For constructive interference

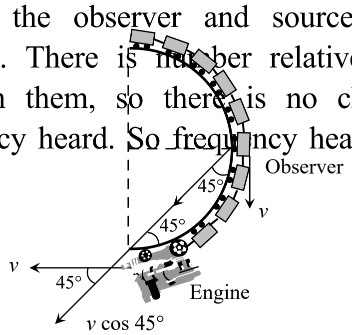
$\Delta x = 10 + \frac{\lambda}{2} = n\lambda \Rightarrow (2n-1)\frac{\lambda}{2} = 10 (n = 1, 2, 3....)$

$\therefore$ Wavelength $\lambda = \frac{2\times 10}{(2n-1)} = \frac{20}{2n-1}$. The possible wavelength are $\lambda =$ $20, \frac{20}{3}, \frac{20}{5}, \frac{20}{7}, \frac{20}{9}, ...$

$= 20\ m, 6.67\ m, 4m, 2.85\ m, 2.22\ m, ...$

5. (c) The situation is shown in the fig.

Both the source (engine) and the observer (Person in the middle of the train) have the same speed, but their direction of motion is right angles to each other. The component of velocity of observer towards source is $v\cos 45°$ and that of source along the time joining the observer and source is also $v\cos 45°$. There is number relative motion between them, so there is no change in frequency heard. So frequency heard is 200 *Hz*.



6. (b) Velocity of sound increases if the temperature increases. So with $v = n\lambda$, if v increases n will increase

at $27^oC, v_1 = n\lambda$, at 31^oC, $v_2 = (n+x)\lambda$

Now using $v \propto \sqrt{T}$ $\left(\because v = \sqrt{\frac{\gamma RT}{M}}\right)$

$\frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}} = \frac{n+x}{n}$

$\Rightarrow \frac{300+x}{300} = \sqrt{\frac{(273+31)}{(273+27)}} = \sqrt{\frac{304}{300}} = \sqrt{\frac{300+4}{300}}$

$\Rightarrow 1 + \frac{x}{300} = \left(1 + \frac{4}{300}\right)^{1/2} = \left(1 + \frac{1}{2}\times\frac{4}{300}\right) \Rightarrow x = 2.$

$[\because (1+x)^n = 1 + nx]$

7. (b) Let x be the end correction then according to question.

$\frac{v}{4(l_1 + x)} = \frac{3v}{4(l_2 + x)} \Rightarrow x = 2.5\ cm = 0.025\ m.$

8. (c) Frequency of first over tone of closed pipe = Frequency of first over tone of open pipe

$\Rightarrow \frac{3v}{4L_1} = \frac{v}{L_2} \Rightarrow \frac{3}{4L_1}\sqrt{\frac{\gamma P}{\rho_1}} = \frac{1}{L_2}\sqrt{\frac{\gamma P}{\rho_2}}$ $\left[\because v = \sqrt{\frac{\gamma P}{\rho}}\right]$

$\Rightarrow L_2 = \frac{4L_1}{3}\sqrt{\frac{\rho_1}{\rho_2}} = \frac{4L}{3}\sqrt{\frac{\rho_1}{\rho_2}}$

9. (b) For string, $\frac{\text{Mass}}{\text{Length}} = m = \frac{10^{-2}}{0.4} = 2.5\times 10^{-2} kg/m$

$\therefore$ Velocity $v = \sqrt{\frac{T}{m}} = \sqrt{\frac{16}{2.5\times 10^{-2}}} = 8 m/s$

For constructive interference between successive pulses.

$\Delta t_{\min} = \frac{2l}{v} = \frac{2(0.4)}{8} = 0.1 \sec$

(After two reflections, the wave pulse is in same phase as it was produced since in one reflection it's phase changes by π, and If at this moment next identical pulse is produced, then constructive interference will be obtained.

