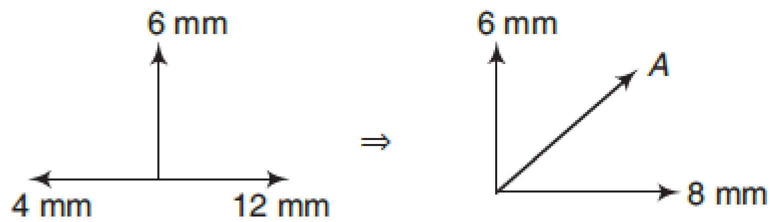
1. (C)

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,

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

$= 2(2A) = 4A$

15. (A)

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

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

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

$$\therefore \quad l_1 = \left(\frac{12}{12+4+3}\right)(114)$$
$$= 72\,\text{cm}$$
$$l_2 = \left(\frac{4}{12+4+3}\right)(114)$$
$$= 24 \text{ cm}$$
$$l_3 = \left(\frac{3}{12+4+3}\right)(114)$$
$$= 18 \text{ cm}$$

16. (B)

$$\frac{f_5}{f_2} = \frac{5f_1}{2f_1} = \frac{5}{2}$$
$$\therefore \quad f_2 = \frac{2}{5} f_5$$
$$= \frac{2}{5} \times 480$$
$$= 192 \text{ Hz}$$

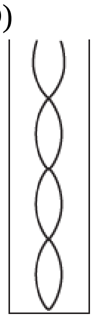
17. (A)

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

18. (C)

$$v = \sqrt{\frac{\gamma RT}{M}} \propto \sqrt{\frac{T}{M}} \qquad (\gamma = 1.4 \text{ for both})$$
$$\therefore \quad \frac{T_{O_2}}{M_{O_2}} = \frac{T_{N_2}}{M_{N_2}}$$
$$\therefore \quad T_{O_2} = \left(\frac{M_{O_2}}{M_{N_2}}\right) T_{N_2}$$
$$= \left(\frac{32}{28}\right)(273+15)$$
$$= 329\,\text{K} = 56^\circ\text{C}$$

19. (D)



Third overtone

20. (A)

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

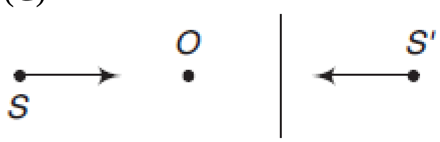
21. (A)

$f \propto v \propto \sqrt{T}$ $\quad\quad\quad\quad$ ($T \to$ 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 $\quad I_1 = I_2 = I_0$, then

$$I_R = 4I_0$$

25. (B)

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

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

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

$$= 350 \text{ m/s}$$

26. (B)

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

At $\quad \theta = 90°;\ f' = f$

$$\therefore \quad n_1 = 0$$

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

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

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

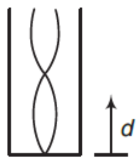
$$L_2 - L_1 = 10\log_{10}\frac{I_1}{I_2}$$

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)

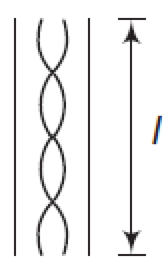
$$\Delta p_{\text{max}} = BAk \qquad \text{...(i)}$$

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

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

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

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



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

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

Substituting in Eq. (i), we have

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

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

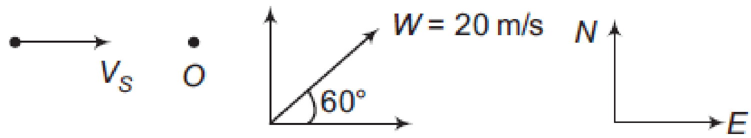
$$= 0.025\,\text{m} = 2.5\,\text{cm}$$

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)

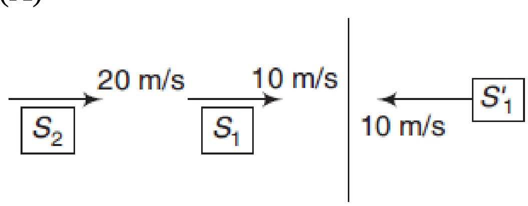


$$f' = f\left(\frac{v + w\cos 60°}{v + w\cos 60° - v_s}\right)$$

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

$$= 534 \text{ Hz}$$

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

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

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

Now as $v=\lambda f$

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

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 $\lambda=20\pi$

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 $t=\frac{T}{4}=\frac{1}{4n}$

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

47. (1092)

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

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

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

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

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 $f_B=330$ 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) $V = \frac{8}{0.4} = 20$ cm/s and $\lambda = 4 \times 2 = 8$ cm

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

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

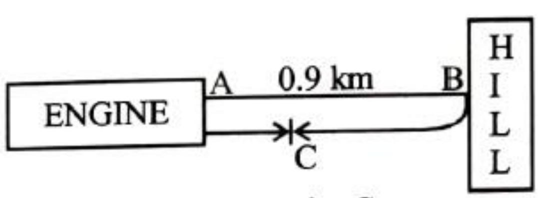
Hence the bridges should be placed at 72 cm and 72 + 24 = 96 cm from one end.

3. (C)

4. (D)

(c)

(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, $f = 800$ Hz

Speed of observer, u = 2 m/s

Velocity of sound, v = 320 m/s

No. of beats heard per second = ?

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

$\therefore$ No. of beats/ sec

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

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

8. (C)

(c) According to Doppler's effect,

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

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

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

Hence, option (c) is the correct answer.

9. (A)

(a) Reflected frequency of sound reaching bat

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

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

$= 8516$ Hz

10. (B)

11. (D)

12. (D)

(d) We know that the apperent frequency

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

where $v_0 = v_s = 30$ m/s, velocity of observer and source
Speed of sound $v = 330$ m/s

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

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

13. (B)

(b) $n_1 = n_2$

$T \rightarrow \text{Same} \Rightarrow r \rightarrow \text{Same}$

$l \rightarrow \text{Same}$

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 $v = \frac{\omega}{k} = \frac{200\pi}{5\pi/4} = 160 \text{ m/s}$

15. (A)

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

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

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

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

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

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

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

$\Rightarrow$ N = 7.1 ≈ 7

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

No reflected signal,

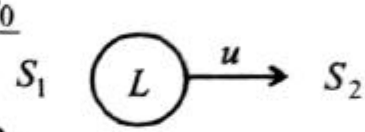
$f_2 = f_1\left(\frac{v + v_o}{v + v_s}\right) = f_1\left(\frac{1500 + 7.5}{1500 + 5}\right)$

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

502 Hz

29. (C)

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



But frequency,

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

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

30. (A)

31. (A)

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

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

32. (A)

33. (A)

(a) As we know,

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

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

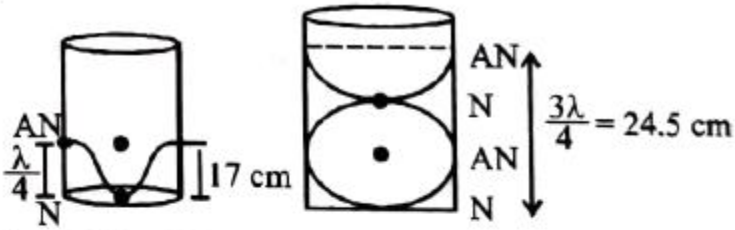
$\Rightarrow S_0 = \frac{\Delta P_0}{\rho V \omega} \approx \frac{10}{1 \times 300 \times 1000}\text{m} = \frac{1}{30}\text{ mm} \approx \frac{3}{100}\text{ mm}$

[**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, $f = ?$



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

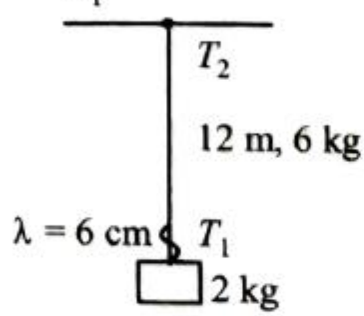
Now, from $v = f\lambda \Rightarrow 330 = \lambda \times 15 \times 10^{-2}$

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

36. (C)

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

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



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

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

$= 12$ 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)

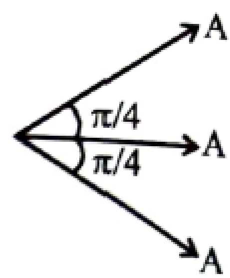
(a) Fundamental frequency, $f = (490 - 420)$ Hz = 70 Hz.
The fundamental frequency of wire vibrating under tension T is given by

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

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) $f_A = 340 \pm 5 = 335$ or 340 Hz

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

$f_A = 335$ 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, $v_p = \frac{\omega}{k}$

$v_p = v_m$

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

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

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

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

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

(L = 1 metre given)

$\therefore f_{2nd}$ harmonic $- f_{fundamental} = \frac{2v}{2\times1} - \frac{v}{2\times1} = \frac{v}{2}$

$\therefore f_{2n}$ 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,

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

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

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, $n = 1$

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

$\Rightarrow \quad L = 34$ 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)

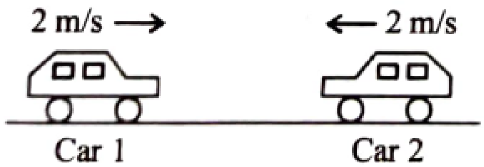
Apparent frequency (f') from doppler's effect

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

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

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, $f_1 = \frac{nv}{0.6} = 400$

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 $v = \sqrt{\frac{T}{\mu}} = 30$

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

59. (104)

For Ist resonance

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

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

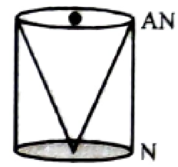
For IIIrd resonance

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

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.

