be (Neglect end correction. Speed of sound in air = 340 m/s)

(A) 2 (B) 5 (C) 3 (D) 4

104.An open organ pipe and a closed organ pipe have the frequency of their first overtone identical. The ratio of length of open pipe to that of closed pipe is

(A) 3 : 4 (B) 2 : 1 (C) 1 : 2 (D) 4 : 3

105.When tension 'T' is applied to a sonometer wire of length 'ℓ', it vibrates with fundamental frequency 'n'. Keeping the experimental setup same, when the tension is increased by 8 newton, the fundamental frequency becomes three times the earlier fundamental frequency (n). The initial tension applied to the wire in newton, was

(A) 2.5 (B) 0.5 (C) 1.0 (D) 2.0

106.A sonometer wire under suitable tension having specific gravity 'ρ' vibrates with frequency 'n' in air. If the load is completely immersed in water the frequency of vibration of wire will become

(A) $\left[\frac{\rho-1}{n\rho}\right]^{\frac{1}{2}}$ (B) $\left[\frac{n\rho}{\rho-1}\right]^{\frac{1}{2}}$ (C) $n\left[\frac{\rho-1}{\rho}\right]^{\frac{1}{2}}$ (D) $n\left[\frac{\rho}{\rho-1}\right]^{\frac{1}{2}}$

107.When open pipe is closed from one end then third overtone of closed pipe is higher in frequency by 150 Hz than second overtone of open pipe. The fundamental frequency of open end pipe will be

(A) 300 Hz (B) 500 Hz (C) 200 Hz (D) 400 Hz

108.Two identical strings of length 'ℓ' and '2ℓ' vibrate with fundamental frequencies 'N" hertz and '1.5 N' hertz, respectively. The ratio of tensions for smaller length to larger

(A) 1 : 9 (B) 9 : 1 (C) 1 : 3 (D) 3 : 1

109.Two waves $Y_1 = 0.25 \sin 316\, t$ and
$Y_2 = 0.25 \sin 310\, t$

Are propagating along the same direction. The number of beats produced per second are

(A) $\frac{3}{\pi}$ (B) $\frac{\pi}{2}$ (C) $\frac{\pi}{3}$ (D) $\frac{2}{\pi}$

110. The extension in a wire obeying Hooke's law is 'x'. The speed of sound in the stretched wire is 'V'. If the extension in the wire is increased to 4x, then the speed of sound in a wire is
(A) 2.5 V (B) 1.5 V (C) V (D) 2V

111. The fundamental frequency of open pipe is 'n'. If it is closed from one end then frequency of the 2^{nd} harmonic of closed pipe is higher by 200 Hz than 'n'. The value of 'n' is
(A) 400 Hz (B) 100 Hz (C) 200 Hz (D) 800 Hz

112. The correct statement about stationary wave is that
(A) displacement at antinode is minimum
(B) displacement at node is maximum
(C) displacement at node is maximum and at antinode is zero
(D) displacement at node is zero and at antinode is maximum

113. In a resonance tube experiment, a tuning fork resonates with air column of length 12 cm and again resonates when air column is 38 cm long. The end correction will be
(A) 0.25 cm (B) 0.75 cm (C) 1 cm (D) 0.5 cm

114. In resonance tube of length 0.8 m, air column vibrates with a source of frequency 375 Hz for a certain height of water from bottom of the tube. Water level corresponding to fundamental frequency is
(Neglect end correction, speed of sound in air = 330 m/s)
(A) 0.8 m (B) 0.58 m (C) 0.45 m (D) 0.65 m

115. A stretched uniform wire of length L under tension T is vibrating with frequency 'n'. A closed pipe of same length is also vibrating with same fundamental frequency 'n'. If T is increased by 16 N, it is in resonance with 2^{nd} harmonic of same closed pipe. The initial tension in the wire is
(A) 2N (B) 1 N (C) 1.5 N (D) 0.5 N

116. If we add 3 kg load to the hanger of sonometer, the fundamental frequency becomes two times its initial value. The initial load must be
(A) 1.5 kg (B) 1 kg (C) 2 kg (D) 2.5 kg

117. A transverse wave is travelling with velocity 'V' through a metal wire of length 'L' and density 'ρ'. The tensile stress on the wire is
(A) $V^2\rho$ (B) $V\rho^2$ (C) $V\rho$ (D) $\frac{V}{\rho}$

118. An air column in a pipe which is closed at one end will be in resonance with a vibrating tuning fork of frequency 415 Hz for various lengths. Which one of the following length is NOT possible : (V = 332 m/s, neglect end correction)
(A) 100 cm (B) 60 cm (C) 40 cm (D) 20 cm

119. If we want to increase the frequency of transverse oscillations of a stretched string by 40%, the tension must be increased by
(A) 140% (B) 96% (C) 40% (D) 100%

120. A sonometer wire of length 'ℓ_1' is in resonance with a frequency 250 Hz. If the length of wire is increased to 'ℓ_2', then 2 beats per second are heard. The ratio of lengths $\frac{\ell_1}{\ell_2}$ of wire will be
(A) 1 : 250 (B) 1 : 2 (C) 2 : 1 (D) 124 : 125

121.A tuning fork of frequency 340 Hz is held vibrating at the open end of an empty measuring cylinder of length 100 cm. Water is then poured in it slowly. What is the minimum height of water in cylinder, for which resonance will be obtained?
Velocity of sound in air = 340 m/s, Neglect end correction.
(A) 25 cm (B) 75 cm (C) 80 cm (D) 50 cm

122.If the ratio of amplitudes of two sound waves is 4 : 3, then the ratio of maximum and minimum intensities is
(A) 7 : 1 (B) 49 : 1 (C) 1 : 49 (D) 1 : 7

123.The length and diameter of a metal wire used in sonometer is doubled. The fundamental frequency will change from 'n' to
(A) $\frac{n}{8}$ (B) $\frac{n}{2}$ (C) $\frac{n}{4}$ (D) $\frac{n}{16}$

124.A pipe closed at one end has length 1m and at its open end, 0.25 m long uniform string is vibrating in its third harmonic and resonates with fundamental frequency of pipe. If the tension in the string is 100 N and speed of sound is 340 $\frac{m}{s}$, then mass of the string is nearly
(A) 125 gram (B) 200 gram (C) 150 gram (D) 175 gram

125.A wire of radius 'r', density 'δ', stretched between the bridges 'L' unit apart, is subjected to an extension 'ℓ'. The lowest frequency of transverse vibration in the wire (n) is
Y = Young's modulus of material of the wire
(A) $\frac{1}{2L^2}\sqrt{\frac{Y\ell}{\delta}}$ (B) $\frac{Y}{L}\sqrt{\frac{\ell}{\delta L}}$ (C) $\frac{1}{L}\sqrt{\frac{Y\ell}{\delta L}}$ (D) $\frac{1}{2L}\sqrt{\frac{Y\ell}{\delta L}}$

126.A transverse wave of ampliltude 0.05 m and frquency 250 Hz is travelling along a stretched string with a speed of 100 m/s. What would be the displacement of a particle at a distance 1.1 m origin after 0.02 second?
$\left[\sin\frac{\pi}{2}=1, \cos\frac{\pi}{2}=0\right]$
(A) 0.1 m (B) 0.15 m (C) 0.05 m (D) 0.02 m

127.An organ pipe has fundamental frequency 100 Hz. If its one end is closed, the frequencies produced will be
(A) 100, 200, 300, ... Hz (B) 50, 100, 200, ... Hz
(C) 50, 150, 250, ... Hz (D) 50, 100, 150, 200, ... Hz

128.Two waves are represented by y_1 = A sin $\left(\omega t+\frac{\pi}{6}\right)$ and y_2 = A cos ωt. Their resultant amplitudeis given by (sin 30° = cos 60° = 0.5)
(A) A (B) $\sqrt{3}$ A (C) $\sqrt{2}$ A (D) 2 A

129.The equation of stationary wave on a string clamped at both ends and vibrating in third harmonic is given by y = 0.5 sin (0.314 x) cos (600 πt), where x and y are in cm and t in second. The length of the vibrating string is (π = 3.14)
(A) 15 cm (B) 40 cm (C) 10 cm (D) 30 cm

130.In a stationary wave all particles
(A) vibrate in S.H.M. of same period and same amplitude.
(B) vibrate in S.H.M. of different periods and different amplitudes.
(C) except at nodes vibrate in S.H.M. of same period but of different amplitudes.
(D) except at nodes vibrate in S.H.M. of same period and same amplitude.

131. The fundamental frequency of a wire stretched by 2 kg wt. is 100 Hz. The weight required to produce its octave will be

(A) 12 kg wt (B) 16 kg wt (C) 4 kg wt (D) 8 kg wt

132. A string of length 'L' and linear density 'm' has a fundamental frequency 'n' when stretched by tension 'T'. The fundamental frequency of another string having double the length and double linear density, when same tension is applied is

(A) $\frac{n}{2}$ (B) $\frac{n}{2\sqrt{2}}$ (C) $\frac{n}{\sqrt{2}}$ (D) 2n

133. The fundamental frequency of a string stretched with a weight 'M' kg is 'n' hertz. Keeping the vibrating length constant, the weight required to produce its octave is

(A) M (B) 4M (C) 2 M (D) 8 M

134. A uniform wire has length 'L' and weight 'W'. One end of the wire is attached rigidly to a point in the roof and weight 'W_1' is suspended from its lower end. If 'A' is the cross-sectional area of the wire then the stress in the wire at a height $\frac{3L}{4}$ from its lower end is

(A) $\frac{3W_1-4W}{2A}$ (B) $\frac{4W_1-3W}{4A}$ (C) $\frac{4W_1+3W}{4A}$ (D) $\frac{3W_1+4W}{2A}$

135. A note produces 4 beat/s with a tuning fork of frequency 510 Hz and 6 beat/s with a fork of frequency 512 Hz. The frequency of the note is

(A) 518 Hz (B) 506 Hz (C) 510 Hz (D) 514 Hz

136. In resonance tube, the first and second resonance are heard when water level is 24.1 cm and 74.1 cm respectively, below the open end of the tube. The inner diameter of the tube is

(A) 2 cm (B) 5 cm (C) 4 cm (D) 3 cm

137. The length and diameter of a metal wire used in sonometer experiment is doubled. The fundamental frequency will change from 'n' to

(A) 4 n (B) 2 n (C) $\frac{n}{4}$ (D) $\frac{n}{2}$

138. The sequence of harmonics of a pipe open at one end and closed at the other end is 250 Hz and 350 Hz, The resonating length of the air column in its fundamental mode will be (Velocity of sound in air = 340 m/s)

(A) 0.25 m (B) 0.85 m (C) 1.7 m (D) 1.35 m

139. A transverse wave Y = 2 sin (0.01 x + 30 t) moves on a stretched string from one end to another end in 0.5 s. If x and Y are in cm and t in second, then the length of the string is

(A) 20 m (B) 15 cm (C) 10 m (D) 5 m

140. If the length and diameter of a wire are decreased, then for the same tension the natural frequency of stretched wire will

(A) decrease (B) become zero (C) increase (D) not change

141. Two waves given as $y_1 = 10 \sin \omega t$ cm and $y_2 = 10 \sin\left(\omega t + \frac{\pi}{3}\right)$ cm are superimposed. What is the amplitude of the resultant wave? $\left[\cos\frac{\pi}{3} = \frac{1}{2}\right]$

