TOPIC : SOUND WAVE
EXERCISE # 1

SECTION (A)

1. Frequency depends on source not on medium.

2. $n = \frac{V}{\lambda} = \frac{.21}{15 \times 10^{-3}} = \frac{210}{15}$

$V_{max} = A\,\omega = 5 \times 10^{-3} \times \frac{210}{15} \times 2\pi = 70 \times 2 \times \frac{22}{7} \times 10^{-3} = .44$ m/sec.

3. $f_1 \lambda_1 = f_2 \lambda_2$
$(300)(1) = (f_2)(1.5)$
$200\text{ Hz} = f_2$

4. $\lambda = 2d = 2\text{m}$
$v = \frac{v}{\lambda} = \frac{360\text{ ms}^{-1}}{2\text{m}} = 180\text{ Hz}$
Reason: As it can be understood from the figure, distance between successive compressions and rarefactions is one half of the wavelength.

5. time to reach sound wave = $\frac{500}{340}$
time to reach bullet = $\frac{500}{(340-20)} = \frac{500}{320}$
$\Delta t = 500\left[\frac{1}{320} - \frac{1}{340}\right] = 500 \times \frac{20}{320 \times 340} = 0.09$ sec

6. $x_{FBP} - x_{FAP} = 12$ $\quad\lambda = 36 - 12 = 24$
$\lambda = 24$ cm $\quad n = \frac{330 \times 100}{24} = 1375$ Hz

7. There is no relative motion between source and observer so frequency remain constant $n = \frac{V}{\lambda_0}$
when wind start blowing in the direction of wave motion then velocity of sound $= V + u_w$
so apparent wave length $\lambda_1 = \frac{V + u_w}{n} = \frac{V + u_w}{V}\lambda_0$

8. During claping multiple wave are produced with different wave parameters so wave is resultant of all these wave

9. $\omega = 400\pi = 2\pi f$

10. $\because \frac{2\pi}{\lambda} = K$
$x = \frac{2\pi}{k} = \frac{\frac{2\pi}{\pi}}{0.85} = 2 \times .85 = 1.70$ m

12. $y = 0.0015 \sin(316 + 62.8x)$
$\because = K\ \frac{2\pi}{\lambda}$
$\lambda = \frac{2\pi}{\lambda} = \frac{2\pi}{62.8} = \frac{3.14 \times 2}{62.8} = \frac{6.28}{628} = \frac{1}{10} = 0.1 = 0.1$ unit

13. When a wave enters from one medium to another, its frequency remains unchanged, i.e. $n_1 = n_2$ but wavelength, intensity and velocity get changed.

14. The standard wave equation is

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

The given wave equation is

$y = a\sin\left(100t - \frac{x}{10}\right)$

Compare it with the standard wave equation we obtain

$\omega = 100,\ k = \frac{1}{10}$

Velocity of the wave,

$v = \frac{\omega}{k} = \frac{100}{\frac{1}{10}} = 100 \times 10 = 1000$ m/s

15. Frequency n = 5.4 per minute = $\frac{5.4}{60}$ Hz

Velocity $v = n\lambda = \frac{5.4}{60} \times 10 = 0.9$ m/s

16. V = 360 M/S

$\lambda \times \frac{360}{50} = \frac{360}{50} = \frac{36}{5}$ cm. $\Rightarrow$ $\frac{2\pi}{\lambda}.\Delta x = \Delta\phi$

$\frac{2\pi}{36} \times \Delta x = \frac{\pi}{3}$ $\Rightarrow$ $\Delta x = \frac{1}{3} \times \frac{36}{10} = 1.2$ cm

17. The frequency is a characteristic of source. It is independent of the medium. Hence, the correct option is (2).

18. In a longitudinal wave, the particles of the medium oscillate about their mean or equilibrium position along the direction of propagation of the wave itself. Sound waves are longitudinal in nature. In transverse wave, the particles of the medium oscillate about their mean or equilibrium position at right angles to the direction of propagation of wave itself. Light waves being electromagnetic are transverse waves.

19. **Key Idea :** Phase difference = $\frac{2\pi}{\lambda}$ × path difference

Path difference between two points

$\Delta x = 15 - 10 = 5$ m

Time period, T = 0.05 s $\Rightarrow$ frequency $\nu = \frac{1}{T} = \frac{1}{0.05} = 20$ Hz

Velocity, v = 300 m/s

$\therefore$ Wavelength, $\lambda = \frac{v}{n} = \frac{300}{20} = 15$ m

Hence, phase difference

$\Delta\phi = \frac{2\pi}{\lambda} \times \Delta x = \frac{2\pi}{15} \times 5 = \frac{2\pi}{3}$

SECTION (B)

2. $\frac{V_1}{V_2} = \sqrt{\frac{\gamma_1}{\gamma_2} \times \frac{M_2}{M_1}} = \sqrt{\frac{5}{3} \times \frac{3}{4} \times \frac{1.8}{2.02}} = 1.0553$

3. The speed of sound in air is $v = \sqrt{\frac{\gamma RT}{M}}$

$\frac{\gamma}{M}$ of H_2 is gratest in the given gesses, hence speed of sound in H_2 shall be maximum.

5. Both tranel same distance

So

$4.5 \times t = 8 \times (t - 4 \times 60)$

$\frac{8}{4.5} = \frac{t}{4t - 240}$

$\frac{8}{3.5} = \frac{t}{240}$

$t = 240 \times \frac{80}{315}$ sec

distance = $4.5 \times 240 \times \frac{80}{35}$ km = $\frac{45 \times 24 \times 80}{35}$ = 2468.57 km = 2500 km

6. On increasing the temperature of sound by 1°C, its velocity increases by 0.6 m/s.

7. Speed of sound $\upsilon = \sqrt{\left\{\frac{\gamma RT}{M}\right\}} \propto \sqrt{T}$ $\therefore$ $\frac{\upsilon_2}{\upsilon_1} = \sqrt{\frac{T_2}{T_1}}$

Given $\frac{\nu_2}{\nu_1} = 3$ $\therefore$ $3 = \sqrt{\frac{T_2}{T_1}}$ or $\frac{T_2}{T_1} = 9$

$\Rightarrow$ $T_2 = 9T_1$

Here : T_1 = 0°C = 273 K

$\therefore$ T_2 = 9 × 273 K = 2457 K = (2457 – 273)°C = 2184°C

8. Frequency of tuning fork decreases with temperature.

9. Speed of sound in an ideal gas is given by

$V = \sqrt{\frac{\gamma RT}{M}} \Rightarrow V \propto \sqrt{\frac{\gamma}{M}}$ [T is same for both the gasses]

$\frac{V_{N_2}}{V_{He}} = \sqrt{\frac{\gamma_{N_2}}{\gamma_{He}} \times \frac{M_{He}}{M_{N_2}}} = \sqrt{\frac{(7/5)}{(5/3)}\left(\frac{4}{28}\right)} = \sqrt{3}/5$

$\gamma_{N_2} = 7/5$ (Diatomic)

$\gamma_{He} = 5/3$ (Monoatomic)

10. Speed of sound in a gas is given by :

$v = \sqrt{\frac{\gamma RT}{M}} \Rightarrow v \,\mu\, \frac{1}{\sqrt{M}}$ $\therefore$ $\frac{v_1}{v_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{m_2}{m_1}}$

Here $\gamma = \frac{C_p}{C_v} = \frac{5}{3}$ for both the gases $\left(\gamma_{monoatomic} = \frac{5}{3}\right)$.

