UNIT # 06 (PART - II)

WAVE THEORY

EXERCISE –I

1. Waves on surface of water are combination of longitudinal and transverse waves. (पानी की सतह पर तरंगे अनुदैर्ध्य व अनुप्रस्थ तरंगों का संयोजन होती है)

2. $\lambda = 100m,\ v = 25m/s,\ T = \frac{1}{f} = \frac{\lambda}{v} = \frac{100}{25} = 4\ s$

3. $\lambda = \frac{v}{f} = \frac{600/2}{500} = \frac{3}{5}\ m$

$\therefore$ Number of waves (तरंगों की संख्या)

$$= \frac{600}{\lambda} = \frac{600 \times 5}{3} = 1000$$

4. $f = \frac{2 waves}{1 sec} = 2Hz\ ;\ \lambda = 5m\ \therefore\ v = f\lambda = 10m/s$

5. $y_1 = a \sin \omega t$

$y_2 = a \cos \omega t = a \sin(\omega t + \pi/2)$

y_1 lags y_2 behind by phase $\frac{\pi}{2}$.

6. y_1 propagartes in +x-axis and y_2 along –ve x-axis. (तरंग y_1 दूसरी तरंग y_2 ऋणात्मक x-अक्ष के अनुदिश संचरित होती है)

7. $y_1 = \cos kx \sin \omega t = \frac{1}{2}[\sin(\omega t + kx) + \sin(\omega t - kx)]$

(Stationary Wave) (अप्रगामी तरंग)

$y_3 = \cos^2(k\alpha + \omega t) = \frac{1}{2}[1 + \cos 2(kx + \omega t)]$

(Progressive Wave) (प्रगामी तरंग)

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

$$= 2 \cos\frac{t}{2}\left[\sin\left(1000 + \frac{1}{2}\right)t + \sin\left(1000 - \frac{1}{2}\right)t\right]$$

$= \sin 1001\ t + \sin 1000t + \sin 1000t + \sin 999t$

$= \sin 1001t + 2 \sin 1000t + \sin 999t$

9. $y = y_0 \sin 2\pi\left(ft - \frac{x}{\lambda}\right)\ ;\ v = y_0(2\pi f) \cos 2\pi\left(ft - \frac{x}{\lambda}\right)$

$\therefore\ v_{max} = y_0 2\pi f\ ;\ v_{wave} = f\lambda$

Given (दिया है): $v_{max} = 4v_{wave}$

$\Rightarrow y_0(2\pi f) = 4(f\lambda) \Rightarrow \lambda = \frac{\pi y_0}{2}$

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

$$= 10\left(\frac{1}{2}\sin 3\pi t + \frac{\sqrt{3}}{2}\cos 3\pi t\right) = 10\sin\left(3\pi t + \frac{\pi}{3}\right)$$

$\therefore\ A_1/A_2 = 10/10 = 1:1$

11. $y_1 = 0.25 \cos(2\pi t - 2\pi x)$ $\quad f\lambda = \text{const.}$

$f = f/2 \Rightarrow \lambda = 2\lambda$

$y_2 = 2\ \ 0.25\ \cos\left(\frac{2\pi t}{2} + \frac{2\pi x}{2}\right) = 0.5 \cos(\pi t + \pi x)$

12. $I = \frac{2\pi^2 \rho A^2 v}{T^2} \Rightarrow I \propto \left(\frac{A}{T}\right)^2$

$$\Rightarrow \frac{I_1}{I_2} = \left(\frac{A_1}{A_2}\frac{T_2}{T_1}\right)^2 = \left(\frac{1}{2} \times \frac{2}{1}\right)^2 = 1:1$$

13. $I \propto A^2$ and $I \propto \frac{1}{2}\pi RL$

$$\frac{I_1}{I_2} = \frac{R_2}{R_1} = \frac{A_1^2}{A_2^2} \Rightarrow \frac{A_1}{A_2} = \sqrt{\frac{R_2}{R_1}} = \sqrt{\frac{25}{9}} = 5:3$$

14. $a = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\frac{\pi}{2}} = \sqrt{a_1^2 + a_2^2}$

15. $\frac{I_1}{I_2} = \left(\frac{A_1}{A_2}\right)^2 = \frac{9}{1} \Rightarrow \frac{A_1}{A_2} = \frac{3}{1}$

$$\therefore\ \frac{I_{max}}{I_{min}} = \left(\frac{A_1 + A_2}{A_1 - A_2}\right)^2 = \left(\frac{\frac{A_1}{A_2} + 1}{\frac{A_1}{A_2} - 1}\right)^2 = \left(\frac{3+1}{3-1}\right)^2 = \left(\frac{4}{2}\right)^2 = 4:1$$

16. $v \propto \sqrt{Tension} \Rightarrow v = \sqrt{kx}$

$v' = \sqrt{k(1.5x)} \Rightarrow \frac{v'}{v} = \sqrt{1.5} = 1.22 \Rightarrow v' = 1.22\ v$

17. $v = \frac{\text{coeff of } \omega}{\text{coeff of k}} = \frac{30}{1} = 30\ m/s = \sqrt{\frac{I}{\mu}}$

$\Rightarrow T = \mu\ \ 900 = 1.3\ \ 10^{-4}\ \ 900 = 0.12\ N$

18. $\Delta L = \frac{TL}{AY} \Rightarrow T = \frac{\Delta LAY}{L} = \frac{L\alpha\theta AY}{L} = \alpha\ \theta\ Ay$

$\mu = dA\ \therefore\ v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{\alpha\theta AY}{dA}} = 70\ m/s$

19. $f_1 = f_2$ (m $\rightarrow$ no. of loops in steel wire n $\rightarrow$ no. of loops in aluminium wire) (m $\rightarrow$ स्टील के तार में लूपों की संख्या n $\rightarrow$ एल्यूमिनियम के तार में लूपों की संख्या)

$$\Rightarrow \frac{m}{2L_1}\sqrt{\frac{T}{\rho_1 A_1}} = \frac{n}{2L_2}\sqrt{\frac{T}{\rho_2 A_2}}$$

$$\Rightarrow \frac{m}{2\times 60}\sqrt{\frac{80}{7800\times 10^{-6}}} = \frac{n}{2\times 45}\sqrt{\frac{80}{2600\times 3\times 10^{-6}}}$$

$\Rightarrow \frac{m}{n} = \frac{4}{3}$ (minimum) (न्यूनतम)

$\therefore f = \frac{m}{2L_1}\sqrt{\frac{T}{\rho_1 A_1}} = \frac{4}{2\times 0.6}\sqrt{\frac{80}{7800\times 10^{-6}}} =$ 337.5Hz

20. $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{\mu x g}{\mu}} = \sqrt{gx} \Rightarrow v^2 = gx$

(symmetrical about x) (x के सापेक्ष सममित)

21. The right end will shoot up on the wire.
(दायां सिरा तार पर यकायक ऊपर उठता है)

23. The equation represents a progressive wave moving along x-axis of single frequecy.
(समीकरण x अक्ष के अनुदिश, एकल आवृति की एक प्रगामी तरंग को प्रदर्शित करती है)

24. $L = 5\frac{\lambda}{2} \Rightarrow 10 = 5\frac{\lambda}{2} \Rightarrow \lambda = 4m\ \therefore\ f = \frac{v}{\lambda} = \frac{20}{4} =$ 5Hz

25. $y_{res} = y + y' = 0$ (at x =0) $\Rightarrow$ a sin (kx – ωt) + y' =0
put x = 0 and get $y_{res} = 0$

26. Distance between position having 3 nodes and 2 antinodes = wavelength = 1.21 Å
(3 निस्पंद व 2 प्रस्पंदों के मध्य दूरी = तरंगदैर्ध्य)

27. $n_1\ell_1 = n_2\ell_2 = n_3\ell_3 = n\ell$

$$\Rightarrow \ell_1 + \ell_2 + \ell_3 = \ell \Rightarrow \frac{n\ell}{n_1} + \frac{n\ell}{n_2} + \frac{n\ell}{n_3} = \ell$$

$$\Rightarrow \frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3}$$

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

$$f' = \frac{2}{2L}\sqrt{\frac{T}{\mu}\left(1 - \frac{1}{2\rho}\right)} \Rightarrow f' = f\sqrt{\frac{2\rho - 1}{2\rho}}$$

29. $7\lambda = 0.14\ ;\ \lambda = 0.02$

$f = \frac{v}{\lambda} = \frac{3\times 10^8}{0.02} = 1.5 \quad 10^{10}$ Hz

30. $d = vt = 330 \quad 5.5 = 1815$ m

31. $v = \sqrt{\frac{\gamma RT}{M}} \Rightarrow M_{H_2+O_2} < M_{O_2}\ \therefore\ V_{H_2+O_2} > V_{O_2}$

32. $f_{air} = f_{water} \Rightarrow \lambda_{air} = \frac{v_{air}}{f_{air}} = \frac{330}{60\times 10^3} = 5.5\,mm$

33. $v = f_1\lambda_1 = f_2\lambda_2 \Rightarrow 512 \quad 4L = f_2 \quad 2L$
$\Rightarrow f_2 = 1024$ Hz

34. $v = f_1\lambda_1 = f_2\lambda_2 \Rightarrow f \quad 2L = f' \quad 2L \Rightarrow f' = f$

35. $f_1 = f_2,\ \frac{v}{\lambda_1} = \frac{v}{\lambda_2} \Rightarrow \lambda_1 = 4L_1 = \lambda_2 = \frac{2}{3}L_2$

$\Rightarrow \frac{L_1}{L_2} = \frac{2}{3\times 4} = \frac{1}{6}$

36. $f_1\lambda_1 = v$

$f_1\left(\frac{4L}{3}\right) = v \Rightarrow f_1 = \frac{3v}{4L}$; $f_2(2L) = v \Rightarrow f_2 = \frac{v}{2L}$

Given that $f_1 - f_2 = 100$

$\Rightarrow \frac{3v}{4L} - \frac{v}{2L} = 100 \Rightarrow \frac{v}{2L} = 200Hz$

37. $v = f\lambda \Rightarrow 333 = 333\ \lambda \Rightarrow \lambda = 1$
= Length of pipe in second harmonic.
(द्वितीय सन्नादि में पाईप की लम्बाई)

38. $v = f\lambda\ (\lambda/4 = L) \Rightarrow 336 = 20 \quad 4L \Rightarrow L = 4.2$ m

39. $\lambda = \frac{v}{f} = \frac{330}{330} = 1m$

$L = \lambda/4, 3\lambda/4, 5\lambda/4.... = 25cm, 75cm, 125cm$

Minimum length of water column =120–75 = 45cm

(जल स्तम्भ की न्यूनतम लम्बाई)

40. $\frac{\lambda}{4} = L + 0.6\ r_1$

(closed organ pipe) (बंद आर्गन पाइप)

$\lambda = L + 1.2\ r_1$

(open organ pipe) (खुला आर्गन पाइप)

$\Rightarrow 4\ (L + 0.6\ r_1) = (L + 1.2r_2) \Rightarrow r_2 - 2r_1 = 2.5\ L$

41. $f_1 = \frac{500\pi}{2\pi} = 250$; $f_2 = \frac{506\pi}{2\pi} = 253$

$\therefore \Delta f = 3\ s^{-1} = 3 \quad 60\ min^{-1} = 180\ min^{-1}$

42. If $f_B > f_A$; $f_B = 260$ Hz ; If $f_B < f_A$; $f_B = 252$ Hz

43. For sonometer wire (सोनोमीटर तार के लिये)

n 100 = (n+1) 95

n = no of harmonics (सन्नादि की संख्या)