(A) $10\sqrt{2}$ cm (B) $5\sqrt{3}$ cm (C) $10\sqrt{3}$ cm (D) 10 cm

142.A given metal wire has length 1m, linear density 0.6 kg/m and uniform cross-sectional area 10^{-7} m^2 is fixed at both ends. The temperature of wire is decreased by 40°C. The fundamental frequency of the transverse wave is
$Y = 2 \times 10^{11}$ N/m^2, coefficient of linear expansion of metal is = 1.2×10^{-5} /°C
(A) 2 Hz (B) 2.5 Hz (C) 1 Hz (D) 0.5 Hz

143.In a transverse progressive wave of amplitude 'a', the maximum particle velocity is six times its wave velocity. The wavelength of wave is
(A) $6\pi a$ (B) $3\pi a$ (C) $\frac{\pi a}{3}$ (D) $\frac{\pi a}{6}$

144.A pipe open at both ends has length 1m. The air column in the pipe can not resonate for a frequency (Neglect end correction; speed of sound in air = 340 m/s)
(A) 510 Hz (B) 170 Hz (C) 85 Hz (D) 340 Hz

145.Two strings of same material having lengths as 'L', '2L', and radii '2r', 'r' respectively, are vibrating in the fundamental mode. Tension applied to both the strings is same. The ratio of their respective fundamental frequencies is
(A) 1 : 2 (B) 4 : 3 (C) 1 : 1 (D) 3 : 4

146.A stationary wave is represented by $y = 10\sin\frac{\pi x}{4}\cos 20\pi t$ where 'x' and 'y' are expressed in cm and 't' in second. Distance between two consecutive nodes is
(A) 1 cm (B) 2 cm (C) 4 cm (D) 8 cm

147.On closing an open organ pipe from one end, it is noticed that the frequency of third harmonic is 50 Hz more than the fundamental frequency of vibration in open organ pipe. The fundamental frequency of open organ pipe is
(A) 250 Hz (B) 100 Hz (C) 50 Hz (D) 200 Hz

148.The frequency of two tuning forks A and B are 1.5% more and 2.5% less than that of the tuning fork C. When A and B are sounded together, 12 beats are produced in 1 second. The frequency of tuning fork C is
(A) 300 Hz (B) 240 Hz (C) 360 Hz (D) 200 Hz

149.A pipe open at one end has length 0.8 m. At the open end of the tube a string 0.5 m long is vibrating in its 1st overtone and resonates with fundamental frequency of pipe. If tension in the string is 50N, the mass of string is (speed of sound = 320 m/s)
(A) 15 gram (B) 20 gram (C) 10 gram (D) 25 gram

150.Two identical wires are vibrating in unison. If the tension in one of the wires is increased by 2%, five beats are produced per second by the two vibrating wires. The initial frequency of each wire is $\left(\sqrt{1\cdot 0.2} \doteqdot 1\cdot 0.1\right)$
(A) 500 Hz (B) 200 Hz (C) 1000 Hz (C) 400 Hz

151.Two progressive waves $Y_1 = \sin 2\pi\left(\frac{t}{0.4} - \frac{x}{4}\right)$ and $Y_2 = \sin 2\pi\left(\frac{t}{0.4} + \frac{x}{4}\right)$ superpose to form a standing wave. x, Y_1 and Y_2 are in SI system. Amplitude of the particle at x = 0.5 m is $\left[\sin 45° = \cos 45° = \frac{1}{\sqrt{2}}\right]$
(A) $2\sqrt{2}$ m (B) 2 m (C) $\frac{1}{\sqrt{2}}$ m (D) $\sqrt{2}$ m

152.In melde's experiment, when the tension decreases by 0.009 kg-wt, the number of loops changes from 4 to 5. The initial tension is
(A) 0.025 kg-wt (B) 0.036 kg-wt (C) 0.009 kg-wt (D) 0.018 kg-wt

153.A closed organ pipe and an open organ pipe have their first overtones identical in frequency. Their lengths are in the ratio
(A) 3 : 4 (B) 2 : 3 (C) 1 : 2 (D) 4 : 5

154.Two identical progressive waves moving in opposite direction superimpose to produce a stationary wave. The wavelength of each progressive wave is 'λ'. The wavelength of the stationary wave is
(A) $\frac{\lambda}{4}$ (B) 2λ (C) $\frac{\lambda}{2}$ (D) λ

155.The air column in an organ pipe closed at one end is made to vibrate so that there are 2 nodes and antinodes each. The mode of vibration is called
(A) fundamental (B) 2nd overtone (C) 3rd overtone (D) 1st overtone

156.In fundamental mode, the time required for the sound wave to reach upto to closed end of a pipe filled with air is 't' second. The frequency of vibration of air column is
(A) $\frac{1}{4t}$ (B) $\frac{1}{t}$ (C) $\frac{1}{3t}$ (D) $\frac{1}{2t}$

157.A sonometer wire resonates with a given tuning fork forming standing wave with 5 antinodes between two bridges when mass of 9 kg is suspended from the wire. When mass 'm' is suspended from the wire, with same fork and same length between two bridges 3 antinodes are formed. Mass m is
(A) 20 kg (B) 10 kg (C) 15 kg (D) 25 kg

158.Two wires of same material are vibrating under the same tension. If the first overtone of first wire is equal to the second overtone of second wire and radius of first wire is twice the radius of the second then the ratio of length of first wire to second wire is
(A) 1 : 3 (B) 3 : 1 (C) 2 : 1 (D) 1 : 2

159.Two open organ pipes of fundamental frequencies n_1 and n_2 are joined in series. The fundamental frequency of the new pipe is
(A) $\frac{n_1+n_2}{n_1n_2}$ (B) $\frac{1}{n_1n_2}$ (C) $\frac{n_1n_2}{(n_1+n_2)}$ (D) n_1-n_2

160.A tuning fork 'A' produces 5 beats per second with a tuning fork of frequency 480 Hz. When a little wax is stuck to a prong of fork A, the number of beats heard per second becomes 2. What is the frequency of tuning fork A before the wax is stuck to it?
(A) 475 Hz (B) 482 Hz (C) 478 Hz (D) 485 Hz

161.A uniform metal wire has length 'L', mass 'M' and density 'ρ'. It is under tension 'T' and 'v' is the speed of transverse wave along the wire. The area of cross-section A of the wire is
(A) $T^2\rho V$ (B) $\frac{v^2\rho}{T}$ (C) $\frac{T}{v^2\rho}$ (D) $Tv^2\rho$

162.At the poles, a stretched wire of a given length vibrates in unison with a tuning fork. At the equator, for same setting to produce resonance with same fork, the vibrating length of wire
(A) should be decreased (B) should be increased
(C) should be 3 times the original length (D) should be same

163. What should be the length of a closed pipe to produce resonance with sound wave of wavelength 62 cm, in fundamental mode? Neglect end correction

(A) 31 cm (B) 20.6 cm (C) 15.5 cm (D) 46.5 cm

164. The fundamental frequency of a sonometer wire is 50 Hz for some length and tension. If the length is increased by 25% keeping tension same, then frequency change of second harmonic is

(A) decreased by 10% (B) decreased by 15%
(C) decreased by 5% (D) decreased by 20%

165. The equation of simple harmonic wave is given as $y = 5\sin\frac{\pi}{2}(100t - x)$, where 'x' and 'y' are in metre and time in second. The period of the wave is

(A) 0.02 s (B) 25 s (C) 0.04 s (D) 5 s

166. Two progressive waves are travelling towards each other with velocity 50 m/s and frequency 200 Hz. The distance between two consecutive antinodes is

(A) 0.125 m (B) 0.031 m (C) 0.250 m (D) 0.0625 m

167. A stationary sound wave has a frequency of 165 Hz. If the speed of sound in air is 330 m/s, then the distance between a node and the adjacent antinode is

(A) 20 cm (B) 2 cm (C) 80 cm (D) 50 cm

SOLUTIONS

1. (B)

Phase difference $= \frac{2\pi}{\lambda} \times$ Path difference.

Phase difference between any two particles in a wave determines lack of harmony in the vibrating state of two particles i.e. how for one particle leads the other or lags behind the other.

From relation, $\Delta\phi = \frac{2\pi}{\lambda} \times \Delta x \Rightarrow \Delta x = \frac{\lambda}{2\pi} \times \Delta\phi$ ...(i)

Also, $\lambda = \frac{v}{n}$ ...(ii)

Now, from Eqs. (i) and (ii), we get

$$\Delta x = \frac{v}{2\pi n} \times \Delta\phi = \frac{330}{2\pi \times 50} \times \frac{\pi}{3} = 1.1\text{m}$$

2. (C)

Phase difference between any two particles in a wave determines lack of harmony in the vibrating state of two particles, i.e. how far one particle leads the other or lags behind the other.

Relation of path difference and phase difference is given by $\Delta\phi = \frac{2\pi}{\lambda} \times \Delta x$, where Δx is path difference.

But path difference between two crests, $\Delta x = \lambda$

Hence, $\Delta\phi = \frac{2\pi}{\lambda} \times \lambda = 2\pi$

3. (C)

The transverse vibrations of a string are determined by Melde's method.

The frequency of vibration of a string of length ℓ, mass per unit length m and vibrating in p loops under tension T is given by

$$n = \frac{p}{2\ell}\sqrt{\frac{T}{m}} \Rightarrow p\sqrt{T} = \text{constant}$$

If n, l and m are constant.

Hence, $T \propto \frac{1}{p^2} \Rightarrow \frac{T_1}{T_2} = \frac{p_2^2}{p_1^2}$

or $\frac{(50+15)}{T_2} = \frac{(6)^2}{(4)^2} \Rightarrow \frac{65}{T_2} = \frac{36}{16}$

$\therefore \quad T_2 = \frac{65 \times 16}{36} = 29g$

So, weight removed from the pan = 65 − 29 = 36 g = 0.036 kg−wt

4. (A)

Wavelength of closed organ pipe is, $\lambda = \frac{4L}{(2n-1)}$

Putting n = 1,2,3… we find that $\lambda_1 = 4L, \frac{4L}{3}, \frac{4L}{5}, ...$

So, frequency of vibration corresponding to modes n = 1, 2, 3, … is

$$v_1 = \frac{v}{\lambda_1} = \frac{v}{4L} = v_1$$

$$v_2 = \frac{v}{\lambda_2} = \frac{v}{4L/3} = \frac{3v}{4L} = 3v_1$$

$$v_3 = \frac{v}{\lambda_3} = \frac{v}{4L/5} = \frac{5v}{4L} = 5v_1$$

$\therefore \quad v_1 : v_2 : v_3 ...... = 1 : 3 : 5 : ...$

So, only odd harmonics are present.

