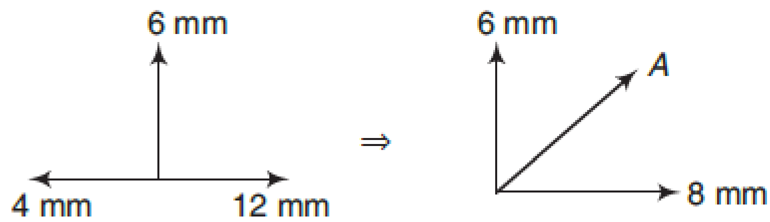
1. (C)

2. (B)



$$A = \sqrt{(8)^2 + (6)^2} = 10 \text{ mm}$$

3. (C)
(i) Two waves must travel in opposite directions.
(ii) At $x = 0$, $y = y_1 + y_2$ should be zero at all times.

4. (D)

5. (A)

6. (C)
$f_1 : f_2 : f_3 = 1:2:3$

$$\lambda = \frac{v}{f} \text{ or } \lambda \propto \frac{1}{f}$$

$$\therefore \quad \lambda_1 : \lambda_2 : \lambda_3 = 1 : \frac{1}{2} : \frac{1}{3}$$

7. (D)

8. (C)
All frequencies are integral multiples of 35 Hz.

9. (B)

$$3\left(\frac{v}{2l}\right) = 300$$

$$\therefore \quad v = 200\, l = (200)(1)$$

$$= 200 \text{ m/s}$$

10. (C)
These are multiples of 30 Hz. Hence, fundamental frequency

$$f_0 = 30 \text{ Hz}$$

Now, $f_0 = \dfrac{v}{2l}$

$$\therefore \quad v = 2 f_0 I$$

$= 2 \times 30 \times 0.8$

$= 40 \text{ m/s}$

11. (D)

$\because \quad \Delta\phi = \left(\frac{2\pi}{l}\right)(\Delta x)$

$= \left(\frac{2\pi}{v/f}\right)(\Delta x) = \left(\frac{2\pi}{vT}\right)(\Delta x)$

$= \left(\frac{2\pi}{300 \times 0.04}\right)(16 - 10)$

$= \pi$

12. (B)

$v = \frac{\omega}{k} = \sqrt{\frac{T}{\rho S}}$

$\therefore \ T = \rho S \left(\frac{\omega}{k}\right)^2 = \left(8000 \times 10^{-6}\right)\left(\frac{30}{1}\right)^2$

$= 7.2 \text{ N}$

13. (B)

$f \propto \frac{1}{l} \Rightarrow k = \frac{k}{f}$

Now, $l = l_1 + l_2 + l_3$

$\therefore \quad \frac{k}{f_0} = \frac{k}{f_1} + \frac{k}{f_2} + \frac{k}{f_3}$

$\therefore \quad \frac{1}{f_0} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$

14. (A)

$y_1 + y_2 = 2A\sin(\omega t - kx) = y_4$ (say)

Now, y_4 and y_3 produce standing waves where,

$A_{\text{max}} = 2$ (Amplitude of constituent wave)

$= 2(2A) = 4A$

15. (A)

$\because \quad f \propto \frac{1}{l}$

$\therefore \quad l_1 : l_2 : l_3 = \frac{1}{f_1} : \frac{1}{f_2} : \frac{1}{f_3}$

$= \frac{1}{1} : \frac{1}{3} : \frac{1}{4} = 12 : 4 : 3$

$\therefore \quad l_1 = \left(\frac{12}{12+4+3}\right)(114)$

$= 72\,\text{cm}$

$l_2 = \left(\frac{4}{12+4+3}\right)(114)$

= 24 cm

$l_3 = \left(\frac{3}{12+4+3}\right)(114)$

= 18 cm

16. (B)

$\frac{f_5}{f_2} = \frac{5 f_1}{2 f_1} = \frac{5}{2}$

$\therefore \quad f_2 = \frac{2}{5} f_5$

$= \frac{2}{5} \times 480$

= 192 Hz

17. (A)

$f_0 = \frac{v}{2l}$ and $f_c = \frac{v}{4l}$

$\therefore \quad f_0 = 2 f_c$

18. (C)

$v = \sqrt{\frac{\gamma RT}{M}} \propto \sqrt{\frac{T}{M}}$ $\quad (\gamma = 1.4$ for both)

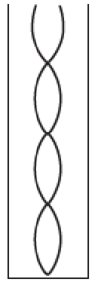
$\therefore \quad \frac{T_{O_2}}{M_{O_2}} = \frac{T_{N_2}}{M_{N_2}}$

$\therefore \quad T_{O_2} = \left(\frac{M_{O_2}}{M_{N_2}}\right) T_{N_2}$

$= \left(\frac{32}{28}\right)(273+15)$

$= 329\,\text{K} = 56°\text{C}$

19. (D)



Third overtone

20. (A)

$$\frac{v}{2l_0} = \frac{v}{4l_c} \Rightarrow l_c : l_0 = 1:2$$

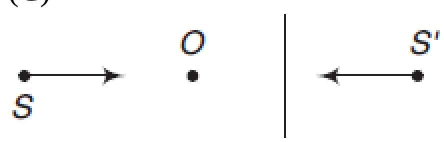
21. (A)