11. $V_{O_2} = \sqrt{\frac{\gamma RT}{M}} = \sqrt{\frac{7}{5}\frac{RT}{32}} = 460$

$V_{He} = \sqrt{\frac{\gamma RT}{M}} = \sqrt{\frac{\frac{5}{3}RT}{4}} = \sqrt{\frac{5}{12} 460 \times 460 \times 32 \times \frac{5}{7}} = 1419$ m/s

[BONUS] Correct ans. is 1419 m/s

13. $v = \sqrt{\frac{B}{\rho}} \Rightarrow 1050 = \sqrt{\frac{B}{1000}}$ $B \approx 10^9$ N/m^2

SECTION (C)

1. $\beta = 10 \log \frac{I}{I_o}$, $60 = 10 \log \frac{I}{I_o}$

$\beta = 10\log\frac{8I}{I_o} = 10\log 8 + 10\log\frac{I}{I_o} = 30\log 2 + 60 \quad = 69$ dB.

2. In the interference the energy is redistributed and the distribution remains constant in time

3. path difference = $\pi r - 2r$

$\Delta S = r(\pi - 2) \qquad n\lambda = \Delta S$

for constructive interference

$n\lambda = r(\pi - 2) \qquad \lambda = \frac{r(\pi-2)}{n} \qquad n = \frac{V}{\lambda} = \frac{Vn}{r(\pi-2)}$

5. We know that intensity $I \propto a^2$, where a is amplitude of the wave. The maximum amplitude is the sum of two amplitudes i.e. (a + a = 2a)

Hence, maximum intensity $\propto 4a^2$

Therefore the required ratio i.e. retio of maximum intensity (loudness) and intensity (loudness) of one wave is given by n,

$n = \frac{4a^2}{a^2} = 4$

6. Let intensity of sound be I and I' Loudness of sound initially

$\beta_1 = 10\log\left(\frac{I}{I_0}\right)$

Later $\quad \beta_2 = 10\log\left(\frac{I'}{I_0}\right)$

Given $\quad \beta_2 - \beta_1 = 20 \quad \therefore \quad 20 = 10\log\left(\frac{I'}{I}\right) \quad \therefore \quad I' = 100\,I$

8. Decible is unit of intensity of sound.

9. The average power per unit area that is incident perpendicular to the direction of propagation is called the intensity.

Intensity of sound

$I = \frac{P}{4\pi r^2} \quad$ or $\quad I \propto \frac{1}{r^2} \quad$ or $\quad \frac{I_1}{I_2} = \left(\frac{r_2}{r_1}\right)^2$

Here, $r_1 = 2$m, $r_2 = 3$m

Substituting the values, we have

or $\quad \frac{I_1}{I_2} = \left(\frac{3}{2}\right)^2 = \frac{9}{4}$

Note : As amplitude $A \propto \sqrt{\ell}$, a spherical harmonic wave emanating from a point source can therefore, be written as

$y(r, t) = \frac{A}{r}\sin(kr - \omega t)$

10. Resultant intensity of two periodic waves is given by

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

where δ is the phase difference between the waves.

For maximum intensity, $\delta = 2n\pi$, n = 0, 1, 2, ...etc.

Therefore, for zero order maxima, $\cos\delta = 1$

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

For minimum intensity, $\delta = (2n - 1)\pi$,

n = 1, 2,......etc

Therefore, for Ist order minima, $\cos\delta = -1$

$I_{min} = I_1 + I_2 - 2\sqrt{I_1 I_2} = (\sqrt{I_1} - \sqrt{I_2})^2$

Therefore,

$$I_{max} + I_{min} = (\sqrt{I_1}+\sqrt{I_2})^2 + (\sqrt{I_1}-\sqrt{I_2})^2 = 2(I_1+I_2)$$

11. $\beta_1 = 10 \log \frac{I_1}{I_0}$ $\beta_2 = 10 \log \frac{I_2}{I_0}$

$\beta_1 - \beta_2 = 10 \log \frac{I_1}{I_2} = 20$

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

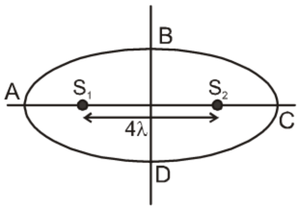
12. $\beta = 10 \log \frac{I}{I_o} = 3.0103 = 10 \log \frac{I}{10^{-9} \times 10^4 \times 10} \Rightarrow I = 2 \times 10^{-4}$ w/m^2

13. $B_o = 10 \log \frac{I}{I_o}$ $B_1 = 10 \log \frac{4I}{I_o} = 10 \log 4 + 10 \log \frac{I}{I_o}$
$= 20 \log 2 + B_o = B_o + 6$
Hence when intensity is increased four times, level becomes (B_0 + 6) decibels

14. $\frac{P}{4\pi r^2} = I$ for an isotropic point sound source.
$\Rightarrow$ $P = I.4\pi r^2$
$=$ $(0.008 \text{ w/m}^2)(4.\pi.10^2) = 10.048$
$\cong$ 10 watt. **Ans.**

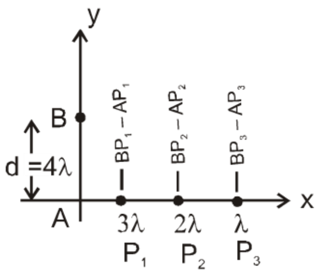
15*. Energy per unit area associated with progressive sound wave $I = 2\pi^2 a^2 n^2 sV$ if we increase amplitude to $\sqrt{2}$ times or frequency to $\sqrt{2}$ times I will be doubled.
So % increement 41% of either amplitude or frequency **Ans – C , D**

16.



AT B Path difference is O and AI A path difference is 4λ . From nλ formula there are 3 maxima position between A & B . So total maxima in ellipse = 16
Note → if there were circle, rectangle, square instead of ellipse, answer is same.

17.



n = 3

SECTION (D)

1. When a sound wave gets reflected from a rigid boundary, the particles at the boundary are unable to vibrate. Thus, a reflected wave is generated which interferes with the oncoming wave to produce zero displacement at the rigid boundary. At these points (zero displacement), the pressure variation is maximum. Thus, a reflected pressure wave has the same phase as the incident wave.

2. v = dist × time

$2d = \text{dist} = \frac{v}{1}$

$d = \frac{v}{2} = \frac{332}{2} = 166$ M.