5. (A)

Wavelength of vibration in open organ pipe is given by $\lambda = \frac{2L}{n}$,

where, n = 1, 2, 3, …

Let λ_1 be the wavelength of stationary waves set up in the open organ pipe corresponding to n=1.

$$\lambda_1 = \frac{2L}{1} \Rightarrow L = \frac{\lambda_1}{2}$$

The frequency of vibration in this mode is given by

$$v_1 = \frac{v}{\lambda_1} = \frac{v}{2L} \Rightarrow v_1 = \frac{v}{2L}$$

Similarly for n = 2, $v_2 = \frac{2v}{2L} = 2v_1$

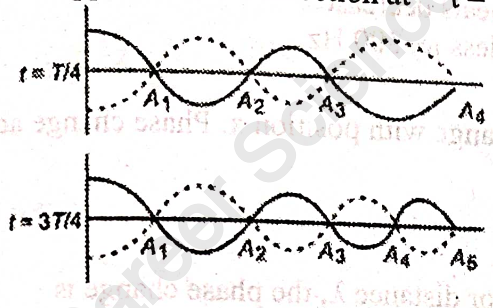
for n = 3, $v_3 = \frac{3v}{2L} = 3v_1$

In general, the frequency of vibration in n^{th} normal mode of vibration in open organ pipe would be, $v_n = nv_1$

Hence, frequency of fifth overtone

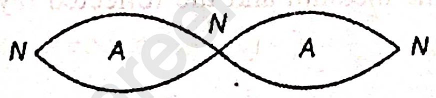
$$= 6 \times \text{fundamental frequency} = 6 \times \frac{v}{2L} = \frac{6 \times 333}{2 \times 33.3 \times 10^{-2}} = 3000 \text{ Hz}$$

6. (A)
At instant $t = T/4$ and $t = 3T/4$, the incident wave travels a distance $3\lambda/4$ to the right and the reflected wave travels the same distance on the string to the left. The equivalent path difference between the waves is $\lambda/2$ or $3\lambda/2$. Therefore, crest of one wave falls on through of the other and vice-versa. The resultant displacement at all points is zero and is represented by thick horizontal line in figure. Thus, all the particles are passing simultaneously through their mean position, but in direction opposite to the direction at $t = T/4$.



7. (D)
A series of notes arranged, such that their fundamental frequencies have definite ratios is called a musical scale.
In 1588, Zarlino constructed a musical scale by introducing six notes between an octave. These eight notes constitute major diatonic scale. The first note or the note of the lowest frequency is called keynote and ratio of the frequencies of the two notes is called interval between them. It means two octaves higher means four times the given frequency.
$\therefore$ Required frequency $= 4 \times 128 = 512$ Hz

8. (A)
The given standing wave has 2 segments.
The given standing wave is shown in the figure.



As length of one loop of segment is $2\left(\dfrac{\lambda}{2}\right)$.

$$\therefore \qquad 2\frac{\lambda}{2} = 1.21\ \text{Å} \ \Rightarrow \ \lambda = 1.21\ \text{Å}$$

9. (D)
The sum of the intervals between adjacent notes of the major diatonic scale is an octave.
A series of notes arranged, such that their fundamental frequencies have definite ratios is called a musical scale.
In 1588, Zarlino constructed a musical scale by introducing six notes between an octave. These eight notes constitute major diatonic scale. The first note or the note of the lowest frequency is called keynote and ratio of the frequencies of the two notes is called interval between them.
It means two octaves higher means four times the given frequency.
$\therefore$ Required frequency $= 4 \times 128 = 512$ Hz

10. (A)
The phenomenon of beats is used in the determination of unknown frequencies.
Suppose v_2 is the unknown frequency of a tuning fork B.
Let this fork B produce m beats per second with another tuning fork A of known frequency v_1,
As number of beats/s is equal to difference in frequency of two sources.
Therefore, $\qquad v_2 = v_1 \pm m.$

When the prong of fork B is filed a little, it becomes lighter and its frequency of vibration increases on sounding the filed fork B with fork A, we count the number of beats s^{-1}. Proceeding as, we conclude that, if number of beats s^{-1} on filing fork B of unknown frequency increases, m would be positive and vice-versa.

So, frequency of tuning fork B

$$= 305 \pm 5 = 310 \text{ Hz}, 300 \text{ Hz}$$

Since, on filing tuning fork B, number of beats decreases.

This means that frequency of B should be less ie, 300 Hz.

11. (B)

At a given time (t = constant) the phase change with position x. Phase change at a given time for a distance Δx is

$$\Delta\phi = \frac{2\pi}{\lambda} \times \Delta x$$

As, the distance between two crests is λ. For distance λ, the phase change is

$$\Delta\phi = \frac{2\pi}{\lambda} \cdot \lambda = 2\pi$$

12. (A)

A harmonic oscillation of constant amplitude and of single frequency is called simple harmonic oscillation.

Here, $x = 8 \sin \omega t + 6 \cos \omega t$

So, $a_1 = 8$ cm and $a_2 = 6$ cm

$\therefore$ Amplitude of motion $A = \sqrt{a_1^2 + a_2^2} = \sqrt{8^2 + 6^2} = \sqrt{64 + 36} = \sqrt{100} = 10 \text{cm}$

13. (C)

A pulse of a wave train when travels along a stretched string and reaches the fixed end of the string, then it will be reflected back to the same medium and the reflected ray suffers a phase change of π

14. (C)

Displacement equation, $y = A \sin \omega t - B \cos \omega t$

Let $A = a \cos \theta$ and $B = a \sin \theta$

So, $A^2 + B^2 = a^2 \Rightarrow a = \sqrt{A^2 + B^2}$

Then, $y = a \cos \theta \sin \omega t - a \sin \theta \cos \omega t$

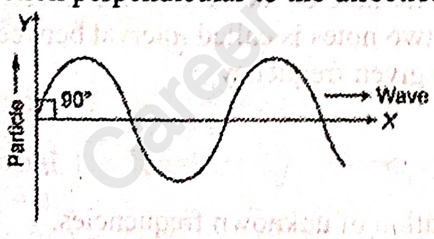
$y = a \sin (\omega t - \theta)$

which is the equation of simple harmonic oscillator.

The amplitude of the oscillator, $a = \sqrt{A^2 + B^2}$

15. (C)

In a transverse wave the particles of the medium vibrate about their mean positions in a direction perpendicular to the direction of wave propagation.



Here, the particle velocity is given by $\frac{dy}{dt}$ and wave velocity is given by $\frac{dx}{dt}$.

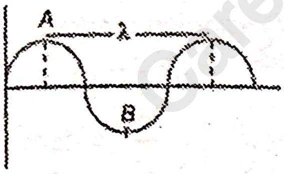
Hence, the angle between particle velocity in a transverse wave is $\frac{\pi}{2}$.

16. (B)
For closed organ pipe
$n_1 : n_2 : n_3 \ldots = 1 : 3 : 5 : \ldots$

17. (A)
For end correction x, $\frac{\ell_2 + x}{\ell_1 + x} = \frac{3\lambda/4}{\lambda/4} = 3$

$\Rightarrow \quad x = \frac{\ell_2 - 3\ell_1}{2} = \frac{70.2 - 3 \times 22.7}{2} = 1.05\,\text{cm}$

18. (A)
Sine wave,



Particle velocity, $v_p = \frac{dy}{dt} =$ slope of wave at that point

As slope at A and B is zero. Hence the velocity at A and B will be same. Distance between A and B is $\frac{\lambda}{2}$.

19. (A)
Given, $y = A \sin(100\,\pi t - 3x)$
The general equation, $y = A \sin(\omega t - kx)$

$\therefore \quad k = 3$ and $k = \frac{2\pi}{\lambda}$ or $\lambda = \frac{2\pi}{k} = \frac{2\pi}{3}$

Phase difference, $\phi = \frac{\pi}{3}$

$$\frac{2\pi}{\lambda} \cdot x = \frac{\pi}{3} \text{ or } x = \frac{\pi}{3} \times \frac{\lambda}{2\pi} = \frac{\pi}{3} \times \frac{2\pi}{3 \times 2\pi}$$

Distance, $x = \frac{\pi}{9}\,\text{m}$

20. (B)

The velocity of a transverse wave, $v = \sqrt{\frac{T}{\rho A}}$

$$v \propto \frac{1}{\sqrt{A}} \quad \Rightarrow v \propto \frac{1}{R}$$

Because the velocity of wire depend on the radius. So transverse wave travels faster in thinner wire.

21. (A)

Frequency of closed pipe, $\quad n_1 = \frac{v}{4l_1} \quad \Rightarrow l_1 = \frac{v}{4n_1}$

Frequency of open pipe, $\quad n_2 = \frac{v}{2l_1} \quad \Rightarrow l_2 = \frac{v}{2n_2}$

When both pipe are joined, then length of closed pipe

$$I = I_1 + I_2$$

$$\frac{v}{4n} = \frac{v}{4n_1} + \frac{v}{2n_2} \Rightarrow \frac{1}{2n} = \frac{1}{2n_1} + \frac{1}{n_2}$$

$$\text{or } \frac{1}{2n} = \frac{n_2 + 2n_1}{2n_2 n_2} \Rightarrow n = \frac{n_1 n_2}{n_2 + 2n_1}$$

22. (A)

In the fundamental mode, frequency,

$$n = \frac{v}{\lambda} \Rightarrow n = \frac{v}{4\ell}$$

$$n = \frac{\ell}{t \times 4\ell}\left[\because v = \frac{\ell}{t}\right] \Rightarrow n = \frac{\ell}{0.01 \times 4\ell} = 25$$

23. (A)

For closed pipe $\ell_1 = \frac{v}{4n}$ and $\ell_2 = \frac{3v}{4n}$

$$v = 2n(\ell_2 - \ell_1)$$

$$\Rightarrow n = \frac{v}{2(\ell_2 - \ell_1)} = \frac{330}{2 \times (0.49 - 0.16)} = 500 \text{ Hz}$$

24. (A)

Due to rise in temperature, the speed of sound increases. Since, frequency $n = \frac{v}{\lambda}$ and λ remains unchanged. Hence, frequency n increases.

25. (A)

On comparing given equation with standard equation,

We get, $\frac{2\pi}{\lambda} = \frac{\pi}{15} \Rightarrow \lambda = 30$

Distance between the node and antinode $= \frac{\lambda}{4} = \frac{30}{4} = 7.5$

26. (B)

General equation of plane progressive wave is given by

$$y = a \sin(kx + \omega t) \quad \ldots(i)$$

Given equation

$$y = 0.0015 \sin(62.4x + 316\, t) \quad \ldots(ii)$$

Comparing Eqs. (i) and (ii), we get

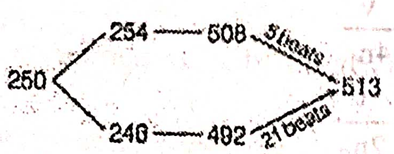
$$k = 62.4$$

$$\therefore \frac{2\pi}{\lambda} = 62.4$$

$$\lambda = \frac{2\pi}{62.4} = 0.1 \text{ unit}$$

27. (A)

Here,



Hence, unknown frequency is 254 Hz.

28. (A)

Given a = 1m

As $\quad y = a\sin(kx - \omega t) = \sin\left(\frac{2\pi}{2\pi} \times -2\pi \times \frac{1}{\pi} t\right) = \sin(x - 2t)$

29. (D)

Statement (D) is not true, because at the open ends pressure change will be zero.

30. (D)

Frequency (n) = b, $\quad$ wavelength $(\lambda) = \frac{1}{c}$

Wave velocity $(V_w) = n\lambda = \frac{b}{c}$

Max. Particle velocity $(V_p) = A\omega = a \times 2\pi n = 2\pi ab$

$$V_p = 2V_w$$

$$2\pi ab = 2\frac{b}{c}$$

$$\therefore \quad c = \frac{1}{\pi a}$$

31. (B)

$$y = a\sin 2\pi\left(nt - \frac{x}{5}\right)$$

$\therefore \ \lambda = 5$

$\therefore$ wave velocity $V = n\lambda$

Max. particle velocity $V_p = \omega a = 2\pi na$

$$\therefore \frac{V_p}{V} = \frac{2\pi a}{5}$$

32. (C)

$$n = \frac{1}{2\ell}\sqrt{\frac{T}{m}}$$

$$\text{or} \quad n = \frac{1}{2\ell}\sqrt{\frac{T}{\pi r^2 \rho}} = \frac{1}{2\ell r}\sqrt{\frac{T}{\pi\rho}}$$

$$\therefore \frac{n_2}{n_1} = \frac{r_1}{r_2}\sqrt{\frac{T_2}{T_1}} \qquad \therefore \frac{n_2}{n_1} = \frac{r_1}{r_2} \times 2$$

As r_2 is slightly less than r_1, $\frac{n_2}{n_1}$ is slightly greater than 2.