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



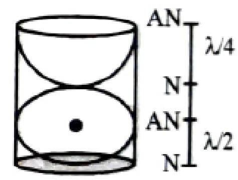
In first resonance

$\lambda = 4L_1$

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

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

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

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

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

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

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

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

SSP ~~exercise~~ — I

Ex — I

SAMCQ

Q.1 (A) At $t=0$, $y = \exp\left(-(x+2)^2\right)$

1

Ex I

At $t = 1s$, $y = \exp\left[-(x-c+2)^2\right]$

(Replaced x by $x-ct$)

But at $t=2$, $y = \exp\left[-(x-2)^2\right]$

$\Rightarrow -2 = 2-c$ or $C = 4\ m/s$

Q.2 (D) At $x=0$, $t=0$, $y<0$

2

Ex I

Also $\frac{\partial y}{\partial t} = -c\frac{\partial y}{\partial x} < 0$ at $x=0$ & $t=$

These conditions are met by $y = \sin\left(kx - \omega t - \frac{\pi}{6}\right)$ and not by others.

(1) Exercise I — 54 question

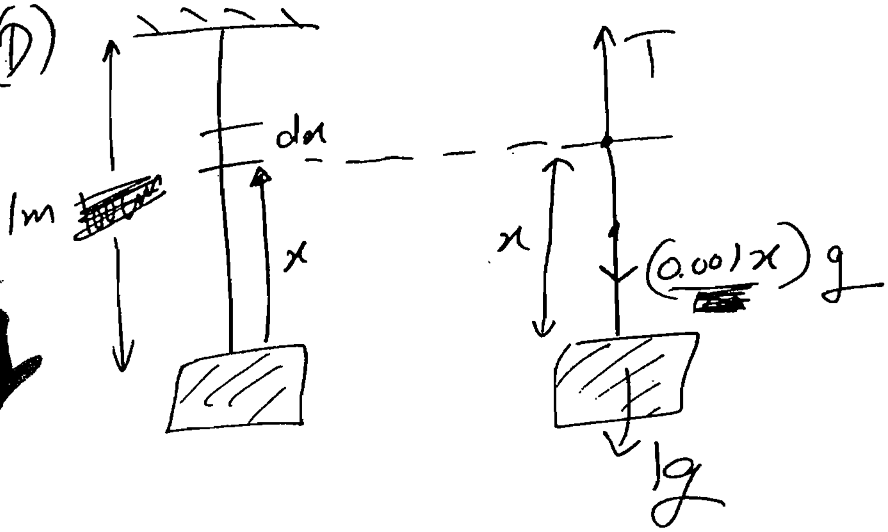
Q.3 (A) $\lambda = 0.4\,cm$, $f = 250\,Hz$

3

$$c = f\lambda = 250 \times 0.4 = 100\,cm\,s^{-1}$$
$$= 1\,m/s$$

Q.4 (D)

4



$$T = (1 + 0.001x)\,g$$

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{(1+0.001x)g}{0.001}} \quad , \text{let } g = 10\,m/s^2$$

$$\frac{dx}{dt} = \sqrt{(1000 + x)10} = \sqrt{10000 + x}$$

$$\int_0^1 \frac{dx}{\sqrt{10000+x}} = \int dt$$

$$\Rightarrow t = 0.01\,s$$

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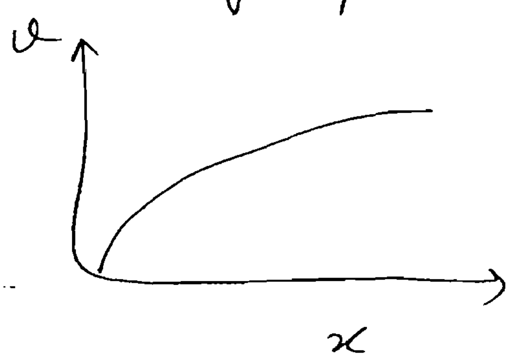
m/s^2

Q.5 (c) $V = \sqrt{\dfrac{4xg}{4}}$ or $v^2 = g.x$

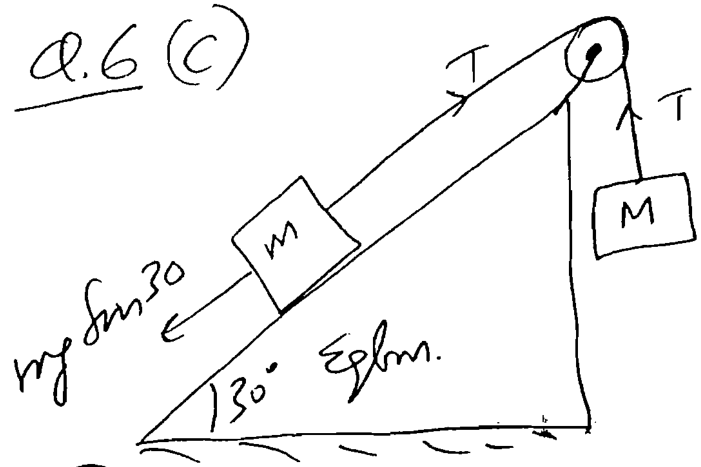
$\Rightarrow$ (parabola)

5

5/5



Q.6 (C)



6

$$T = mg\sin 30° \quad \& \quad T = Mg$$

$$mg\sin 30° = Mg \quad \text{or} \quad M = \frac{m}{2}$$

$$V = \sqrt{\frac{T}{\mu}} \quad \text{or} \quad T = \mu \cdot v^2$$

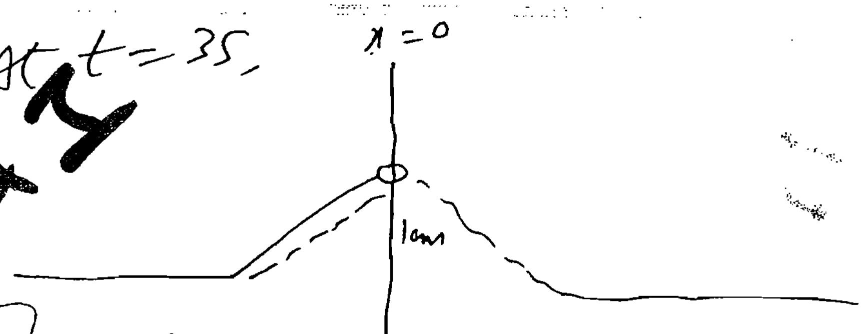
$$= \frac{10^{-2}\,kg}{m} \times (100)^2$$

$$= 10^2\,N = 100\,N$$

$$\Rightarrow M = 10\,N \quad \text{and} \quad m = 2M = 20\,N$$

Q.7 (D) At $t = 3s$,

7



$$y = y_1 + y_2 \Big]_{x=0} \Rightarrow y = 2\,cm$$

There is no phase change on reflection from free end.

MAMCQ

Q.1(c) $y = 2\,mm \sin\left(2\pi x - 100\pi t + \frac{\pi}{3}\right)$

When $x = 4$,

$$y = 2\sin\left(8\pi - 100\pi t + \frac{\pi}{3}\right) = 0$$

1

3.2

$$\Rightarrow \sin\left(8\pi - 100\pi t + \frac{\pi}{3}\right) = 0$$

or $25\pi - 300\pi t = 3n\pi$

or $t = \dfrac{25 - 3n}{300}$ where n is an integer ~~~~

If we put $n = 8$, $t = \frac{1}{300}$ s

Q.2 (B) $2\pi f A = 4 f \lambda$ (As max m. particle speed $= \omega A$ & wave speed $= \frac{\omega}{k}$)

$\frac{2}{4 \cdot I}$ or $\lambda = \frac{\pi A}{2}$

Q.3 (B, D) $y = \cos(500t - 70x)$

$\frac{3}{4 \cdot I}$ is a wave transverse or longitudinal?

$v = \frac{\omega}{k} = \frac{500}{70} = \frac{50}{7}$ m/s

$k = \frac{2\pi}{\lambda} = 70$ or $\lambda = \frac{2\pi}{70}$ m $= \frac{20\pi}{7}$ cm

$f = \frac{\omega}{2\pi} = \frac{500}{2\pi} = \frac{250}{\pi}$ Hz

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ticle
l &
$\frac{v}{k}$

Q.4 (C, D) $\frac{\partial y}{\partial t} = -c \cdot \frac{\partial y}{\partial x}$

Ex II

Q & R are symmetric about origin, hence $\left|\frac{dy}{dx}\right|_Q = \left|\frac{dy}{dx}\right|_R$

ind.

$\left|\frac{\partial y}{\partial x}\right|_P > \left|\frac{\partial y}{\partial x}\right|_Q$ is visible

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Q.5 to Q.8 5-8 / Ex II

$\frac{20\pi}{7}$ cm

$$\frac{\partial y}{\partial t} = -c \frac{\partial y}{\partial x}$$

Here c is -ve, so $\frac{\partial y}{\partial t}$ will have the same sign as $\frac{\partial y}{\partial x}$.

Hence,

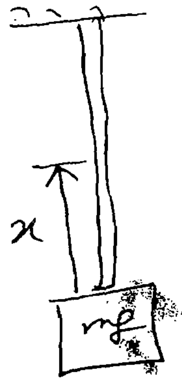
Q.5 (A, D)

Q.6 (C)

Q.7 (B, C)

Q.8 (C, D)

Q.9 (B, D) $T = \mu x g + mg$



$$v = \frac{dx}{dt} = \sqrt{\frac{T}{\mu}} = \sqrt{xg + \frac{mg}{\mu}}$$

As $x \uparrow$, $\frac{dx}{dt} \uparrow s$.

$$\frac{dv}{dt} = \cancel{\frac{1}{2}\left[xg + \frac{mg}{\mu}\right]^{-\frac{1}{2}}} \cdot \frac{dv}{dx} \cdot \frac{dx}{dt}$$

$$= v \cdot \frac{dv}{dx} = v \cdot \frac{1}{2}\left[xg + \frac{mg}{\mu}\right]^{-\frac{1}{2}} \cdot g$$

$$= \frac{g}{2}$$ (constant acceleration)

SUBJECTIVE – I

Q.1 At $t=0$, point P is moving upward, so its $\frac{\partial y}{\partial t} > 0$,

further $\left.\frac{\partial y}{\partial x}\right|_P > 0$

$$\Rightarrow \frac{\partial y}{\partial t} = -c\,\frac{\partial y}{\partial x}$$

(a) $\Rightarrow c < 0$.