10. (d) Frequency of vibration in tight string

$n = \frac{p}{2l}\sqrt{\frac{T}{m}} \Rightarrow n \propto \sqrt{T} \Rightarrow \frac{\Delta n}{n} = \frac{\Delta T}{2T} = \frac{1}{2}\times(4\%) = 2\%$

$\Rightarrow$ Number of beats $=$ $\Delta n = \frac{2}{100}\times n = \frac{2}{100}\times 100 = 2$

11. (b) When the source approaches the observer

Apparent frequency $n' = \frac{v}{v - v_s}.n = n\left[\frac{1}{1 - \frac{v_s}{v}}\right]$

$= n\left[1 - \frac{v_s}{v}\right]^{-1} = n\left[1 + \frac{v_s}{v}\right]$

(Neglecting higher powers because $v_S << v$)

When the source recedes the observed apparent frequency $n'' = n\left[1 - \frac{v_s}{v}\right]$

Given $n' - n'' = \frac{2}{100}n$, $v = 300\ m/\sec$

$\therefore \frac{2}{100}n = n\left[1 + \frac{v_s}{v}\right] - n\left[1 - \frac{v_s}{v}\right] = n\left[2\frac{v_s}{v}\right]$

$\Rightarrow \frac{2}{100} = 2\frac{v_s}{v} \Rightarrow v_s = \frac{v}{100} = \frac{300}{100} = 3\ m/\sec.$

12. (a,b,c) Number of waves striking the surface per second (or the frequency of the waves reaching surface of the moving target) $n' = \frac{(c+v)}{\lambda} = \frac{\nu(c+v)}{c}$

Now these waves are reflected by the moving target

(Which now act as a source). Therefore apparent frequency of reflected second $n'' = \left(\frac{c}{c-v}\right)n' = \nu\left(\frac{c+v}{c-v}\right)$

The wavelength of reflected wave $= \frac{c}{n''} = \frac{c(c-v)}{\nu(c+v)}$

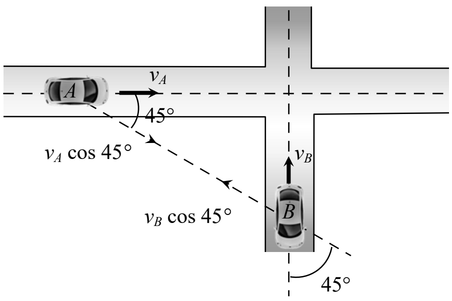
The number of beats heard by stationary listener $= n'' - \nu = \nu\left(\frac{c+v}{c-v}\right) - \nu = \frac{2v\nu}{(c-v)}$

Hence option (a) (b) and (c) are correct.

13. (b) Here $v_A = 72 km/hr = 20 m/\sec$

$v_B = 36 km/hr = 10 m/\sec$

$n' = n\left(\frac{v + v_B\cos 45^o}{v - v_A \cos 45^o}\right)$



$\Rightarrow n' = 280\left(\frac{340 + 10/\sqrt{2}}{340 - 20/\sqrt{2}}\right) = 298\ Hz$

14. (b) For observer note of B will not change due to zero relative motion.

Observed frequency of sound produced by A

$= 660\frac{(330-30)}{330} = 600\ Hz$

$\therefore$ No. of beats = 600 – 596 = 4

15. (a) $\lambda = \frac{v}{n} = \frac{340}{170} = 2m,\ n' = \frac{340}{340-17} \times 170 \Rightarrow n' = 178.9 Hz$

Now $\lambda' = \frac{v}{n'} = \frac{340}{178.9} = 1.9$

$\Rightarrow \lambda - \lambda' = 2 - 1.9 = 0.1$

16. (b) n_1 = Frequency of the police car horn observer heard by motorcyclist

n_2 = Frequency of the siren heard by motorcyclist.

v_2 = Speed of motor cyclist

$n_1 = \frac{330 - v}{330 - 22} \times 176$; $n_2 = \frac{330 + v}{330} \times 165$

$\because\ n_1 - n_2 = 0 \Rightarrow v = 22\ m/s.$

17. (a) $n' = \frac{v + v_0}{v}.n = \frac{v + \frac{v}{5}}{v}.f = \frac{6}{5}f = 1.2f$ and since the source is stationary, so wave length remains unchanged for observer.

18. (d) Time of fall = $\sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 10}{1000}} = \frac{1}{\sqrt{50}}$

In this time number of oscillations are eight.