33. (B)

$$n_{open} = \frac{v}{2\ell} \cdot p \ ;$$

$$n_{closed} = \frac{v}{4\ell}(2p - 1)$$

$$\therefore \frac{n_{open}}{n_{closed}} = \frac{2p}{2p - 1}$$

34. (C)

35. (A)

$$n = \frac{1}{2\ell}\sqrt{\frac{T}{m}} \quad \text{but } m = \pi r^2.\rho$$

$$\therefore\ n = \frac{1}{2r\ell}\sqrt{\frac{T}{\pi\rho}}$$

$$\therefore\ n \propto \frac{1}{r\ell}$$

$$\frac{n_1}{n_2} = \frac{2r\cdot 2\ell}{r\ell} = \frac{4r\ell}{r\ell} = 4$$

$$n_2 = \frac{n_1}{4}$$

36. (A)

For wire vibrating under tension, the fundamental frequency is given by

$f_1 = \frac{1}{2}\sqrt{\frac{T}{\mu}}$, Where T is tension & μ is mass per unit length of the string.

It is given that, when it is sounded with a tuning fork of frequency x, 6 beats per seconds were heard

$$\therefore\ (x - f_1) = 6$$

$$\therefore\ f_1 = \frac{1}{2\ell}\sqrt{\frac{225}{\mu}}; \quad f_2 = \frac{1}{2L}\cdot\sqrt{\frac{256}{\mu}}$$

$$\therefore\ \frac{f_1}{f_2} = \frac{15}{16}$$

$$\therefore\ f_2 = \frac{16}{15}\times f_1 = \frac{16}{15}(x-6)$$

$$f_2 = (x+6)$$

$$\therefore\ (x+6) = \frac{16}{15}(x-6)$$

$$\therefore\ 15x + 90 = 16x - 96$$

$$\therefore\ X = 186 \text{ Hz}$$

37. (B)

The velocity of wave travelling on string is

$$V = \sqrt{\frac{T}{m}} = \sqrt{\frac{T}{\pi r^2\rho}} = \frac{1}{r}\sqrt{\frac{T}{\pi\rho}} \quad \text{where } \rho \text{ is the density}$$

$$\therefore\ V \propto \frac{1}{r} \qquad \therefore\ \frac{V_A}{V_B} = \frac{r_B}{r_A} = \frac{1}{2}$$

38. (D)

Let $f_0 = \frac{v_0}{2L}$ be the fundamental frequency of the open pipe

$\therefore$ Its second overtone is $3f_0 = \frac{3v_0}{2L}$

Let $f = \frac{v_0}{4L}$ be the fundamental frequency of closed pipe.

And third overtone of the organ pipe closed at one end only is, $(f_3)_{closed} = \frac{7}{4}\frac{v_0}{L}$

As given $\frac{7v_0}{4L} - \frac{3V_0}{2L} = 150$

$\left(\frac{7}{4} - \frac{6}{4}\right)\frac{v_0}{L} = 150$

$\therefore \frac{v_0}{4L} = 150 \qquad \frac{v_0}{2L} = 300\text{ Hz}$

39. (B)

For open organ pipe, $\Delta L = 1.2 \times r$

$\therefore r = \Delta L \times \frac{1}{1.2} = \frac{0.8}{1.2} = \frac{2}{3}$ cm.

40. (C)

$y = 12\,m(5t - 4x)$.

Comparing in $y = A\sin(wt - kx)$

We have $A = 12$, $w = 15$ and $k = 4 = \frac{2\pi}{\lambda} \qquad \therefore \lambda = \frac{\pi}{2}$

phase difference $= \frac{2\pi x}{\lambda} \qquad \therefore \frac{\pi}{2} = \frac{2\pi x}{\lambda} \qquad \therefore x = \frac{\lambda}{4} = \frac{\pi}{8}$ cm

41. (D)

$$y = 3\sin\left[2\pi\left(\frac{t}{6} - \frac{x}{10}\right) + \frac{\pi}{4}\right]$$

Compare $y = A\sin\left[2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right) + \frac{\pi}{4}\right]$ x and y are metre

$\therefore \lambda = 10$ m

42. (C)

For open pipe first overtone $v_1 = \frac{v}{L}$

For closed pipe first overtone $v_1' = \frac{3v}{4L}$

$\therefore v_1 - v_1' = \frac{v}{L} - \frac{3v}{4L} = 3$

$\therefore \frac{v}{4L} = 3 \qquad \therefore \frac{v}{L} = 12$

When length of open pipe is made $\frac{L}{3}$ the fundamental frequency

$$v = \frac{v}{2\left(\frac{L}{3}\right)} = \frac{3v}{2L}$$

When length of closed pipe is made 3 times, the fundamental frequency

$$v' = \frac{v}{4(3L)} = \frac{v}{12L}$$

Beats produced $= v - v' = \frac{3v}{2L} - \frac{v}{12L} = \frac{17}{12}\cdot\frac{v}{L} = \frac{17}{12} \times 12 = 17$

43. (A)

Fundamental frequency of the first wire

$$f = \frac{1}{2L_1}\sqrt{\frac{T}{m}} = \frac{1}{2L_1}\sqrt{\frac{T}{\pi r_1^2 \rho}} = \frac{1}{2L_1 r_1}\sqrt{\frac{T}{\pi\rho}}$$

The first overtone $f_1 = 2f = \frac{2}{2L_1 r_1}\sqrt{\frac{T}{\pi\rho}} = \frac{1}{L_1 r_1}\sqrt{\frac{T}{\pi\rho}}$

The second overtone of the second wire

$$f_2 = \frac{3}{2L_2 r_2}\sqrt{\frac{T}{\pi\rho}}$$

$$f_1 = f_2$$

$$\frac{1}{L_1 r_1}\sqrt{\frac{T}{\pi\rho}} = \frac{3}{2L_2 r_2}\sqrt{\frac{T}{\pi\rho}}$$

$\therefore\ 3L_1 r_1 = 2L_2 r_2$

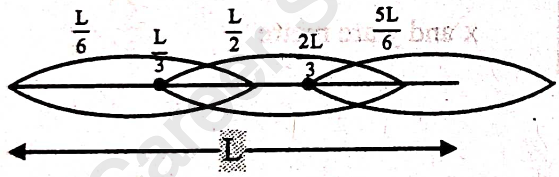
$$\frac{L_1}{L_2} = \frac{2}{3}\cdot\frac{r_2}{r_1}$$

$$= \frac{2}{3}\cdot\frac{r_2}{2r_2} \qquad \because r_1 = 2r_2$$

$$= \frac{1}{3}$$

44. (D)

String vibrating in second overtone :



45. (D)

For a closed pipe fundamental frequency $n_1 = \frac{V}{4L} = 100$ Hz

For an open pipe fundamental frequency $n_1' = \frac{V}{2L} = 2n_1 = 200$Hz

In an open pipe all multiples of the fundamental are produced.

46. (B)

In fifth overtone the string is vibrating forming 6 loops.

$\therefore$ length of 6 loops is 2.4 m

$\therefore$ length of 1 loop is $\frac{2.4}{6} = 0.4$ m

$\therefore$ Distance between a node and antinode is half of loop length i.e. $\frac{0.4}{2} = 0.2$ m.

47. (B)

$$\frac{N_2}{N_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{2}$$

$$N_2 = \sqrt{2}N_1$$

48. (C)

$\ell = 83 \times 10^{-2}$ m

$v = 332$ m/s

$$n_0 = \frac{v}{4L} = \frac{332}{4 \times 83 \times 10^{-2}} = 100$$

$n_0 : n_1 : n_2 : n_3 : n_4 = 1:3:5:7:9 = 100:300:500:700:900$

$\therefore$ Number of possible natural frequency = 5.

49. (A)

50. (D)

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

$$\Rightarrow V^2 = \frac{T}{m}$$

$$\Rightarrow T = V^2 m = V^2 10^{-3}$$

Now $V = \dfrac{\omega}{K} = 15$

$\therefore\ V^2 = 15^2 = 225\ m^2/s^2$

$T = 225 \times 10^{-3} = 0.225$ N

51. (A)

$Y = a \sin 2\pi(bt - cx)$

$$\frac{dY}{dt} = 2\pi ab \cos 2\pi(bt - cx)$$

$$\left.\frac{dY}{dt}\right|_{max} = 2\pi ab$$

$$\frac{\omega}{k} = \frac{2\pi b}{2\pi c} = \frac{b}{c}$$

$$2\pi ab = \frac{2b}{c} \text{ or } c = \frac{1}{\pi a}$$

52. (B)

$n = n_1 - n_2$

53. (C)

Wave velocity $= \dfrac{\omega}{k} = n\lambda$

$$\left.\frac{dy}{dt}\right|_{max} = an \cdot 2\pi$$

$$\frac{an2\pi}{P} = n\lambda$$

$$\therefore\ \lambda = \frac{2\pi a}{P}$$

54. (C)

$n_1 - n_2 = 3 \;\therefore\; n_2 - n_1 = -3$

$n_2 - n_3 = 3 \quad n_3 = n_2 - 3 = n_1 - 6 = n_1 - 2 \,.\, 3 = n_1 - (3-1)\,.\,3$

$n_{25} = n_1 - (25-1)\,.\,3$

$\frac{n_1}{2} = n_1 - 72$

$\therefore\; n_1 = 72 \times 2 = 144 \text{ Hz}$

$n_{15} = 144 - 14.3 = 144 - 42 = 102 \text{ Hz}$

55. (C)

$$\begin{aligned} y &= 0.4\sin(5\pi t + 2.5\pi)\cos(5\pi t + 2.5\pi) \\ &= 0.2\, 2\sin(5\pi t + 2.5\pi)\cos(5\pi t + 2.5\pi) \\ &= 0.2\sin(10\pi t + 5\pi) \end{aligned}$$

$\therefore\; \omega = 10\pi$

$T = \frac{2}{10} = 0.2$

56. (B)

λ corresponds to 2π phase difference

25m corresponds to $\frac{2\pi}{\lambda}.25$

Now $k = \frac{2\pi}{\lambda} = 0.01\,\pi$

$\therefore\; \lambda = 200$

$\therefore\; \frac{2\pi}{200} \times 25 = .$

57. (B)

$n_1 = \frac{v}{2L_1} \Rightarrow L_1 = \frac{v}{2n_1}$

$n_2 = \frac{v}{2L_2} \Rightarrow L_2 = \frac{v}{2n_2}$

$n = \frac{v}{2(L_1 + L_2)}$

$n = \frac{v}{2\left(\frac{v}{2n_1} + \frac{v}{2n_2}\right)} = \frac{n_1 n_2}{n_1 + n_2}$

58. (C)

$V = n\lambda \quad L = \frac{\lambda}{4}$

$n = \frac{v}{\lambda} = \frac{v}{4L} = \frac{1}{4L/v} = \frac{1}{4t}$

59. (C)