$f \propto v \propto \sqrt{T}$ $(T \to \text{tension})$

$$\therefore \quad \frac{f_1}{f_2} = \sqrt{\frac{T_1}{TA_2}} \Rightarrow T_2 = T_1\left(\frac{f_2}{f_1}\right)^2$$

$$= (10)\left(\frac{256}{320}\right)^2 = 6.4 \text{ kg}$$

22. (C)



Both S and S' are moving toward observer. Hence,

$$f_S = f_{S'} \text{ or } f_b = 0$$

23. (B)

$$f_b = \frac{10}{3} = f_1 - f_2 = \frac{v}{1} - \frac{v}{1.01}$$

Solving we get, v = 337 m/s

24. (C)

$$I_R = I_{\max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$$

If $I_1 = I_2 = I_0$, then

$$I_R = 4I_0$$

25. (B)

$$\frac{\lambda}{2} = 52 - 17 = 35 \text{ cm}$$

$\therefore$ $\lambda = 70 \text{ cm} = 0.7 \text{ m}$

$v = f\lambda = 500 \times 0.7$

= 350 m/s

26. (B)

$$f' = f\left(\frac{v}{v \pm v_s \cos\theta}\right)$$

At $\theta = 90°$; $f' = f$

$\therefore$ $n_1 = 0$

27. (A)

$$n = n_1 - n_2 = \frac{v}{\lambda_1} - \frac{v}{\lambda_2}$$

$$\therefore \quad v = \frac{n\lambda_1\lambda_2}{\lambda_2 - \lambda_1}$$

28. (B)

By putting wax on *A*. Its frequency will decrease.
But beat frequency between *A* and *B* is also decreasing.

$\therefore \quad f_A > f_B$

or $\quad f_A - f_B = 5\,\text{Hz} \qquad ...(\text{i})$

$\therefore \quad f_B = f_A - 5 = 345\,\text{Hz}$

Now, $f_B \sim f_C = 4\,\text{Hz}$

f_C is either 341 Hz or 349 Hz.
If it is 341 Hz, then beat frequency with *A* will be 9 Hz.
If it is 349 Hz, then beat frequency will be 1 Hz.
If wax is loaded on *A*, its frequency will decrease.
To produce 6 beats/s with *C* it should become either 347 Hz (if $f_C =$ 341 Hz) or it should become 343 Hz (if $f_C = 349$ Hz).
If it becomes 347 Hz, then only it produces 2 beats/s with *B*, which is given in the question.

$\therefore \quad f_C = 341\,\text{Hz}$

29. (C)

$$f \propto \sqrt{T}$$

$$\frac{f'}{f} = \sqrt{\frac{T'}{T}} = \sqrt{\frac{101}{100}} = 1.0049$$

$$f' = (1.0049)(200)$$

$$\approx 201\,\text{Hz}$$

$$\therefore \quad f_b = f' - f = 1\,\text{Hz}$$

30. (D)

$$\lambda = \frac{v}{f} = \frac{340}{340} = 1\,\text{m} = 100\,\text{cm}$$

$$\frac{\lambda}{4} = 25\,\text{cm}$$

Air column lengths required are,

$$\frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4} \text{ etc.}$$

or 25 cm, 75 cm, 125 cm etc.
Maximum we can take 75 cm.
$\therefore$ Minimum water length
= 120 − 75 = 45 cm

31. (C)

Number of moles $\propto$ Volume

$$M = \frac{n_1 M_{O_2} + n_2 M_{H_2}}{n_1 + n_2}$$

$$= \frac{(1)(32)+(1)(2)}{2} = 17$$

Now, $v = \sqrt{\frac{\gamma RT}{M}} \propto \frac{1}{\sqrt{M}}$

$$\frac{v_1}{v_2} = \sqrt{\frac{M_2}{Ml1}} = \sqrt{\frac{2}{17}}$$

32. (B)

$f_1 = f\left(\frac{v}{v - v_s}\right)$ = constant. But $f_1 > f$

$f_2 = f\left(\frac{v}{v + v_s}\right)$ = constant, but $f_2 < f$

33. (B)

$$f_b = 243\left(\frac{320}{320-4}\right) - 243\left(\frac{320}{320+4}\right) = 6 \text{ Hz}$$

34. (D)

Closed pipe

Fundamental frequency is

$$f_1 = \frac{v}{4l} = \frac{320}{4\times 1} = 80 \text{ Hz}$$

Other frequencies are

$3f_1 : 5f_1$ etc. or 240 Hz, 400 Hz etc.

Open pipe

Fundamental frequency is

$$f_1 = \frac{v}{2l} = \frac{320}{2\times 1..6} = 100 \text{ Hz}$$

Other frequencies are $2f_1 : 3f_1 : 4f_1$ etc. or 200 Hz, 300 Hz and 400 Hz etc.

So, then resonate at 400 Hz.

35. (C)

Resultant amplitude will become 4 time.