So time for 1 oscillation = $\frac{1}{8\sqrt{50}}$

Frequency = $8\sqrt{50}\ Hz$ = 56 Hz

19. (a) Density of mixture $= \rho_{\text{mix}} = \frac{V_{O_2}\rho_{O_2} + V_{H_2}\rho_{H_2}}{V_{O_2} + V_{H_2}}$

$= \frac{V(\rho_{O_2} + \rho_{H_2})}{2V} = \frac{\rho_{O_2} + \rho_{H_2}}{2}$ (since $V_{O_2} = V_{H_2} = V$)

$= \frac{\rho_{H_2} + 16\rho_{H_2}}{2} = 8.5\rho_{H_2} \Rightarrow v \propto \frac{1}{\sqrt{\rho}}$

$\Rightarrow \frac{V_{\text{mix}}}{V_{H_2}} = \sqrt{\frac{\rho_{H_2}}{\rho_{\text{mxn}}}} = \sqrt{\frac{\rho_{H_2}}{8.5\rho_{H_2}}} \approx \sqrt{\frac{1}{8}}$

20. (c) $y_1 = 10\sin\left(3\pi t + \frac{\pi}{3}\right)$ ...(i)

and $y_2 = 5[\sin 3\pi t + \sqrt{3}\cos 3\pi t]$

$= 5 \times 2\left[\frac{1}{2} \times \sin 3\pi t + \frac{\sqrt{3}}{2} \times \cos 3\pi t\right]$

$= 10\left[\cos\frac{\pi}{3}\sin 3\pi t + \sin\frac{\pi}{3}\cos \pi t\right]$

$= 10\left[\sin\left(3\pi t + \frac{\pi}{t}\right)\right]$ ... (ii)

($\because$ sin(A + B) = sin$A$ cos$B$ + cos$A$ sin$B$)

Comparing equation (i) and (ii) we get ratio of amplitude 1 : 1.

21. (a) The given equation can be x written as

$$y = \frac{A}{2}\cos\left(4\pi nt - \frac{4\pi x}{\lambda}\right) + \frac{A}{2}$$

$$\left(\because \cos^2\theta = \frac{1+\cos 2\theta}{2}\right)$$

Hence amplitude $= \frac{A}{2}$ and frequency $= \frac{\omega}{2\pi} = \frac{4\pi n}{2\pi} = 2n$

and wave length $= \frac{2\pi}{k} = \frac{2\pi}{4\pi/\lambda} = \frac{\lambda}{2}$.

22. (a,b,c,d) In case of sound wave, y can represent pressure and displacement, while in case of an electromagnetic wave it represents electric and magnetic fields.

(In general y is any general physical quantity which is made to oscillate at one place and these oscillations are propagated to other places also).

23. (b) In case of interference of two waves resultant intensity

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

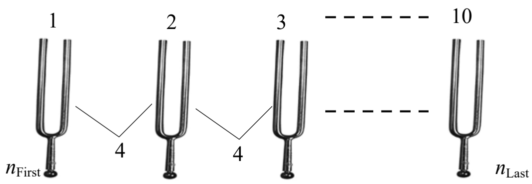
If ϕ varies randomly with time, so $(\cos\phi)_{av} = 0$

$\Rightarrow I = I_1 + I_2$

For n identical waves, $I = I_0 + I_0 + ... = nI_0$

here $I = 10I_0$.

24. (d)



Using $n_{Last} = n_{First} + (N-1)x$

where N = Number of tuning fork in series

x = beat frequency between two successive forks

$\Rightarrow 2n = n + (10-1)\times 4 \Rightarrow n = 36\ Hz$

$\therefore n_{First} = 36\ Hz$ and $n_{Last} = 2\times n_{First} = 72\ Hz$

25. (a) Similar to previous question

$n_{First} = n_{First} + (N-1)x$

$2n = n + (41-1)\times 5$

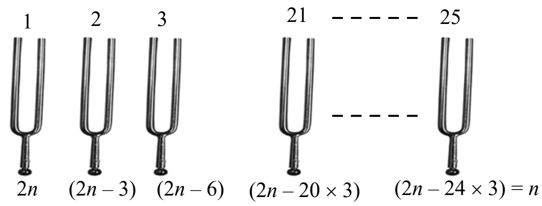
$\Rightarrow n_{First} = 200\ Hz$ and $n_{Last} = 400\ Hz$