Length of the string $= (m-1)\frac{\lambda}{2}$

60. (A)

$$\ell_1 + \ell_2 + \ell_3 = 260$$

$$C\left[\frac{1}{2}+\frac{1}{3}+\frac{1}{4}\right] = 260 \qquad \left[n \propto \frac{1}{\ell}\right]$$

$$\therefore C = 240$$

$$\ell_1 = \frac{240}{2} = 120 \text{ cm}$$

$$\ell_2 = \frac{240}{3} = 80 \text{ cm}$$

$$\ell_3 = \frac{240}{4} = 60 \text{ cm}$$

61. (B)

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

$$\therefore k = \frac{2\pi}{\lambda} = \pi$$

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

$$a = \frac{0.04}{2} = 0.02\text{m}$$

$$V = \frac{\omega}{K} = \frac{50\pi}{\pi} = 50 \text{ m/s}$$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{50\pi} = 0.04 \text{ s}$$

62. (A)

$$n \propto \sqrt{T}$$

$$\frac{n_1}{n_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\frac{n_1}{n_1+9} = \sqrt{\frac{T_1}{1.69T_1}} = \sqrt{\frac{100}{169}} = \frac{10}{13}$$

$$13n_1 = 10\,n_1 + 90$$

$$3\,n_1 = 90$$

$$n_1 = 30$$

63. (C)

$$n_0 \rightarrow (p+1)\,n$$

$$n_c \rightarrow (2p+1)\,n$$

$$\therefore \frac{n_o}{n_c} = \frac{p+1}{2p+1}$$

64. (C)

$$n = \frac{1}{2L}\sqrt{\frac{\text{Tension}}{m}}$$

$$\therefore n \propto \frac{\sqrt{T}}{\ell}$$

$$\frac{n_1}{n_2} = \frac{\sqrt{T_1}}{\ell_1} \times \frac{\ell_2}{\sqrt{T_2}} = 1$$

$$\therefore \sqrt{T_1}\ell_2 = \sqrt{T_2}\ell_1$$

$$\therefore \frac{\ell_1}{\ell_2} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{W}{W/4}} = 2$$

65. (C)

$n = \dfrac{V}{4\ell}$ does not depend on density of liquid used.

66. (C)

3^{rd} overtone = 4th harmonic = 4 loops

67. (A)

$$\frac{5V}{4L} = \frac{V}{L} + 100$$

$$\left(\frac{5}{4} - 1\right)\frac{V}{L} = 100$$

$$\frac{V}{2L} = 200$$

68. (B)

$$N = \frac{1}{2L}\sqrt{\frac{T}{m}} = \frac{1}{2L}\sqrt{\frac{T}{\pi r^2 \rho}}$$

$$N_2 = \frac{1}{42}\sqrt{\frac{2T}{\pi 4 r^2 \rho}}$$

$$\therefore \frac{N_2}{N} = \frac{1}{2\sqrt{2}}$$

$$N_2 = \frac{N}{2\sqrt{2}}$$

69. (A)

$$e_1 = \frac{n_2\ell_2 - n_1\ell_1}{n_1 - n_2} \qquad e_2 = \frac{n_2\ell_2 - n_1\ell_1}{2(n_1 - n_2)}$$

$$\therefore \frac{e_1}{e_2} = 2$$

70. (A)

$$\frac{100}{4} = 25\text{ cm}$$

71. (A)

$$n_c = \frac{V}{4L} \qquad n_o = \frac{v}{2L}$$

$$n_o - n_c = 2$$

$$\therefore 2 = \frac{v}{L}\left[\frac{1}{2} - \frac{1}{4}\right]$$

$\therefore \quad \frac{v}{L} = 8$

$n_o' = \frac{v}{2 \times \frac{L}{2}} = \frac{v}{L}$

$n_c' = \frac{v}{4 \times 2L} = \frac{v}{8L}$

$n_o' - n_c' = \frac{v}{L}\left[1 - \frac{1}{8}\right] = \frac{v}{L} \times \frac{7}{8} = 8 \times \frac{7}{8} = 7$

72. (C)

$n = (x+1) n_{o\ open}$

$N = (2y+1)\ n_{o\ close}$

But $n_{o\ open} = 2n_{o\ close}$

$\frac{N}{n} = \frac{(2y+1) n_{o\ close}}{(x+1) n_{o\ open}} = \frac{(2y+1) n_{o\ close}}{(x+1) 2n_{o\ open}} = \frac{2y+1}{2(x+1)}$

73. (A)

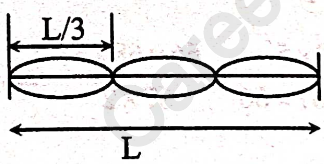
$\ell_1 = 0.2\ m \quad \ell_2 = 0.62\ m$

$e = \frac{\ell_2 - 3\ell_1}{2} = \frac{0.62 - 0.60}{2} = 1\ cm$

$\therefore \quad e = 0.3d$

$d = \frac{1}{0.3} = \frac{10}{3} = 3.33\ cm$

74. (A)



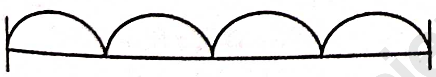
$\frac{3\lambda}{2} = L$

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

Antinode at $\frac{\lambda}{4} = \frac{2L}{4 \cdot 3} = \frac{L}{6}, \quad \frac{3\lambda}{4} = \frac{3}{4} \times \frac{2L}{3} = \frac{L}{2}, \quad \frac{5\lambda}{4} = \frac{5}{4} \times \frac{2L}{3} = \frac{5L}{6}$

75. (C)

3^{rd} overtone = 4^{th} harmonic



5 nodes, 4 antinodes

76. (D)

$\ell = 34\ cm \quad v = 340\ m/s$

$n_0 = \frac{v}{2\ell} \qquad 3n_0 = \frac{3V}{2\ell}$

2^{nd} overtone = 3^{rd} harmonic $\qquad \because\ 1^{st}$ harmonic $n_0 = \frac{v}{2\ell}$

$3n_0 = \frac{3v}{2\ell} = \frac{3 \times 340 \times 100}{2 \times 34} = 1.5 \times 1000 = 1500$

77. (C)

According to question,

$$(f_7)_{close} = (f_3)_{open}$$

$$\frac{7v}{4\ell_c} = \frac{3v}{2\ell_o}$$

$$\frac{\ell_c}{\ell_o} = \frac{7}{6}$$

78. (B)

$$n = \frac{1}{2\ell}\sqrt{\frac{T}{m}}$$

$$n_1 = \frac{1}{2(\ell-1)}\sqrt{\frac{T}{m}} \qquad n_1 - n = 3$$

$$n_2 = \frac{1}{2(\ell+1)}\sqrt{\frac{T}{m}} \qquad \frac{n - n_2 = 2}{n_1 - n_2 = 5}$$

$$n = \frac{1}{2\times 67}\sqrt{\frac{T}{m}} \qquad n_1 = \frac{1}{2\times 66}\sqrt{\frac{T}{m}} \qquad n_2 = \frac{1}{2\times 68}\sqrt{\frac{T}{m}}$$

$n = ?$

$$\frac{n}{n_1} = \frac{2\times 66}{2\times 67} = \frac{66}{67} \qquad n = \frac{66}{67}n_1$$

$$\frac{n}{n_2} = \frac{68}{67} \qquad n = \frac{68}{67}n_2$$

$$\therefore \quad \frac{67}{66}n - \frac{67}{68}n = 5$$

$$n = \frac{66\times 68\times 5}{67\times 68 - 67\times 66} = \frac{66\times 68\times 5}{67\times 2} = 33.49\times 5 = 167.46 \text{ Hz}$$

79. (B)

$y = 0.35 \sin(2\pi t - 10\pi x)$

$\omega = 2\pi$

$$\frac{2\pi}{T} = 2\pi$$

$T = 1$

$$\therefore \quad \frac{1}{f} = 1$$

$$\frac{2\pi}{\lambda} = 10\pi$$

$$\lambda = \frac{1}{5}\text{m} = 0.2 \text{ m}$$

It is moving in +ve direction.

80. (C)

$L = 1\text{m}, \rho = 9\times 10^3 \text{ kg/m}^3, \; Y = 9\times 10^{10} \text{ N/m}^2, \; \Delta\ell = 4.9\times 10^{-4}\text{ m}$

Fundamental frequency $\nu = \dfrac{1}{2L}\sqrt{\dfrac{T}{m}}$

Young's modulus $Y = \frac{T/A}{\Delta\ell/L} = \frac{TL}{A\Delta\ell}$

$\therefore\ T = \frac{YA\Delta\ell}{L}$

$\therefore\ v = \frac{1}{2L}\sqrt{\frac{YA\Delta\ell}{LA\rho}} = \frac{1}{2}\sqrt{\frac{9\times10^{10}\times4.9\times10^{-4}}{9\times10^{3}}} = 35\text{ Hz}$

81. (B)

The third overtone has (n + 1) = 4 antinodes and (n + 2) = 5 nodes

82. (D)

$y = Y_0 \sin 2\pi\left(nt - \frac{x}{\lambda}\right)$.

Wave velocity = $n\lambda$

Particle velocity = $\frac{dy}{dt} = Y_0 2\pi n \cos 2\pi\left(nt - \frac{x}{\lambda}\right)$

$\left.\frac{dy}{dt}\right|_{max} = Y_0\ 2\pi n$

According to condition given

$8n\lambda = Y_0\ 2\pi\ n$

$\lambda = \frac{2\pi Y_0}{8} = \frac{\pi Y_0}{4}$

83. (D)

$n_c = \frac{v}{4\ell_c}\quad n_o = \frac{v}{2\ell_o}$

$\because\ n_c = n_o\quad \therefore\ \frac{v}{4\ell_c} = \frac{v}{2\ell_o}$

$2\ell_c = \ell_o$

$\therefore\ \frac{\ell_o}{\ell_c} = 2$

84. (A)

$300 : 420 : 540$

$\equiv\ 30 : 42 : 54$

$\equiv\ 10 : 14 : 18$

$\equiv\ 5 : 7 : 9$

So it is a closed pipe.

Now v = 360 m/s

If the length is ℓ, then fundamental frequency is

$\frac{300}{5} = 60\text{ Hz}$

$\therefore\ 60 = \frac{V}{4\ell} = \frac{360}{4\ell} = \frac{90}{\ell}$

$\therefore\ \ell = \frac{90}{60}\text{m} = 1.5\text{ m}$

85. (A)

$f_1 = 340$ Hz $\qquad v = 340$ m/s

$$340 = \frac{v}{4\ell} = \frac{340}{4\ell}$$

$$4\ell = 1$$

$$\ell = \frac{1}{4}\text{ m} = 0.25\text{ m}$$

$\therefore$ Maximum height the water should be poured is

$1.5 - 0.25 = 1.25$ m

$= 125$ cm

For 2^{nd} resonant frequency

$$340 = \frac{3v}{4\ell} \Rightarrow 4\ell = 3$$

$$\ell = \frac{3}{4} = 0.75\text{ m}$$

$\therefore$ height of the water to be poured

$1.5 - 0.75 = 75$ cm

For the 3^{rd} resonant frequency

$$340 = \frac{5v}{4\ell}$$

$$\therefore\ \ell = \frac{5}{4} = 1.25$$

$\therefore$ water to be poured is $(1.5 - 1.25) = 0.25$ cm $= 25$ cm

86. (D)

$$y = 0.3\sin(x + 20t)$$

$$v = \sqrt{\frac{T}{m}} \qquad \therefore T = v^2 m$$

$$\frac{dy}{dt} = 0.3 \times 20\cos(x + 20t))$$

$$\frac{dy}{dt}_{max} = 6$$

$$\therefore\ T = 36 \times 1.2 \times 10^{-4}\ \text{kg/m}$$

$$= 43.2 \times 10^{-4}\text{ kg}$$

$$= 0.00432 \quad = 0.0423\text{ N}$$

87. (C)

End correction $e = 0.6d$ for open pipe

So, the effective length increases from tube of larger diameter.

$$\text{Frequency} \propto \frac{1}{\text{length}}$$

Since effective length of pipe A increases more, so, the fundamental frequency for pipe A will be lesser than fundamental frequency of pipe B.