ANS . 4

3. f = 660 Hz, v = 330 m/s

w = 2πf = 1320 π radus

particles amplitude will be maximum

M– $d = \frac{\pi}{4} = \frac{330}{660} \times \frac{1}{4} = \frac{1}{8}$ = 0.125 m

SECTION (E)

1. $n_1; n_2; n_3 = 1 : 2 : 3$

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

2. In an open pipe the ends are points of displacement antinodes and hence pressure node. The midpoint (for fundamental mode) is a point of displacement node and hence pressure antinode. (variation of presure is maximum at pressure antinode and zero at pressure - node).

3. Closed Open

$\frac{V}{4\ell_1} = \frac{V}{\ell_2}$

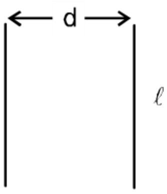
$\ell_2 = 4\ell_1$

$\ell_1 = \frac{\ell_2}{4} = \frac{50}{4}$ = 12.5 cm

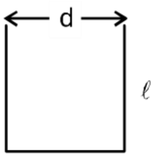
4. Now the tube becomes a closed pipe with length $\ell/2$.

Fundamental freqeuncy = $\frac{v_{sound}}{4(\ell/2)} = \frac{v_{sound}}{2\ell}$ which is the fundamental frequency of the original open pipe.

5. $\frac{\lambda_1}{2} = \ell + .6d, \qquad \upsilon_1 = \frac{V}{\lambda_1}$



$\frac{\lambda_2}{4} = \ell + .3d, \qquad \upsilon_2 = \frac{V}{\lambda_2}$



$\frac{\upsilon_2}{\upsilon_1} = \frac{2(\ell + .6d)}{4\ (\ell + .3d)} = \frac{(\ell + .6d)}{2(\ell + .3d)}$

6. For first closed organ pipe $n_1 = \frac{v}{4\ell_1} = \frac{v}{4 \times 0.75}$

For second closed organ pipe $n_2 = \frac{v}{4\ell_2} = \frac{v}{4 \times 0.77}$ But $n_1 - n_2 = 3$

$\frac{v}{4 \times 0.75} - \frac{v}{4 \times 0.77} = 3 \quad \Rightarrow \quad \frac{v}{3} - \frac{v}{3.08} = 3$

$v\left(\frac{3.08-3}{3\times3.08}\right)$ **= 3** $\Rightarrow$ $v = \frac{3\times3\times3.08}{0.08}$ = 346.5 m/sec

7. In resonant vibrations of a body, the frequency of external force applied on the body is equal to its natural frequency. If on increasing and decreasing the frequency by a factor, the amplitude of vibrations reduces very much. In this case sharp resonance will take place. But if it reduces by a small factor then flat resonance will take place.

8. $\lambda = 50\ \lambda/4 \Rightarrow \lambda = 200$ cm.

next vesonatiy lenth = $3\times\frac{\lambda}{4} = 3\times\frac{200}{4}$ = 150 cm

9. l = 33 cm , f_0 = 1000 HZ,
v = 330 m/s

$\lambda = v\ \frac{v}{330} = \frac{v}{f} = \frac{330\,m/s}{1000\,Hz} = \frac{33}{100}m$ = 33 cm

This is open organ pipe so fundamental mode = l = $\frac{\lambda}{2} = \frac{33}{2}$ at 33 there will be first overtone (2) us correct

10. In organ pipes waves produced are longitudinal and stationary.

11. For a closed pipe, fundamental frequency,

$n = \frac{V}{4\ell}$ = 512 Hz

For an open pipe, fundamental frequency

$n' = \frac{V}{2\ell} = 2\times\left(\frac{V}{4\ell}\right)$ = 2 × 512 Hz = 1024 Hz

12. Let the tubes A and B have equal length called as l. Since, tube A is opened at both the ends, therefore, its fundamental frequency

$n_A = \frac{v}{2\ell}$

Since, tube B is closed at one end, therefore, its fundamental frequency

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

From eqs. (1) and (2), we get

$\frac{n_A}{n_B} = \frac{v/2\ell}{v/4\ell} = \frac{4}{2}$ = 2 : 1

13. for open pipe first overtone freqency = $\frac{v}{2\ell_1}\times 2$

for closed pipe 1st overtone frequency = $\frac{v}{4\ell_2}\times 3$

the two frequences are equal. $\Rightarrow$ $\frac{\ell_2}{\ell_1} = \frac{3}{4}$

14. Let Δe be the end correction. Given that,
Frequency of fundamental tone for a length 0.1 m = Frequency of first overtone for the length 0.35 m.

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

Solving this equation we get

Δe = 0.025 m = 2.5 cm

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

or $3\left(\frac{v_c}{4L}\right) = 2\left(\frac{v_0}{2L_0}\right)$ $\therefore$ $\ell_0 = \frac{4}{3}\left(\frac{v_0}{v_c}\right)L = \frac{4}{3}\sqrt{\frac{\rho_1}{\rho_2}}L$ as $v \propto \frac{1}{\sqrt{\rho}}$.

16. $f_1 = \frac{2v}{2L} = \frac{v}{L}$ $\Rightarrow$ $f_2 = \frac{nv}{4L}$ $\Rightarrow$ As given $\frac{nv}{4L} > \frac{v}{L}$
$n > 4$ $\therefore$ $n = 5$

17. Second overtone of open pipe = $\frac{3V}{2\ell_1}$
second overtone of closed pipe = $\frac{5V}{4\ell_2}$
Since, these frequency are same
$\therefore$ $\frac{3V}{2\ell_1} = \frac{5V}{4\ell_2}$ $\Rightarrow$ $\frac{\ell_1}{\ell_2} = \frac{4\times3}{2\times5} = \frac{6}{5}$

Now, the ratio of fundamental frequencies : $\frac{f_1}{f_2} = \frac{\frac{V}{2\ell_1}}{\frac{V}{4\ell_2}} \Rightarrow \frac{2\ell_2}{\ell_1}$
= 10 : 6 = 5 : 3 **Ans.**

18. $\frac{\lambda}{4} = \ell_1 + e$ ......(1)
$\frac{3\lambda}{4} = \ell_2 + e$ ....(2)
from (1) and (2) e = 2 cm

19. During summer speed of sound increases. So wavelength increases.
so x > 3 × 18 so x > 54

20. $f_{fun.} = \begin{cases} \frac{v}{2\ell} & \text{for open pipe} \\ \frac{v}{4\ell} & \text{for closed pipe} \end{cases}$

$f \propto \sqrt{T}$, but f does not depend on pressure.
for closed pipe $f_{1st\ overtone} = 3f_{fundamental}$.