$\Rightarrow n = 19$

$\therefore f = 19\left(\frac{L}{2}\right) + 4 = 20\left(\frac{L}{2}\right) - 4 \Rightarrow L = 16$

$\Rightarrow f = 20\left(\frac{L}{2}\right) - 4 = 156$ Hz

44. $v = f_1 \quad 50 = f_2 \quad 51$

$\Rightarrow f_1 - f_2 = \frac{v}{50} - \frac{v}{51} = 0.1 \Rightarrow v = 255$ m/s

45. $2f = f \quad 15 \quad 8 \Rightarrow f = 120$ Hz

46. $\boxed{C_1}$ A $\boxed{C_2}$ B

f_1 256 Hz f_2 262 Hz

$2(f_1 - 256) = (f_1 - 262) \Rightarrow f_1 = 250$Hz

$2(f_2 - 256) = (262 - f_2) \Rightarrow f_2 = 258$ Hz

47. $\lambda_1 = 2L$; $\lambda_2 = 2(L-y)$

$\Delta f = f_2 - f_1 = \frac{v}{\lambda_2} - \frac{v}{\lambda_1} = \frac{v}{2}\left[\frac{1}{L-y} - \frac{1}{L}\right]$

$\Rightarrow \frac{vy}{2(L-y)L} \simeq \frac{vy}{2L^2}$

48. $dB = 10\log \frac{I_2}{I_1} = 10 \log \frac{400}{20} = 10 \log 20$

$= 10(1 + 0.3) = 13$dB

49. $dB = 10 \log \frac{I_2}{I_1} \Rightarrow 20 = 10 \log \frac{I_2}{I_1}$

$\Rightarrow I_2 = 100\ I_1$ (taking antilog)

50. $f = f_o\left(\frac{v}{v - v_{obs}}\right)$

(observer is approaching) (प्रेक्षक पास आ रहा है)

$= 450\left(\frac{330}{330 - 33}\right) = 500$ Hz

51. $\Delta f = f_{app} - f_o = f_o\left(\frac{v}{v - v_s}\right) - f_o$

$\frac{\Delta f}{f_o} = \frac{v}{v - v_s} - 1 = \frac{v_s}{v - v_s} = \frac{2.5}{100}$

$\Rightarrow \frac{v_s}{v - v_s} = \frac{1}{40} \Rightarrow v_s = \frac{v}{41} \simeq 8\ m/s$

52. $f_B = f_A\left(\frac{v + v_B}{v + v_A}\right) = 450\left(\frac{330 + 10}{330 + 30}\right) = 425$ Hz

53. $f_{min} = f_o\left(\frac{v}{v + \omega R}\right) = 385\left(\frac{340}{340 + 20 \times 0.5}\right) = 374$ Hz

EXERCISE –II

1. No. of wave striking the surface $f = f\left(\frac{c+v}{c}\right)$

(पृष्ठ पर आपतित होने वाली तरंगों की संख्या)

freqeuncy of the reflected wave

(परावर्तित तरंग की आवृति)

$f' = f\left(\frac{c}{c-v}\right) = f\left(\frac{c+v}{c-v}\right)$

Wavelength of the reflected wave

(परावर्तित तरंग की तरंगदैर्ध्य)

$\lambda = \frac{c}{f'} = \frac{c}{f}\left(\frac{c-v}{c+v}\right)$

2. $\frac{2\pi}{\lambda} = 10\pi \Rightarrow \lambda = 0.2$ m

Node occurs at $x = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4} = 0.05$ m,

0.15 m,.....; (पर निस्पंद बनता है)

Antinode occurs at $x = \frac{\lambda}{2}, \lambda, 3\frac{\lambda}{2}$ .....= 0.1m,0.2m,

0.3m,.....; (पर प्रस्पंद बनता है)

wave speed (तरंग की चाल) $v = \frac{50\pi}{10\pi} = 5$ m/s

3. y=0 at x=0.

This can be statisfied by the term $\sin\left(\frac{n\pi x}{L}\right)$

(यह पद $\sin\left(\frac{n\pi x}{L}\right)$ द्वारा संतुष्ट होता है)

4. $f_1 - f_2 = 5 \Rightarrow \frac{v}{2\times 16} - \frac{v}{2\times 16.2} = 5$

$\Rightarrow \frac{v\times 0.2}{2\times 16\times 16.2} = 5$

$\Rightarrow f_1 = \frac{v}{2\times 16} = \frac{5\times 16.2}{0.2} = 405$Hz

and $f_2 = \frac{v}{2\times 16.2} = \frac{5\times 16}{0.2} = 400$Hz

5. For closed tube (बंद नली के लिए)

$\frac{\lambda}{4} = \frac{V}{4f} = L$ and $\frac{\lambda'}{4} = \frac{V+v}{4f'} = L + \ell \Rightarrow f' = \frac{V+v}{4(L+\ell)}$

6. Let wave equation be (माना तरंग समीकरण)

$z = e^{-[x-v(t-t_0)]^2}$

At t=0, $x + vt_0 = x + 2 \Rightarrow vt_0 = 2$

At t=1s, $x - v(1-t_0) = x - 2 \Rightarrow v = +4$ m/s

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

$v = \omega\cos(\omega t - kx + \phi)$

at t =0, x = 0, y =–0.5, v >0 $\Rightarrow \phi = -\frac{\pi}{6}$

$\therefore y = \sin\left(\omega t - kx - \frac{\pi}{6}\right)$

8. $f = f_o\left(\frac{v+gt}{v}\right) \Rightarrow \frac{df}{dt} = f_o\left(0 + \frac{g}{v}\right)$

$\Rightarrow \frac{1000}{30} = \frac{1000\times 10}{v} \Rightarrow v = 300$ m/s

9. $y = 2\text{mm}\ \sin\left(2\pi x - 100\pi t + \frac{\pi}{3}\right)$

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

$\Rightarrow n\pi = 8\pi - 100\pi t + \frac{\pi}{3}$ (n = 0,1,2,3,....)

$\Rightarrow t_{min} = \frac{\frac{25\pi}{3} - n\pi}{100\pi} = \frac{\pi}{3}/100\pi = \frac{1}{300}$s

10. $\mu = \frac{\lambda}{L}x$

(at a distance 'x' from free end)

(मुक्त सिरे से x दूरी पर)

$\therefore T = \int_0^x \mu dx(g+2g) = \frac{3\lambda g x^2}{2L}$

$\therefore v_{wave} = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{3\lambda g x^2}{2L\left(\frac{\lambda x}{L}\right)}} = \sqrt{\frac{3xg}{2}}$

$\Rightarrow v^2 = \frac{3xg}{2} \Rightarrow 2v\frac{dv}{dx} = \frac{3g}{2} \Rightarrow a = 3g/4$

(constant everywhere) (सभी जगह नियत)

Now $S = ut + \frac{1}{2}at^2 \Rightarrow L = 0 + \frac{3g}{8}t^2$

$\Rightarrow t = \sqrt{8L/3g}$

11. Total energy (कुल ऊर्जा)

$= \frac{1}{2}\mu\omega^2A^2 = 2\pi^2f_n^2\mu A^2 = 2\pi^2n^2f_1^2\mu A^2$

(f_1 = fundamental frequency (मूल आवृति)

f_n = Frequency of n^{th} harmonic (सन्नादि की आवृति))

$<KE> = <PE> = \frac{TE}{2}$

12. In the stationary waves, the particles in the alternate loops are out of phase.
(अप्रगामी तरंगों में एकान्तर लूपों में कण विपरीत कला में होते हैं)

13. $f = \frac{\sqrt{\gamma RT}}{2L\sqrt{M}} = \frac{k}{L\sqrt{M}}, \qquad f_A = \frac{k}{L\sqrt{2}}$

$f_B = \frac{2k}{L\sqrt{32}}, f_C = \frac{3k}{2L\sqrt{28}}$

$f_D = \frac{3k}{L\sqrt{44}}, \therefore f_C/f_D = \sqrt{\frac{11}{28}}$

14. $\frac{3\pi}{2} = \frac{2\pi}{\lambda} \Rightarrow \lambda = \frac{4}{3}m$

Pr. Amp. $= P_0\cos\left(\frac{3\pi x}{2}\right) = P_0$ at x = 0

(x=0 पर दाब आयाम $P_0\cos\left(\frac{3\pi x}{2}\right) = P_0$)

and $-P_0$ at x = 2/3= P_0 at x = 4/3

$\therefore$ Pipe may be closed at x = 0 and open at x = $\frac{2}{3}$m.

(x=0 पर पाईप बंद तथा x = $\frac{2}{3}$m पर पाईप खुला होगा)

17. $\lambda = \frac{300m/s}{25Hz} = 12m.$

Separation between A and B = 6 m = $\lambda/2$
(A व B के मध्य दूरी)

18. Comparing with the equation
(निम्न समीकरण से तुलना करने पर)

$y = 2A\sin\left(\frac{n\pi x}{L}\right)\cos(\omega t)$

2A = 2mm or A = 1mm

$\frac{n\pi x}{L} = 6.28x = 2\pi x$ or $L = \frac{n}{2}$m.

For n =1, L = 0.5 m.

20. Let a = initial amplitude due to S_1 and S_2 each.
(माना a= s_1 व s_2 प्रत्येक के कारण प्रारम्भिक आयाम है)

$I_0 = k(4a^2)$, where k is a constant (जहां k नियत है)

After reduction of power of S_1, amplitude due to S_1=0.6a.

(S_1 की शक्ति कम होने के बाद, S_1 के कारण आयाम S_1=0.6a)

Due to superposition (अध्यारोपण के कारण)

$a_{max} = a + 0.6a = 1.6a$, and

$a_{min} = a - 0.6a = 0.4a$

$I_{max}/I_{min} = (a_{max}/a_{min})^2 = (1.6a/0.4a) = 16$

EXERCISE –III

Comprehension#1

1. $v_{\uparrow}$ = Point a

2. $v_{\downarrow}$ = Points c,d,e

3. $v_{=0}$ = points b,f

4. v_{max} = points 0,d,h

5. $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{w + \mu xg}{\mu}} = \sqrt{\frac{w}{\mu} + xg}$

$\Rightarrow v^2 = \frac{w}{\mu} + xg \Rightarrow 2v\frac{dv}{dx} = g \Rightarrow a = \frac{g}{2}$

Comprehension#2

1. $\frac{2\pi}{\lambda}\Delta = 2\pi n$ (n = 0,1,2,3,.....) $\Rightarrow \frac{2\pi}{\lambda}(\pi R) = 2\pi n$

$\Rightarrow \lambda = \frac{\pi R}{n} = \pi R, \ \frac{\pi R}{2}, \frac{\pi R}{3}, \frac{\pi R}{4}$ .....

2. $\frac{2\pi}{\lambda}\Delta = (2n+1)\pi$ (n=0,1,2,....)

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

$\Rightarrow \lambda = \frac{2\pi R}{2n+1} = 2\pi R, \frac{2\pi R}{3}, \frac{2\pi R}{5}$.....