26. (a) $n \propto \sqrt{T} \Rightarrow \frac{\Delta n}{n} = \frac{1}{2}\frac{\Delta T}{T}$

Beat frequency $= \Delta n = \left(\frac{1}{2}\frac{\Delta T}{T}\right)n = \frac{1}{2}\times\frac{2}{100}\times 400 = 4$

27. (c) According to the question frequencies of first and last tuning forks are $2n$ and n respectively.

Hence frequency in given arrangement are as follows



$\Rightarrow 2n - 24\times 3 = n \Rightarrow n = 72\ Hz$

So, frequency of 21^{st} tuning fork

$n_{21} = (2\times 72 - 20\times 3) = 84\ Hz$

28. (a) Using $n_{Last} = n_{First} + (N-1)x$

$\Rightarrow 2n = n + (16-1)\times 8 \Rightarrow n = 120\ Hz$

29. (b) Using $n = \frac{1}{2l}\sqrt{\frac{T}{m}}$;

As $T_1 > T_2 \Rightarrow n_1 > n_2$ giving $n_1 - n_2 = 6$

The beat frequency of 6 will remain fixed when

(i) n_1 remains same but n_2 is increased to a new value $(n_2' - n_2 = 12)$ by increasing tension T_2.

(ii) n_2 remains same but n_1 is decreased to a new value $(n_1 - n_1' = 12)$ by decreasing tension T_1.

30. (a) According to problem

$$\frac{1}{2L}\sqrt{\frac{T}{m}} = \frac{v}{4L} \quad .....(i)$$

and $$\frac{1}{2L}\sqrt{\frac{T+8}{m}} = \frac{3v}{4L} \quad .....(ii)$$

Dividing equation (i) and (ii), $\sqrt{\frac{T}{T+8}} = \frac{1}{3} \Rightarrow T = 1N$

31. (b) In condition of resonance, frequency of a.c. will be equal to natural frequency of wire

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}} = \frac{1}{2\times 1}\sqrt{\frac{10\times 9.8}{9.8\times 10^{-3}}} = \frac{100}{2} = 50\ Hz$$

32. (b) For wire if

M = mass, ρ = density, A = Area of cross section

V = volume, l = length, Δl = change in length

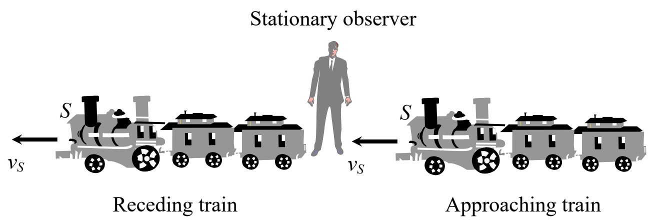
Then mass per unit length $m = \frac{M}{l} = \frac{Al\rho}{l} = A\rho$

And Young's modules of elasticity $y = \frac{T/A}{\Delta l/l}$

$\Rightarrow T = \frac{Y\Delta lA}{l}$. Hence lowest frequency of vibration $n = \frac{1}{2l}\sqrt{\frac{T}{m}} = \frac{1}{2l}\sqrt{\frac{y\left(\frac{\Delta l}{l}\right)A}{A\rho}} = \frac{1}{2l}\sqrt{\frac{y\Delta l}{l\rho}}$

$\Rightarrow n = \frac{1}{2\times 1}\sqrt{\frac{9\times 10^{10}\times 4.9\times 10^{-4}}{1\times 9\times 10^{3}}} = 35\,Hz$

33. (a)



Frequency of sound heard by the man from approaching train

$n_a = n\left(\frac{v}{v - v_s}\right) = 240\left(\frac{320}{320-4}\right) = 243\,Hz$

Frequency of sound heard by the man from receding train

$n_r = n\left(\frac{v}{v + v_s}\right) = 240\left(\frac{320}{320+4}\right) = 237\,Hz$