21. For pipe A, second resonant frequency is third harmonic thus $f = \frac{3V}{4L_A}$
For pipe B, second resonant frequency is second harmonic thus $f = \frac{2V}{2L_B}$
Equating $\frac{3V}{4L_A} = \frac{2V}{2L_B}$ $\Rightarrow$ $L_B = \frac{4}{3} L_A = \frac{4}{3}.(1.5) =$ **2m.**

SECTION (F)

1. $f_A - f_B = 4$, $f_B - f_A = 4$,
A is loaded with vap f_A. Now beats are also decreased
$f_A - f_B = 4$ is acceptable
$256 - 4$ fB = 252H2

2. f_1 f_2 f_3 .... f_{151}, f_{16}
a, aed , a × 2d . a + 15d

$2a = (a+15d)$
$a = 15d \quad \because d = 8$
$a = 15 \times 8 = 120Hz$

3. $f_A = \frac{103}{100} f_0$

$f_B = \frac{97}{100} f_0$

$f_A - f_B = 6$

$\frac{(103-97)}{100} \times f_0 = 6$

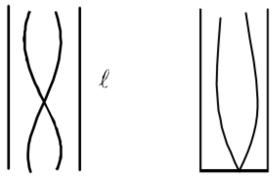
$\frac{6}{100} f_0 = 6$

$f_0 = 100Hz$

4. Beats
Frequency of timing for 512 Hz Frequency of sonomete wire either 512 + 6 or 512 – 6
As tersion increas Frequency of sonometre wire increase $n \propto \sqrt{T}$
No. of beat reduces. so that Frequency of sonometa wire is = 512 – 6 = 506 Hz

5. 256 – n = 262 – 2n
n = 6
∴ Unknown Frequency is 256 – 6 = 250 Hz.
(4) 256 + n = 262 – 2n
3n = 6
n = 2
∴ Unknown frequency is 256 + 2 = 258 Hz
Unknown Frequency can not be greater than 262 Hz. became no. of beat heard with 262 Hz is more then the no. of beats heard with 256 Hz.

6. 256 + n = 262 – 2n
3n = 6
n = 2



$\eta_1 = \frac{V}{2\ell}$ $\qquad \eta_2 = \frac{V}{4\ell}$

no. of beat heard $n_1 - n_2 = \frac{V}{4\ell} = 4$

if length pipes are doubled. no of beats heard $n_1^1 - n_2^1 = \frac{V}{8\ell} = \frac{4}{2} = 2$

7. Avoiding end correction, the length of closed organ pipe is

$\ell_2 = \frac{\lambda_1}{4}$ or $\lambda_1 = 4\ell_1$

The length of open organ pipe is

$\ell_2 = \frac{\lambda_2}{2}$ or $\lambda_2 = 2\ell_2$

Here $n_1 = n_2$

$\Rightarrow \frac{v}{\lambda_1} = \frac{v}{\lambda_2}$ or $\frac{v}{4\ell_1} = \frac{v}{4\ell_2}$

Therefore, $\ell_1 : \ell_2 = 1 : 2$

9. To get beat frequency 1, 2, 3, 5, 7, 8, it is possible when other three tuning fork have frequencies 551, 553, 558, etc.

10. $f_1 - 514 = 2$ or , $514 - f_1 = 2$
$f_1 - 510 = 6$, $510 + f_1 = 6$
if eq (1) is correct , eq (3) gives satisfied reaset is . f1 = 510 + 6 = 516
and eq (4) does not given satis factory resnet.
Support equ (2) is true so $f_1 = 512$, there fore eq (3) and (4) does not satisfy $f_1 = 512$
Hence frequence of for k = 516 Hz

11. $f_1 - f_2 = 12 = v1\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)$
$v = 12 \times \frac{\lambda_1 \lambda_2}{\lambda_2 - \lambda_1} = 12 \times \frac{50 \times 51}{f} \times 10^{-2} = 306$ m/s

12. $300 \times \frac{v_0 \times 0.61 \times t_1}{4\ell}$ ⇒ $4l \times 300 = v_0 + 0.61 \times t1$
$4l = 4\ell \times \frac{v_0 \times 0.61 \times t_1}{300}$ ⇒ $f_2 = \frac{v_0 \times 0.61 \times t_2}{v_0 + 0.61 \times t_1} \times 300$
$f_1 = f_2 = \frac{(v_0 \times 0.61 \times t_2 - v_0 - 0.61 \times t_1)\, 300}{v_0 + 0.61\ t_1}$ ⇒ beats = $\frac{0.61 \times 4 \times 300}{v_0 + 0.61 \times 27} = \frac{.61 \times 4 \times 3}{332 + (.61 \times 27)}$
= 2.10061
So, MO of beats Heard = 2

13. Maximum difference in frequencies to hear beats = 15 Hz

14. f_1, f_2 ...., f_{25}, f_{26}
f_0 , f × 4 , f + 8 ,........... f +100
3 × f = f + 100
2f = 100 f = 50

15. Comparing given equation with standard equations y = A sin ωt
We get $A_1 = 4$, $\omega_1 = 500\pi$ and $A_2 = 2$, $\omega_2 = 506\pi$
Frequency $n = \frac{\omega}{2\pi}$ ∴ $n_1 = \frac{\omega_1}{2\pi} = \frac{500\pi}{2\pi} = 250$
$n_2 = \frac{\omega_2}{2\pi} = \frac{506\pi}{2\pi} = 253$ ∴ number of beats = $n_2 - n_1 = 253 - 250 = 3$
$$\frac{I_{max}}{I_{min}} = \frac{(A_1 + A_2)^2}{(A_1 - A_2)^2} = \frac{(4+2)^2}{(4-2)^2} = \left(\frac{6}{2}\right)^2 = \frac{9}{1}$$

16. The tuning fork of frequency 288 Hz is producing 4 beats /sec with the unknown tuning fork i.e., the frequency difference between them is 4. Therefore, the frequency of unknown tuning fork
= 288 ± 4 = 292 or 284
On placing a little wax on unknown tuning fork, its frequency decreases but now the number of beats produced per second is 2 i.e. the frequency difference now decreases. It is possible only when before placing the wax, the frequency of unknown fork is greater than the frequency of given tuning fork. Hence, the frequency of unknown tuning fork = 292 Hz

17. Frequency of string is 256 ± 5.
Since number of beats is decreasing when frequency of string is increasing so frequency of string is 256 – 5.

18. **Key Idea:** To reach the solution the given wave equations must be compared with standard equation of progressive wave.
So, $y_1 = 4 \sin 500\,\pi t$. ...(i)
$y_2 = 2 \sin 506\,\pi t$. ...(ii)
Comparing Eqs. (i) and (ii) with
y = a sin ωt ...(iii)
We have,

$\omega_1 = 500\pi$

$\Rightarrow \quad f_1 = \frac{500\pi}{2\pi} = 250$ beats/s

and $\quad \omega_2 = 506\pi$

$\Rightarrow \quad f_2 = \frac{506\pi}{2\pi} = 253$ beats/s

Thus, number of beats produced = $f_2 - f_1 = 253 - 250$
= 3 beats/s = 3 × 60 beats/min = 180 beats/min

19. Let $\lambda_1 = 5.0$ m, v = 330 m/s and $\lambda_2 = 5.5$ m
The relation between frequency, wavelength and velocity is given by

$v = n\lambda$

$\Rightarrow \quad n = \frac{v}{\lambda}$ ...(i)

The frequency corresponding to wavelength λ_1,

$n_1 = \frac{v}{\lambda_1} = \frac{330}{5.0} = 66\text{Hz}$

The frequency corresponding to wavelength λ_2,

$n_2 = \frac{v}{\lambda_2} = \frac{330}{5.5} = 60\text{Hz}$

Hence, no. of beats per second
$= n_1 - n_2 = 66 - 60 = 6$

20. The frequency of fork 2 is = 200 ± 4 = 196 or 204 Hz
Since, on attaching the tape on the prong of fork 2, its frequency decreases, but now the number of beats per second is 6 i.e., the frequency difference now increases. It is possible only when before attaching the tape, the frequency of fork 2 is less than the frequency of tuning fork 1. Hence, the frequency of fork 2 = 196 Hz.