Also,

$$K = \frac{2\pi}{\lambda} = \frac{2\pi}{4\times10^{-2}\,m} = 50\pi\ m$$

$$c = \frac{\frac{\partial y}{\partial t}}{\frac{\partial y}{\partial x}} = \frac{20\pi\ \frac{cm}{s}}{\tan 60^\circ} = \frac{20\pi\times10^{-2}\ m/s}{0.105}$$

$$\Rightarrow c = 6\ m/s \Rightarrow \omega = Kc = 50\pi\times6 = 300\pi$$

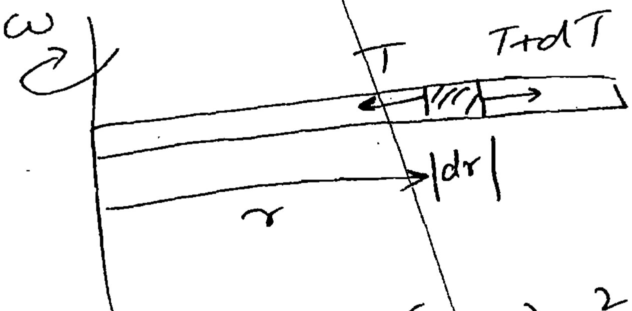
(b) Thus $y = 4\times10^{-3}\sin 100\pi\left(3t + 0.5x + \frac{1}{400}\right)$

where x, y are in metres.

(c) Total energy carried by wave per cycle of the string $= \frac{1}{2}\mu\omega^2 A^2 \lambda$

$$= 144\pi^2 \times 10^{-5}\ \mathrm{J}$$

Q.2



$$-dT = (\mu\, dr)\,\omega^2 r$$

$$-\int_T^0 dT = \mu\omega^2 \int_r^R r\,dr$$

$$T = \frac{\mu\omega^2}{2}(R^2 - r^2)$$

$$\frac{dr}{dt} = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{\omega^2}{2}\left(R^2 - r^2\right)}$$

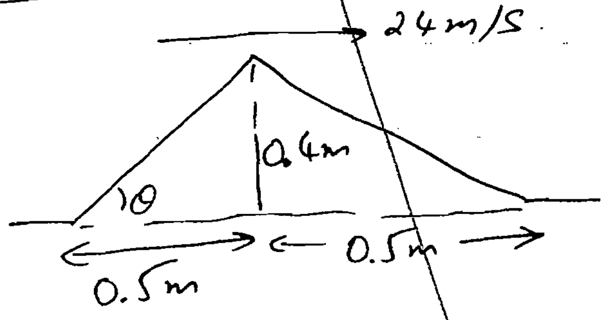
$$\int_0^R \frac{dr}{\sqrt{R^2 - r^2}} = \frac{\omega}{\sqrt{2}} \int_0^t dt$$

$$\sin^{-1}\left(\frac{r}{R}\right)\Bigg|_0^R = \frac{\omega}{\sqrt{2}} \cdot t$$

$$\frac{\pi}{2} = \frac{\omega}{\sqrt{2}} \cdot t$$

$$t = \frac{\pi}{\omega\sqrt{2}}$$

Q.3



$$\tan\theta = \frac{4}{5}$$

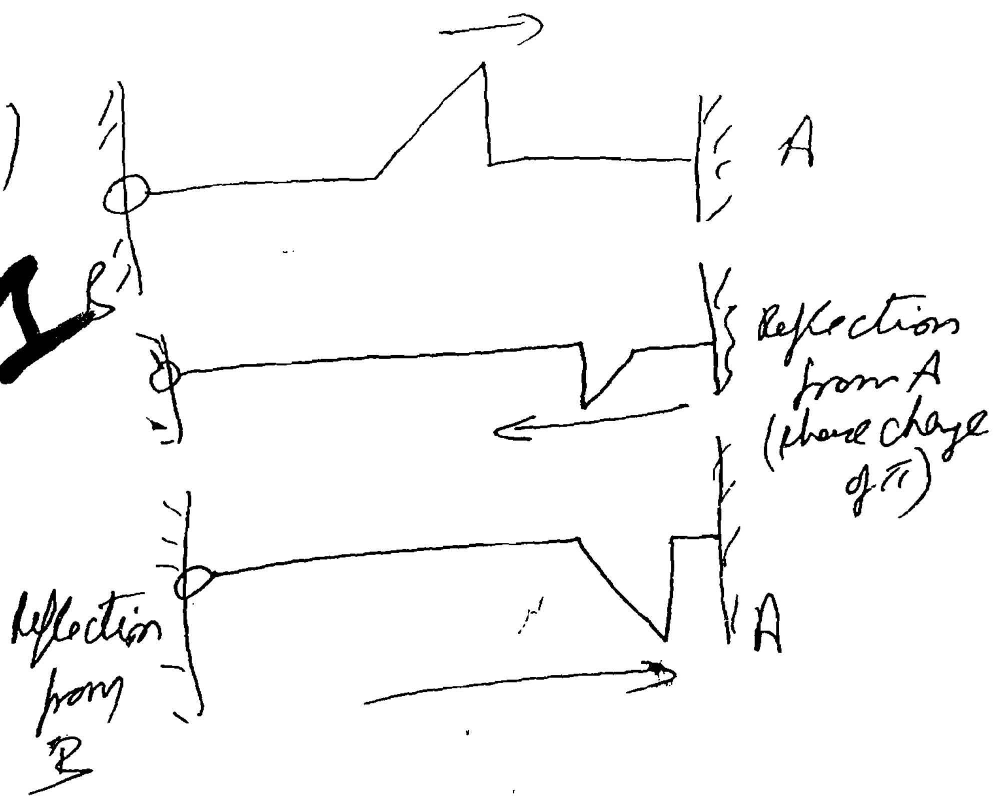
$$\frac{\partial y}{\partial t} = -c \cdot \frac{\partial y}{\partial x} = -24\,\frac{m}{s} \times \left(\frac{\pm 4}{5}\right)$$

$$= \mp 19.2 \text{ m/s}$$

Exercise — II

Q.1 (A)

8/8 1



Q.2 (C) use:

9/8 2

$$A_r = \frac{\left(\sqrt{\frac{T}{\mu}} - \sqrt{\frac{T}{4\mu}}\right)}{\sqrt{\frac{T}{\mu}} + \sqrt{\frac{T}{4\mu}}} \cdot A_i$$

Q.3 (B) use:

10/8 2

$$P_t = \frac{1}{2}(4\mu)\,\omega^2 \cdot A_t^2 \cdot \left(\sqrt{\frac{T}{4\mu}}\right) \quad \text{and}$$

$$P_i = \frac{1}{2}(\mu)\,\omega^2 A_i^2 \left(\sqrt{\frac{T}{\mu}}\right)$$

Q.4

Q.5

Q.6 (

Q.4 (B) $\frac{3\lambda}{2} = 1m$

11/Ex I

$\Rightarrow c = f\lambda = 300 \times \frac{2}{3} = 200 \frac{m}{s}$

Q.5(B) $A_{max} = 2A = 2(10) = 20$ units

12 Kx I

$\frac{\lambda}{2} = \frac{1}{2}\left(\frac{2\pi}{K}\right) = \frac{\pi}{2\pi(0.02)} = 25$ units

---

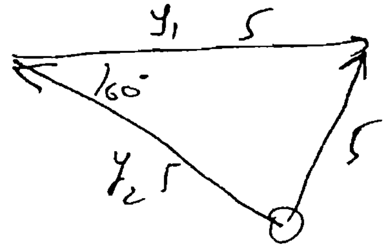
Q6(A) $y_1 = 5 \sin(\omega t - Kx)$

13/Ex y I

$y_2 = -5 \cos(\omega t - Kx - 110^\circ)$

Now $\cos\theta = \sin(90 + \theta)$

$\Rightarrow y_2 = -5 \sin(\omega t - Kx - 60^\circ)$



$\Rightarrow$ Amplitude of resultant = 5

Q.7(B) The resultant wave must have $y = 0$ at $x = 0$.

14/ ~~As~~ $y_1 = A\cos(kx - \omega t)$

$y_2 = -A\cos(kx + \omega t)$

$y_1 + y_2 = 2A \sin kx \cos \omega t$

(At $x = 0$, $\sin kx = 0$)

Q.8(A) $(n+1)\frac{\lambda}{2} = L$

15/ and $\frac{\lambda}{4} = d$ (Gap between adjacent node & Antinode)

$\Rightarrow L = 2d(n+1)$

Q.9 Verify dimensionally.

$$[Y] = \left[\frac{\text{Stress}}{\text{Strain}}\right] = \frac{MLT^{-2}}{L^2} = ML^{-1}T^{-2}$$

$$[\rho] = ML^{-3}$$

$$[\alpha] = \text{dimensi}$$

ntimde)

Q.9 (B) Stress = Y. Strain

$$= Y.\frac{\Delta l}{l}$$

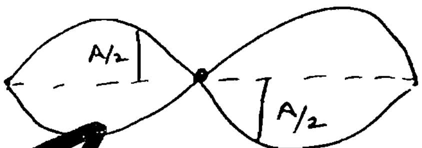
16/2

$$\frac{T}{A} = Y\alpha\Delta T$$

$$\text{frequency} \propto \sqrt{\frac{T}{\mu}} = \sqrt{\frac{T}{\rho A}}$$

$$\text{frequency} \propto \sqrt{\frac{Y\alpha}{\rho}}$$

Q. 10 (C)



17/8/2

$$\sin\left(\frac{20\pi x}{3}\right) = \pm\frac{1}{2}$$

$$\frac{20\pi}{3}(x_2 - x_1) = \left(\pi + \frac{\pi}{6}\right) - \left(\pi - \frac{\pi}{6}\right)$$

$$\frac{20\pi}{3}(x_2 - x_1) = \frac{\pi}{3}$$

$$(x_2 - x_1) = \frac{1}{20} = 0.05\text{ m} = 5\text{ cm}$$

---

11 (D) $f = \frac{n}{2l}\sqrt{\frac{T}{\mu}}$ (when both ends are fixed)

18/8/3

$$f_1 = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

$$f_2 = \frac{2}{2l}\sqrt{\frac{T}{\mu}}$$

$$f_3 = \frac{3}{2l}\sqrt{\frac{T}{\mu}}$$

$$f' = \frac{(2n-1)}{4l}\sqrt{\frac{T}{\mu}} \quad \left(\text{when only one end is fixed}\right)$$

$$n_1 = \frac{1}{4l}\sqrt{\frac{T}{\mu}}$$

$$n_2 = \frac{3}{4l}\sqrt{\frac{T}{\mu}}$$

$$n_3 = \frac{5}{4l}\sqrt{\frac{T}{\mu}}$$

$n_2 = \frac{n_1+n_3}{2}$ is evident.