Therefore, resultant intensity is 16 times

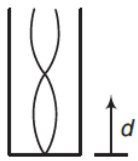
$$L_2 - L_1 = 10\log_{10}\frac{I_1}{I_2}$$

or $L_2 - 10 = 10\log_{10}(16)$

or $L_2 = 22 \text{ dB}$

36. (A)

$$\lambda = \frac{v}{f} = \frac{330}{600} = 0.55\text{ m} = 55\text{ m}$$



The desired distance, $d = \frac{\lambda}{4} = 13.75\text{ cm}$

37. (A)

$$f_a = f\left(\frac{v+v_0}{v}\right)$$

$$\therefore \quad \frac{v_0}{v} = \frac{f_a}{f} - 1 \qquad \text{...(i)}$$

$$f_r = f\left(\frac{v-v_0}{v}\right)$$

$$\therefore \quad \frac{v_0}{v} = 1 - \frac{f_r}{f} \qquad \text{...(ii)}$$

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

$$f = \frac{f_a + f_r}{2}$$

38. (A)

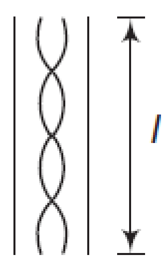
$$\Delta p_{\text{max}} = BAk \qquad \text{...(i)}$$

$$v = \sqrt{\frac{B}{\rho}}$$

$$\therefore \quad B = \rho v^2$$

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

$$\therefore \quad \lambda = \frac{2l}{3}$$



$$k = \frac{2\pi}{\lambda} = \frac{2\pi}{2l/3} = \frac{3\pi}{l}$$

$$= \frac{3\pi}{3.9\pi} = \frac{1}{1.3}\text{ m}^{-1}$$

Substituting in Eq. (i), we have

$$A = \frac{\Delta p_{\text{max}}}{Bk} = \frac{\Delta p_{\text{max}}}{\rho v^2 k}$$

$$= \frac{\left(0.01\times 10^5\right)}{1.3\times(200)^2\times\left(\frac{1}{1.3}\right)}$$

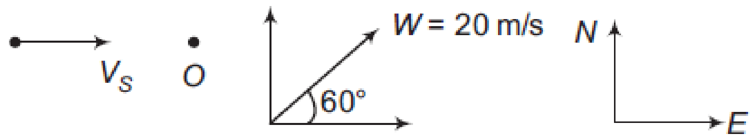
$$= 0.025\text{ m} = 2.5\text{ cm}$$

39. (D)

$$A_t = \left(\frac{2v_2}{v_1 + v_2}\right) A_i$$

$$\therefore \quad \frac{A_t}{A_i} = \frac{2 \times 100}{200 + 100} = \frac{2}{3}$$

40. (C)

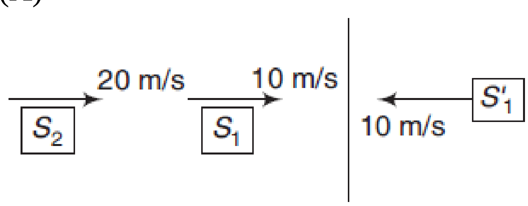


$$f' = f\left(\frac{v + w\cos 60°}{v + w\cos 60° - v_s}\right)$$

$$= 500\left(\frac{300 + 10}{300 + 10 - 20}\right)$$

$$= 534 \text{ Hz}$$

41. (A)



$$f_b = f_{S'} - f_{S_1}$$

$$= 500\left[\frac{340 + 20}{340 - 10}\right] - 500\left[\frac{340 + 20}{340 + 10}\right]$$

$$\approx 31 \text{ Hz}$$

42. (B)

$$\because \quad f_1 = f_2$$

$$\therefore \quad 176\left(\frac{330 - v}{330 - 22}\right) = 165\left(\frac{330 + v}{330}\right)$$

Solving this equation we get,

$$v = 22 \text{ m/s}$$

43. (C)

$\because \quad v_P = -v\left(\frac{\partial y}{\partial x}\right)$, where v = + ve.

At E, $\frac{\partial y}{\partial x}$ or slope is positive.

Hence, v_p is negative.

At D, $\frac{\partial y}{\partial x}$ or slope is zero.

Hence, v_p is zero.

44. (660)

As, phase difference $= \frac{2\pi}{\lambda} \times$ path difference

$\Rightarrow \quad 1.6\pi = \frac{2\pi}{\lambda} \times 40$

$\Rightarrow \quad \lambda = 50\,\text{cm} = 0.5\,\text{m}$

Now as $v = \lambda f$

$\Rightarrow \quad f = \frac{v}{\lambda} = \frac{300}{0.5} = 660\,\text{Hz}$

45. (100)

Given, $y = 10^{-4} \sin\left[100t - \frac{x}{10}\right]$

Comparing it with the standard equation of wave motion

$y = r\sin\left[\frac{2\pi}{T}t - \frac{2\pi}{\lambda}x\right]$, we get

$\frac{2\pi}{T} = 100$ or $T = \frac{2\pi}{100} = \frac{\pi}{50}\,\text{s}$

$\frac{2\pi}{\lambda} = \frac{1}{10}$

or $\quad \lambda = 20\pi$

and velocity, $v = \frac{\lambda}{T} = \frac{20\pi}{\pi/50} = 100\ \text{ms}^{-1}$