Hence, number of beats heard by man per sec

$= n_a - n_r = 243 - 237 = 6$

Short trick : Number of beats heard per sec

$= \frac{2nvv_S}{v^2 - v_S^2} = \frac{2nvv_S}{(v - v_S)(v + v_S)} = \frac{2\times 240\times 320\times 4}{(320-4)(320+4)} = 6$

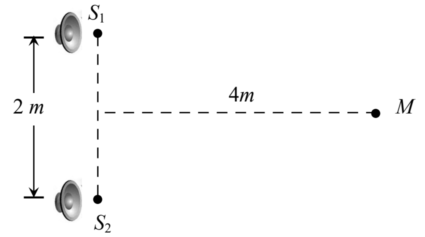
34. (c) Open pipe resonance frequency $f_1 = \frac{2v}{2L}$

Closed pipe resonance frequency $f_2 = \frac{nv}{4L}$

$f_2 = \frac{n}{4}f_1$ (where n is odd and $f_2 > f_1$) $\therefore n = 5$

35. (b) Initially $S_1M = S_2M$

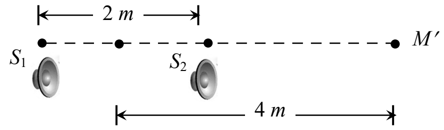
$\Rightarrow$ Path Difference $(\Delta x) = S_1M - S_2M = 0$.



Finally when the box is rotated

Path Difference $= S_1M' - S_2M' \Rightarrow$

$\Delta x = 5 - 3 = 2m$



For maxima

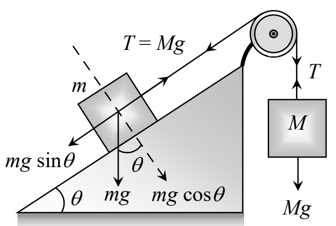
Path Difference = (Even multiple)$\frac{\lambda}{2} \Rightarrow$

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

For 5 maximum responses

$\Rightarrow 2 = 2(5)\frac{\lambda}{2}\ \left\{\because \Delta x = (2n)\frac{\lambda}{2}\right\} \Rightarrow \lambda = \frac{2}{5} = 0.4m$.

36. (a) $v = \sqrt{\frac{T}{\mu}}$



For equilibrium $Mg = mg\sin 30 = T$

$\Rightarrow M = \frac{m}{2} \Rightarrow 100 = \sqrt{\frac{Mg}{9.8\times 10^{-3}}} = \sqrt{\frac{M(9.8)}{9.8\times 10^{-3}}}$

$\Rightarrow 100 = \sqrt{M(1000)} \Rightarrow M = 10kg$ and $m = 20kg$

37. (d) For not hearing the echo the time interval between the beats of drum must be equal to time of echo.

$\Rightarrow t_1 = \frac{2d}{v} = \frac{60}{40} = \frac{3}{2}$ ......(i)

and $t_2 = \frac{2(d-90)}{v} = \frac{60}{60} = 1$

$\Rightarrow 2d - 180 = v$ ......(ii)

Form (i), we get $2d = \frac{3}{2}v$. Substituting in (ii), we get

$\Rightarrow \frac{3}{2}v - 180 = v \Rightarrow 180 = \frac{v}{2} \Rightarrow v = 360 ms^{-1}$

$\Rightarrow \frac{2(d)}{360} = \frac{3}{2} \Rightarrow d = 270m$.

38. (b) Path difference between the wave reaching at D

$\Delta x = L_2P - L_1P = \sqrt{40^2 + 9^2} - 40 = 41 - 40 = 1m$

For maximum $\Delta x = (2n)\frac{\lambda}{2}$

For first maximum (n = 1) $\Rightarrow 1 = 2(1)\frac{\lambda}{2} \Rightarrow$

$\lambda = 1m$

$\Rightarrow n = \frac{v}{\lambda} = 330 Hz$.

39. (a) In a wave equation, x and t must be related in the form $(x - vt)$.