Q.12 (D) $f \propto \sqrt{T}$

19/Ex I

$f = K\sqrt{V\rho g}$

$\frac{f}{2} = K\sqrt{V(\rho-1)g}$

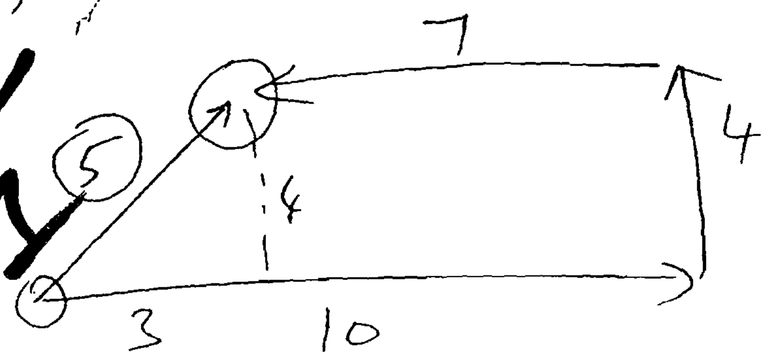
$\Rightarrow \rho = \frac{4}{3}$

$\frac{f}{3} = \sqrt{V(\rho-x)g}$

or $x = \frac{32}{27}$

Q.13 (A)

20/Ex I



Q.1

Q.1

Q.14 (A) $\cancel{\boxed{10 - 6}}$

21/Ex 3

Path difference = $10 - 6 = 4\,m$

$4 = n\lambda$ or $\lambda = \frac{4}{n}$

Here 4m qualifies

Q.15 (B) $I_{max} = K(\sqrt{4}+\sqrt{1})^2$

$= 9K$

22/Ex 3

$I_{min} = K(\sqrt{4}-\sqrt{1})^2$

$= K$

$dB_{max} = 10 \log_{10} \frac{I_{max}}{I_0}$

$dB_{min} = 10 \log_{10} \frac{I_{min}}{I_0}$

$dB_{max} - dB_{min} = 10 \log_{10} \frac{I_{max}}{I_0} = 10 \log_{10} 9$

$= 20 \cdot \log_{10} 3$

Q.16 (B) $x = 5cm$

23
Ex.3

$2x = 10\lambda$

$\lambda = \frac{2x}{10} = 1cm$

Q.17 (A) $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right)^2 = \frac{49}{9}$

24
Ex.3

$\Rightarrow \frac{I_1}{I_2} = \frac{25}{4}$

Q.18 (B) $I = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\delta$

25
Ex.3

~~A~~ $I_A = I + 4I + 2\sqrt{I}\sqrt{4I}\cos\frac{\pi}{2}$
$= 5I$

At B,

$I_B = I + 4I + 2\sqrt{I}\sqrt{4I}\cos\pi$

$= 5I - 4I = I$

$I_A - I_B = 5I - I = 4I$

$\frac{49}{9}$

Q.19 (A) $\lambda = \frac{c}{f} = \frac{330 m/s}{660 Hz} = 0.5 m$

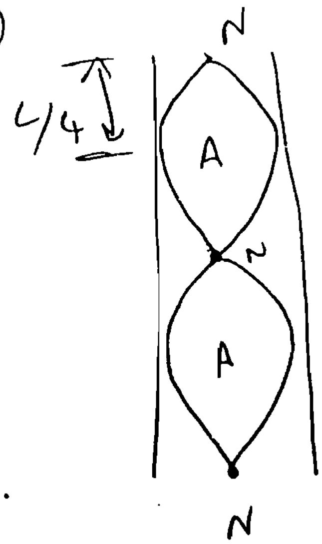
26 ~~Ex~~ Maxm. amplitude will be produced at an Anti-node, which is at $\frac{\lambda}{4}$ from the wall (node)

$\frac{\lambda}{4} = \frac{0.5}{4} = 0.125 m$

$\frac{1}{2}$

Q.20 (B)

17



Because wave in 2^{nd} harmonic in an open pipe.

Q.21 (C)

28

$$\frac{V\cancel{E}}{2l} - \frac{\cancel{E}V}{2(l+x)}$$

$$= \frac{V\cancel{E}}{2l}\left[1 - \frac{1}{\left(1+\frac{x}{l}\right)}\right]$$

$$= \frac{V\cancel{E}}{2l}\left[1 - \left(1-\frac{x}{l}\right)\right]$$

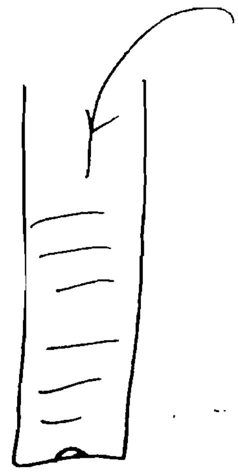
$$= \frac{Vx}{2l^2}$$

ie

ifl.

29.2 (B)

Ex 7



As water is poured, initially air-column reduces, so frequency increases.
Later steady-state is achieved so frequency becomes constant.

30.2 (C) $\lambda = 1m$, the resonance heights of air column are

Ex 1

$\frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}$ – –

25cm, 75cm 12~~5cm~~ – –

Water column $= 120 - 75 = 45$cm when the resonance happens for the 1st time

.24 (B) $\frac{3v}{4l_1} = \frac{4v}{2l_2}$

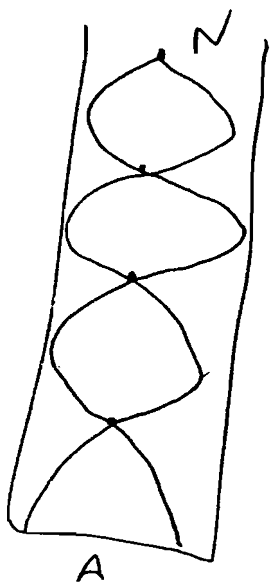
31/63

or $\frac{l_1}{l_2} = \frac{3}{8}$

Q.26

.25 (D)

32/63



$\frac{7\lambda}{4} = \cancel{B}\, l$

$\frac{\lambda}{4} = \frac{l}{7}$

$\lambda = \frac{105 \times 4}{7} = 60\text{cm}$

Q.2

Q.28

Q.26 (D) $\lambda = \frac{v}{f} = \frac{350 \text{ m/s}}{1750 \text{ Hz}} = 20\text{cm}$

33

Ex 2 The required minimum distance $= \frac{\lambda}{2} = 10\text{cm}$

Q.27 (A) $f_{p^{\text{th}}\text{ overtone}} = \frac{(2p+1) \cdot v}{4l}$

34

Ex 3 1st harmonic $= \frac{v}{4l}$

60cm Q.28 (C) $\frac{V}{4(L+0.6r_1)} = \frac{V}{(L+1.2r_2)}$

35

Ex 3 $\Rightarrow r_2 - 2r_1 = 2.5L$

Q.29 (C)

$$\frac{3v}{4L_c} = \frac{2v}{2L_o}$$

36/42 Also,

$$\frac{nc}{4L_c} = \frac{mL}{2L_o}$$

$$\Rightarrow \frac{n}{3} = \frac{m}{2}$$

$$n : m = 3 : 2 = 9 : 6$$

Q.30 (C) $l_1 + e = \frac{\lambda}{4}$

37/42 $l_2 + e = \frac{3\lambda}{4}$

$$\frac{l_2 + e}{l_1 + e} = 3 \text{ or } l_2 + e = 3(l_1 + e)$$

$$\Rightarrow e = \frac{1}{2}(l_2 - 3l_1)$$

Q.

Q.31 (B) $A = A_{max} \sin Kx$

38

$K = \frac{2\pi}{\lambda}$ where $(2n+1)\frac{\lambda}{2} = L$

$n=3$ for IIIrd overtone

$\Rightarrow \frac{7\lambda}{2} = L$

for $x = \frac{L}{7}$

$A = A_{max} \sin \frac{2\pi}{\left(\frac{2L}{7}\right)}\left(\frac{L}{7}\right)$

$= A_{max}$

$|A| = a$

$= E)$

$3Q_1)$

39
E2

Q.32 (D)

$$\frac{\lambda}{4} + e = 40$$

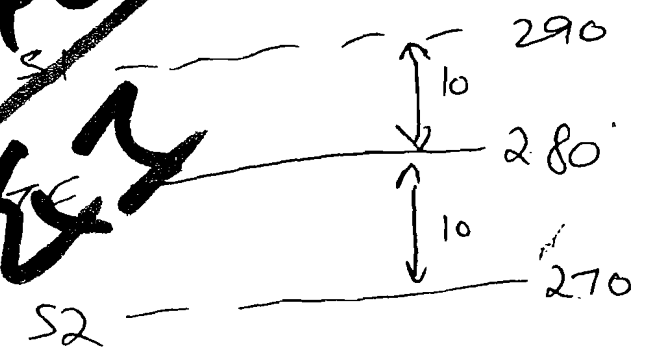
$$\frac{3\lambda}{4} + e = 122$$

for III rd resonance

$$\frac{5\lambda}{4} + e = 204\text{ cm}$$

40
E2

Q.33 (D) Sonometer (S1 or S2) = 280 + 10 = 290 or 280 − 10 = 270



When tension increases in the sonometer, the frequency increases. ~~The~~ 11 beats/s ⇒ gap increases, so it is S1.

Q.34 (C)

41/EI

$256 - x = f$

$262 - x = 2f$

$\Rightarrow x = 250$ Hz

Q.35 (A)

42/EI

-290

270

Initially,

$\frac{V}{2l} - \frac{V}{4l} = \pm 4$

$\frac{V}{4l} = +4$

If their lengths were twice, then

$\frac{V}{2(2l)} - \frac{V}{4(2l)} = \frac{c}{8l} = \frac{1}{2}\left(\frac{c}{4l}\right)$

$= \frac{4}{2} = 2$

re

eares

eacy,

1.