46. (1.47)

Time required for a point to move from maximum displacement to zero displacement is $t = \frac{T}{4} = \frac{1}{4n}$

$\Rightarrow \quad n = \frac{1}{4t} = \frac{1}{4 \times 0.170} = 1.47\ \text{Hz} \quad \left(\text{as } T = \frac{1}{n}\right)$

47. (1092)

As, $v \propto \sqrt{T}$

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

$\Rightarrow \quad T_2 = T_1\left(\frac{v_2}{v_1}\right)^2$

$\Rightarrow \quad T_2 = 273 \times 4 = 1092\,\text{K}$

48. (318)

Given, frequency of A, $f_A = 324\,\text{Hz}$

Now, frequency of B, $f_B = f_A \pm$ beat frequency

$= 324 \pm 6$

or $\quad f_B = 330$ or 318 Hz

Now, if tension in the string is slightly reduced its frequency will also reduce from 324 Hz.

Now, if $f_B = 330$ and f_A reduce, then beat frequency should increase which is not the case but if $f_B = 318\,\text{Hz}$ and f_A decreases the beat frequency should decreases, which is the case and hence $f_B = 318\,\text{Hz}$.

49. (4)

Distance between two consecutive node is $\frac{\lambda}{2}$

$\therefore \quad \frac{\lambda}{2} = \frac{2}{2}\,\text{m} = 1\,\text{m}$

So, the distance of another node from the surface will be

$$3 + \frac{\lambda}{2} = 3 + 1 = 4\,\text{m}$$

50. (10)

As, $\frac{n_2}{n_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{81}{100}} = \frac{9}{10}$

$\therefore \quad \frac{(n_1 - n_2)}{n_1} \times 100 = 10\%$

51. (500)

For closed pipe, $l_1 = \frac{v}{4n}, l_2 = \frac{3v}{4n}$

$\Rightarrow \quad n = \frac{v}{2(l_2 - l_1)} = \frac{330}{2 \times (0.49 - 0.16)} = 500\,\text{Hz}$

52. (5)

$\nu = 165\,\text{Hz}$, and $\nu' = \frac{335+5}{335} \times \frac{335}{330} \times 165 = 170\,\text{Hz}$

$\therefore$ Number of beats per second $= v' - v = 170 - 165 = 5$

53. (7)

$n_c = \frac{v}{4l}$ and $n_0 = \frac{v}{2l}$

Now, $n_0 - n_c = 2$

$\therefore \quad \frac{v}{2l} - \frac{v}{4l} = 2$

or $\quad \frac{v}{l} = 8$

Also $n_0' = \frac{v}{2l/2} = \frac{v}{l}$

and $n_c' = \frac{v}{4(2l)} = \frac{v}{8l}$

Number of beats per second $= n_0' - n_c'$

$$= \frac{v}{l} - \frac{v}{8l} = \frac{7v}{8l}$$

$$= \frac{7}{8} \times 8 = 7$$

54. (941)

As, $v_s = r\omega = r \times 2\pi = \frac{70}{100} \times 2 \times \frac{22}{7} \times 5 = 22 \text{ ms}^{-1}$

Frequency is minimum when source is moving away from listenery.

Therefore from Doppler's effects,

$$\nu' = \frac{u \times v}{u + u_s} = \frac{352 \times 1000}{352 + 22} = 941 \text{ Hz}$$

1. (B)

(b) $V = \frac{8}{0.4} = 20\ \text{cm/s}$ and $\lambda = 4 \times 2 = 8\ \text{cm}$

and, $\omega = VK = 20 \times \frac{2\pi}{8} = 5\pi\ \text{rad/sec}$

So, $(V_{max})_{particle} = \omega A = 5\pi \times \frac{1\ \text{cm}}{2} = \frac{5\pi}{2}\ \text{cm/s}$

2. (D)

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

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

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

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

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

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

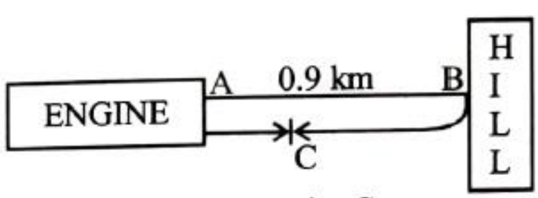
$L_2 = \left(\frac{4}{19} \times 114\right) = 24$ cm and $L_3 = \left(\frac{3}{19} \times 114\right) = 18$ cm

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

3. (C)

4. (D)

(d)



Let after 5 sec engine at point C

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

$\therefore BC = 750\,\text{m}$

Distance travelled by engine in 5 sec

$= 900\,\text{m} - 750\,\text{m} = 150\,\text{m}$

Therefore velocity of engine $= \frac{150\,\text{m}}{5\,\text{sec}} = 30$ m/s

5. (A)

Given, amplitude a = 10 cm

wave velocity = 2 × maximum particle velocity

i.e, $\frac{\omega\lambda}{2\pi} = 2\frac{a\omega}{\pi}$ or, $\lambda = 4a = 4\times 10 = 40\,\text{cm}$

6. (B)

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

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

Tension in the wire, T = 400 N

Mass per unit length, m = 0.01 kg

Minimum common frequency = ?