88. (A)

$$n \propto \sqrt{T}$$

$$\therefore \quad \frac{n_1}{n_2} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{T_1}{4T_1}} = \frac{1}{2}$$

$$\therefore \quad n_2 = 2n_1$$

89. (A)

$$\text{Velocity} = \sqrt{\frac{\text{Tension}}{\text{mass per length}}}$$

$$\frac{k}{T} \propto \sqrt{\text{Tension}}$$

$$kf \propto \sqrt{\text{Tension}}$$

$\therefore$ If tension is doubled, the number of waves or frequency will be $\sqrt{2}$ times

$\therefore$ $\sqrt{2}\,n$

90. (A)

91. (D)

$$y_1 = 10^{-2} \cos\left[50t + \frac{x}{25} + 0.3\right] m$$

$$y_2 = 10^{-2} \sin\left[50t + \frac{x}{25} + \frac{\pi}{2}\right] m$$

$\therefore$ Phase difference between the two waves is

$$\phi = \frac{\pi}{2} - 0.3 = 1.57 - 0.3 = 1.27 \text{ rad}$$

92. (D)

$$Y = 3 \sin(200\,\pi t \cos(0.4x))$$

Given $\frac{2\pi}{\lambda} = 0.4$

$\therefore \quad \lambda = 5\pi$

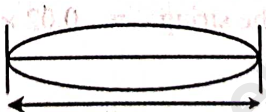
For 4^{th} harmonic, there are 4 loops.

It consists of 2λ

$\therefore$ Length of the string is $2 \times 5\pi = 10\pi$

93. (C)

For fundamental frequency in a string



$\therefore \lambda = 2\ell$

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

94. (C)

$$\nu = \frac{v}{4L} \qquad \nu_1 = \frac{v}{2(L/2)} = \frac{v}{L} = 4\nu$$

$$\nu_2 = \frac{v}{4(L/2)} = \frac{v}{2L} = 2\nu$$

95. (D)

$P_1^2T_1 = P_2^2T_2$

$16 \times m = 1(m + 6)$

$16\ m = 6$

$m = \frac{6}{15} = 0.4\ gm$

96. (C)

4^{th} overtone of close pipe

$(2P + 1)n_0 = 9n_{oc} = \frac{9v}{4\ell_c}$

2^{nd} overtone of open pipe

$(P + 1)\ n = 3n_{oc} = \frac{3V}{2\ell_0}$

$\therefore \frac{9v}{2\ell_c} = \frac{3v}{2\ell_o}$

$\therefore \frac{\ell_o}{\ell_c} = \frac{2}{3}$

97. (C)

$T = 2$ kg.wt

$\therefore \frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}} \qquad V_2 = 3V_1$

$\frac{V_1}{3V_1} = \sqrt{\frac{T_1}{T_2}} \Rightarrow \frac{1}{9} = \frac{T_1}{T_2}$

$T_2 = 9T_1$

$\therefore$ Increased $= T_2 - T_1 = 8T_1 = 16$ kg wt

98. (D)

$2 \times \left[\frac{1}{2\ell_1}\sqrt{\frac{T}{m}}\right] = \frac{v}{4\ell_2}$

$\frac{1}{0.5}\sqrt{\frac{50}{m}} = \frac{320}{4 \times 0.8}$

$\therefore \quad m = 0.02$ kg/m

$\therefore$ Total mass of the string $= 0.02 \times 0.5$ kg $=$ 10 gm

99. (D)

3^{rd} overtone of closed pipe = 3^{rd} overtone of open pipe

$(2p + 1)n_c = (p + 1)n_o$

$7\ n_c = 4\ n_o$

$7\frac{v}{4\ell_c} = 4\frac{v}{2\ell_o}$

$\frac{\ell_c}{\ell_o} = \frac{7}{8}$

100.(A)

$$Y = A \sin 2\pi\left(nt - \frac{\pi}{\lambda}\right) cm$$

$$\frac{dy}{dt} = A2\pi n \cos 2\pi\left(nt - \frac{x}{\lambda}\right)$$

$$\left.\frac{dy}{dt}\right|_{max} = A2\pi n$$

Wave velocity $= n\lambda$

According to condition,

$$2\pi An = 4n\lambda$$

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

101.(A)

For 5^{th} harmonic, the string of length L vibrates in 5 loops

$$\frac{5\lambda}{2} = L$$

Now $\frac{2\pi}{\lambda} = 0.4 \quad \therefore \lambda = \frac{2\pi}{0.4} = \frac{20\pi}{4} = 5\pi$

$$\therefore \quad L = \frac{5 \times 5\pi}{2} = \frac{25\pi}{2} = 12.5\pi$$

102.(B)

$v = 960$ m/s $\quad \lambda = ?$

900 waves passes in 30 sec.

$\therefore$ 30 waves passes in 1 sec

$\therefore \nu = 30$

$$\therefore \lambda = \frac{v}{\nu} = \frac{960}{30} = 32 \text{ m}$$

103.(A)

$\ell = 0.8$ m $\quad f = 500$ Hz $\quad v = 340$ m/s

$v = f\lambda \qquad \lambda = \frac{v}{f} = \frac{340}{500} = \frac{34}{50} = \frac{34}{50} = \frac{17}{25}$ m

$$\frac{\lambda}{4} = \frac{17}{100} = 0.17 \text{ m}$$

$$\frac{3\lambda}{4} = 0.51 \text{ m}$$

$$\frac{5\lambda}{4} = 0.85 \text{ m}$$

So, only 2 resonances will be heard.

104.(D)

$$\frac{\ell_o}{\ell_c} = ?$$

For closed pipe $\qquad n_p = n_o(2p+1) \Rightarrow n_{1c} = n_o^3$

For open pipe $\qquad n_p = n_o(p+1) \Rightarrow n_{1o} = n_o^2$

$$n_{1c} = 3n_o = \frac{3V}{4\ell_c}$$

$$n_{1o} = 2n_o = \frac{2V}{2\ell_o}$$

$$\therefore \frac{3V}{4\ell_c} = \frac{2V}{2\ell_o}$$

$$\therefore \frac{\ell_o}{\ell_c} = \frac{4}{3}$$

105.(C)

$$n = \frac{1}{2\ell}\sqrt{\frac{T}{m}}$$

$$3n = \frac{1}{2\ell}\sqrt{\frac{T+8}{m}}$$

$$\therefore \frac{n}{3n} = \sqrt{\frac{T}{T+8}}$$

$$\frac{n^2}{9n^2} = \frac{T}{T+8}$$

$$T + 8 = 9T \quad \Rightarrow \quad 8T = 8\text{ N}$$

$$\therefore T = 1\text{ N}$$

106.(C)

$$T_1 = mg = v\rho g$$

$$T_2 = v(\rho - \sigma)g \qquad \sigma = 1 \text{ for water}$$

$$\frac{T_1}{T_2} = \frac{v\rho g}{v(\rho-1)g} = \frac{\rho}{\rho-1}$$

$$\therefore \frac{n_1}{n_2} = \sqrt{\frac{\rho}{\rho-1}} \qquad \therefore n_2 = n_1\sqrt{\frac{\rho-1}{\rho}}$$

107.(A)

3^{rd} overtone of closed pipe $= 7\ n_{oc} = \dfrac{7v}{4\ell}$

2^{nd} overtone of closed pipe $= 3\ n_{oo} = \dfrac{3v}{2\ell}$

$$\text{Now, } \frac{7v}{4\ell} = \frac{3v}{2\ell} + 150$$

$$\frac{7v}{4\ell} - \frac{3v}{2\ell} = 150$$

$$\frac{7v - 6v}{4\ell} = 150$$

$$\frac{v}{4\ell} = 150$$

$\therefore \quad \ell = \dfrac{v}{4 \times 150}$

$\therefore \quad n_{oo} = \dfrac{v}{2\ell} = \dfrac{v \times 4 \times 150}{2 \times v} = 300 \text{ Hz}$

108.(A)

$N = \dfrac{1}{2\ell}\sqrt{\dfrac{T_1}{m}}$

$1.5\,N = \dfrac{1}{4\ell}\sqrt{\dfrac{T_2}{m}}$

$\therefore \quad \sqrt{\dfrac{T_1}{T_2}} = \dfrac{N \times 2\ell}{1.5N \times 4\ell} = \dfrac{1}{3}$

$\dfrac{T_1}{T_2} = \dfrac{1}{9}$

109.(A)

No. of beats $= n_1 - n_2$

$Y_1 = 0.25 \sin 316\, t$

$\therefore \quad \dfrac{2\pi}{T} = 316 \quad \therefore \quad n_1 = \dfrac{316}{2\pi}$

$Y_2 = 0.25 \sin 310\, t$

$\therefore \quad n_2 = \dfrac{310}{2\pi}$

$n_1 - n_2 = \dfrac{316 - 310}{2\pi} = \dfrac{6}{2\pi} = \dfrac{3}{\pi}$

110.(D)

$V = \sqrt{\dfrac{T}{m}} \qquad T_1 = -kx \qquad T_2 = -k\,4\,x$

$\therefore \quad \dfrac{V_1}{V_2} = \sqrt{\dfrac{T_1}{T_2}} = \dfrac{1}{2}$

$\therefore \quad V_2 = 2V_1$

111.(A)

$n = \dfrac{v}{2\ell}$

2^{nd} harmonic $= 1^{st}$ overtone $= (2p + 1)n_0 = 3\, n_0$

$\dfrac{3v}{4\ell} - \dfrac{v}{2\ell} = 200$

$\dfrac{v}{2\ell}\left(\dfrac{3}{2} - 1\right) = 200$

$\dfrac{v}{2\ell} = 400$

112.(D)

113.(C)

$$e = \frac{\ell_2 - 3\ell_1}{2} = \frac{38 - 3\times 12}{2}$$

$$= \frac{38-36}{2} = 1\,\text{cm}$$

114.(B)

$\ell = 0.8\,\text{m}$ $\quad f = 375\,\text{Hz}$ $\quad v = 330\,\text{m}$

$$n_0 = \frac{v}{4\ell} = 375$$

$$\therefore\ \ell = \frac{330}{4\times 375} = 0.22\,\text{m}$$

$$\therefore\ L - \ell = 0.8 - 0.22\,\text{m} = 0.58\,\text{m}$$

115.(A)

$$n = \frac{1}{2\ell}\sqrt{\frac{T}{m}} = \frac{v}{4\ell} \quad = \frac{1}{2\ell}\sqrt{\frac{T+16}{n}} = \frac{3v}{4\ell}$$

$$\sqrt{\frac{T}{T+16}} = \frac{1}{3}$$

$$\frac{T}{T+16} = \frac{1}{9}$$

$$9T = T + 16 \quad \therefore\ 8T = 16 \quad \therefore\ T = 2\,\text{N}$$

116.(B)

$$n \propto \sqrt{T} \qquad \frac{n_1}{n_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\frac{1}{2} = \left(\frac{T}{T+3}\right)^{1/2} \Rightarrow \frac{1}{4} = \frac{T}{T+3}$$

$$1 + \frac{3}{T} = 4$$

$$\frac{3}{T} = 3 \Rightarrow T = 1\,\text{kg}$$

117.(A)

$V = \sqrt{\dfrac{T}{m}}$ where T is the tension and m is mass per unit length.