MAMCQ

Q.1 (A,B)

10 / Ex I

$$Amp = 2\sin\pi x$$

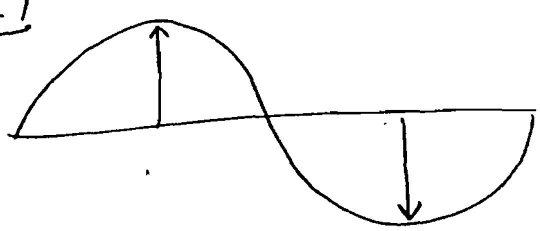
$$= 2\sin\pi\cdot\left(\tfrac{1}{6}\right)$$

$$= 2\times\tfrac{1}{2} = 1\,mm$$

$$\frac{\partial y}{\partial t} = 200\pi\sin(\pi x)\cdot\cos(100\pi t)$$

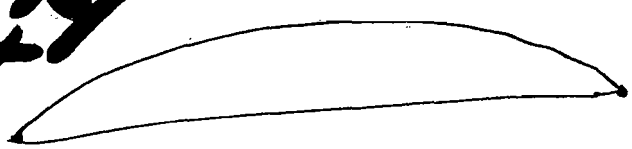
Q.2 (B,C)

Look!



(B) is wrong.

11 / Ex I

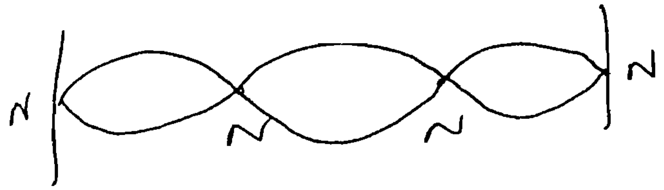


(D) is wrong.

Q.3

Q.4

Q.3 (D)



$\frac{12}{\Sigma\, I}$

$$\frac{3\lambda}{2} = L \quad \text{or} \quad \lambda = \frac{2L}{3}$$

$$K = \frac{2\pi}{\lambda} = \frac{2\pi}{(2L/3)} = \left(\frac{3\pi}{L}\right)$$

further $x = 0$ is a node.

$$y(x,t) = A \sin Kx . \cos \omega t$$

$$= A \sin\left(\frac{3\pi}{L} \cdot x\right) \cos\left(\frac{3\pi v}{L} \cdot t\right)$$

Q.4 (C, D) use: $f = \frac{1}{2L}\sqrt{\frac{T}{\mu}} = \frac{1}{2L}\sqrt{\frac{T}{\rho \pi r^2}}$

$\frac{13}{\Sigma\, II}$

Now, $d = 2r$

$$f = \frac{1}{L . d}\sqrt{\frac{T}{\rho \pi}}$$

Q.5 (B)

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

$$L = n\,(2\,cm)$$

$$L = (n+1)(1.6\,cm)$$

14
Ex II

$$\Rightarrow L = \left(\frac{L}{2}+1\right)(1.6\,cm)$$

$$\Rightarrow L = 8\,cm$$

Q.6 (A, C)

15
Ex II

$$E_{Total} = \frac{1}{4}\mu\omega^2 A^2 L$$

$$\omega = 2\pi f$$

$$E_{Total} \propto f^2 \propto n^2 (f_0^{\,2})$$

In stationary wave each particle does an SHM with a different amplitude so time average KE is half that of the total energy

Q.7(c) In a stationary wave, points in the same loop are in phase and out of phase with points in the neighbouring loop.

16
E&II

Q.8(c) Put $x = 0$

$y_1 = A\cos Kvt$ and ~~$y_2 = A\cos(Kvt + \phi)$~~

17
E&II

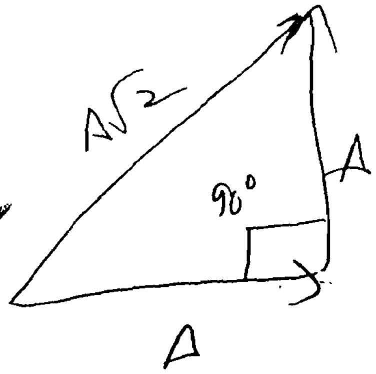
$y_2 = A\cos(Kvt + \phi)$

$y = y_1 + y_2 =$ ~~$2\sin\cos$~~ $2A\cos\left(Kvt + \frac{\phi}{2}\right)\cdot\cos\left(\frac{\phi}{2}\right)$

for $\phi = \pi$, $y = 0$

).9 (C)

18



Q.16
(D)

Q.1

).10 $\frac{3\pi R}{2} - \frac{\pi R}{2} = n\lambda$ (for Maxima)

(B,C)

19

Hence $\lambda = \frac{\pi R}{n}$

$\lambda = \pi R, \frac{\pi R}{2}, \frac{\pi R}{3}$

Q.1(
(B,

).11 $\frac{3\pi R}{2} - \frac{\pi R}{2} = \frac{(2n+1)\lambda}{2}$ (for Minima)

(?,C,D)

20

$\lambda = \frac{2\pi R}{2n+1}$

$\Rightarrow \lambda = 2\pi R, \frac{2\pi R}{3}, \frac{2\pi R}{5}$

Q.15
(C,D

Q.12

(D) $I_{max} = 4I_0$

21 / Ex II

Here I_0 is $\frac{I_0}{2}$ so, $I_{max} = 2I_0$

Q.13(A) $\lambda = \frac{\pi R}{n}$ (for Maxima)

22 / Ex II

$\lambda_{max} = \pi R$

Q.14 $\lambda = \frac{2\pi R}{2n+1}$ (for minima)

(B) 23 / Ex II

$\lambda_{max} = 2\pi R$

Minima

Q.15

(C, D)

24 / Ex II

IInd overtone of open pipe = IInd overtone of closed pipe

$\frac{3v}{2l_0} = \frac{5v}{4l_c}$

$\Rightarrow \frac{l_c}{l_0} = \frac{10}{12} = \frac{5}{6}$

Ist overtone of open pipe (A) $= \frac{2v}{2l_0}$

Ist overtone of closed pipe (B) $= \frac{3}{4l}$

$\Rightarrow f_A / f_B = \frac{4 l_c}{3 l_0} = \frac{4\times}{3\times}$

$= 10/9$

Q.16 $c = \sqrt{\frac{\gamma RT}{M}}$ $\frac{c}{l}$

$\frac{f_C}{f_D} = \sqrt{\frac{M_D}{M_C}} = \sqrt{}$

$\frac{f_C}{f_D} = \frac{l_D}{l_C}\sqrt{\frac{M_D}{M_C}} = \frac{l/3}{2l/3}\sqrt{\frac{44}{28}}$

$= \frac{1}{2}\sqrt{\frac{44}{28}} = \sqrt{\frac{11}{28}}$

Q.16 (C)

$f = \frac{v}{2l} = \frac{1}{2l}\sqrt{\frac{\gamma RT}{M}}$

Here, $\frac{f_1}{f_2} = \frac{l_2}{l_1}\sqrt{\frac{M_2}{M_1}}$

25 / Ex II

$\frac{f_C}{f_D} = \frac{l/3}{2l/3}\sqrt{\frac{44}{28}} = \sqrt{\frac{11}{28}}$

Q.1 (B, ...

Q.1 (B)

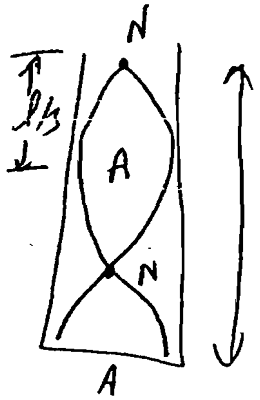
Q. (C

Q.2 (C

Q.17 (B,D) $f \propto \frac{1}{\sqrt{M}}$ $\frac{26}{Ex\ II}$

If $M \uparrow$, $f \downarrow$ and vice-versa

Q.18 (B) 1st overtone



$\frac{27}{Ex\ II}$

Pressure amplitude is at $\frac{l}{3}$ from open end $\Rightarrow \frac{1.2}{3} = 0.4\,m$

Q.19 (C) $\frac{\omega}{K} = \frac{50\pi}{10\pi} = \frac{5m}{5}$ $\frac{28}{Ex\ II}$

Q.20 (C)

$5\,|\,425, 595, 765$

$17\,|\,85, 119, 153$

$5, 7, 9$

Fundamental frequency $= 17 \times 5 = 85\,Hz$

$\lambda = \frac{c}{f} = \frac{340}{85} = 4\,m$

$l = \frac{\lambda}{4} = 1\,m$

$\frac{29}{Ex\ II}$

Exercise — III

Q.1 $\left(\frac{V}{1} - \frac{V}{1.02}\right) = 6$

(B)

43/Ex $\Rightarrow V = 300 \frac{m}{s}$

Q.2 $\frac{110}{100} = \frac{C}{C-V_s}$

(D)

44/Ex $\frac{100-x}{100} = \frac{C}{C+V_s}$

$\Rightarrow x = 8.5$

Q.3 45/Ex $f' = \left(\frac{C-V_L}{C-V_s}\right) \cdot f_0$

(C)

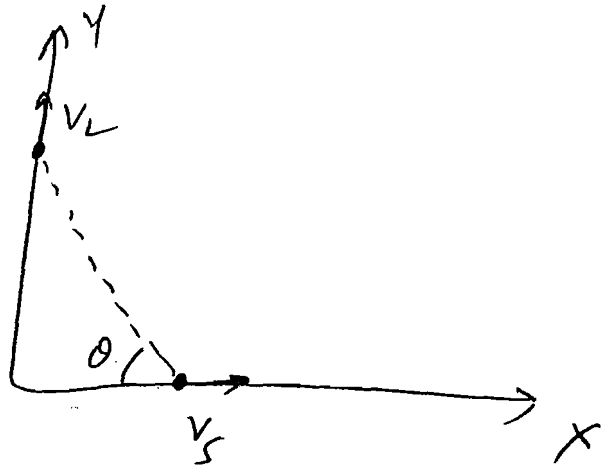
$V_L = V_s = 30 m/s$

$\Rightarrow f' = f_0$

~~Q.4~~ Q.4 Cancel

Q.5
(B)

46



θ = constant here
so apparent frequency remains constant.