21. frequency of two source $n_1 = 50$ $n_2 = 51$
so beat frequency = 1/sec.

Now intensity ratio of maximum & minimum value = $\frac{I_{max}}{I_{min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2} = \left(\frac{16}{8}\right)^2 = \frac{4}{1}$

SECTION (G)

1. Doppler effect in Frequency deepends upone relative velocity between source and observer

2. $n_1 = \left(\frac{V+v_s}{V}\right)n_r$, $\quad n_r = \left(\frac{V}{V-V_s}\right)n$

$n_1 = \left(\frac{V+V_s}{V-V_s}\right)n = \frac{350+50}{350-50} \times 1.2 = \frac{400}{300} \times 1.2 = 1.6$ KHz

3. $n_1 = \left(\frac{V+V_s}{V-V_s}\right)n \qquad \frac{9}{8}n = \left(\frac{V+V_s}{V-V_s}\right)n \qquad \frac{9}{8} = \frac{V+V_s}{V-V_s}$

$9V - 9V_s = 8V + 8V_s \qquad V = 17 V_s \qquad V_s = \frac{340}{17} = 20$ m/s

5. $f_1 = \frac{v}{v-vs}f_0$, $\quad f_2 = \frac{v}{v+vs}.f_0$

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

$\frac{f_2-f_2}{f_0} = \frac{2}{100} = \frac{2v.vs}{v^2-vs^2} \Rightarrow \quad vs = \frac{v}{100} = \frac{350}{100}$ 3.5 ml.

Sime speed of sound v >> vs.

6. $f_1 = \frac{vf_0}{v - vs}$, $\Rightarrow$ $f_2 = \frac{v.f_0}{v + vs}$

$f_1\ f_2 = 3 = \frac{2.v.vs.f_0}{v^2 - vs^2}$ $\Rightarrow$ vs = 1.5

7. Number of beats $\Delta n = n_1 - n_2$

For no beats observed $n_1 - n_2 = 0$

$\therefore$ $\left(\frac{v - v_0}{v}\right) \times 324 - \left(\frac{v + v_0}{v}\right) \times 320 = 0$ where, v_0 = speed of observer and v = 344 m/s

On solving v_0 = 2.1 m/sec

8. The apparent frequency heard by traveller moving towards stationary train

$n' = n\left(\frac{v + v_0}{v + v_s}\right) = n\left(\frac{v + v_0}{v}\right)$ $(\because\ v_s = 0)$

Where v = speed of sound,

v_0 = speed of traveller

9. Apparent frequency heard by stationary observer

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

Here v = 330 m/sec, v_s = 20 m/s,

n = 440 Hz

$\therefore$ $n' = 440\left(\frac{330}{330 - 20}\right) = 468.38$

$\approx$ 468 Hz

10. From the relation,

$f' = f_0\left[\frac{v_{sound} - v_{observer}}{v_{sound} - v_{source}}\right]$

$v_{observer} = 0$, because observer is stationary

$\Rightarrow$ $f' = f_0\left[\frac{v}{v - \frac{v}{10}}\right] = f_0\left[\frac{1}{\frac{9}{10}}\right]$ $\Rightarrow \frac{f'}{f_0} = \frac{10}{9}$

11. From the relation,

$f = f_0\left[\frac{v + v_0}{v - v_s}\right]$ where v is the velocity of sound in air or vacuum.

$400 = f_0\left[\frac{340 + 50}{340 - 50}\right]$

$f_0 = \frac{400 \times 290}{390} = 300$ cycles/s

12. Given : $v_0 = \frac{v}{5}$ $\Rightarrow v_0 = \frac{320}{5} = 64$ m/s

When obsserver moves towards the stationary source, then

$n' = \left(\frac{v + v_0}{v}\right)n$ $\Rightarrow$ $n' = \left(\frac{320 + 64}{320}\right)n$ $\Rightarrow$ $\frac{n'}{n} = \frac{384}{320}$

Hence, percentage increase

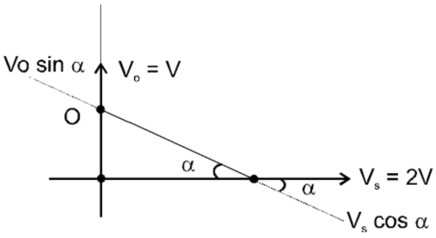
$\left(\frac{n' - n}{n}\right) = \left(\frac{384 - 320}{320} \times 100\right)\% = \left(\frac{64}{320} \times 100\right)\% = 20\%$

13. $f_{app} = \frac{V}{V - V_t}.f$ $\Rightarrow$ $\frac{5}{3} = \frac{V + V_t}{V - V_t}$ $\Rightarrow$ $5V - 5V_t = 3V + 3V_t$

$f_{ree} = \frac{V}{V + V_t} f$ $2V = 8V_t$

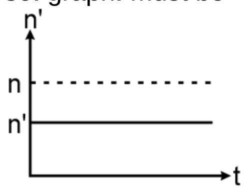
$V_t = \frac{V}{4} = \frac{332}{4}$ = 83 m/sec.

14.



$n_1 = \left(\frac{V - V_o \sin\alpha}{V - V_s \cos\alpha}\right) n$ tan α = $\frac{1}{2}$ const and n_1 remains const and $n_1 < n$.

so. graph. must be



15. Let original frequency is f
by the concept of Doppler effect
frequency of reflected wave

$f = \frac{V + u}{V - u} f = \frac{332 + 12}{332 - 12} \times f$, $f_1 - f = 6$,

$\frac{344}{320} f - f = 6$ $\Rightarrow$ $f = \frac{320 \times 6}{24}$ = 80 Hz

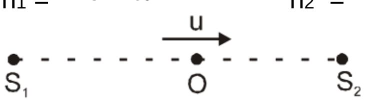
16. frequency of sound for approaching observes $f_a > \frac{V + u}{V} f$

For receding observer $f_r = \frac{V + u}{V} f$

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

17. frequency heard by listener

$n_1 = \frac{V - u}{V} \frac{V}{\lambda}$ $n_2 = \frac{V + u}{V} \frac{V}{\lambda}$



beat frequency = $n_2 - n_1 = \frac{2u}{\lambda}$

19. $\frac{v.f_0}{v - vs}$

$\frac{f_1}{f_2} = \frac{\frac{v.f0}{v - vs}}{\frac{v.f0}{v + vs}} = \frac{5}{3} = \frac{v + vs}{v - vs} \Rightarrow \frac{5 - 3}{5 + 3} = \frac{2vs}{2v}$