We rewrite the given equations $y = \frac{1}{1 + (x - vt)^2}$

For $t = 0$, this becomes $y = \frac{1}{(1 + x^2)}$, as given

For $t = 2$, this becomes

$y = \frac{1}{[1 + (x - 2v)^2]} = \frac{1}{[1 + (x - 1)^2]}$

$\Rightarrow 2v = 1$ or $v = 0.5 m/s$.

40. (c) $dB = 10\log_{10}\left(\frac{I}{I_0}\right)$; where $I_0 = 10^{-12} Wm^{-2}$

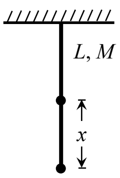
Since $40 = 10\log_{10}\left(\frac{I_1}{I_0}\right) \Rightarrow \frac{I_1}{I_0} = 10^4$ ....(i)

Also $20 = 10\log_{10}\left(\frac{I_2}{I_0}\right) \Rightarrow \frac{I_2}{I_0} = 10^2$ ....(ii)

$\Rightarrow \frac{I_2}{I_1} = 10^{-2} = \frac{r_1^2}{r_2^2} \Rightarrow r_2^2 = 100 r_1^2 \Rightarrow r_2 = 10m$

$\{\because r_1 = 1m\}$

41. (b) Velocity $v = \sqrt{\frac{T}{m}}$; where T = weight of part of rope hanging below the point under consideration $= \left(\frac{M}{L}\right)xg$



$\Rightarrow v = \sqrt{\frac{\left(\frac{M}{L}\right)xg}{\left(\frac{M}{L}\right)}} = \sqrt{xg}$.

42. (b) When the piston is moved through a distance of 8.75cm, the path difference produced is $2 \times 8.75\, cm = 17.5\, cm$. This must be equal to $\frac{\lambda}{2}$ for maximum to change to minimum. $\therefore$

$\frac{\lambda}{2} = 17.5\ cm \Rightarrow \lambda = 35 cm = 0.35 m$

So, $v = n\lambda \Rightarrow n = \frac{v}{\lambda} = \frac{350}{0.35} = 1000 Hz$

43. (c) Frequency of vib. is stretched string $n = \frac{1}{2(\text{Length})}\sqrt{\frac{T}{m}}$

When the stone is completely immersed in water, length changes but frequency doesn't ($\because$ unison reestablished)

Hence length $\propto \sqrt{T} \Rightarrow \frac{L}{l} = \sqrt{\frac{T_{air}}{T_{water}}} = \sqrt{\frac{V\rho g}{V(\rho - 1)g}}$

(Density of stone = ρ and density of water =1)

$\Rightarrow \frac{L}{l} = \sqrt{\frac{\rho}{\rho - 1}} \Rightarrow \rho = \frac{L^2}{L^2 - l^2}$

44. (a,c) $y = \cos kx \sin \omega t$ and $y = \cos(kx + \omega t)$ represent wave motion, because they satisfies the wave equation $\frac{\partial^2}{\partial t^2} = v^2 \frac{\partial^2 y}{\partial x^2}$.

45. (c) The wave 1 and 3 reach out of phase. Hence resultant phase difference between them is π.

$\therefore$ Resultant amplitude of 1 and 3 = $10 - 7 =$ 3 μm

This wave has phase difference of $\frac{\pi}{2}$ with 4 μm

$\therefore$ Resultant amplitude = $\sqrt{3^2 + 4^2} = 5\ \mu m$

46. (b) Let n – 1 (= 400), n (= 401) and n + 1 (= 402) be the frequencies of the three waves. If a be the amplitude of each then

$y = a\sin 2\pi(n-1)t$, $y = a\sin 2\pi nt$ and

$y_3 = a\sin 2\pi(n+1)t$

Resultant displacement due to all three waves is $y = y_1 + y_2 + y_3$

$= a\sin 2\pi nt + a[\sin 2\pi(n-1)t + \sin 2\pi(n+1)t]$

$= a\sin 2\pi nt + a[2\sin 2\pi nt \cos 2\pi t]$

$\left[\text{Using} \sin C + \sin D = 2\sin\frac{C+C}{2}\cos\frac{C-D}{2}\right]$