Q.6
(D)

47

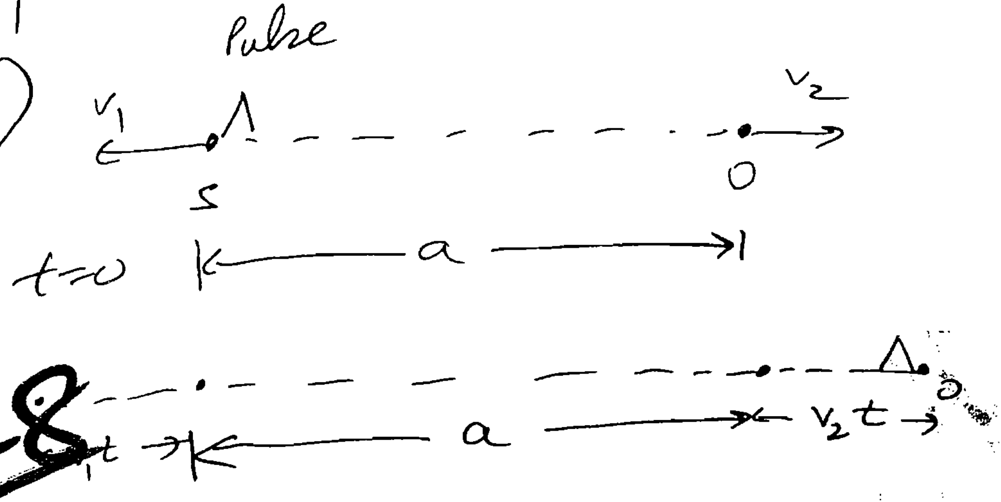
$$f' = \left(\frac{334-2}{334}\right) f_0 \times \left(\frac{334}{334+2}\right)$$

$$= \frac{332}{336} \times 334$$

$$\simeq 330 \text{ Hz}$$

Q.7

(C)



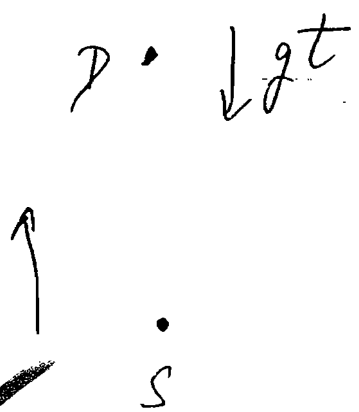
48/50

$$v_s t = (a + v_2 t)$$

$$(v_s - v_2)t = a$$

$$\text{or } t = \frac{a}{(v_s - v_2)}$$

Q.8



49/50

$$f' = \left(\frac{c - v_2}{c - v_s}\right) f_0$$

$$= \left(\frac{c + gt}{c}\right) f_0$$

$$f' = \cancel{1 \mp \left(\frac{g}{c}t\right)} f_0 + \left(\frac{f_0 g}{c}\right) t$$

$$\frac{f_0 \cdot g}{c} = \text{Slope}$$

$$\text{Have Slope} = \frac{1000}{30}$$

or

$$\frac{1000 \times 10}{c} = \frac{1000}{30}$$

$$\Rightarrow \quad c = 300\ m/s$$

Q. 9
(A)

$$f' = \left(\frac{c + at}{c}\right) \cdot f_0$$

$$\frac{50}{\cancel{\text{ZLI}}}$$

---

f_0

Q.10 One second after its fuel,
(A)

speed of source = 10 m/s

51/64

Before crossing

S $\downarrow$ $10\frac{m}{s}$

L $\uparrow$ $2\frac{m}{s}$

$$f_1 = \left(\frac{330+2}{330-10}\right) \times 150 = 155.625 \text{ Hz}$$

After Crossing

L $\uparrow$ $2\frac{m}{s}$

S $\downarrow$ $10\frac{m}{s}$

$$f_2 = \left(\frac{330-2}{330+10}\right) \times 150 \simeq 145$$

$$f_1 - f_2 \simeq 12$$

Q.

(A)

Q.

(B)

1

Q.11

(A) $\frac{5}{2}$ & I $\lambda = \dfrac{c+u}{f}$

Here wind speed increases the speed of sound.

Q.12

(B, C) $\frac{3D}{\&\,II}$

(Rest) A (500 Hz) — 25 m/s → O — 50 m/s → B (500 Hz)

.625 Hz

[redacted] $c = 350 \text{ m/s}$

Apparent frequency of whistle B as heard by observer $= \left(\dfrac{c-v_L}{c-v_s}\right) \cdot f_0$

.5

$= \left(\dfrac{350+25}{350+50}\right) \times 500$

$\simeq 469 \text{ Hz}$

Also apparent frequency of whistle A heard by observer $= \left(\frac{350-25}{350}\right) \times 500$

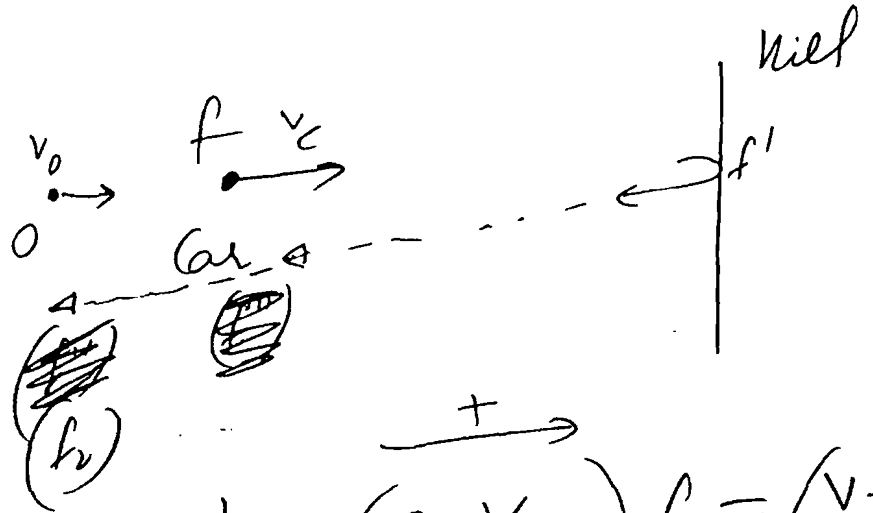
$= \frac{325}{350} \times 500 = \cancel{428.6\,Hz}$ $\cancel{464.3}$ $464.5\,Hz$

$\Rightarrow \Delta f = 4.5\,Hz$

Q.13 (C) $\frac{31}{Ex\,II}$ $\lambda' = (C - V_s)T$

Q.14 (B, C) $\frac{32}{Ex\,II}$ $\lambda' = (C - V_s)T$

$= \frac{V - V_c}{f}$



$$f' = \left(\frac{c - v_L}{c - v_S}\right) \cdot f_0 = \left(\frac{V - 0}{V - V_c}\right) \cdot f$$

$$= \frac{Vf}{V - V_c}$$

Then,

$$f_2 = \left(\frac{c - v_L}{c - v_S}\right) \cdot f_0$$

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

$$= \left(\frac{V + V_0}{V}\right) \cdot \left(\frac{Vf}{V - V_c}\right)$$

$$f_2 = \left(\frac{V + V_0}{V - V_c}\right) f$$

Now, observer hears the frequency of the car directly,

$$f_1 = \left(\frac{V+V_o}{V+V_c}\right) \cdot f$$

Q. 1 (D)

and hears the

Q. 2 (A)

echo of the car's "horn" from the hill (f_2)

$$\cancel{f_2 = \left(\frac{V+V_o}{V}\right) \cdot f''}$$

$$\cancel{= \left(\frac{V+V_o}{V}\right) \cdot \left(\frac{V+V_c}{V-V_c}\right) f}$$

$$\text{Beat frequency} = \left|\left(f_2 - f_1\right)\right| = \frac{2v_c f (V+V_o)}{V^2 - v_c^2}$$

Exercise - IV

Q.1 53 $90 - 40 = 50 = 10 \log_{10} \frac{I_x}{I_y}$

(D) Ex I

$I_x = 10^5 I_y$

Q.2

(A) 54 Ex I

$160 = 10 \log_{10} \frac{(I_{Jet}/100^2)}{I_0}$

$120 = 10 \log_{10} \frac{(I_{Jet}/h^2)}{I_0}$

$\Rightarrow 40 = 10 \log_{10} \frac{h^2}{100^2}$

$\log_{10} \frac{h}{100} = 2$

$h = 100 \times 10^2 = 10000\,m = 10\,km$

?.3 (D)

$$A_r = \left(\frac{V_2 - V_1}{V_1 + V_2}\right) A_i$$

Q.33/ Ex I

$$A_t = \left(\frac{2V_2}{V_1 + V_2}\right) A_i$$

A_t is always +ve, whereas

A_r can be -ve if $(V_1 > V_2)$.

?.4 (?, B, C, D)

34/ Ex I

$$V = \sqrt{\frac{\gamma RT}{M}}$$

$V \propto \sqrt{T}$

M depends on density of air,

~~M~~ M also depends on Humidity.

Q.5 (A, C,

Q.6

V_2

V_1

Q.5 35
(A, C, D) Ex II Use: $\Delta P = -B \frac{\partial \xi}{\partial x}$

Q.6 — Q.11
36—41 / Ex II
Use: $\frac{\partial y}{\partial t} = -v \frac{\partial y}{\partial x}$

and

$$\Delta P = -B \frac{\partial y}{\partial x}$$

$P_{compression} = P_0 + \Delta P_{max}$

$P_{rarefaction} = P_0 - \Delta P_{max}$

Q.6 (A, B)
Q.7 (C)
Q.8 (A)
Q.9 (A, [illegible]
Q.10 (A, D,
Q.11 (C,

dity.