$v \times \frac{2}{8} = vs = \frac{v}{4} = \frac{340}{4} = 85$ m/s

20. f = 240Hz , v = 330 m/s vs = 11m/s

$f = \frac{v}{v - vs} \times f_0 = \frac{330}{330 - 11} \times 240 = 248\text{Hz}$

21. $f_1 = \frac{v}{v-4} \times 240$

$f_2 = \frac{v}{v+4} \times 240$

$f_1\ f_2 = 240 \times v\left[\frac{1}{v-4} - \frac{1}{v+4}\right] = 6$ (but v = 320m/s)

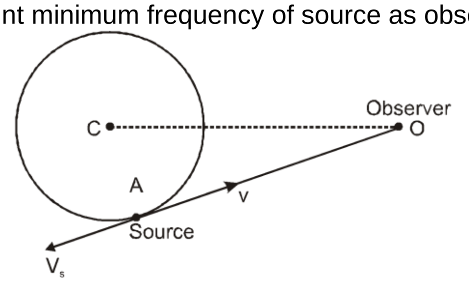
22. Velocity of source (whistle) is given by

$v_s = r\omega$

$= (0.5\text{m})\ (20\ \text{rad/s})$

$= 10$ m/s

The frequency of sound observed by the observer will be minimum when whistle is at point A. Thus, at this point minimum frequency of source as observed by observer is



$n_{min} = \left(\frac{v}{v + v_s}\right)n$

$n_{min} = \frac{340}{340 + 10} \times 385 = \frac{34}{35} \times 385 = 34 \times 11 = 374$ Hz

23. When an observer moves towards an stationary source of sound, then apparent frequency heard by the observer increases. The apparent frequency heard in this situation

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

as source is stationary hence, $v_s = 0$

$\therefore \quad f' = \left(\frac{v + v_0}{v}\right) f$

Given $v_0 = \frac{v}{5}$

Substituting in the relation for f', we have

$f' = \left(\frac{v + v/5}{v}\right) f = \frac{6}{5} f = 1.2\ f$

Motion of observer does not affect the wavelength reaching the observer, hence, wavelength remains λ

24. $f_0 = 300\text{Hz}$, $\lambda = 1\text{m}$

$v = f_0 \times \lambda = 300$ m/s.

$f = \frac{v}{v + vs}.f_0 = \frac{300}{300 + 30} \times 300 = \frac{300}{330} \times 300 = \frac{10 \times 300}{11} = 273$ Hz

25. When source and observer move towards each other, the apparent frequency,

$n' = \frac{v}{v - v_s}\, n$

Here $\upsilon_s = 20$ m/s, $\upsilon = 340$ m/s

$n = 240$ Hz

$\therefore \quad n' = \frac{340}{340 - 20} \times 240$ Hz

$= 270$ Hz.

26. $f_1 = f\left(\frac{V}{V - V_s}\right) \Rightarrow f_1 = f\left(\frac{340}{340 - 34}\right) = f\left(\frac{340}{306}\right)$

and $f_2 = f\left(\frac{V}{V - V_s}\right) = \left(\frac{340}{340 - 17}\right) = \frac{340}{323} f$

$\frac{f_1}{f_2} = \frac{323}{306} = \frac{19}{18}$

27. Using the formula

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

we get $5.5 = 5\left(\frac{v + v_A}{v}\right)$ ....(1)

and $6.0 = 5\left(\frac{v + v_B}{v}\right)$ ....(2)

here v = speed of sound

v_A = speed of train A

and v_B = speed of train B

solving eqn. (1) and (2) we get :

$$\frac{v_B}{v_A} = 2$$

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

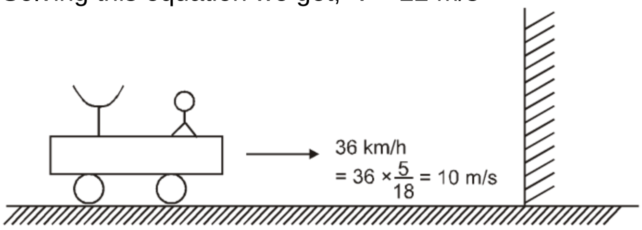
f_1 = Frequency recorded by motorcyclist from police car.

f_2 = Frequency recorded by motorcyclist from stationary siren.

For no beats $\Rightarrow f_1 = f_2$ $\quad \therefore 176\left(\frac{330 - v}{330 - 22}\right) = 165\left(\frac{330 + v}{330}\right)$

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

29.



$f_{inisident} = f_{reflected} = \frac{320}{320 - 10} \times 8$ kHz

$f_{observed} = \frac{320 + 10}{320} f_{reflected}$

$= 8 \times \frac{330}{310} = 8.51$ kHz ≈ 8.5 kHz

30. When the sound is reflected from the cliff, it approaches the driver of the car. Therefore, the driver acrts as an observer and both the source (car) and observer are moving.
Hence, apparent frequency heard by the observer (driver) is given by

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

where v = velocity of sound,
v_0 = velocity of car = v_s

Thus, Eq. (i) becomes

$\therefore \quad 2f = f\left(\frac{v+v_0}{v-v_0}\right)$ or $2v - 2v_0 = v + v_0$ or $3v_0 = v$ or $v_0 = \frac{v}{3}$

31. Given ; $\upsilon_0 = \frac{\upsilon}{5} \Rightarrow \upsilon_0 \Rightarrow \upsilon_0 d = \frac{320}{5}$ = 64 m/s
When observer moves towards the stationary source, then

$$n' = \left(\frac{\upsilon+\upsilon_0}{\upsilon}\right)n$$

$$n' = \left(\frac{320+64}{320}\right)n$$

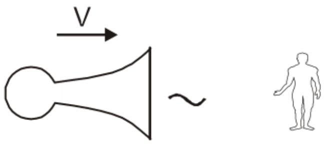
$$n' = \left(\frac{384}{320}\right)n$$

$$\frac{n'}{n} = \frac{384}{320}$$

Hence, percentage increase.

$$\left(\frac{n'-n}{n}\right) = \left(\frac{384-320}{320}\times100\right)\% = \left(\frac{64}{320}\times100\right)\% = 20\%$$

32. $f' = f\,\frac{C}{C-V}$



$10000 = 9500 \times \frac{300}{300-V}$
$300 - V = 3 \times 95$
$V = 15$ m/s **Ans**

EXERCISE # 2

1. Fundamental frequency of close organ pipe = $\frac{V_1}{4\ell_1}$

Second harmonic frequency of string = $\frac{2V_2}{2\ell_2}$

So, $\frac{V_1}{4\ell_1} = \frac{V_2}{\ell_2} = \frac{320}{4\times0.8}\ \frac{1}{0.5} = \sqrt{\frac{50}{\mu}}$

$2500 = \frac{50}{\mu} \quad \Rightarrow \quad \mu = \frac{1}{50} = \frac{m}{0.5}$
m = 10 gm.