$\Rightarrow y = a(1+\cos 2\pi t)\sin 2\pi nt$

This is the resultant wave having amplitude $= (1+\cos 2\pi t)$

For maximum amplitude cos $2\pi t = 1 \Rightarrow 2\pi t = 2m\pi$ where $m = 0, 1, 2, 3, ...$

$\Rightarrow t = 0, 1, 2, 3 ...$

Hence time interval between two successive maximum is 1 *sec*. So beat frequency = 1

Also for minimum amplitude (2cos $2\pi t$) = 0

$\Rightarrow \cos 2\pi t = -\frac{1}{2}$

$\Rightarrow 2\pi t = 2m\pi + \frac{2\pi}{3} \Rightarrow t = +\frac{1}{3}$

$\Rightarrow t = \frac{1}{3}, \frac{4}{3}, \frac{7}{3}, \frac{10}{3}, ...$ (for $m = 0, 1, 2, ..$)

Hence time interval between two successive minima is 1 *sec* so, number of beats per second = 1

Note : PET/PMT Aspirants can remember result only.

47. (d) Because the tuning fork is in resonance with air column in the pipe closed at one end, the frequency is $n = \frac{(2N-1)v}{4l}$ where $N = 1, 2, 3$ .... corresponds to different mode of vibration

putting $n = 340 Hz$, $v = 340\ m/s$, the length of air column in the pipe can be

$l = \frac{(2N-1)340}{4 \times 340} = \frac{(2N-1)}{4} m = \frac{(2N-1)\times 100}{4} cm$

For $N = 1, 2, 3, ...$ we get $l = 25\ cm$, $75\ cm$, $125\ cm$ ...

As the tube is only 120 *cm* long, length of air column after water is poured in it may be 25 *cm* or 75 *cm* only, 125 *cm* is not possible, the corresponding length of water column in the tube will be (120 – 25) *cm* = 95 *cm* or (120 – 75) *cm* = 45 *cm*.

Thus minimum length of water column is 45 *cm*.

48. (c) Critical hearing frequency for a person is 20,000*Hz*.

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 $= (2N-1)\times 1500 \Rightarrow N = 7.1 \approx 7$

Also, in closed pipe

Number of over tones = (No. of mode of vibration) –1

$= 7 - 1 = 6.$

49. (c) Frequency of vibration of string is given by

$n = \frac{p}{2l}\sqrt{\frac{T}{m}} \Rightarrow p\sqrt{T} = \text{constant} \Rightarrow \frac{p_1}{p_2} = \sqrt{\frac{T_2}{T_1}}$

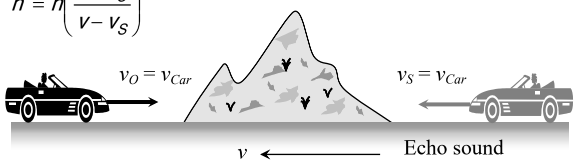
Hence $\frac{4}{6} = \sqrt{\frac{T_2}{(50+15)gm\text{-}force}} \Rightarrow T_2 = 28.8\ gm\text{-}f$

Hence weight removed from the pan

$= T_1 - T_2 = 65 - 28.8 = 3.62$ *gm-force* = 0.036 *kg-f*.

50. (c) Frequency of reflected sound heard by driver

$n' = n\left(\frac{v+v_O}{v-v_S}\right)$



It is given that $n' = 2n$

Hence, $2n = n\left(\frac{v+v_{car}}{v-v_{car}}\right) \Rightarrow v_{car} = v/3.$

51. (c) Suppose d = distance of epicenter of Earth quake from point of observation

v_S = Speed of *S*-wave and v_P = Speed of *P*-wave then $d = v_P t_P = v_S t_S$ or $8\ t_P = 4.5\ t_S$

$\Rightarrow t_P = \frac{45}{8} t_S$, given that $t_S - t_P = 240$

$\Rightarrow t_S - \frac{4.5}{8} t_S = 240 \Rightarrow t_S = \frac{240 \times 8}{3.5} = 548.5\ s$

$\therefore d = v_S t_S = 4.5 \times 548.5 = 2468.6 \approx 2500\ km$