Q.12 (B, C)

~~Q~~# 42 / 4 II

for graph A,
velocity of sound is independent of pressure as $\frac{P}{\rho}$ is constant at a given temperature.

for graph B,

$$v = \sqrt{\frac{\gamma RT}{M}} \quad \text{or} \quad v^2 \propto T$$

for graph C,

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

for graph D, $f = \frac{c}{2L}$

At $L \to 0$, $f \to \infty$

Q.13 (c) ~~43~~ ~~Organ~~ pipe must have anti-nodes at closed ends

4

Na Mg Al Si P Cl Ar

C ✓

D ✓

Only One Option Correct

1. (B)

2. (C)

Length of pipe = 85 cm = 0.85 m

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

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

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

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

3. (D)

Here, $\nu=\frac{v}{4l}=\sqrt{\frac{\gamma RT}{M\times 10^{-3}}}\times\frac{1}{4l} \Rightarrow v=\nu\lambda=\nu\times 4l$

$\Rightarrow v(244)\times 4\times l=336.7\text{ m/s to }346.5\text{ m/s}$ $[\therefore l=0.350\pm 0.005]$

For monatomic gas $\gamma=1.67$

$$\therefore v=\sqrt{\frac{\gamma RT}{M\times 10^{-3}}}=\sqrt{100\gamma RT}\times\sqrt{\frac{10}{M}}$$

For Neon $M=20 \therefore v=640\times\frac{7}{10}=448\text{ ms}^{-1}$

For Argon $M=36$, $\therefore v=640\times\frac{17}{32}=340\text{ ms}^{-1}$

For diatomic gas $\gamma=1.4$

$$v=\sqrt{140RT}\sqrt{\frac{10}{M}}=590\times\sqrt{\frac{10}{M}}$$

For oxygen $M=32 \therefore v=590\times\frac{9}{16}=331.87\text{ ms}^{-1}$

For Nitrogen $M=28 \therefore v=590\times\frac{3}{5}=354\text{ ms}^{-1}$

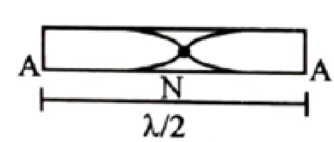
4. (D)

5. (A)

6. (A)

In solids, Velocity of wave

$$V=\sqrt{\frac{Y}{\rho}}=\sqrt{\frac{9.27\times 10^{10}}{2.7\times 10^{3}}} \Rightarrow v=5.85\times 10^{3}\text{ m/sec}$$



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

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

$\lambda = 1.2\,\text{m}$ ($\because$ L = 60 cm = 0.6 m (give)

Using $v = f\lambda$

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

One or More than One Option Correct

1. (B, C)

$y = [0.01\sin(62.8x)]\cos(628t)$. [Given]

From the given equation, $k = \frac{2\pi}{\lambda} = 62.8 \quad \therefore \; \lambda = \frac{2\pi}{62.8} = 0.1\,\text{m}$

Length of string, $l = 5\times\frac{\lambda}{2} = 5\times\frac{1}{20} = 0.25\,\text{m}$

The mid point M is an antinode and has the maximum displacemnet = 0.01 m

The fundamental frequency, $v = \frac{v}{2l} = \frac{\omega/k}{2l}$

$$= \frac{628}{2\times0.25\times62.8} = 20 \text{ Hz}$$

2. (A, C, D)

There should be a displacement node at x = 0 and a displacement antinode at x = 3 m.

Therefore, y = 0 at x = 0 and $y = \pm A$ at $x = 3\,\text{m}$.

Speed of wave, $v = \frac{\omega}{k} = 100\text{ ms}^{-1}$.

Hence options (A), (C) & (D) satisfy the above conditions.

3. (A, B, C)

(A) $\nu_P = (V_n - V_m)\left[\frac{v + v_c\cos\theta}{v}\right] = 121 - 118\left[\frac{v + v_c\cos\theta}{v}\right]$

$\nu_Q = (v_N - v_M) = 121 - 118 = 3$

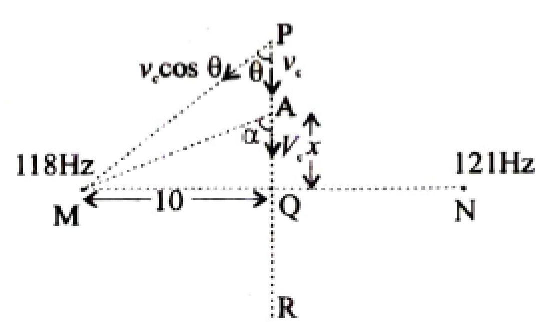
$\nu_R = (v_N - v_M)\left[\frac{v + v_c\cos\theta}{v}\right] = (121-118)\left[\frac{v - v_c\cos\theta}{v}\right]$

$\therefore \; \nu_P + \nu_R = 2\nu_Q$

In general when the car is passing through A

$$\nu = 3\left[\frac{v + v_c\cos\alpha}{v}\right] \qquad ...(i)$$

$\therefore \; \frac{d\nu}{d\alpha} = -3\left[\frac{v_c\sin\alpha}{v}\right] \; \left|\frac{d\nu}{d\alpha}\right|$ is max when $\sin\alpha = 1$



i.e., $\alpha = 90°$ (at Q)

From eq. (i) $\frac{dv}{dt} = \frac{3v_c}{v}(-\sin\alpha)\frac{d\alpha}{dt} \qquad ...(ii)$

Also, $\tan\alpha = \frac{10}{x}$ $\quad \therefore\ \sec^2\alpha \frac{d\alpha}{dt} = -\frac{10}{x^2}\frac{dx}{dt}$

$\therefore\ \frac{d\alpha}{dt} = \frac{-10v}{x^2 \sec^2\alpha}$ ...(iii)

From eq. (ii) & (iii)

$\frac{d\text{v}}{dt} = -\frac{3v_c}{v}\sin\alpha \times \left(\frac{-10v}{x^2\sec^2\alpha}\right) = \frac{30V_c \sin\alpha}{x^2\sec^2\alpha}$

$\therefore\ \frac{d\text{v}}{dt} = \frac{30v_c\sin\alpha}{(10\cot\alpha)^2\sec^2\alpha} = 0.3\,v_c\sin^3\alpha$.

At $\alpha = 90°$

$\frac{d\text{v}}{dt} = \max$

4. (A, D)

Wavelength of pulse, $\lambda = \frac{v}{f} = \frac{1}{f}\sqrt{\frac{T}{\mu}}$ or $T \propto \sqrt{T}$

Where T = tension of string.

Here $T_1 > T_2$ $\quad \therefore\ \lambda_1 > \lambda_2$

The velocities of the two pulses cannot be same at mid-point as velocity being vector quantity has direction.

$V = \sqrt{\frac{T}{\mu}}$, so speed at any position will be same for both pulses, therefore time taken by both pulses will be same i.e., $T_{AO} = T_{OA}$

5. (A, B, C)

According to question, the length of the air column is varied by changing the level of water in the resonance tube,

So, $(2n+1)\frac{\lambda}{4} = 50.7 + e$ ...(i)

and $(2n+3)\frac{\lambda}{4} = 83.9 + e$ ...(ii)

Dividing eq. (i) by (ii)

If n = 1, $\frac{3\lambda/4}{5\lambda/4} = \frac{50.7+e}{83.9+e}$ $\quad \therefore\ 3\times 83.9 + 3e = 5\times 50.7 + 5e$

$\Rightarrow\ 2e = 1.8$ $\quad \therefore e = 0.9\,\text{cm}$

$\therefore\ \frac{3\lambda}{4} = 50.7 + 0.9 = 51.6$ $\quad \Rightarrow\ \lambda = 66.4\,\text{cm} = 0.664\,\text{m}$

Also speed of sound, $V = v\lambda = 500 \times 0.664\ \text{ms}^{-1} = 332.0\ \text{ms}^{-1}$

6. (A, D)

From Doppler's effect

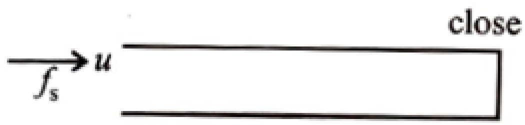
$$f = f_s\left(\frac{v}{v-u}\right)$$

As the pipe is closed at one end

$\therefore$ For resonance,

$$f = f_0\left(\frac{v}{v-u}\right) = nf_0 \text{ where } n = \text{odd integer}$$

(A) For, $u = 0.8v$ and $f_s = f_0$,



$$f = f_0\left(\frac{v}{v-0.8v}\right) = 5f_0$$

(B) For, $u = 0.8v$ and $f_s = 2f_0 \Rightarrow f = 2f_0\left(\frac{v}{v-0.8v}\right) = 10f_0$

(C) For, $u = 0.8v$ and $f_s = 0.5f_0$

$$f = 0.5f_0\left(\frac{v}{v-0.8v}\right) = 2.5f_0$$

(D) For $u = 0.5v$ and $f_s = 1.5f_0$

$$f = 1.5f_0\left(\frac{v}{v-0.5}v\right) = 3f_0$$

Matrix-Match Type

1. (C)

Frequency, $\nu = \frac{1}{2\ell}\sqrt{\frac{T}{m}}$ for first mode of vibration

For 'v' to be maximum, 'ℓ' should be minimum.