3. $I_{max} = \left(\sqrt{\frac{I_0}{2}} + \sqrt{\frac{I_0}{2}}\right)^2 = 2I_0$

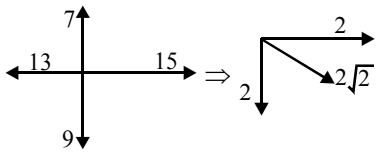
4. λ_{max} to produce maxima at D = πR
(D पर उच्चिष्ठ प्राप्त करने के लिये λ_{max}=πR)

5. λ_{max} to produce minima at D = 2πR
(D पर निम्निष्ठ प्राप्त करने के लिये λ_{max}=2πR)

EXERCISE –IV(A)

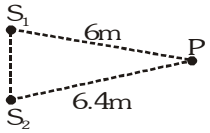
1. $h = \frac{1}{2}gt_1^2 \Rightarrow t_1 = \sqrt{\frac{2h}{g}}$ and $h = vt_2$, $t_2 = \frac{h}{v} = \frac{300}{340}$

$\therefore t = t_1 + t_2 = 8.707$ sec

2. 

$A = 2\sqrt{2} = 2.828$ mm $\simeq 2.83$ mm

3. $I \propto \left(\frac{A}{T}\right)^2 \Rightarrow \frac{I_1}{I_2} = \left(\frac{A_1}{A_2}\right)^2\left(\frac{T_2}{T_1}\right)^2 = \left(\frac{2}{1}\right)^2 \times \left(\frac{1}{2}\right)^2 = 1$

4. 

$\frac{2\pi}{\lambda}\Delta = (2n+1)\pi$

for destructive interference (विनाशी व्यतिकरण के लिए)

$\frac{2\pi}{v}f(6.4-6) = (2n+1)\pi$

$\Rightarrow f = \frac{(2n+1)v}{0.8} = 400(2n+1)$ (v = 320 m/s)

=400 Hz, 1200Hz, 2000 Hz,
2800 Hz, 3600 Hz,4400 Hz

5. $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{90\times 9.8}{8\times 10^{-3}}} = 105\sqrt{10}$ m/s

f = 256 Hz; A = 5cm = 0.05 m

Equation of the wave (तरंग का समीकरण)

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

$= 0.05\sin\left(2\pi ft - \frac{2\pi f}{v}x\right)$

$= 0.05\sin(1609\,t - 4.84x)$

6. $V_{bottom} = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{2\times 10}{1/2}} = 2\sqrt{10}$ m/s

$V_{top} = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{8\times 10}{1/2}} = 4\sqrt{10}$ m/s

$\Rightarrow f = \frac{v_{top}}{\lambda_{top}} = \frac{v_{bottom}}{\lambda_{bottom}} \Rightarrow \lambda_{top} = \frac{4\sqrt{10}}{2\sqrt{10}} \times 0.06 = 0.12$m

7. For wire, $\Delta L = L\,\alpha\,\theta = \frac{FL}{AY} \Rightarrow F = AY\,\alpha\,\theta$

$\therefore f = \frac{1}{2L}\sqrt{\frac{F}{\mu}} = \frac{1}{2\times 1}\sqrt{\frac{10^{-6}\times 2\times 10^{11}\times 1.21\times 10^{-5}\times 20}{0.1}}$

= 11 Hz

8. $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{2\times 10}{\frac{4.5\times 10^{-3}}{2.25}}} = 100\text{m/s}$

$t = \frac{L}{v} = \frac{2}{100} = 0.02\,\text{sec}$

9. $v = \sqrt{\frac{1\times 10}{10^{-3}/10^{-2}}} = 10\text{m/s}$, $t = \frac{L}{v} = \frac{0.5}{10} = 0.05\,\text{sec}$

10. $y = 5\sin\left(\frac{\pi x}{3}\right)\cos(40\pi t)$

$= 2.5\sin\left(40\pi t + \frac{\pi x}{3}\right) - 2.5\sin\left(40\pi t - \frac{\pi x}{3}\right)$

(i) Equation of incident wave
(आपतित तरंग का समीकरण)

$y_1 = 2.5\sin\left(40\pi t + \frac{\pi x}{3}\right)$

Equation of reflected wave
(परावर्तित तरंग का समीकरण)

$y_2 = -2.5\sin\left(40\pi t - \frac{\pi x}{3}\right)$

(ii) $\frac{2\pi}{\lambda} = \frac{\pi}{3} \Rightarrow \lambda = 6$cm

$\therefore$ Distance between adjacent nodes = 3cm
(क्रमागत निस्पंदों के मध्य दूरी)

(iii) $v = -5(40\pi)\sin\left(\frac{\pi x}{3}\right)\sin(40\,\pi t)$

$= -200\,\pi\sin\left(\frac{\pi\times 1.5}{3}\right)\sin\left(40\pi\times\frac{9}{8}\right) = 0$

11. $\lambda_{air} = \frac{340}{10^6} = 3.4\times 10^{-4}$m, $\lambda_{water} = \frac{1486}{10^6} = 1.49\ 10^{-3}$ m

12. (i) $(y_{max})_{x=5cm} = 4\sin\left(\frac{\pi x}{15}\right) = 4\sin\left(\frac{5\pi}{15}\right) = 2\sqrt{3}$

(ii) $\frac{2\pi}{\lambda} = \frac{\pi}{15} \Rightarrow \lambda = 30$cm

$\therefore$ Position of nodes (निस्पंदों की स्थिति)
= 15cm, 30cm.....

(iii) $v=-4\ (96\pi)\ \sin\left(\frac{\pi x}{15}\right)\sin\ (96\pi t)$

at x = 7.5 cm, t = 0.25 sec

$v = -4 \quad 96\pi\sin\left(\frac{7.5\pi}{15}\right)\sin\left(\frac{96\pi}{4}\right)=0$

(iv) $Y = 4\ \sin\left(\frac{\pi x}{15}\right)\cos\ (96\ \pi t)$

$=2\sin\left(\frac{\pi x}{15}-96t\right)+\ 2\sin\left(\frac{\pi x}{15}+96\pi t\right)$

14. $v=\sqrt{\frac{B}{\rho}}=\sqrt{\frac{4000\times10^6}{1000}}=2000\,m/s$

15. $\frac{\lambda}{2}=1 \Rightarrow \lambda = 2m$

$v = f\lambda = 2.53 \quad 10^3 \quad 2 = 5.06 \quad 10^3$ m/s

16. Let the pipe resonates in n^{th} & $(n+1)^{th}$ harmonic
(माना पाइप nवीं व (n+1) वीं सन्नादि में अनुनादित होते हैं)

$\Rightarrow$ (n+1) 1944 = n(2592)

$\Rightarrow n = 4 \ \therefore L = \frac{324}{1296} = 0.25$ m

18. $F_{string} > F_{pipe}$

$F_{string} = \frac{2}{2L}\sqrt{\frac{T}{\mu}}=4\sqrt{\frac{T}{10^{-2}}}=40\sqrt{T}$

$F_{pipe} = \frac{v}{\lambda}=\frac{320}{4\times0.4}=200\,Hz$

$\Rightarrow 40\sqrt{T}-200=8 \ \Rightarrow T = 27.04$ N

19. $\Delta f = 305 - 300 = 5Hz$

(i) $\therefore$ Total beats produced in 5s = 5 5 = 25
(5 सेकण्ड में उत्पन्न कुल विस्पंद)

(ii) Time interval in which max intensity becomes minimum (वह समय अन्तराल जब अधिकतम तीव्रता न्यूनतम हो जाये) $=\frac{1}{2}\times\frac{1}{\Delta f}=\frac{1}{2}\times\frac{1}{5}=0.1\,sec$

20. The frequency of B < frequency of A
(B की आवृति <A की आवृति)

$\Rightarrow f_A - f_B = 5 \Rightarrow 427 - f_B = 5 \Rightarrow f_B = 422$ Hz

21. Frequency reaching the wall $f_1' = f_0\left(\frac{v}{v-v_s}\right)$
(दीवार पर पहुंच रही आवृति)

Frequency received by the observer
(प्रेक्षक द्वारा प्राप्त आवृति)

$f_1 = f_1'\left(\frac{v+v_s}{v}\right) = f_0\left(\frac{v+v_s}{v-v_s}\right)$

$\therefore$ Beat frequency (विस्पंद आवृति)

$\Delta f = f_0\left(\frac{v+v_s}{v-v_s}\right)-f_0 = 256\left(\frac{330+5}{330-5}\right)-256$

= 7.87 Hz

22. $f_{observer} = f_0\left(\frac{v+v_w-v_0}{v+v_w}\right)=700\left(\frac{340+10-10}{340+10}\right)$

= 680 Hz

23. $\Delta f = f_0\left(\frac{v}{v-v_S}\right)=180\left(\frac{330}{330-60}\right)=220Hz$

24. $\Delta f_1 = f_0\left(\frac{v}{v-v_S}\right)=440\left(\frac{330}{330-20\times1.5}\right)=484Hz$

$f_2 = f_0\left(\frac{v}{v+v_S}\right)=440\left(\frac{330}{330+20\times1.5}\right)=403.3Hz$

25. $\Delta f = f_0\left(\frac{v}{v-v_S}\right)-f_0\left(\frac{v}{v+v_S}\right)=3$

$\Rightarrow 3=340\left[\frac{330}{330-v_S}-\frac{330}{330+v_S}\right] \Rightarrow v_S = 1.5$m/s

26. Frequency received by subnarine
(पनडुब्बी द्वारा प्राप्त आवृति)

$f_1 = f_1 = f_0\left(\frac{v}{v-v_s}\right)$

Frequency reflected by subrnarine,
(पनडुब्बी द्वारा परावर्तित आवृति)

$f_2 = f_1\left(\frac{v+v_s}{v}\right) = f_0\left(\frac{v+v_s}{v-v_s}\right) = 140\left(\frac{1450+100}{1450+100}\right)$

= 45.93 kHz

27. $\mu = \frac{1gm}{10cm}=\frac{10^{-3}kg}{0.1m}= 10^{-4}$ kg/m, T = 64 N

$v = \sqrt{\frac{T}{\mu}} \Rightarrow f_0 = \frac{v}{2L}=\frac{1}{2\times0.1}\sqrt{\frac{64}{10^{-4}}}=5 \quad 8 \quad 100$

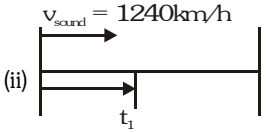
$= 4000$ m/s $\Rightarrow v_{string} - v_{fork} = 1$

$\Rightarrow 4000 - 4000\left(\frac{300}{300-v}\right)=1 \ \Rightarrow v = 0.073$ m/s

28. (i) $f_{Hill} = f_0\left(\frac{v + v_w}{v + v_w - v_s}\right)$

$= 580\left(\frac{1200+40}{1200+40-40}\right) = 599$ Hz

(ii)



$1240\ t_1 = 1 \Rightarrow t_1 = \frac{1}{1240}$ hr

where t_1 = time the sound to reach the hill

(जहां t_1 = पहाड़ी पर ध्वनि को पहुंचने में लगा समय)

Let t_2 = time for the echo to reach the train

(माना t_2= प्रतिध्वनि को रेलगाड़ी तक पहुंचने में लगा समय)

v_{echo} = speed of echo (प्रतिध्वनि की चाल)