As we know,

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

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

$\nu_2 = \frac{1000}{3}\text{Hz} \Rightarrow \nu_3 = \frac{1000}{2}\text{Hz}$

Hence common frequency = 1000 Hz

7. (D)

(d) Given: Frequency of sound produced by siren, $f = 800\,\text{Hz}$

Speed of observer, u = 2 m/s

Velocity of sound, v = 320 m/s

No. of beats heard per second = ?

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

∴ No. of beats/ sec

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

$= \frac{2\times 2}{\frac{320}{800}} = \frac{2\times 2\times 800}{320} = 10 \qquad \left(\because \lambda = \frac{V}{f}\right)$

8. (C)

(c) According to Doppler's effect,

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

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

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

Hence, option (c) is the correct answer.

9. (A)

(a) Reflected frequency of sound reaching bat

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

$= \left(\dfrac{320+10}{320-10}\right)\times 8000$

$= 8516$ Hz

10. (B)

11. (D)

12. (D)

(d) We know that the apperent frequency

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

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

Speed of sound v = 330 m/s

$\therefore\ f' = \dfrac{330+30}{330-30}\times 540 = 648$ Hz.

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

13. (B)

(b) $n_1 = n_2$

$T \to$ Same $\Rightarrow r \to$ Same

$l \to$ Same

Frequency of vibration

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

As T, r, and l are same for both the wires

$$n_1 = n_2 \Rightarrow \frac{p_1}{\sqrt{\rho_1}} = \frac{p_2}{\sqrt{\rho_2}} \Rightarrow \frac{p_1}{p_2} = \frac{1}{2} \quad \because \quad \rho_2 = 4\rho_1$$

14. (A)

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

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

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

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

15. (A)

(a) For first resonance, $\frac{\lambda}{4} = \ell_1 + e = 11$ cm

($\because$ end correction e = 1 cm given)

For second resonance, $\frac{3\lambda}{4} = \ell_2 + e$

$\Rightarrow \ell_2 = 3 \times 11 - 1 = 32$ cm

16. (D)

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

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

17. (A)

18. (D)

(d) $n_A = 425$ Hz, $n_B = ?$

Beat frequency x = 5 Hz which is decreasing ($5 \rightarrow 3$) after increasing the tension of the string B.

Also tension of string B increasing so

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

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

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

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

19. (A)

(a) Loudness (dB) $= 10\log_{10}\left(\dfrac{I_2}{I_{ref}}\right)$

or $120 = 10\log_{10}\left(\dfrac{I}{10^{-12}}\right) \Rightarrow I = 1$

Also $I = \dfrac{P}{4\pi r^2} = \dfrac{2}{4\pi r^2} \Rightarrow 1 = \dfrac{2}{4\pi r^2} \Rightarrow r = \sqrt{\dfrac{1}{2\pi}}$

$\Rightarrow r = 40$ cm

20. (A)

(a) On comparing with $P = P_0 \sin(wt - kx)$, we have

$w = 1000$ rad/s, $K = 3\ m^{-1}$

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

$\dfrac{v_1}{v_2} = \sqrt{\dfrac{T_1}{T_2}}$ $\qquad \left[\because V = \sqrt{\dfrac{\gamma RT}{M_o}}\right]$

or $\dfrac{333.3}{336} = \sqrt{\dfrac{273+0}{273+T_2}} \Rightarrow T_2 = 277$ K

$\therefore\ T_2 = 4°C$

21. (B)

22. (B)

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

23. (B)

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

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

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

24. (B)

(b) Given, y = 0.3 sin (0.157 x) cos (200 πt)
So k = 0.157 and w = 200π

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

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

$\therefore l = \frac{2v}{f} = \frac{2 \times 4000}{100} = 80m$

25. (C)

26. (A)

(a) If a closed pipe vibration in N^{th} mode then frequency of vibration $n = \frac{(2N-1)v}{4l} = (2N-1)n_1$

(where n_1 = fundamental frequency of vibration)
Hence 20,000 = (2N – 1) × 1500
⇒ N = 7.1 ≈ 7
∴ Number of over tones = (No. of mode of vibration) – 1
= 7 – 1 = 6

27. (D)

(d) $\frac{\lambda_1}{v} = 11\text{cm}$. So $\frac{v}{512 \times 4} = 11\text{cm}$ ...(i)

$\frac{\lambda_2}{v} = 27\text{cm}$. So, $\frac{v}{256 \times 4} = 27\text{cm}$ ...(ii)

Substracting (ii) from (i), we get $\frac{v}{256 \times 4} \times 0.5 = 0.16\text{cm}$

v = 328 m/s

28. (D)

(d) $f_1 = f\left(\dfrac{v - v_o}{v - v_s}\right) = f\left(\dfrac{1500 - 5}{1500 - 7.5}\right)$