$m = A\cdot\rho$ where A is area of cross section.

$$\therefore\ V = \sqrt{\frac{T}{A\rho}} \quad \therefore\ V^2 = \frac{T}{A\rho}$$

$$\therefore\ \frac{T}{A} = V^2\rho$$

118.(C)

$n = 415\,\text{Hz}, \quad V = 332\,\text{m/s}$

$$\therefore\ \lambda = \frac{V}{n} = \frac{332}{415} = 0.8\,\text{m} = 80\,\text{cm}$$

The air column will resonate for lengths

$\frac{\lambda}{4} = 20$ cm, $3\frac{\lambda}{4} = 60$ cm, $5\frac{\lambda}{4} = 100$ cm

It will not resonate for 40 cm

119.(B)

Frequency of vibration of a string is given by

$$n = \frac{1}{2\ell}\sqrt{\frac{T}{m}} \qquad \therefore \frac{n_2}{n_1} = \sqrt{\frac{T_2}{T_1}}$$

$$n_2 = n_1 + \frac{40}{100}n_1 = n_1 + 0.4\,n_1 = 1.4\,n_1$$

$$\therefore \frac{n_2}{n_1} = 1.4$$

$$\therefore 1.4 = \sqrt{\frac{T_2}{T_1}}$$

$$\therefore \frac{T_2}{T_1} = (1.4)^2 = 1.96$$

$$\therefore T_2 = 1.96\,T_1$$

$\therefore$ Tension must be increased by 96%.

120.(D)

$$n_1\ell_1 = n_2\ell_2$$

$$n_1 = 250 \text{ Hz}, n_2 = 250 - 2 = 240 \text{ Hz}$$

$$\therefore 250\,\ell 1 = 248\,\ell 2$$

$$\therefore \frac{\ell_1}{\ell_2} = \frac{248}{250} = \frac{124}{125}$$

121.(A)

In the first mode we have

$$n = \frac{V}{4L_1} \text{ or } L_1 = \frac{V}{4n} = \frac{340}{4\times 340} = 0.25 \text{ m} = 25 \text{ cm}$$

In this case $L_1 = \frac{\lambda}{4} = 25\,\text{cm}$

Resonance can also be obtained when the length of the air column is $\frac{3\lambda}{4} = 75\,\text{cm}$

Hence the minimum height of water = 100 − 75 = 25 cm

122.(B)

$$\frac{A_1}{A_2} = \frac{4}{3}$$

$$\therefore \frac{A_{max}}{A_{min}} = \frac{4+3}{4-3} = \frac{7}{1}$$

$$\therefore \frac{I_{max}}{I_{min}} = \left(\frac{7}{1}\right)^2 = \frac{49}{1}$$

123.(C)

The fundamental frequency is given by $n = \frac{1}{\ell r}\sqrt{\frac{I}{\pi\rho}}$

If length and radius both are doubled the frequency will become one-fourth.

124. (A)

Fundamental frequency of the pipe

$$n = \frac{V}{4L} = \frac{340}{4\times1} = 85\text{ Hz}$$

$\therefore$ Third harmonic of the string = 85 Hz

$$\therefore\ 85 = \frac{3}{2\ell}\sqrt{\frac{T}{m}} = \frac{3}{2\times0.25}\sqrt{\frac{100}{m}}$$

$$\therefore\ 85 = \frac{3}{0.5}\times\frac{10}{\sqrt{m}}$$

$$\therefore\ \sqrt{m} = \frac{3\times10}{85\times0.5} \approx 0.7$$

$\therefore$ $m = 0.49\text{ kg} \approx 0.5\text{ kg/m}$

Mass of the wire $M = mL = 0.5 \times 0.25 = 0.125\text{ kg} = 125\text{ g}$

125.(D)

Fundamental frequency of stretched string is given by

$$n = \frac{1}{2\ell L}\sqrt{\frac{T}{m}}$$

Tension $T = \frac{YA\ell}{L}$ $\quad$ A = area of cross section

Mass per unit length $m = \rho A$

$$\therefore\ \frac{T}{m} = \frac{YA\ell}{L}\times\frac{1}{\rho A} = \frac{Y\ell}{\rho L}$$

$$\therefore\ n = \frac{1}{2L}\sqrt{\frac{Y\ell}{\rho L}}$$

126.(C)

Equation of a travelling wave is given by $y = A\sin 2\pi n\left(t - \frac{x}{v}\right)$

$n = 250$ Hz, $v = 100$ m/s

$$\therefore\ y = 0.05\sin 500\pi\left(t - \frac{x}{100}\right)$$

For $t = 0.02$ s and $x = 1.1$ m

We have $y = 0.05\sin 500\pi\left(0.02 - \frac{1.1}{100}\right)$

$$= 0.05\sin500\pi\left(\frac{0.9}{100}\right) = 0.05\sin4.5\pi$$

$$= 0.05\sin\left(4 + \frac{1}{2}\right)\pi = 0.05\sin\left(4\pi + \frac{\pi}{2}\right) = 0.05\sin\frac{\pi}{2} = 0.05\text{ m}$$

127.(C)

For open pipe fundamental frequency

$$= \frac{V}{2\ell} = 100\text{ Hz}$$

For closed pipe fundamental frequency

$$= \frac{V}{4\ell} = 50\text{ Hz}$$

For closed pipe only odd harmonics are produced, which are 50, 150, 250, ...

128.(B)

$$y_1 = A\sin\left(\omega t + \frac{\pi}{6}\right) = A\cos\left(\omega t + \frac{\pi}{6} + \frac{\pi}{2}\right) = A\cos\left(\omega t + \frac{2\pi}{3}\right)$$

$y_2 = A\cos\omega t$

Phase difference $\phi = \frac{2\pi}{3}$

$\therefore$ Resultant amplitude is given by

$$R = \sqrt{A^2 + A^2 + 2A^2\cos\frac{2\pi}{3}} = \sqrt{A^2 + A^2 + 2A^2\left(-\frac{1}{2}\right)} = A$$

129.(D)

$y = 0.5\sin(0.314\,x)\cos(600\,\pi t)$

$0.314\,x = 2\pi\frac{x}{\lambda}$

$$\lambda = \frac{2\pi}{3.14} = \frac{2\times 3.14}{0.314} = 20\text{ cm}$$

The string is vibrating in third harmonic, forming three loops.

$\therefore$ Length of string $= 3\cdot\frac{\lambda}{2} = \frac{3\times 20}{2} = 30\text{ cm}$

130.(C)

131.(D)

$$n = \frac{1}{2\ell}\sqrt{\frac{T}{m}} \quad \therefore n \propto \sqrt{T}$$

$$\therefore \frac{n_2}{n_1} = \sqrt{\frac{T_2}{T_1}}$$

If $n_2 = 2n_1$, then $2 = \sqrt{\frac{T_2}{T_1}}$ or $4 = \frac{T_2}{T_1}$ $\quad\therefore T_0 = 4T_1 = 4\times 2 = 8\text{ kg wt}$

132.(B)

$$n = \frac{1}{2L}\sqrt{\frac{T}{m}}$$

$$\therefore \frac{n_2}{n_1} = \frac{L_1}{L_2}\sqrt{\frac{m_1}{m_2}} = \frac{1}{2}\sqrt{\frac{1}{2}}$$

$$n_2 = \frac{1}{2\sqrt{2}}n_1 = \frac{n}{2\sqrt{2}}$$

133.(B)

$n \propto \sqrt{T}$, $n_2 = 2n_1$

$$\therefore \frac{n_2}{n_1} = \sqrt{\frac{T_2}{T_1}}$$

$$2 = \sqrt{\frac{T_2}{T_1}}$$

$$\therefore \frac{T_2}{T_1} = 4$$

$$\therefore T_2 = 4T_1$$

$$\therefore M_2 = 4M$$

134.(C)

The weight of length L of the wire is W. Hence weight of $\frac{3L}{4}$ length will be $\frac{3W}{4}$

The tension at a height $\frac{3L}{4}$ from the lower end will be due to the weight of the wire of length $\frac{3L}{4}$ and due to the weight W_1 attached to it. Total tension will $W_1 + \frac{3W}{4}$

$$\text{Stress} = \frac{W_1 + \frac{3W}{4}}{A} = \frac{4W_1 + 3W}{4A}$$

135.(B)

It produces 4 beats/s with a fork of frequency 510 Hz.
Hence its frequency can be 514 or 506 Hz. It also produces 6 beats/s with a fork of frequency 512 Hz. Hence its frequency can be 518 Hz or 506 Hz.
Hence the frequency 506 Hz is possible in both the cases.

136.(D)

$\ell_1 = 24.1\text{ cm}$ and $\ell_2 = 74.1\text{ cm}$

Let e be the end correction

$e = 0.3\text{ d}$ where d = inner diameter

$$\ell_1 + e = \frac{\lambda}{4} \text{ and } \ell_2 + e = \frac{3\lambda}{4}$$

$$\therefore \ell_2 + e = 3(\ell_1 + e) = 3\ell_1 + 3e$$

$$\ell_2 - 3\ell_1 = 2e$$

$$\therefore 74.1 - 3 \times 24.1 = 2e$$

$$74.1 - 72.3 = 2e$$

$$\therefore 1.8 = 2e \text{ or } e = 0.9\text{ cm}$$

$$d = \frac{e}{0.3} = \frac{0.9}{0.3} = 3\text{ cm}$$

137.(C)

The fundamental frequency is given by

$$n = \frac{2}{2\ell r}\sqrt{\frac{T}{\pi\rho}}$$

If ℓ and r are doubled, the frequency n will become $\frac{n}{4}$.

138.(C)

For a pipe closed at one end only odd harmonics are produced.
If n is the fundamental frequency, then the frequencies produced are n, 3n, 5n etc.
Difference of successive harmonics is 2n.

$\therefore$ $350 - 250 = 100$ Hz $= 2n$

$\therefore$ $n = 50$ Hz

$\therefore$ $\lambda = \frac{v}{n} = \frac{340}{50}$ m $= 6.8$ m

Resonating length of air column in its fundamental mode is equal to $\frac{\lambda}{4}$.

$\therefore$ $\ell = \frac{6.8}{4} = 1.7$ m

139.(B)

$Y = 2 \sin (0.01 x + 30 t)$

$\therefore$ $\omega = 30$ rad/s, $k = 0.01$/cm

Speed of the wave $= \frac{\omega}{k} = \frac{30}{0.01} = 3000$ cm/s $= 30$ m/s

$\therefore$ Distance travelled in 0.5 s $= 30 \times 0.5 = 15$ m

140.(C)

Frequency $n = \frac{1}{2Lr}\sqrt{\frac{T}{\pi\rho}}$

$\therefore$ If L and r decrease, the frequency will increase.

141.(C)

Both the waves have amplitude equal to 10 cm. The phase difference between them is $\frac{\pi}{3}$.