= 1200 – 40 = 1160 km/hr

$\therefore\ v_{train} + v_{echo} = d - v_{train}\ t_1$

$\Rightarrow (40 + 1160)\ t_2 = 1 - \frac{40}{1240} = \frac{1200}{1240}$

$\Rightarrow t_2 = \frac{1}{1240}$ hr

$\therefore$ Distance from the hill where echo reaches the train

(वह दूरी जहां रेलगाड़ी से आने वाली प्रतिध्वनि पहुंचती है)

$= d - v(t_1 + t_2) = 1 - \frac{40\times 2}{1240} = 0.935$ km

Frequency reaching the hill

(पहाड़ी पर पहुंची ध्वनि की आवृति)

$f_1' = f_0\left(\frac{v + v_w}{v + v_w - v_t}\right)$

Frequency of echo (प्रतिध्वनि की आवृति)

$f_1 = f_1'\left(\frac{v - v_w + v_t}{v - v_w}\right)$

$= f_0\left(\frac{v + v_w}{v + v_w - v_t}\right)\left(\frac{v - v_w + vt}{v - v_w}\right)$

$= 580\ \ \frac{1240}{1200}\times\frac{1200}{1160} = 620$ Hz

29. $f_{guard} = f_o\left(\frac{v + v_s}{v + v_s}\right) = f_o$

EXERCISE –IV (B)

1. $f_{max} = f_0\left(\frac{v + v_0}{v + v_s}\right)$

$= 340\left(\frac{340 + 2\pi\left(\frac{5}{\pi}\right)6}{340 - 10\times 3}\right)$

= 438.7 Hz

$f_{min} = f_0\left(\frac{v - v_0}{v + v_s}\right) = 340\left(\frac{340-60}{340+30}\right) = 257.3$ Hz

2. $I = 4I_0\cos^2\theta$ where $\theta = (\omega_1 - \omega_2)t = 10^3 t$

(i) For successive maxima

(क्रमागत उच्चिष्ठ के लिए)

$\Delta t = \frac{2\pi}{10^3} = 6.28\ \ 10^{-3}$ sec

(ii) For detection of sound (ध्वनि के संसूचन के लिए)

$2A^2 = 4A^2\cos^2\theta$

$\Rightarrow \cos\theta = \pm\frac{1}{\sqrt{2}} \Rightarrow \theta = -\frac{\pi}{4}, \frac{\pi}{4}$

$\Rightarrow\ 10^3 t = 2\left(\frac{\pi}{4}\right) = \frac{\pi}{2}$

$\Rightarrow\ t = \frac{\pi}{2}\times 10^{-3} = 1.57\times 10^{-3}$ s

3. Frequency reaching the wall $f_1' = f_0\left(\frac{v}{v - v_b}\right)$

(दीवार पर पहुंच रही आवृति)

Frequency reaching the motorist after reflection from wall (दीवार से परावर्तित होने के बाद मोटर साईकिल पर पहुंच रही आवृत्ति)

$f_1 = f_1'\left(\frac{v + v_m}{v}\right) = f_0\left(\frac{v + v_m}{v - v_b}\right)$

Frequency directly reaching the motorist

(सीधे ही मोटरसाइकिल पर पहुंच रही आवृत्ति)

$f_2 = f_0\left(\frac{v + v_m}{v + v_b}\right)$

$\therefore$ Beat frequency (विस्पंद आवृति)

$\Delta f = f_1 - f_2 = f_0(v + v_m)\left(\frac{2v_b}{v^2 - v_b^2}\right)$

4. (i) For the particle P (कण P के लिए)

$$\frac{\partial y}{\partial t} = -v\left(\frac{\partial y}{\partial x}\right) \Rightarrow +20\sqrt{3} = -v(\sqrt{3})$$

$\Rightarrow$ v =–20 cm/s

(along negative x-axis)

(ऋणात्मक x-अक्ष के अनुदिश)

(ii) Equation of wave (तरंग का समीकरण)

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

at t =0, x = 0, y = $2\sqrt{2}$, A= 4

$\Rightarrow 4 = 2\sqrt{2} \sin\phi \Rightarrow \phi = \frac{\pi}{4}$, λ = 5.5 – 1.5 = 4 cm

$$f = \frac{v}{\lambda} = \frac{20cm/s}{4cm} = 5Hz$$

$$\therefore y = 4 \sin\left(10\pi t + \frac{\pi x}{2} + \frac{\pi}{4}\right)$$

(iii) Energy carried in one wavelength

(एक तरंगदैर्ध्य में ले जाई गई ऊर्जा)

$$E = \frac{1}{2}\mu A^2\omega^2\lambda$$

$$= \frac{1}{2} \times \frac{50}{1000} \times (4\times10^{-2})^2 \times (10\pi)^2 \times \frac{4}{100}$$

$= 16\pi^2 \quad 10^{-5}$ J

5. Amplitude of reflected wave (परावर्तित तरंग का आयाम)

$$A_r = A_i\left(\frac{k_2 - k_1}{k_2 + k_1}\right) = 2\left(\frac{25-50}{25+50}\right)\times10^{-3}$$

$= 0.667 \quad 10^{-3} = 6.67 \quad 10^{-4}$

Amplitude of transmitted wave

(पारगमित तरंग का आयाम)

$$A_t = \left(\frac{2k_1}{k_1 + k_2}\right)A_i = \frac{2\times50\times2}{50+25}\times10^{-3}$$

$= 2.67 \quad 10^{-3}$

$\therefore$ Equation of reflected wave

(परावर्तित तरंग का समीकरण)

$y_r = 6.67 \quad 10^{-4} \cos\pi(2x + 50t)$

Equation of transmited wave

(पागमित तरंग का समीकरण)

$y_t = 2.67 \quad 10^{-3} \cos\pi(x - 50t)$

6. For air (वायु के लिए)

$\frac{\lambda_1}{2} = L_1 \Rightarrow \lambda_1 = 2L_1$

$v_1 = 330 \Rightarrow v_1 = f\lambda \Rightarrow 330 = 500\ (2L_1)$

$\Rightarrow L_1 = 33$ cm

For CO_2 (CO_2 के लिए) $\frac{\lambda_2}{4} = L_2$

$\lambda_2 = 4L_2$, $v_2 = 264$

$\Rightarrow v_2 = f\lambda_2 \Rightarrow 264 = 500\ (4L_2)$

$\Rightarrow L_2 = 13.2$ cm.

7. (i) $\lambda = \frac{v}{f} = \frac{330}{200} = 1.65$ m, $\frac{d}{\lambda} = \frac{4}{1.65} = 2.4242$

At infinity, path difference = 0

(अनन्त पर, पथान्तर शून्य है)

As the man approaches, the path difference changes as

(जैसे ही आदमी पास आता है तो पथान्तर में परिवर्तन)

$$0, \frac{\lambda}{2}, \lambda, \frac{3\lambda}{2}, 2\lambda$$

$\therefore$ Hence only minima will appear to the man.

(अत: आदमी को केवल निम्निष्ठ प्रेक्षित होगा)

(ii)For $\Delta = \frac{\lambda}{2} = \sqrt{d^2 + x_1^2} - x_1$ and $\frac{3\lambda}{2} = \sqrt{d^2 + x_2^2} - x_2$

$\Rightarrow x_1 = 9.28$ m , $x_2 = 1.99$ m

9. $\frac{2\pi}{\lambda} = \frac{\pi x}{10} \Rightarrow \lambda = 20$cm

(i) Total no of wavelength = $\frac{L}{\lambda} = \frac{100}{20} = 5$

(तरंगदैर्ध्य की कुल संख्या)

$\therefore$ Number of loops formed = 2 5 =10

(बनने वाले लूपों की संख्या)

(ii) Maximum displacement at x = $\frac{5}{3}$

(x पर अधिकतम विस्थापन)

$$A = 6 \sin\left(\frac{\pi}{10}\times\frac{5}{3}\right) = 3cm$$

(iii) $y = 6 \sin\left(\frac{\pi x}{10}\right) \cos(100\pi t)$

$= 6 \sin(10\pi x) \cos(100\pi t)$

$v = 6\pi \sin(10\pi x) \sin(100\pi t)$ m/s

$$\therefore KE_{max} = \int_0^1 \frac{1}{2}\mu v^2 dx = \frac{1}{2}\mu\int_0^4 [6\pi\sin(10\pi x)]^2 dx$$

where $\sqrt{\frac{T}{\mu}} = \frac{100\pi}{10\pi} = 10$ =μ=0.4 ∴ KE_{max} = 36J

(iv) $y = 6 \sin\left(\frac{\pi x}{10}\right) \cos(100\pi t) = y_1 + y_2$

$\Rightarrow y_1 = 3\sin\left(\frac{\pi x}{10} - 100\pi t\right)$, $y_2 = 3 \sin\left(\frac{\pi x}{10} + 100\pi t\right)$

10. (i) Combination of waves producing standing wave : $Z_1 + Z_2$
(अप्रगमी तरंग उत्पन्न करने वाली तरंगों का संयोजन)

(ii) Combination of waves prodcuing a wave travelling along x = y line : $Z_1 + Z_3$
(x=y रेखा के अनुदिश गति करने वाली तरंग को उत्पन्न करने वाली तरंगों का संयोजन)

(iii) Position of nodes in case (i)$x = (2n + 1)\frac{\pi}{2k}$
(निस्पंदों की संख्या स्थिति (i) में)

case (ii) $x-y = (2n+1)\ \frac{\pi}{k}$

12. $v = \sqrt{\frac{Y}{\rho}} = \sqrt{\frac{2\times10^{11}}{8000}} = 5000\,m/s$

$\frac{5}{2}\lambda = L \Rightarrow \lambda = \frac{2L}{5} = \frac{2\times1}{5} = 0.4$ m

$\therefore k = \frac{2\pi}{\lambda} = \frac{2\pi}{0.4} = 5\pi$

$\Rightarrow \quad \omega = 2\pi f = \frac{2\pi v}{\lambda} = \frac{2\pi\times5000}{0.4} = 2,5000\,\pi$

(i) Equation of the wave (तरंग का समीकरण)
= 2 10^{-6}cos(5πx) sin(25,00 πt)

(ii) $y_1 = 10^{-6}$ sin (25000πt – 5πx)
$y_2 = 10^{-6}$ sin (25000 πt + 5πx)

13. Amplitude after reflection
(परावर्तन के पश्चात् आयाम)

$A_r = A_i\left(\frac{k_2 - k_1}{k_2 + k_1}\right) = 0.3\left(\frac{2.5-5}{2.5+5}\right) = -0.1$

Amplitude after transmission
(पारगमन के पश्चात् आयाम)

$A_t = A_i\left(\frac{2k_1}{k_1 + k_2}\right) = 0.2$ cm

EXERCISE –V-A

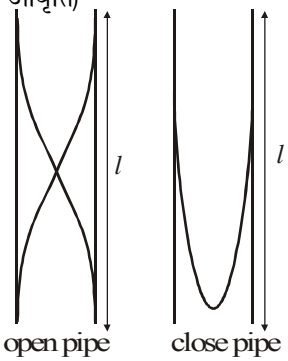
1. The fundamental frequency for an open pipe is
(एक खुले पाईप के लिये मूल आवृति)

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

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

$f_{open} = \frac{v}{2\ell}$

$\ell = \frac{\lambda}{4}$

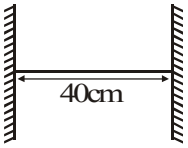


$\lambda = 4\ell$; $f_{closed} = \frac{v}{\lambda} = \frac{v}{4\ell}$

$\frac{f_{open}}{f_{closed}} = \frac{f_A}{f_B} = \frac{v}{2\ell} \times \frac{4\ell}{v} = 2:1$