No reflected signal,

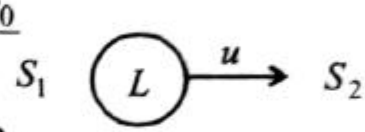
$f_2 = f_1\left(\dfrac{v + v_o}{v + v_s}\right) = f_1\left(\dfrac{1500 + 7.5}{1500 + 5}\right)$

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

502 Hz

29. (C)

(c) $f_1 = f\dfrac{v - v_0}{v}$ and $f_2 = f\dfrac{v + v_0}{v}$



But frequency,

$f_2 - f_1 = f \times \dfrac{2v_0}{v}$ or $10 = 660 \times \dfrac{2u}{330}$

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

30. (A)

31. (A)

(a) $f' = f\dfrac{v - v_0}{v + v_s}$

or $2000 = f\dfrac{340 - 20}{340 + 20}$ $\therefore f = 2250$ Hz.

32. (A)

33. (A)

(a) As we know,

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

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

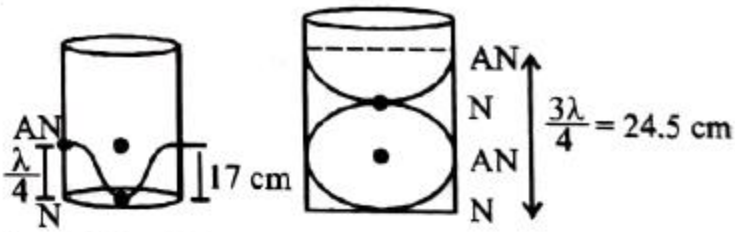
$\Rightarrow S_0 = \dfrac{\Delta P_0}{\rho V \omega} \approx \dfrac{10}{1 \times 300 \times 1000}\text{m} = \dfrac{1}{30}\text{ mm} \approx \dfrac{3}{100}\text{ mm}$

[**Note: -** '2π' is ignored here. So as to match the answer]

34. (B)

35. (A)

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



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

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

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

36. (C)

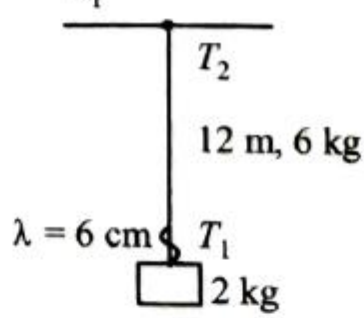
(c) As tension is different at every point of rope. So velocity of wave will be different at different point.

$$f = \text{constant} \Rightarrow \frac{V_1}{\lambda_1} = \frac{V_2}{\lambda_2} \Rightarrow \lambda_2 = \frac{V_2}{V_1}\lambda_1$$

$$\lambda_2 = \sqrt{\frac{T_2}{T_1}} \quad \lambda_1 \quad [\because V \propto \sqrt{T}]$$

$$= \sqrt{\frac{8g}{4g}} .\lambda_1 = 2 \times 6 \text{ cm}$$

$$= 12 \text{ cm}$$



37. (A)

(a) Given, $l = 60$ cm, $m = 6$ g, $A = 1$ mm², $v = 90$ m/s and $Y = 16 \times 10^{11}$ Nm^{-2}

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

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

$$\Delta L = \frac{Tl}{YA} = \frac{mv^2 \times l}{l(YA)} = \frac{6 \times 10^{-3} \times 90^2}{16 \times 10^{11} \times 10^{-6}} = 3 \times 10^{-4} m$$

$= 0.03$ mm

38. (A)

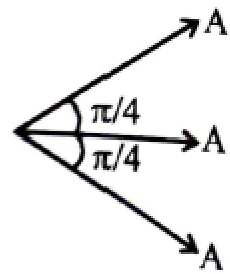
(a) Fundamental frequency, f = (490 – 420) Hz = 70 Hz.
The fundamental frequency of wire vibrating under tension T is given by

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

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

$$70 = \frac{1}{2L}\sqrt{\frac{540}{6\times10^{-3}}} \Rightarrow L \approx 2.14\,\text{m}$$

39. (A)



(a) $A_{res} = \sqrt{2}A + A$
$= (\sqrt{2}+1)A$ as $I \propto A^2$
$I_{res} = (\sqrt{2}+1)^2 I_o = 5.8 I_o$

40. (A)

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

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

Here, v = speed of bus,
f = actual frequency of source
Frequency heard after reflection from wall (f') is

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

$$\Rightarrow v = \frac{330\times7}{91} \approx 25.38 \text{ m/s} = 91 \text{ km/s}$$

41. (C)

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

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

Here, c = velocity of sound
v = velocity of source
Frequency of sound heard (f_2) when source is receding

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

Beat frequency = $f_1 - f_2$

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

For $c >> v$

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

42. (A)

(a) $f_A = 340 \pm 5 = 335 \text{ or } 340 \text{ Hz}$

When fork A is filled, then beat frequency decreases to 2 beats/s.
It is possible only when

$$f_A = 335 \text{ Hz}$$

43. (C)