String-1 $f_0 = \frac{1}{2L_0}\sqrt{\frac{T_0}{\mu}}$

String-2 $f_2 = \frac{1}{2L_0}\sqrt{\frac{T_0}{2\mu}} = \frac{f_0}{\sqrt{2}}$

String-3 $f_3 = \frac{1}{2L_0}\sqrt{\frac{T_0}{4\mu}} = \frac{f_0}{\sqrt{3}}$

String-4 $f_4 = \frac{1}{2L_0}\sqrt{\frac{T_0}{4\mu}} = \frac{f_0}{2}$

2. (B)

As $\nu = \frac{p}{2\ell}\sqrt{\frac{T}{m}} \quad \therefore\ T = \frac{\nu^2\ell^2 m}{p^2}$

String-1 $T_0 = \frac{f_0^2 4L_0^2\mu}{\ell^2}$

String-2 $T_2 = \frac{f_0^2 4\left(\frac{3}{2}\right)^2 L_0^2(2\mu)}{(3)^2} = \frac{T_0}{2}$

String-3 $T_3 = \frac{f_0^2 4\left(\frac{5}{2}\right)^2 L_0^2(3\mu)}{5^2} = \frac{3}{16}T_0$

String-4 $T_4 = \frac{f_0^2 4\left(\frac{7}{4}\right)^2 L_0^2(4\mu)}{(14)^2} = \frac{T_0}{16}$

Integer / Numerical Answer Type

1. (3)

Resultant of amplitude, Ar

$$= \sqrt{I_0}\left[\sin O + \sin\frac{\pi}{3} + \sin\frac{2\pi}{3} + \sin\pi\right]$$

$$= \sqrt{I_O}\left[\frac{\sqrt{3}}{2} + \frac{\sqrt{3}}{2}\right] = \sqrt{3}\sqrt{I_0}$$

$\therefore\ I_R = A_R^2 = 3I_0$

$\therefore\ n = 3$

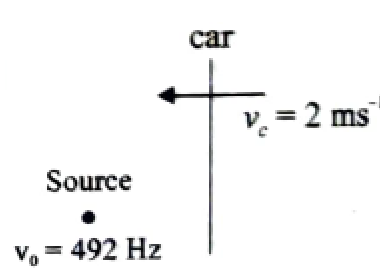
2. (6)

Frequency observed at car

$$\upsilon_1 = \upsilon_0\left(\frac{v+v_c}{v}\right)$$

Frequency of reflected sound as observed at the source

$$\upsilon_2 = \upsilon_1\left(\frac{v}{v-v_c}\right) = v_0\left(\frac{v+v_c}{v-v_c}\right)$$



$\therefore$ Beat frequency $= v_1 - v_0$

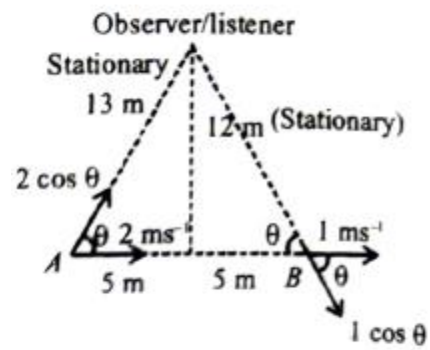
$$= \upsilon_0\left[\frac{v+v_c-v+v_c}{v-v_c}\right] = \upsilon_0\left[\frac{v+v_c-v+v_c}{v-v_c}\right]$$

$$= \upsilon_0\left[\frac{2v_c}{v-v_c}\right] = 492\left[\frac{2\times 2}{330-2}\right] = \frac{492\times 4}{328} = 6\ \text{Hz}$$

3. (5.00)

Apparent frequency at O due to source at – A

$$\nu_A = \nu\left[\frac{v}{v-2\cos\theta}\right]$$



Apparent frequency at 'O' due to source at – B

$$\nu_B = \nu\left[\frac{v}{v+1\cos\theta}\right]$$

$\therefore$ Beat frequency,

$$v_b = \nu\left[\frac{v}{v-2\cos\theta}\right] - \nu\left[\frac{v}{v+\cos\theta}\right]$$

$$= \nu\, v\left[\frac{1}{v-2\cos\theta} - \frac{1}{v+\cos\theta}\right]$$

$$= 1430\times 330\left[\frac{1}{330-2\times\frac{5}{13}} - \frac{1}{330+\frac{5}{13}}\right]$$

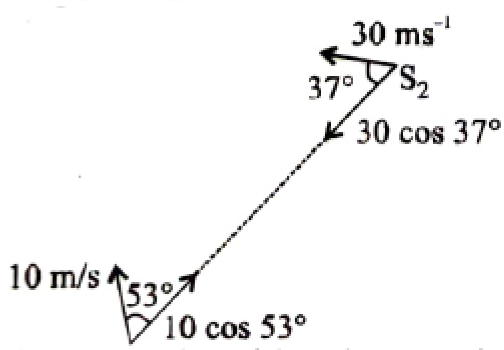
$$= 1430\times 330\times 13\left[\frac{1}{330\times 13-10} - \frac{1}{330\times 13+5}\right]$$

$$= 1430\times 330\times 13\left[\frac{1}{4280} - \frac{1}{4295}\right] \approx 5\text{ Hz}$$

4. (8.13)

Apparent frequency heard by observer due to source S_1

$$v_1 = v\left[\frac{v+v_0}{v}\right] = 120\left[\frac{330+10}{330}\right] = 120\times\frac{34}{33} = 123.636\text{ Hz}$$



Apparent frequency heard by observer due to source S_2

$$v_2 = v\left[\frac{v+v_0}{v-v_s}\right] = 120\left[\frac{330+10\cos 53^\circ}{330-30\cos 37^\circ}\right]$$

$$\therefore\ v_2 = 120\left[\frac{330+10\times 0.6}{330-30\times 0.8}\right] = 120\left[\frac{336}{306}\right] = 131.764\text{ Hz}$$

$\therefore$ Beat frequency, $v_b = v_2 - v_1$

$$131.764 - 123.636 = 8.125\text{ Hz} \approx 8.13\text{ Hz}$$

5. (0.62 to 0.63)

Let $\ell_1 =$ initial length of pipe

$\ell_2 =$ new length of pipe

$V_T =$ Speed of tuning fork

In closed organ pipe, $f = \dfrac{V}{4\ell_1}$

When tuning fork is moved, $f' = f = \left(\dfrac{V}{V - V_T}\right) = \dfrac{V}{4\ell_2}$

$\Rightarrow \dfrac{V}{4\ell_1}\left(\dfrac{V}{V - V_T}\right) = \dfrac{V}{4\ell_2} \qquad \Rightarrow \dfrac{V - V_T}{V} = \dfrac{\ell_2}{\ell_1}$

$\Rightarrow \dfrac{\ell_2}{\ell_1} - 1 = \dfrac{V - V_T}{V} - 1 \Rightarrow \dfrac{\ell_2 - \ell_1}{\ell_1} = \dfrac{-V_T}{V}$

Percentage change required in the length of the pipe

$\dfrac{\ell_2 - \ell_1}{\ell_1} \times 100 = \dfrac{-2}{320} \times 100 = -0.625\%$

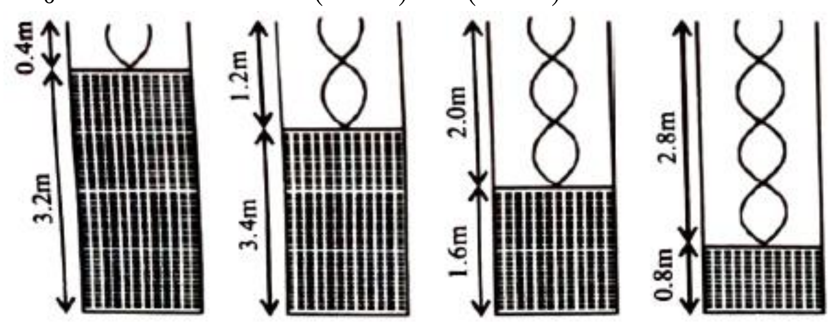
Hence, smallest value of percentage change required in the length of pipe is 0.625%

Subjective Type

1. Speed of sound, $v = 340$ m/s.

Let ℓ_0 be the length of air column corresponding to the fundament frequency. Then

$\dfrac{v}{4\ell_0} = 212.5 \Rightarrow \ell_0 = \dfrac{v}{4(212.5)} = \dfrac{340}{4(212.5)} = 0.4\,\text{m}$.



In closed pipe only odd harmonics are obtained. Now, let $\ell_1, \ell_2, \ell_3, \ell_4,$ etc. be the lenghts corresponding to the 3rd harmonic, 5th harmonic, 7th harmonic etc. Then

$3\left(\dfrac{v}{4\ell_1}\right) = 212.5 \Rightarrow \ell_1 = 1.2$ m;

$5\left(\dfrac{v}{4\ell_2}\right) = 212.5 \Rightarrow \ell_2 = 2.0$ m;

$7\left(\dfrac{v}{4\ell_3}\right) = 212.5 \Rightarrow \ell_3 = 2.8$ m;

$9\left(\dfrac{v}{4\ell_4}\right) = 212.5 \Rightarrow \ell_4 = 3.6$ m

or heights of water level are (3.6 – 0.4) m, (3.6 – 1.2) m, (3.6 – 2.0) m and (3.6 – 2.8) m.
Hence heights of water level are 32.2 m, 2.4 m, 1.6 m and 0.8 m.
Let *A* and a be the area of cross-sections of the pipe and hole respectively. Then

$$A = \pi\left(2\times10^{-2}\right)^2 = 1.26\times10^{-3}\ \text{m}^{-2}$$

and $a = \pi\left(10^{-3}\right)^2 = 3.14\times10^{-6}\ \text{m}^2$

Velocity of efflux, $v = \sqrt{2gH}$

Continuity equation at 1 and 2 gives,

$$a\sqrt{2gH} = A\left(\frac{-dH}{dt}\right)$$

So, rate of fall of water level in the pipe,

$$\left(\frac{-dH}{dt}\right) = \frac{a}{A}\sqrt{2gH}$$

Substituting the values, we get

$$\frac{-dH}{dt} = \frac{3.14\times10^{-6}}{1.26\times10^{-3}}\sqrt{2\times10\times H}$$

$$\Rightarrow \frac{-dH}{dt} = \left(1.11\times10^{-2}\right)\sqrt{H}$$

Between first two resonances, the water level falls from 3.2 m to 2.4 m

$$\therefore \quad \frac{dH}{\sqrt{H}} = -1.11\times10^{-2}\,dt$$

$$\Rightarrow \int_{3.2}^{2.4}\frac{dH}{\sqrt{H}} = -\left(1.11\times10^{-2}\right)\int_0^t dt$$

$$\Rightarrow \quad 2\left[\sqrt{2.4}-\sqrt{3.2}\right] = -\left(1.1\times10^{-2}\right).t$$

or, $t \approx 43s$