4. As the string is tied between two rigid supports hence there will be nodes at both ends. The longest wavelength for nodes at both ends will be the one for which) (चूंकि रस्सी दो दृढ़ आधारों के मध्य लगी है। अत: वहां दोनों सिरों पर निस्पंद होंगे। दोनों सिरों पर निस्पंद के लिये सबसे लम्बी तरंगदैर्ध्य वह होगी जिसके लिये)

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



$\lambda_{longest}$ = 2 40 = 80 cm

5. $y = 10^{-4} \sin\left(600t - 2x + \frac{\pi}{3}\right)$

On comparing the given equation with the general equation of wave, we get (दी गई समीकरण की तरंग की व्यापक समीकरण से तुलना करने पर)

$y = y_0 \sin(\omega t - kx + \phi)$

ω = 600 ; k =2

Wave speed (तरंग की चाल)= $\frac{\omega}{k} = \frac{600}{2}$ =300 m/s

6. The frequency of the vibrating string with respect to tuning fork is either (256+5) Hz or (256–5) Hz (स्वरित्र के सापेक्ष कम्पन्न कर रही डोरी की आवृति या तो (256+5) Hz या (256–5) Hz) होगी)

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

On increasing tension; the beat frequency decreases to 2Hz, so probable frequency of the wire with respect to fork none is (डोरी में तनाव बढ़ाने पर : विस्पंद आवृति घटकर 2Hz रह जाती है। अत: स्वरित्र के सापेक्ष तार की सम्भावित आवृति कुछ नहीं होगी)

$$256 \begin{matrix} < 256 \\ < 258 \end{matrix}$$

But on increasing the tension of wire, the frequency of the wire must have to increase. So, if the original frequency of the wire is assumed to be 261 then it reduces to 258 whereas if it is assumed to be 251 it has increased to 254. As we were expecting increase, so the correct frequency of the piano wire is (256–5) Hz.

(किन्तु तार में तनाव बढाने पर : तार की आवृति बढ़ती है। अत: यदि तार की वास्तविक आवृति 261 है तो यह घटकर 258 हो जाती है। यदि यदि यह माना 251 Hz है तो यह बढ़कर 254 हो जाती है। यदि तनाव बढ़ाने पर उसकी आवृति बढ़ रही है तो पियानों की डोरी की आवृति (256–5) Hz होगी))

7. If the frequency of fork 1 is 200 Hz then probable frequencies of fork 2 is either 196 Hz or 204 Hz. As on attaching some tape on fork 2, be at frequency increases, this is possible only if the frequency of fork 2 is 196 Hz.

(यदि स्वरित्र 1 की आवृति 200 Hz है तो स्वरित्र 2 की सम्भावित आवृतियां या तो 196 Hz या 204 Hz होगी। जब स्वरित्र 2 की भुजा पर कुछ टेप चिपका देते हैं तो आवृति बढ़ती है ऐसा तभी सम्भव है यदि स्वरित्र 2 की आवृति 196 Hz हो)

8. Given that (दिया है) $v_{observer} = \frac{v_{sound}}{5}$

Applying Doppler's effect, we get

(डॉप्लर प्रभाव लगाने पर)

$$f' = f\left[\frac{v+v_0}{v}\right];\ f' = f\left[\frac{6v/5}{v}\right] = \frac{6}{5};\ \frac{f'}{f} = \frac{6}{5}$$

$$\frac{f'-f}{f} = \frac{6}{5} - 1 = \frac{1}{5} = 20\%$$

9. $\because\ n' = \left(\frac{v}{v-v_s}\right)n$

$$\therefore\ 10000 = \left(\frac{300}{300-v_s}\right)(9500)$$

$$\Rightarrow 300 - v_s = \frac{300\times 9500}{10000} = 285 \Rightarrow v_s = 15\ ms^{-1}$$

10. Intensity change in decibel

(तीव्रता परिवर्तन (डेसीबल में))

$$= 10 \log \frac{I_2}{I_1} = 20 \Rightarrow \log \frac{I_2}{I_1} = 2 \Rightarrow \frac{I_2}{I_1} = 10^2 = 100$$

11. $n = \frac{1}{4x}\sqrt{\frac{\gamma RT}{M}}, xn = \frac{1}{4}\sqrt{\frac{\gamma RT}{M}}, x \propto \sqrt{T}$

12. $y = 0.005 \cos(\alpha x - \beta t)$

comparing the equation with the standard form,

(मानक समीकरण से तुलना करने पर)

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

$\Rightarrow 2\pi/\lambda = \alpha$ and $2\pi/T = \beta$

$\Rightarrow \alpha = 2\pi/0.08 = 25.00\pi$ and $\beta = \pi$

13.

A	B	C
ν–1	ν	ν+1

Between A & B 1 b/s (1)

B & C 1 b/s (1)

C & A 2 b/s $\frac{1}{2}$ $\left(\frac{2}{2}\right)$

$\Rightarrow$ 2 b/s

14. $n' = \frac{v-v_0}{v}n = \frac{94}{100}n$

from (iii) eq^n. of motion $v^2 = u^2 + 2as$

$\Rightarrow\ v_0^2 = 0 + 2as \Rightarrow v_0 = \sqrt{2as}$

$$\Rightarrow \frac{94}{100}n = \left(\frac{v-\sqrt{2as}}{v}\right)n \Rightarrow s = 98\ m.$$

15. $y = 0.2 \sin\left[2\pi\left(\frac{t}{0.04} - \frac{x}{0.50}\right)\right]$

$$v = \sqrt{\frac{T}{m}} = \frac{\omega}{k} \Rightarrow \sqrt{\frac{T}{0.04}} = \frac{\frac{1}{0.04}}{\frac{1}{0.50}}$$

$$T = \left(\frac{0.50}{0.04}\right)^2 \times 0.04 = 6.25\ N$$

16. $y(x_1t) = e^{-[\sqrt{a}x+\sqrt{b}t]^2}$

$v = \omega/K = \dfrac{\sqrt{b}}{\sqrt{a}}$ in –ve x direction.

17. $y_1(x, t) = 2a \sin(wt - kx)$
$y_2(x, t) = a \sin(2wt - 2kx)$
But Intensity (लेकिन तीव्रता)

$I = 2\pi^2n^2a^2\rho v \Rightarrow \dfrac{I_1}{I_2} = \left(\dfrac{2a}{a} \times \dfrac{n}{2n}\right)^2 = \dfrac{1}{1}$

Intensity depends on frequency and amplitude
So statement-1 is true statement-2 is false
(तीव्रता, आवृति व आयाम पर निर्भर करती है अत: कथन 1 सत्य व कथन–2 असत्य है)

18. $y_1 = A \sin(wt - kx)$ & $y_2 = A \sin(wt + kx)$
By superposition principle (अध्यारोपण के सिद्धांत से)

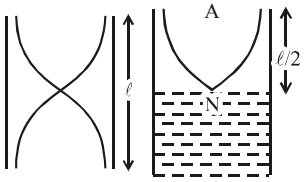
$y = y_1 + y_2$
$= A \sin(wt - kx) + A \sin(wt + kx)$
$= 2A \sin wt \cos kx$

Amplitude (आयाम)= $2A \cos kx$
At nodes displacement is minimum
(निस्पंद पर विस्थापन न्यूनतम होगा)
$2A \cos kx = 0 \Rightarrow \cos kx = 0$

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

$x = (2n+1)\dfrac{\pi}{4}$ where n = 0, 1, 2....

19.



$n_0 = \dfrac{v}{2\ell}$ $\quad n_c = \dfrac{v}{4(\ell/2)} = \dfrac{v}{2\ell}$

20. Fundamental frequency (मूल आवृति)

$f = \dfrac{V}{2\ell} = \dfrac{1}{2 \times 1.5}\sqrt{\dfrac{T}{eq}} = \dfrac{1}{3}\sqrt{\dfrac{y \times \text{strain} \times S}{\rho S}}$

(S → cross – section Area) (अनुप्रस्थ काट क्षेत्रफल)

$= \dfrac{1}{3}\sqrt{\dfrac{2.2 \times 10^{11} \times \dfrac{1}{100}}{7.7 \times 10^3}} = 178.2$ Hz

EXERCISE –V-B

1. Mass per unit length of the string,
(रस्सी की प्रति इकाई लम्बाई का द्रव्यमान)

$m = \dfrac{10^{-2}}{0.4} = 2.5 \quad 10^{-2}$kg/m

∴ Velocity of wave in the string.
(रस्सी में तरंग का वेग)

$v = \sqrt{\dfrac{T}{m}} = \sqrt{\dfrac{1.6}{2.5 \times 10^{-2}}} \Rightarrow v = 8$m/s

For constructive interference between successive pulses
(दो क्रमागत विक्षोभों के मध्य संपोषी व्यतिकरण के लिए)

$\Delta t_{min} = \dfrac{2\ell}{v} = \dfrac{(2)(0.4)}{8} = 0.10$s

(After two reflections, the wave pulse is in same phase as it was produced, since in one reflection its phase changes by π, and if at this moment next identical pulse is produced, then constructive interference will be obatined.)
(दो बार परावर्तित होन के बाद तरंग विक्षोभ समान कला में उत्पन्न होते हैं चूंकि एक परावर्तन में इसकी कला π द्वारा परिवर्तित होती है तथा किसी अगले क्षण यदि एकसमान विक्षोभ उत्पन्न करती है तो संपोषी व्यतिकरण होगा)

2. $f_1 = f\left(\dfrac{v}{v - v_s}\right) \Rightarrow f_1 = f\left(\dfrac{340}{340 - 34}\right) = f\left(\dfrac{340}{306}\right)$

and $f_2 = f\left(\dfrac{340}{340 - 17}\right) = f\left(\dfrac{340}{323}\right)$ ∴ $\dfrac{f_1}{f_2} = \dfrac{323}{306} = \dfrac{19}{18}$

3. Fundamental frequency is given by $v = \dfrac{1}{2\ell}\sqrt{\dfrac{T}{\mu}}$
(मूल आवृति दी जाती है)
(with both the ends fixed) (जब दोनों सिरे स्थिर हों)

∴ Fundamental frequency (मूल आवृति) $v \propto \dfrac{1}{\ell\sqrt{\mu}}$

[for same tension in both strings]
[दोनों रस्सियों में समान तनाव के लिए]
where μ = mass per unit length of wire= ρ.A
(जहां μ =तार की प्रति इकाई लम्बाई का द्रव्यमान = ρ.A)

(ρ = density (घनत्व)) = $\rho(\pi r^2) \Rightarrow \sqrt{\mu} \propto r$ ∴ $v \propto \dfrac{1}{r\ell}$

∴ $\dfrac{v_1}{v_2} = \left(\dfrac{r_2}{r_1}\right)\left(\dfrac{\ell_2}{\ell_1}\right) = \left(\dfrac{r}{2r}\right)\left(\dfrac{2L}{L}\right) = 1$

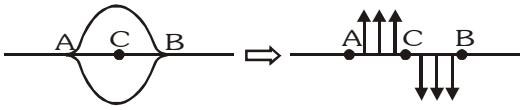
4. Energy $E \propto (\text{amplitude})^2\ (\text{frequency})^2$

(ऊर्जा $E \propto$ (आयाम)^2 (आवृति)^2

Amplitude (A) is same in both the cases, but frequency 2ω, in the second case is two times the frequency (ω) in the first case. (आयाम (A) दोनों स्थितियों में समान है लेकिन आवृति 2ω है। द्वितीय स्थिति में आवृति (ω) प्रथम स्थिति में आवृति की दो गुणा होगी)

Therefore (अत:) $E_2 = 4E_1$

5. After two seconds both the pulses will move 4 cm towards each other. So, by their superposition, the resultant displacement at every point will be zero. Therefore, total energy will be purely in the form of kinetic. Half of the particles will be moving upwards and half of downwards.