2. $\frac{V}{4(\ell + e)} = f$

$\Rightarrow \ell + e = \frac{V}{4f}$

$\Rightarrow \ell = \frac{V}{4f} - e$

here e = (0.6)r = (0.6) (2) = 1.2 cm

so $\ell = \frac{336 \times 10^2}{4 \times 512} - 1.2 = 15.2$ cm

3. Time taken by plate to moves a distance

$10 \times 10^{-2} = \frac{1}{2} gt^2 = \frac{1}{2} 9.8t^2 \Rightarrow t = \frac{1}{7}$ sec.

In t time 8 waves

so time period = $\frac{1}{7 \times 8}$ second.

frequency = 56 Hz.

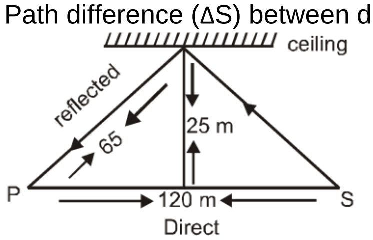
4. First maxima after O will appear when path difference ΔS = λ

so AP – BP = λ

$\sqrt{2.4^2 + 1^2} - 2.4 = \lambda \qquad \lambda = 0.2$

sound velocity = n λ = 1800 × 0.2 = 360 m/s

5. Path difference (ΔS) between direct and reflected wave = 130 – 120 = 10 m

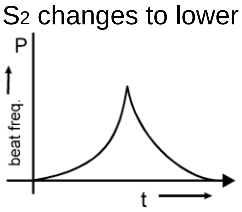


for so constructive interference ΔS = nλ

$\lambda = \frac{\Delta S}{n} = \frac{10}{n}$ (n = 1, 2, 3, ...)

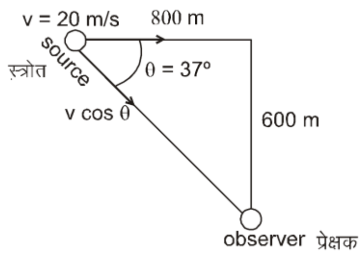
$\lambda = 10, \frac{10}{2}, \frac{10}{3}, \frac{10}{4}$ .....

6. Due to Doppler effect apparent frequency of S_1 will continuously decreases. But apparent frequency of S_2 changes to lower value when it crosses o so best represented graph is



7. $f_1 = f_0 \frac{v_{sound}}{v_{sound} + v_{train}} = \frac{1}{1.2} f_0 \Rightarrow 1.2\, v_{sound} = v_{sound} + v \Rightarrow v = \frac{v_{sound}}{5}$

$f_2 = f_0, \frac{v_{sound} - v_{man}}{v_{sound}} = 0.8 \Rightarrow \frac{f_0}{f_2} = 1.25$



8. $f = f_0 \dfrac{v_{sound}}{v_{sound} - v_{source}} = 600 \cdot \dfrac{330}{330 - v\cos\theta} = 600 \cdot \dfrac{330}{330 - 20\cos 37} = 600 \cdot \left(\dfrac{330}{314}\right) \simeq 630.5$ Hz.

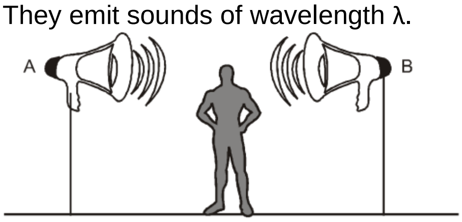
9. $n' = n \cdot \dfrac{v_{sound}}{v_{sound} - v_{train}}$ ⇒ $(n' - n)\, v_{sound} = n' v_{tran}$

$n'' = n \cdot \dfrac{v_{sound}}{v_{sound} + v_{train}}$ ⇒ $(n - n'')\, v_{sound} = n'\, v_{train}$

⇒ $\dfrac{(n'-n)}{n-n''} = \dfrac{n'}{n''}$ ⇒ $n'n'' - nn'' = n'n - n'n''$

⇒ $2n'n'' = (n' + n'')n$ ⇒ $n = \dfrac{2n'-n''}{(n'+n'')}$

10. Let v be the speed of sound and n the original frequency of each source.
They emit sounds of wavelength λ.



When observer moves towards one source (say A), the apparent frequency of A as observed by the observer will be

$n' = n\left(\dfrac{v+u}{v}\right)$

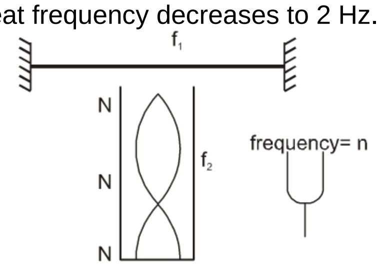
The observes is now receding source B, so the apparent frequency of B observed will be

$n'' = n\left(\dfrac{v-u}{v}\right)$

Thus, number of beats

$x = n' - n'' = n\left[\dfrac{v+u}{v} - \dfrac{v-u}{v}\right] = \dfrac{n}{v}[v + u - v + u] = \dfrac{2nu}{v}$ but $v = n\lambda$ Thus, $x = \dfrac{2nu}{n\lambda} = \dfrac{2u}{\lambda}$

11. As string and tube are in resonance $f_1 = f_2$
$|f_1 - n| = 4$ Hz.
When T increases, f_1 also increases. It is given that beat frequency decreases to 2 Hz.



⇒ $n - f_1 = 4$ ⇒ $n = 4 + f_1$ as $f_1 = f_2$

$n = 4 + f_2$ ⇒ $f_2 = \dfrac{3V}{4\ell} = \dfrac{3 \times 340}{4 \times (3/4)} = 340$

$n = 344$ **Ans. (A)**

EXERCISE # 3

PART - I

1. (a) Given, n = 400 Hz

$v_o = 72\ kmh^{-1} = 72 \times \frac{5}{18} = 20\ ms^{-1}$

$v = 350\ ms^{-1}$

Apparent frequency of a sound heard by policeman when he is moving towards stationary source of sound.

$$n' = \left[\frac{v + v_o}{v}\right] n$$

Now, the apparent frequency when policeman is moving way from stationary source of sound

$$n' = \left[\frac{v - v_o}{v}\right] n$$

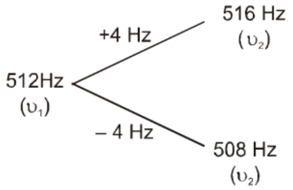
Hence, the change in frequency

$$\Delta n = n' - n'' = n\left[\frac{v + v_o}{v}\right] - n\left[\frac{v - v_o}{v}\right] = \frac{2nv_o}{v} = \frac{2 \times 400 \times 20}{350} = 45.7\ Hz$$

2. Let the frequencies of tuning fork and piano string be υ_1 and υ_2 respectively.

$\therefore\ \upsilon_2 = \upsilon_1 \pm 4 = 512\ Hz \pm 4$

= 516 Hz or 508 Hz



Increase in the tension of a piano string increases its frequecy.

If υ_2 = 516 Hz, further increase in υ_2, resulted in an increase in the beat frequency. But this is not given in the question.