The resultant amplitude is given by

$$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos\theta}$$

$$= \sqrt{(10)^2 + (10)^2 + 2\times10\times10\times\cos\frac{\pi}{3}}$$

$$= \sqrt{3\times10^2} = 10\sqrt{3} \text{ cm}$$

142.(A)

$m = 0.6$ kg/m, $L = 1$ m, $A = 10^{-8}$ m^2

$\Delta\theta = 40°C$, $Y = 2 \times 10^{11}$ N/m^2, $\alpha = 1.2 \times 10^{-5}$ /°C

$\Delta L = L\alpha\,\Delta\theta = 1 \times 1.2 \times 10^{-5} \times 40$

$= 4.8 \times 10^{-4}$

Tension in the wire $F = \frac{YA\Delta L}{L}$

$$= \frac{2\times10^{11}\times10^{-7}\times4.8\times10^{-4}}{1} = 9.6 \text{ N}$$

$$n = \frac{1}{2L}\sqrt{\frac{F}{m}} = \frac{1}{2\times1}\sqrt{\frac{9.6}{0.6}} = \frac{1}{2}\sqrt{16} = 2 \text{ Hz}$$

143.(C)

Maximum particle velocity = $\omega a = 2\pi fa$

Wave velocity = $f\lambda$

$$6f\lambda = 2\pi fa$$

$$\therefore \quad \lambda = \frac{\pi a}{3}$$

144.(B)

Fundamental frequency

$$n = \frac{V}{2\ell} = \frac{340}{2\times1} = 170\text{Hz}$$

It can resonate only at integral multiples of 170 Hz.

$\therefore$ It can not resonate at 85 Hz.

145.(C)

$$n = \frac{1}{2\ell r}\sqrt{\frac{T}{\pi\rho}} \qquad \therefore \quad n \propto \frac{1}{\ell r}; \qquad \text{T, } \rho \text{ are constant}$$

$$\therefore \quad \frac{n_1}{n_2} = \frac{\ell_2 r_2}{\ell_1 r_1} = \frac{2L}{L} \times \frac{r}{2r} = 1$$

146.(C)

$$y = 10\sin\frac{\pi x}{4}\cos 20\pi t$$

comparing with the standard equation

$$y = A\sin\frac{2\pi x}{\lambda}\cos\frac{2\pi T}{t}$$

we have $\frac{\pi x}{4} = \frac{2\pi x}{\lambda}$

$$\therefore \quad \lambda = 8 \text{ cm}$$

Distance between successive nodes $= \frac{\lambda}{2} = 4$ cm

147.(B)

Fundamental frequency of closed pipe = $n_1 = \frac{V}{4\ell}$

Frequency of third harmonic $n_3 = \frac{3V}{4\ell}$

Fundamental frequency of open pipe = $n_1' = \frac{V}{2\ell}$

$$\frac{3V}{4\ell} - \frac{V}{2\ell} = 50$$

$$\therefore \quad \frac{V}{4\ell} = 50 \qquad \therefore \quad \frac{V}{2\ell} = 100 \text{ Hz}$$

148.(A)

$f_A = f_c \times 1.015 \qquad f_B = f_c \times 0.975$

$f_A - f_B = 12$

$(1.015 - 0.975)\, f_c = 12$

$0.040 f_c = 12$

$$\therefore \quad f = \frac{12}{0.040} = 300 \text{ Hz}$$

149.(C)

The fundamental frequency of pipe open at one end is given by

$$n = \frac{V}{4L} = \frac{320}{4\times0.8}$$

$$= \frac{320}{3.2} = 100\text{ Hz}$$

$\therefore$ The first overtone of the string = 100 Hz

$\therefore$ Fundamental frequency of the string $= \frac{100}{2} = 50$ Hz

For a string

$$n_1 = \frac{1}{2\ell}\sqrt{\frac{T}{m}}$$

$$50 = \frac{1}{2\times0.5}\sqrt{\frac{50}{m}}$$

$$50 = \sqrt{\frac{50}{m}}$$

$$\therefore (50)^2 = \frac{50}{m}$$

$$\therefore m = \frac{1}{50}\text{ kg/m}$$

$$\therefore M = mL = \frac{1}{50}\times0.5 = 10^{-2}\text{ kg} = 10\text{ gram}$$

150.(A)

$$n \propto \frac{1}{2\ell}\sqrt{\frac{T}{m}} \qquad \therefore n \propto T$$

$$\frac{n_2}{n_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{1.02\,T_1}{T_1}} = \sqrt{1.02} = 1.01$$

Also $n_2 - n_1 = 5$

$\therefore 1.01\,n_1 - n_1 = 5 \qquad \therefore 0.01\,n_1 = 5$

$$\therefore n_1 = \frac{5}{0.01} = 500\text{ Hz}$$

151.(D)

The stationary wave is given by

$$y = 2\cos\frac{2\pi x}{\lambda}\sin\frac{2\pi t}{T}$$

where $\lambda = 4$ m and $T = 0.4$ s

Amplitude $A = 2\cos\frac{2\pi x}{\lambda}$

At $x = 0.5$ m, $A = 2\cos\frac{2\pi\times0.5}{4}$

$$A = 2\cos\frac{\pi}{4} = 2\times\frac{1}{\sqrt{2}} = \sqrt{2}\text{ m}$$

152.(A)

For Melde's experiment. TP^2 = constant where T is the tension and P is the number of loops.

$\therefore \quad T_1P_1^2 = T_2P_2^2$

$\therefore \quad T_1(4)^2 = (T_1 - 0.009)(5)^2$

$\therefore \quad 9T_1 = 0.009 \times 25$

$\therefore \quad T_1 = 0.025$ kg-wt

153(A)

First overtone of a closed pipe is given by

$$f = \frac{3V}{4\ell}$$

First overtone of an open pipe is given by

$$f' = \frac{V}{\ell'}$$

Since $f = f'$, $\dfrac{3V}{4\ell} = \dfrac{V}{\ell'}$

$$\therefore \quad \frac{\ell}{\ell'} = \frac{3}{4}$$

154.(D)

Wavelength of the stationary wave is same as that of the two interfering waves.

155.(D)

Theory question

156.(A)

The distance between the open end and the closed end in the fundamental mode is $\frac{\lambda}{4}$. If the time required to cover the distance is t, then the time required to travel distance equal to λ will be 4t. Therefore the period of the wave is 4t. Hence the frequency is $\frac{1}{4t}$.

157.(D)

$$n = \frac{P_1}{2\ell}\sqrt{\frac{T}{m_1}} = \frac{P_2}{2\ell}\sqrt{\frac{T}{m_2}}$$

$$\therefore \quad \frac{P_1}{P_2} = \sqrt{\frac{m_2}{m_1}} = \sqrt{\frac{m}{9}} = \frac{\sqrt{m}}{3}$$

$$\therefore \quad \frac{5}{3} = \frac{\sqrt{m}}{3}$$

$$\therefore \quad \sqrt{m} = 5 \qquad \therefore \quad m = 25 \text{ kg}$$

158.(A)

$$n_1 = 2 \cdot \frac{1}{2\ell_1 r_1}\sqrt{\frac{T}{\pi\rho}}; \quad n_2 = 3 \cdot \frac{1}{2\ell_2 r_2}\sqrt{\frac{T}{\pi\rho}}$$

$$n_1 = n_2 \quad \therefore \quad \frac{2}{\ell_1 r_1} = \frac{3}{\ell_2 r_2} \qquad \therefore \quad \frac{\ell_1}{\ell_2} = \frac{r_2}{r_1} \times \frac{2}{3} = \frac{1}{2} \times \frac{2}{3} = \frac{1}{3}$$

159.(C)

$$n_1 = \frac{V}{2\ell_1} \quad \therefore \ \ell_1 = \frac{V}{2n_1}$$

$$n_2 = \frac{V}{2\ell_2} \quad \therefore \ \ell_2 = \frac{V}{2n_2}$$

$$n = \frac{V}{2\ell} \quad \therefore \ \ell = \frac{V}{2n}$$

$$\ell = \ell_1 + \ell_2$$

$$\frac{V}{2n} = \frac{V}{2n_1} + \frac{V}{2n_2}$$

$$\therefore \ \frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2}$$

$$\therefore \ n = \frac{n_1 n_2}{n_1 + n_2}$$

160.(D)

Frequency of tuning fork B = 480 Hz. It produces 5 beats with tuning fork A. Therefore frequency of tuning fork A can be 485 Hz or 475 Hz. On loading the tuning fork A with wax its frequency will decrease. Since the number of beats decreases, it means its frequency is higher than that of B. Hence its frequency is 485 Hz.

161.(C)

$$V = \sqrt{\frac{T}{m}} \qquad \left[m = \frac{M}{L} = \frac{AL\rho}{L} = A\rho\right]$$

$$\therefore \ V = \sqrt{\frac{T}{A\rho}}$$

$$\therefore \ V^2 = \frac{T}{A\rho}$$

$$A = \frac{T}{V^2\rho}$$

162.(A)

Frequency of vibration $n = \frac{1}{2e}\sqrt{\frac{T}{m}}$

If $T = Mg$, then $n = \frac{1}{2e}\sqrt{\frac{Mg}{m}}$

If ℓ_1 and g_1 are length and acceleration due to gravity at the pole and ℓ_2 and g_2 at the equator then, if frequency is same, then

$$n = \frac{1}{2\ell_1}\sqrt{\frac{Mg_1}{m}} = \frac{1}{2\ell_2}\sqrt{\frac{Mg_2}{m}}$$

$$\therefore \frac{\sqrt{g_1}}{\ell_1} = \frac{\sqrt{g_2}}{\ell_2}$$

$$\text{or } \frac{\ell_2}{\ell_1} = \sqrt{\frac{g_2}{g_1}}$$

$g_2 < g_1 \quad \therefore \ell_2 < \ell_1$

163.(C)

In a closed pipe in fundamental mode the length of the pipe is $\frac{\lambda}{4}$.

$$\therefore \ell = \frac{62}{4} = 15.5 \text{ cm}$$

164.(D)

$$n_2\ell_2 = n_1\ell_1$$

$$\therefore n_2 = \frac{\ell_1}{\ell_2} \cdot n_1 = \frac{\ell_1}{1.25R_1} n_1 = 0.8 \, n_1$$

$$\therefore n_1 - n_2 = n_1(1 - 08) = 0.2 \, n_1$$

$$\frac{n_1 - n_2}{n_1} = 0.2$$

165.(C)

$$y = 5 \sin \frac{\pi}{2}(100t - x) = 5 \sin\left(50\pi t - \frac{x\pi}{2}\right)$$

$$\therefore \omega = 50\pi \quad \text{or} \quad \frac{2\pi}{T} = 50\pi$$

$$\therefore T = \frac{1}{25} = 0.04 \text{ s}$$

166.(A)

$V = 50$ m/s, $f = 200$ Hz

$$\lambda = \frac{V}{f} = \frac{50}{200} = 0.25 \text{ m}$$

The distance between two nodes in $\frac{\lambda}{2} = \frac{0.25}{2} = 0.125$ m

167.(D)

$f = 165$ Hz, $v = 330$ m/s

$$v = f\lambda$$

$$\lambda = \frac{v}{f} = \frac{330}{165} = 2$$

$$\therefore \frac{\lambda}{4} = \frac{2}{4} = \frac{1}{2} = 0.5 \text{ m} = 50 \text{ cm}$$