(दो सेकण्ड बाद दोनों स्पन्द एक दूसरे की ओर 4m गति करेंगे। इसलिये इनके अध्यारोपण द्वारा प्रत्येक बिन्दु पर परिणामी विस्थापन शून्य होगा। अत: कुल ऊर्जा पूर्णत: गतिज ऊर्जा के रूप में होगी। आधे कण ऊपर की ओर व आधे कण नीचे की ओर गति करते हैं)

6. Using the formula (सूत्र के प्रयोग से) $f' = f\left(\frac{v + v_0}{v}\right)$

we get, $5.5 = 5\left(\frac{v + v_A}{v}\right)$ ...(i)

and $6.0 = 5\left(\frac{v + v_B}{v}\right)$ ...(ii)

Here (यहां)

v = speed of sound (ध्वनि की चाल)

v_A = speed of train A (ट्रेन A की चाल)

v_B = speed of train B (ट्रेन B की चाल)

Solving equations (i) and (ii) $\frac{v_B}{v_A} = 2$

7. Let f_0 = frequency of tuning fork.

(माना f_0 = स्वरित्र की आवृति तो)

$$f_0 = \frac{5}{2\ell}\sqrt{\frac{9g}{\mu}}$$

(μ = mass per unit length of wire) $= \frac{3}{2\ell}\sqrt{\frac{Mg}{\mu}}$

(μ =तार की प्रति इकाई लम्बाई का द्रव्यमान)

Solving this, we get M = 25 kg

In the first case frequency corresponds to fifth harmonic while in the second case it corresponds to third harmonic.

(प्रथम स्थिति में आवृति पांचवी सन्नादि के संगत होगी जबकि द्वितीय स्थिति में यह तीसरी सन्नादि के संगत होगी।)

8. The motorcyclist observes no beats. So, the apparent frequency observed by him from the two sources must be equal.

(मोटरसाइकिल वाला कोई विस्पंद प्रेक्षित नहीं करता है। अत: दोनों स्रोत से प्रेक्षित आभासी आवृति समान होगी)

$$f_1 = f_2 \ \therefore\ 176\left(\frac{330 - v}{330 - 22}\right) = 165\left(\frac{330 + v}{330}\right)$$

Solving this equation, we get v = 22m/s

9. Let $\Delta\ell$ be the end correction.

(माना $\Delta\ell$ सिरा संशोधन है)

Given that, fundamental tone for a length 0.1m= first overtone for the length 0.35m.

(दिया है 0.1 मीटर लमबाई के लिये मूल स्वर =0.35 m लम्बाई के लिये अधिस्वरक)

$$\frac{v}{4(0.1 + \Delta\ell)} = \frac{3v}{4(0.35 + \Delta\ell)}$$

Solving this equation (हल करने पर)

we get $\Delta\ell$= 0.025m = 2.5 10^{-2} m

10. The frequency is a characteristic of source. It is independent of the medium. (आवृति स्रोत का एक अभिलाक्षणिक है। यह माध्यम से स्वतंत्र है)

11. $f_c = f_0$ (both first overtone)

$$\Rightarrow 3\left(\frac{v_c}{4L}\right) = 2\left(\frac{v_0}{2\ell_0}\right)$$

$$\therefore\quad \ell_0 = \frac{4}{3}\left(\frac{v_0}{v_c}\right)L = \frac{4}{3}\sqrt{\frac{\rho_1}{\rho_2}}L \qquad \text{as } v \propto \frac{1}{\sqrt{\rho}}$$

12. The frequency is a characteristic of source. It is independent of the medium.(आवृति स्रोत का एक अभिलाक्षणिक है। यह माध्यम से स्वतंत्र है)

13. $f_1 = \frac{v}{\ell}$ (2nd harmonic of open pipe)
(खुले पाईप की द्वितीय सन्नादि)

$f_2 = n\left(\frac{v}{4\ell}\right)$ (n^{th} harmonic of closed pipe)
(बंद पाईप की nवीं सन्नादि)

Here, n is odd and $f_2 > f_1$ (यहां n विषम है तथा $f_2 > f_1$)

It is possible when n=5 because with n = 5

(यह सम्भव है जब n=5 क्योंकि n = 5 के लिए)

$\Rightarrow f_2 = \frac{5}{4}\left(\frac{v}{\ell}\right) = \frac{5}{4}f_1$

14. The question is incomplete, as speed of sound is not given. Let us assume speed of sound as 330 m/s. Then, method will be as under.

(प्रश्न अधूरा है क्योंकि ध्वनि की चाल नहीं दी गई है। माना ध्वनि की चाल 330 m/s है तो हल निम्न प्रकार होगा)

$\frac{\lambda}{2}$ = (63.2–30.7)cm or λ = 0.65 m

$\therefore$ speed of sound observed (प्रेक्षित ध्वनि की चाल)

$v_0 = f\lambda = 512 \quad 0.65 = 332.8$ m/s

$\therefore$ Error is calculting velocity of sound

(ध्वनि के वेग में त्रृटि)

= 2.8m/s = 280 cm/s

15. $f \propto v \propto \sqrt{T}$

$f_{AB} = 2f_{CD}$

$\therefore T_{AB} = 4T_{CD}$ ....(i)

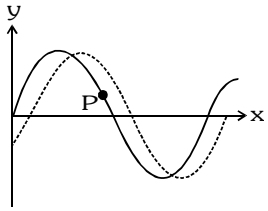
Further $\Sigma\tau_p = 0$

$\therefore \quad T_{AB}(x) = T_{CD}(\ell - x)$

$\Rightarrow \quad 4x = \ell - x \quad$ (as $T_{AB} = 4T_{CD}$)

$\Rightarrow \quad x = \ell/5$

16. Take y=Asin(ωt–kx)



so $v_P = \frac{\partial y}{\partial t} = -A\omega\cos(\omega t - kx)$

$\Rightarrow v_P = \omega\sqrt{A^2 - y^2} = \left(\frac{2\pi v}{\lambda}\right)\sqrt{A^2 - y^2}$

$= \frac{2\pi(10 \times 10^{-2})}{0.5}\left(\sqrt{(10)^2 - (5)^2}\right) \times 10^{-2} = \frac{\sqrt{3}\pi}{50}$ ms^{-1}

17. $\frac{1}{2L}\sqrt{\frac{T}{m}} = \frac{3v}{4\ell}$

where v = 340 ms^{-1}, ℓ = 75 cm = 0.75 m

Now according to given condition

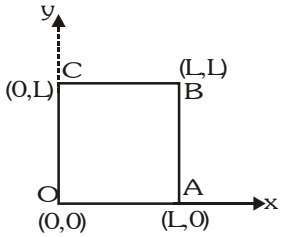
$n - \frac{1}{2L}\sqrt{\frac{T}{m}} = 4$ so $n = \frac{1}{2L}\sqrt{\frac{T}{m}} + 4 = \left(\frac{3v}{4\ell} + 4\right)$

$= \frac{3}{4} \times \frac{340}{0.75} + 4 = 344$ Hz.

MCQ

1. Since, the edges are clamped, displacement of the edges u(x,y) = 0 for

(चूंकि किनारों को क्लैम्प किया गया है अत: निम्न रेखाओं के लिये किनारों का विस्थापन u(x,y) = 0 होगा)



Line	OA i.e. y =0	$0 \le x \le L$
	AB i.e. x =L	$0 \le y \le L$
	BC i.e. y =L	$0 \le x \le L$
	OC i.e. x =0	$0 \le y \le L$

The above conditions are satisfied only i nalternatives (b) and (c). (उपरोक्त स्थितियां केवल विकल्पों (b) व (c) के लिये ही संतुष्ट होगी)

Note that u(x,y)=0, for all four values e.g. in alternative (d), u(x,y)=0 for y=0, y=L but it is not zero for x=0 or x=L, Similarly in option (a) u(x,y)=0 at x=L, y=L but it is not zero for x=0 or y=0 while in options (b) and (c), u(x,y)=0 for x=0, y=0 x = L and y=L.

(सभी चार मानों के लिये u(x,y)=0 होगा। उदाहरण के लिये विकल्प (d) में y=0, y=L के लिये u(x,y)=0 है, परन्तु x=0 अथवा x=L के लिये यह शून्य नहीं है। इसी प्रकार विकल्प (a) में x=L, y=L के लिये u(x,y)=0 है परन्तु x=0 अथवा y=0 के लिये यह शून्य नहीं है, जबकि विकल्प (b) व (c) में x=0, y=0 x = L तथा y=L के लिये u(x,y)=0 है।

2. Maximum speed of any point on the string =aω

(रस्सी पर किसी बिन्दु की अधिकतम चाल)

= a(2πf)

$\therefore = \frac{v}{10} = \frac{10}{10} = 1$ (Given : v=10m/s)

$\therefore$ 2πaf = 1

$\therefore f = \frac{1}{2\pi a} \Rightarrow a = 10^{-3}$m (Given)

$\therefore f = \frac{1}{2\pi \times 10^{-3}} = \frac{10^3}{2\pi}$Hz

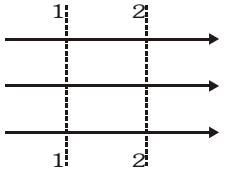
Speed of wave (तरंग की चाल)v = fλ

$\therefore$ (10 m/s) = $\left(\frac{10^3}{2\pi}s^{-1}\right)\lambda$

$\therefore \lambda = 2\pi \quad 10^{-2}$m

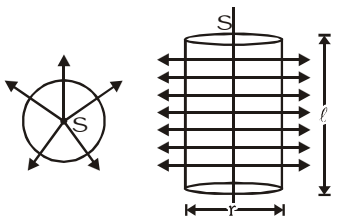
3. For a plane wave intensity (energy crossing per unit area per unit time) is constant at all points.