(c) Let 'l' be the length of water level when the first resonance occurs

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

$$\therefore \frac{\lambda}{4} = l + e = l + 0.3d \qquad (d = \text{diameter of column})$$

$$\Rightarrow \frac{\frac{2}{3}\times 100}{4} = l + .3\times 6 \Rightarrow 16.66 = l + 1.8$$

$$\therefore l = 14.8 \text{ cm}$$

44. (C)

(c) Compairing the given $y = 0.5 \sin\left(\frac{2\pi}{\lambda}400t - \frac{2\pi}{\lambda}x\right)$ with standard equation

$\omega = \frac{2\pi}{\lambda}400$ and $k = \frac{2\pi}{\lambda}$

$\therefore$ velocity of the wave $v = \frac{\omega}{k} = \frac{2\pi}{\lambda}\frac{400}{\frac{2\pi}{\lambda}}$ $\therefore v = 400$ m/s

45. (A)

(a) $y = 2 \sin(\omega t - kx)$

Maximum particle velocity, $v_m = A\omega$

Wave velocity, $v_p = \frac{\omega}{k}$

$v_p = v_m$

$\frac{\omega}{k} = A\omega \qquad k = \frac{1}{A} = \frac{2\pi}{\lambda}$

$\lambda = 2\pi A = 2\pi \times 2 = 4\pi$

46. (D)

(d) We have, $k = \frac{2\pi}{\lambda} = \frac{2\pi}{4} = 0.5\pi\,\text{cm}^{-1}$

$\omega = 2\pi f = 2\pi \times 100 = 200\,\pi s^{-1}$

47. (D)

(d) Beat frequency $= f_1 - f_2$

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

$\Rightarrow \frac{10}{3} = v\left(\frac{0.08}{4.08 \times 4.16}\right) \Rightarrow v = 707.2$ m/s

48. (106)

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

Using, $V = \sqrt{\frac{B}{\rho}}$; $\frac{V_{gas}}{V_{air}} = \frac{\sqrt{\frac{B}{2\rho_{air}}}}{\sqrt{\frac{B}{\rho_{air}}}}$

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

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

(L = 1 metre given)

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

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

49. (1)

(1) At node displacement $y = 0$

$\cos(1.57\text{ cm}^{-1}x) = 0 \Rightarrow 1.57\text{cm}^{-1}x = \frac{\pi}{2} = x = 1$ cm

50. (7)

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

$y_1 = 12 \sin 6.28\,(x - vt)$

$y_2 = 5 \sin 6.28\,(x - vt + 3.5)$

Phase difference, $\Delta\phi = k(\Delta x) = 6.28 \times 3.5 = 7\pi$

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

$\Rightarrow A = \sqrt{(12)^2 + (5)^2 + 2(12)(5)\cos(7\pi)}$

$= \sqrt{144 + 25 - 120} = \sqrt{49} = 7$ mm

51. (10)

(10) Linear mass density $\mu = 9.0 \times 10^{-4} \frac{kg}{m}$

Tension, $T = 900\ N$

Velocity of wire,

$$V = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{900}{9 \times 10^{-4}}} = 10^3\ m/s$$

$$f_n = \frac{nV}{2\ell} = 500 \qquad ...(i)$$

And $(n + 1)v = 550$ ...(ii)

From (i) & (ii), $f_{n+1} - f_n = \frac{v}{2\ell} = 50$

$$\therefore\ \ell = \frac{10^3}{2 \times 50} = 10m$$

52. (34)

(34) The resonant frequency of a closed organ pipe of length L is

$$f = \frac{nv}{4L}$$

Here, n = odd positive integer

v = speed of sound in air

For L to be minimum, $n = 1$

$$\therefore 250 = \frac{v}{4L} \Rightarrow 250 = \frac{340}{4L} \Rightarrow L = \frac{34}{4 \times 25} = 0.34\ m$$

$\Rightarrow\ L = 34$ cm

53. (4)

Velocity $v = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{1}{k\rho}}$ [$\because$ compressibility $K = \frac{1}{B(\text{Bulk modulus})}$]

And both closed and open organ pipes vibrating in their first overtone with same frequency

$\therefore\ f_{\text{closed}} = f_{\text{open}}$

$$\frac{3v_1}{4L} = \frac{2v_2}{2L'} \Rightarrow L' = \frac{4}{3}L\left(\frac{v_2}{v_1}\right)$$

$L' = \frac{4}{3}L\sqrt{\frac{\rho_1}{\rho_2}}$ [$\because$ compressibility are equal]

$\therefore\ x = 4$

54. (1210)

Apparent frequency v

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

$$\Rightarrow 1320 = v_0\left(\frac{340 + 20}{340 - 10}\right) \Rightarrow v_0 = 1210 \text{ Hz}$$

55. (2025)

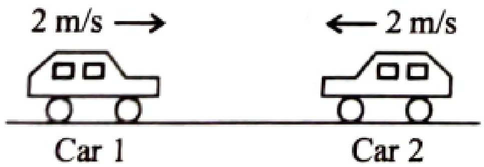
Apparent frequency (f') from doppler's effect

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

$$\Rightarrow 1800 = f_0 \frac{(340-20)}{(340+20)} \Rightarrow f_0 = 2025$$

56. (132)

57. (8)



Frequency of sound heard by driver of car 1 due to reflection of sound from car 2.