(समतल तरंग की तीव्रता (के लिये) (प्रति ईकाई समय प्रति ईकाई क्षेत्रफल से गुजरने वाली ऊर्जा) सभी बिन्दुओं पर नियत होती है।)



But for a spherical wave, intensity at a distance r from a point source of power P (energy transmitted per unit time) is given by :

(लेकिन गोलीय तरंग के लिये शक्ति P के बिन्दु स्रोत से r दूरी पर तीव्रता (प्रति इकाई समय पारगमित ऊर्जा दी जाती है)

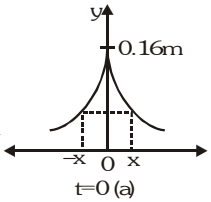


$$I = \frac{P}{4\pi r^2} \text{ or } I \propto \frac{1}{r^2}$$

4. The shape of pulse at x=0 and t=0 would be as shown, in figure (a).

(x=0 व t=0 पर स्पंद की आकृति चित्र (a) में प्रदर्शित है)

$$y(0,0) = \frac{0.8}{5} = 0.16m$$



From the figure it is clear that y_{max} = 0.16m

Pulse will be symmetric (Symmetry is checked about y_{max}) if at t=0

(चित्र से स्पष्ट है कि y_{max} = 0.16m स्पन्द सममित होंगे (सममित y_{max} के सापेक्ष हल करें) यदि t=0 पर)

$$y(x) = y(-x)$$

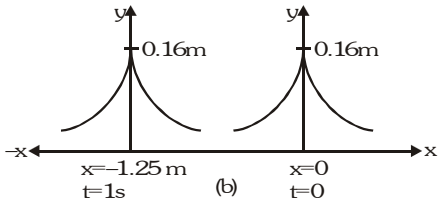
From the given equation and (दी गई समीकरण से एवं)

$$\left.\begin{aligned} y(x) &= \frac{0.8}{16x^2+5} \\ y(-x) &= \frac{0.8}{16x^2+5} \end{aligned}\right\} \text{ at } t=0 \Rightarrow y(x) = y(-x)$$

Therefore, pulse is symmetric.(अत: स्पंद सममित हैं)

Speed of pulse (स्पंद की चाल)

At t=1s and x=–1.25 m



value of y is again 0.16 m, i.e., pulse has travelled a distance of 1.25 m in 1s in negative x- direction or we can say that the speed of pulse is 1.25 m/s and it is travelling in negative x-direciton. Therefore, it will travel a distance of 2.5m in 2s. The above statement can be better understood from figure (b).

(t = 1s व x = –1.25 m पर y का मान पुन: 0.16 m होगा अर्थात् स्पन्द ऋणात्मक x दिशा में 1s में 1.25m की दूरी तय करेगा अथवा हम कह सकते हैं कि स्पंद की चाल 1.25 m/s तथा यह ऋणात्मक x-दिशा में गति कर रहा है। अत: यह 2s में 2.5 m दूरी तय करेगा। उपरोक्त कथन को चित्र (b) द्वारा अच्छी तरह समझा जा सकता है)

5. In case of sound wave, y can represent pressure and displacement, while in case of an electromagnetic wave it represents electric and magnetic fields.

(ध्वनि तरंग की स्थिति में y को दाब व विस्थापन से प्रदर्शित कर सकते हैं। बकि विद्युतचुम्बकीय तरंग की स्थिति में यह विद्युत व चुम्बकीय क्षेत्र को प्रदर्शित करता है)

6. Standing waves can be produced only when two similar type of waves (same frequency and speed, but amplitude may be different) travel in opposite directions.

(अप्रगामी तरंगे केवल जब उत्पन्न होगी जब दो समान प्रकार की (समान आवृति व चाल लेकिन आयाम भिन्न हो, तरंगे विपरीत दिशाओं में गति करती हैं)

Comprehension#1

1. In one second number of maximas is called the beat frequency.

(1s में उच्चिष्ठों की संख्या विस्पंद आवृति कहलाती है)

Hence, $f_b = f_1 - f_2 = \frac{100\pi}{2\pi} - \frac{92\pi}{2\pi} = 4Hz$

2. Speed of wave (तरंग की चाल)

$$v = \frac{\omega}{R} = v = \frac{100\pi}{0.5\pi} \Rightarrow \frac{92\pi}{0.46\pi} = 200 \text{ m/s}$$

3. At x=0, $y=y_1 + y_2 = 2A \cos 96\pi t \cos 4\pi t$

Frequency of cos (96πt) function is 48Hz and that of cos (4πf) function is 2 Hz.

(फलन cos (96πt) की आवृति 48Hz तथा फलन cos (4πf) की आवृति 2 Hz है)

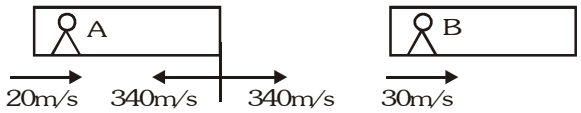
In one second cos function becomes zero at 2f times, where f is the frequency. Therefore, first function will become zero at 96 times and the second at 4 times. But second will not overlap with first. Hence, net y will become zero 100 times in 1s.

(1s में फलन cos, 2f बार शून्य हो जाता है, जहां f आवृति है, अत: प्रथम फलन 96 बार शून्य होगा व दूसरा फलन 4 बार शून्य होगा लेकिन दूसरा फलन, पहले फलन पर अतिव्यापित नहीं होगा। अत: कुल y 1 सेकण्ड में 100 बार शून्य होगा)

Comprehension#2

1. v_{SA}= 340 + 20 = 360 m/s

v_{SB} = 340 – 30 = 310 m/s



2. For the passengers in train A, there is no relative motion between source and observer, as both are moving with velocity 20m/s. Therefore, there is no change in observed frequencies and correspondingly there is no change in their intensities.

(ट्रेन A के यात्रियों के लिये स्रोत व प्रेक्षक के मध्य कोई सापेक्ष गति नहीं है, दोनों 20 m/s वेग से गति कर रही है। अत: वहां प्रेक्षित आवृतियों में कोई परिवर्तन नहीं होगा तथा इसके संगत इनकी तीव्रताओं में कोई परिवर्तन नहीं होगा)

3. For the passengers in train B, observer is receding with velocity 30m/s and source is approaching with velocity 20m/s.

(ट्रेन B के यात्रियों के लिये प्रेक्षक 30 m/s के वेग से पीछे हटते हैं तथा स्रोत 20 m/s वेग के साथ पास आता है)

$$\therefore f_1' = 800\left(\frac{340-30}{340-20}\right) = 775\text{Hz}$$

$$\text{and } f_2' = 1120\left(\frac{340-30}{340-20}\right) = 1085\text{Hz}$$

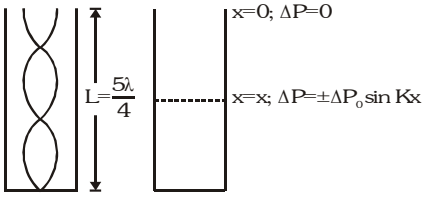
∴ Spread of frequency (आवृति का विस्तार)

$= f_2' - f_1' = 310$ Hz

SUBJECTIVE

1. (i) Frequency of second overtone of the closed pipe (बंद पाईप के द्वितीय अधिस्वरक की आवृति)

$$= 5\left(\frac{v}{4L}\right) = 440$$



$$\therefore L = \frac{5v}{4 \times 440}\text{m}$$

Substituting v= speed of sound in air =330m/s

(v= वायु में ध्वनि की चाल = 330 m रखने पर)

$$L = \frac{5 \times 330}{4 \times 440} = \frac{15}{16}\text{m}$$

$$\lambda = \frac{4L}{5} = \frac{4\left(\frac{15}{16}\right)}{5} = \frac{3}{4}\text{m}$$

(ii) Open end is displacement antinode. Therefore, it would be a pressure node or at x=0; ΔP=0

(खुला सिरा विस्थापन प्रस्पंद के रूप में है, इसलिये यह दाब निस्पंद होगा अथवा x=0 पर ΔP=0)

Pressure amplitude at x=x, (x=x पर दाब आयाम) can be written as $\Delta P = \pm \Delta P_0 \sin kx$

where $k = \frac{2\pi}{\lambda} = \frac{2\pi}{3/4} = \frac{8\pi}{3}\text{m}^{-1}$

Therefore, pressure amplitude at

(अत: पर दाब आयाम)

$x = \frac{L}{2} = \frac{15/16}{2}$ m or (15/32) m will be

$$\Delta P = \pm P_0 \sin\left(\frac{8\pi}{3}\right)\left(\frac{15}{32}\right) = \pm \Delta P_0 \sin\left(\frac{5\pi}{4}\right)$$

$$\Rightarrow \Delta P = \pm \frac{\Delta P_0}{\sqrt{2}}$$

(iii) Open end is a pressure node i.e. ΔP=0

(खुला सिरा एक दाब निस्पंद है अर्थात् ΔP=0)

Hence, $P_{max} = P_{min}$= Mean pressure (P_0)

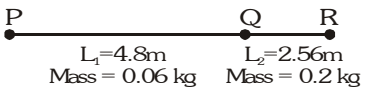
(अत: $P_{max} = P_{min}$= माध्य दाब (P_0))

(iv) Closed end is a displacement node or pressure antinode.(बंद सिरा एक विस्थापन निस्पंद अथवा दाब प्रस्पंद होगा)

Therefore, $P_{max} = P_0 + \Delta P_0$ and $P_{min} = P_0 - \Delta P_0$

2. Amplitude of incident wave (आपतित तरंग का आयाम)

$A_i = 3.5$ cm



Tension (तनाव) T = 80N

Mass per unit length of wire PQ is

(तार PQ की इकाई लम्बाई का द्रव्यमान)

$$m_1 = \frac{0.06}{4.8} = \frac{1}{80}\text{kg/m}$$

and mass per unit length of wire QR is

(तार QR की इकाई लम्बाई का द्रव्यमान)

$$m_2 = \frac{0.2}{2.56} = \frac{1}{12.8}\text{kg/m}$$

(i) Speed of wave in wire PQ is

(तार PQ में तरंग की चाल)

$$v_1 = \sqrt{\frac{T}{m_1}} = \sqrt{\frac{80}{1/80}} = 80\text{m/s}$$

and speed of wave in wire QR is

(तार QR तरंग की चाल)

$$v_2 = \sqrt{\frac{T}{m_2}} = \sqrt{\frac{80}{1/128}} = 32\text{ m/s}$$

$\therefore$ Time taken by the wave pulse to reach from P to R is

(P से R तक पहुंचने में तरंग स्पंद द्वारा लिया गया समय)

$$t = \frac{4.8}{V_1} + \frac{2.56}{V_2} = \left(\frac{4.8}{80} + \frac{2.56}{32}\right)\text{s} \Rightarrow t = 0.14\text{s}$$

(ii) The expressions for reflected and transmitted amplitudes (A_r and A_t) in terms of v_1,v_2 and A_i are as follows :(v_1v_2 के पदों में परावर्तित व पारगमित आयामों (A_r व A_t) व A_i के व्यंजक निम्न हैं)

$$A_r = \frac{v_2 - v_1}{v_2 + v_1}A_i \text{ and } A_t = \frac{2v_2}{v_1 + v_2}A_i$$

Substituting the values, we get (मान रखने पर)

$$A_r = \left(\frac{32 - 80}{32 + 80}\right)(3.5) = -1.5\text{ cm}$$

i.e., the amplitude of reflected wave will be 1.5cm. Negative sign of A_r indicates that there will be a phase change of π in reflected wave. Similarly.

(अर्थात् परावर्तित तरंग का आयाम 1.5 cm होगा। A_r का ऋणात्मक चिन्ह इंगित करता है कि परावर्तित तरंग में π कला का परिवर्तन होगा इसी प्रकार)

$$A_t = \left(\frac{2 \times 32}{32 + 80}\right)(3.5) = 2.0\text{cm}$$

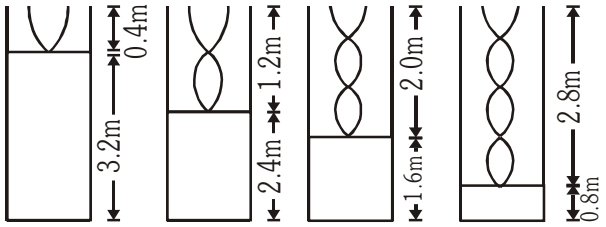
i.e., the amplitude of transmitted wave will be 2.0cm

(अर्थात् पारगमित तरंग का आयाम 2.0 cm होगा)

3. Speed of sound (ध्वनि की चाल)v = 340 m/s

Let ℓ_0 be the length of air column corresponding to the fundamental frequency. (माना ℓ_0 वायु स्तम्भ की मूल आवृति के संगत लम्बाई है) Then (तो)

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



In closed pipe only odd harmonics are obtained. Now let $\ell_1,\ell_2,\ell_3\ell_4$, etc., be the lengths corresponding to the 3rd harmonic, 4th harmonic, 7th harmonic etc. Then,

(बंद पाईप में केवल विषम सन्नादि प्राप्त होती है। माना $\ell_1,\ell_2,\ell_3\ell_4$ आदि तीसरी, चौथी, सातवीं सन्नादि के संगत लम्बाई है तो)

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

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

$$\text{and } 7\left(\frac{v}{4\ell_3}\right) = 212.5 \Rightarrow \ell_3 = 2.8\text{m}$$

$$9\left(\frac{v}{3\ell_4}\right) = 212.5 \Rightarrow \ell_4 = 3.6\text{m}$$

or heights of water level are

(या जल स्तर की ऊंचाईयां)

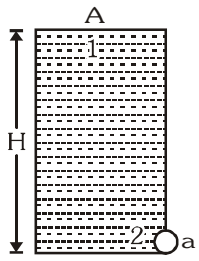
(3.6–0.4)m, (3.6 –1.2)m, (3.6 – 2.0) m,(3.6 – 2.8)m.

$\therefore$ Heights of water level are (जल स्तर की ऊंचाईयां)

3.2m, 2.4m, 1.6m and 0.8m.

Let A and a be the area of cross-sections of the pipe and hole respectively. Then

(माना A व a पाईप व छिद्र के अनुप्रस्थ काट का क्षेत्रफल है तो)



$A = \pi(2 \quad 10^{-2})^2 = 1.26 \quad 10^{-3}\ m^2$

and $a = \pi(10^{-3})^2 = 3.14 \quad 10^{-6}\ m^2$

Velocity of efflux (बहिस्राव का वेग) $v = \sqrt{2gH}$

Continuity equaiton at 1 and 2 gives :

(1 व 2 पर सांतव्य समीकरण)

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

$\therefore$ Rate of fall of water level in the pipe.

(पाईप में जल तल के गिरने की दर)

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

Substituting the values we get (मान रखने पर)

$$\frac{-dH}{dt} = \frac{3.14 \times 10^{-6}}{1.26 \times 10^{-3}}\sqrt{2 \times 10 \times H}$$

$$\Rightarrow \quad -\frac{dH}{dt} = (1.11 \times 10^{-2})\sqrt{H}$$

Between first two resonances, the water level falls from 3.2m to 2.4m. (प्रथम दो अनुनादि अवस्थाओं के मध य जल का स्तर 3.2 m से 2.4 m तक आ जाता है)

$$\therefore \quad \frac{dH}{\sqrt{H}} = -(1.11 \quad 10^{-2})dt$$

$$\Rightarrow \quad \int_{3.2}^{2.4}\frac{dH}{\sqrt{H}} = -(1.11 \quad 10^{-2})\int_0^t dt$$

$$\Rightarrow \quad 2[\sqrt{2.4} - \sqrt{3.2}] = -(1.11 \quad 10^{-2}).t$$

$$\Rightarrow \quad t \approx 43s$$

4. Velocity of sound in water is (पानी में ध्वनि का वेग)

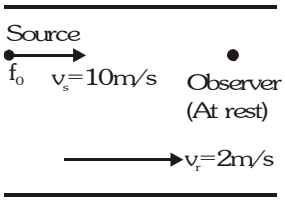
$$v_w = \sqrt{\frac{\beta}{\rho}} = \sqrt{\frac{2.088 \times 10^9}{10^3}} = 1445 m/s$$

Frequency of sound in water will be

(पानी में ध्वनि की आवृति)

$$f_0 = \frac{v_w}{\lambda_w} = \frac{1445}{14.45 \times 10^{-3}}Hz \Rightarrow f_0 = 10^5\ hz$$

(i) Frequency of sound detected by receiver (observer) at rest would be (विरामावस्था में स्थित ग्राही (प्रेक्षक) द्वारा संसूचित ध्वनि की आवृति)



$$f_1 = f_0\left(\frac{v_w + v_r}{v_w + v_r - v_s}\right) = (10^5)\left(\frac{1445 + 2}{1445 + 2 - 10}\right)Hz$$

$f_1 = 1.0069 \quad 10^5$ Hz

(ii) Velocity of sound in air is (वायु में ध्वनि का वेग)

$$v_a = \sqrt{\frac{\gamma RT}{M}} = \sqrt{\frac{(1.4)(8.31)(20 + 273)}{28.8 \times 10^{-3}}} = 344 m/s$$

$\therefore$ Frequency does not depend on the medium. Therefore, frequency in air is also $f_0 = 10^5$ Hz

(आवृति माध्यम पर निर्भर नहीं करती है। अत: वायु में आवृति $f_0 = 10^5$ Hz)

$\therefore$ Frequency of sound detected by receiver (observer) in air would be

(वायु में ग्राही (प्रेक्षक) द्वारा संसूचित ध्वनि की आवृति)

$$f_2 = f_0\left(\frac{v_a - w}{v_a - w - v_s}\right) = 10^5\left[\frac{344 - 5}{344 - 5 - 10}\right]Hz$$

$f_2 = 1.0304 \quad 10^5$ Hz

5. (i) Frequency of second harmonic in pipe A = frequency of third harmonic in pipe B

((i) पाईप A में द्वितीय सन्नादि की आवृति = पाईप B में तृतीय सन्नादि की आवृति)

$$\therefore \ 2\left(\frac{v_A}{2\ell_A}\right) = 3\left(\frac{v_B}{4\ell_B}\right)$$

$$\Rightarrow \frac{v_A}{v_B} = \frac{3}{4} \ (\text{as } \ell_A = \ell_B) \Rightarrow \frac{\sqrt{\frac{\gamma_A RT_A}{M_A}}}{\sqrt{\frac{\gamma_B RT_B}{M_B}}} = \frac{3}{4}$$

$$\Rightarrow \sqrt{\frac{\gamma_A}{\gamma_B}}\sqrt{\frac{M_B}{M_A}} = \frac{3}{4} \text{ (as } T_A = T_B)$$

$$\therefore \frac{M_A}{M_B} = \frac{\gamma_A}{\gamma_B}\left(\frac{16}{9}\right) = \left(\frac{5/3}{7/5}\right)\left(\frac{16}{9}\right)$$

$$\left(\gamma_A = \frac{5}{3} \text{and} \gamma_B = \frac{7}{5}\right)$$

$$\Rightarrow \frac{M_A}{M_B} = \left(\frac{25}{21}\right)\left(\frac{16}{9}\right) = \frac{400}{189}$$

(ii) Ratio of fundamental frequency in pipe A and in pipe B is : (पाईप A व पाईप B में मूल आवृति का अनुपात)

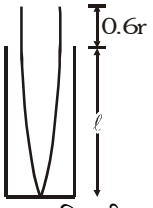
$$\frac{f_A}{f_B} = \frac{v_A/2\ell_A}{v_B/2\ell_B} = \frac{v_a}{v_B} \qquad (\text{as } \ell_A = \ell_B)$$

$$= \frac{\sqrt{\frac{\gamma_A RT_A}{M_A}}}{\sqrt{\frac{\gamma_B RT_B}{M_B}}} = \sqrt{\frac{\gamma_A}{\gamma_B}\cdot\frac{M_B}{M_A}} \text{ (as } T_A = T_B)$$

Substituting $\frac{M_B}{M_A} = \frac{189}{400}$ from part (i), we get

$$\frac{f_A}{f_B} = \sqrt{\frac{25}{21}\times\frac{189}{400}} = \frac{3}{4}$$

6. Fundamental frequency (मूल आवृति)



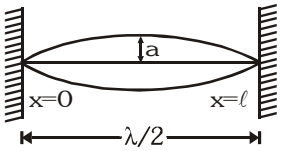
$$f = \frac{v}{4(\ell + 0.6r)}$$

∴ Speed of sound (ध्वनि की चाल) $v = 4f(\ell+0.6r)$

$\Rightarrow v = (4)(480)[(0.16) + (0.6)(0.025)] = 336 m/s$

7. $\ell = \frac{\lambda}{2} \Rightarrow \lambda = 2\ell,\ k = \frac{2\pi}{\lambda} = \frac{\pi}{\ell}$

The amplitude at a distance x from x=0 is given by A = a sin kx (x=0 से x दूरी पर आयाम A = asinkx)



Total mechanical energy at x of length dx is (dx लम्बाई की x पर कुल यांत्रिक ऊर्जा)

$$dE = \frac{1}{2}(dm)\,A^2\omega^2 = \frac{1}{2}(\mu dx)(a\sin kx)^2(2\pi f)^2$$

$$\Rightarrow \quad dE = 2\pi^2 \mu f^2 a^2 \sin^2 kx\, dx$$

Here, $f = \frac{v^2}{\lambda^2} = \frac{\left(\frac{T}{\mu}\right)}{(4\ell^2)}$ and $k = \frac{\pi}{\ell}$

Substituting these values in equation (i) and integrating it from x=0 to x=ℓ, we get total energy of string (ये मान समीकरण (i) में रखने पर तथा x=0 से x=ℓ तक समाकलन करने पर रस्सी में कुल ऊर्जा) $E = \frac{\pi^2 a^2 T}{4\ell}$

8. From the relation $f' = f\left(\frac{v}{v \pm v_s}\right)$

we have $2.2 = f\left[\frac{300}{300 - v_T}\right]$ ...(i)

and $1.8 = f\left[\frac{300}{300 + v_T}\right]$ ...(ii)

Here, $v_T = v_s$ = velocity of source/train

Solving equation (i) and (ii), we get $v_T = 30 m/s$

9. Maximum particle velocity (कण का अधिकतम वेग)

$\omega A = 3 m/s$ ...(i)

Maximum particle acceleration (कण का अधिकतम त्वरण)

$\omega^2 A = 90 m/s^2$ ...(ii)

Velocity of wave (तरंग वेग) $\frac{\omega}{k} = 20 m/s$ ...(iii)

From equation (i), (ii) and (iii), we get $\omega = 30$ rad/s $A = 0.1m$ and $k = 15 m^{-1}$

∴ Equation of waveform should be (तरंग रूप में समी.)

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

$y = (0.1m)\sin[(30 rad/s)t + (1.5m^{-1})x + \phi]$

10. L = 20 cm; m = 1 gm

$$\mu = \frac{m}{L} = \frac{1}{20} gm/cm = \frac{1}{20}\quad\frac{10^{-3}}{10^{-2}} g/m$$

$$\mu = \left(\frac{1}{200}\right) kg/m\ ;\ T = 0.5\ N$$

$$v = \sqrt{\frac{0.5}{\left(\frac{1}{200}\right)}} = 10\ m/s;\ f = 100\ Hz$$

$$\lambda = \frac{v}{f} = \frac{10}{100} = \frac{1}{10} m$$

$$\frac{\lambda}{2} = \frac{1}{20} m = 5\ cm$$