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

Here f_0 is the frequency produced by each car's horn, v is the velocity of sound in air, v_0 is the velocity of car 1, v_s is the velocity of car 2.

$$\Rightarrow \quad f' = 676\left(\frac{340+2}{340+2}\right) = 684 \text{ Hz}$$

$\therefore$ Beat frequency heard by each driver

$= f' - f_0 = 684 - 676 = 8 \text{ Hz}$

58. (3)

For n^{th} harmonic,

Frequency, $f_1 = \dfrac{nv}{0.6} = 400$

For $(n + 1)^{\text{th}}$ harmonic,

$$f_2 = \frac{(n+1)v}{0.6} = 450$$

$$\Rightarrow \left[\frac{0.6 \times 400}{v} + 1\right]\frac{v}{0.6} = 450 \Rightarrow v = 30$$

$\Rightarrow$ Speed of wave on a string $v = \sqrt{\dfrac{T}{\mu}} = 30$

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

59. (104)

For Ist resonance

$$l_1 + e = \frac{\lambda}{4} \Rightarrow 20 + e = \frac{336}{400} \times 100 \text{ cm} \times \frac{1}{4}$$

$$20 + e = \frac{84}{4} \qquad e = 21 - 20 = 1 \text{ cm}$$

For IIIrd resonance

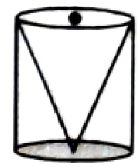
$l_2 + e = \frac{5\lambda}{4} \Rightarrow l_2 + 1 = 5 \times 21 \Rightarrow l_2 = 105 - 1 = 104 \text{ cm}$

60. (50)

If we don't ignore the word fundamental mode, you cannot observer resonance once again whatever be the height of water in column.

$\lambda = \frac{V}{f} = \frac{340}{340} = 1 \text{ m}$.

In first resonance



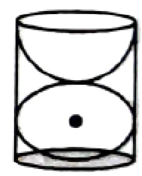
$\lambda = 4L_1$

$L_1 = \frac{\lambda}{4} = 25 \text{ cm}$

In second resonance $\lambda = \frac{4L}{3}$

$L = \frac{3\lambda}{4} = 75 \text{ cm}$

In third resonance



$\lambda = \frac{4L}{5}$ $\qquad L = \frac{\lambda}{2} + \frac{\lambda}{4} = \frac{4\lambda}{3}$

$L = \frac{5\lambda}{4} = 125 \text{ cm}$, So mode of vibration is $L = \frac{5\lambda}{4}$

Now, if 50 cm of water is added, it will vibrate in second resonance mode.

So, height of water required = (125 – 75) cm = 50 cm

61. (60)

The resultant amplitude is given as,

$A_{\text{resultant}} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos\phi}$

$\Rightarrow \sqrt{3}A = \sqrt{A^2 + A^2 + 2A^2 \cos\phi}$

$\Rightarrow 3A^2 = 2A^2 + 2A^2 \cos\phi \Rightarrow \cos\phi = \frac{1}{2}$

$\therefore \phi = 60°$

$\therefore$ Phase different = 60 degree

62. (152)

Let $f_1 = f_0$. Then

$f_2 = f_0 + 4$

$f_3 = f_0 + 2 \times 4$

$f_4 = f_0 + 3 \times 4$

$\vdots \qquad \vdots$

$f_{20} = f_0 + 19 \times 4$

Now, $f_{20} = 2f_1 \Rightarrow f_0 + 19 \times 4 = 2f_0$

$\Rightarrow f_0 = 76 \text{ Hz}$

So, $f_{20} = 76 + 19 \times 4 = 152 \text{ Hz}$

63. (5)

The standing wave equation is

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

Denotes Amplitude

$\therefore\ A = 10\cos\pi x$

$$\frac{A}{x} = \frac{4}{3}\text{cm} = 10\cos\frac{4\pi}{3}$$

Clearly, $|A| = \left|10\cos\frac{4\pi}{3}\right| = 5\text{ cm}$

64. (340)

From Doppler's effect, frequency of the car w.r.t. the hill

$$f_1 = \left(\frac{v}{v - v_s}\right) f = \left(\frac{330}{320}\right) 320 = 330\text{ Hz}$$

$\therefore$ Frequency of the sound reflected by hill w.r.t. the car i.e., echoheard by observer,

$$f_2 = \left(\frac{v + v_0}{v}\right) f_1 = \left(\frac{330 + 10}{330}\right) \times 330 = 340\text{ Hz}$$

65. (20)

Let f_1 be the frequency received directly and f_2 received due to reflection then, $f_1 = \frac{V-5}{V} f_o$

$f_2 = \frac{V+5}{V} f_o$ So, $f_{\text{Beat}} = f_2 - f_1 = \frac{10}{V} f_o$

$$= \frac{10 \times 640}{320} = 20\text{ Hz}$$

66. (680)

Here, the apparent frequency is given by

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

$$= 720\left(\frac{(340 + 20) - 20}{(340 + 20) - 0}\right) = \frac{720 \times 340}{360} = 680\text{ Hz}$$