If υ_2 = 508 Hz, further increase in υ_2 resulted in decrease in the beat frequency. This is given in the question. when the beat frequency decreases to 2 beats per second.

Therefore, the frequency of the piano string before increasing the tension was 508 Hz.

3. increases by a factor 10

4. $\frac{1}{2\ell}\sqrt{\frac{F}{\mu}} = f$ (for fundamental mode)

ℓ & μ are constant

Taking ℓn on both side & differentiating

$= \frac{dF}{2F} = \frac{df}{f} \Rightarrow \frac{dF}{F} = \frac{2 \times df}{f} = 2 \times \frac{6}{600} = 0.02.$

5. $2\pi f_1 = 600\pi$

$f_1 = 300$ ....(1)

$2\pi f_2 = 608\pi$

$f_2 = 304$ ....(2)

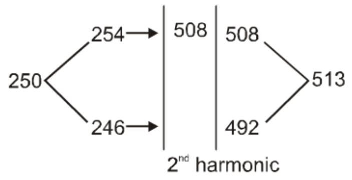
$| f_1 - f_2 | = 4$ beats

$$\frac{I_{max}}{I_{m.n}} = \frac{(A_1 + A_2)^2}{(A_1 + A_2)^2} = \frac{(5 + 4)^2}{(5 - 4)^2} = \frac{81}{1}$$

6. Fequency of the echo detected by the driver of the train is

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

$$f' = \left(\frac{330+220}{330-220}\right)1000 = 5000 \text{ Hz}$$

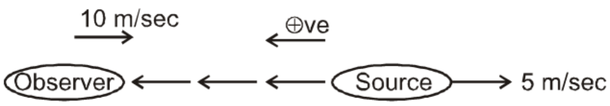
7. 

Ans. 254

8. Pressure change will be minimum at both ends

9. Fundamental freuency of a closed organ pipe is $f_1 = \frac{V}{4\ell} = \frac{340}{4 \times 0.85} = 100$ Hz

The natural freuencies of the organ pipe will be f = 100 Hz, 300 Hz, 500 Hz, 700 Hz, 900 Hz, 1100 Hz which are below 1250 Hz

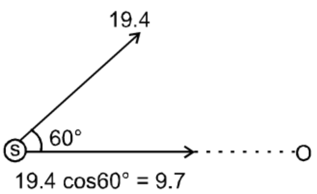
10. 

Appearent frequency heard by the observer is

$$f' = f_0\left(\frac{V - V_0}{V - V_s}\right) \Rightarrow \quad f' = (1392)\left(\frac{343-(-10)}{343-(-5)}\right) = 1412 \text{ Hz}$$

11. 

$$\frac{V}{4(20\text{cm})} = \frac{3V}{2\ell_{open}} \Rightarrow \quad \ell_{open} = 120 \text{ cm}$$

12. 

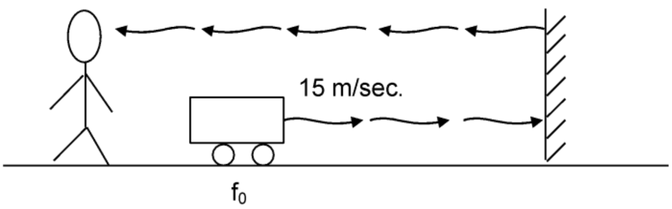
$$t_1 = f_0\left(\frac{v - v}{v - v_s}\right) \Rightarrow \quad f_1 = 100\left(\frac{v - 0}{v - (+9.7)}\right)$$

$$f_1 = 100\,\frac{v}{v\left(1 - \frac{9.7}{v}\right)} \Rightarrow \quad f_1 = 100\left(1 + \frac{9.7}{330}\right) = 103 \text{ Hz}$$

13. No. of mole of gas = 1 so molar mass = 4g/mole

$$V = \sqrt{\frac{\gamma RT}{m}} \Rightarrow 952 \times 952 = \frac{\gamma \times 3.3 \times 273}{4 \times 10^{-3}} \Rightarrow \gamma = 1.6 = \frac{16}{10} = \frac{8}{5}$$

$$\gamma = \frac{C_P}{C_V} = \frac{8}{5} \quad \text{os } C_P = \frac{8 \times 5}{5} = 8\text{jk}^{-1}\text{mole}^{-1}$$

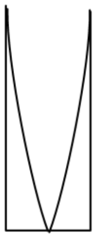
14. 

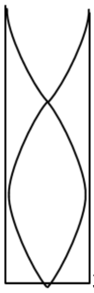
Frequency at the wall will be

$$f' = f_0\left(\frac{v - v_0}{v - v_s}\right) = 800\left(\frac{330 - 0}{330 - 15}\right)$$

$f' = 800\left(\frac{330}{315}\right) = 838$ Hz

Since the observer and the wall are stationary so frequency of echo observed by the observer will also be 838 Hz.

15.  First harmonic at $\frac{\lambda}{4}$

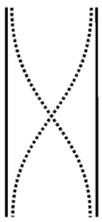
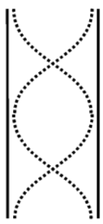
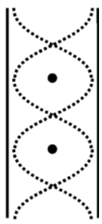


3rd harmonic $\frac{3\lambda}{4}$

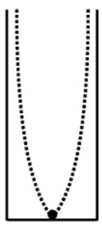
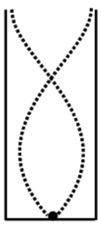
1st length = 50 cm

3rd harmonic length 150 cm

16. Fundamental | Ist overtone | 2nd overtone

$\frac{3\lambda}{2} = \ell_0$ $\Rightarrow$ $\lambda = \frac{3\ell_0}{3}$ $\Rightarrow$ $f = \frac{3V}{2\ell_0}$

$\frac{3\lambda}{4} = L_c$ $\Rightarrow$ $\lambda = \frac{4L_e}{3}$ $\Rightarrow$ $f = \frac{3V}{4L_e} = \frac{3V}{4L} = \frac{3V}{2\ell_0}$

$\ell_0 = 2L$

17. no. of beats = 1

(HCF of beat frequencies)

18. $\frac{(2n+1)V}{4\ell} = 260$ Hz $\Rightarrow$ $\frac{(2n-1)V}{4\ell} = 220$ Hz

differance $= \frac{2V}{4\ell} = 40\text{Hz}$ $\Rightarrow$ Fundamental frequency $= \frac{V}{4\ell} = 20\text{Hz}$

19. 

f = 400 Hz

f' = $\frac{340+16.5}{340-22} \times 400 = 448\text{Hz}$

20. $V = 2f_0 (\ell_2 - \ell_1) = 2 \times 320\ (0.73 - 0.20)$
$V = 2 \times 320\ (0.53) = 339$ m/sec

21. $\frac{v}{2\ell_1} = \frac{3v}{4\ell_2}$ $\Rightarrow$ $\ell_1 = \frac{2h}{3} = \frac{2 \times 20\,\text{cm}}{3}$ = 13.3 cm

22. $V = 2f(\ell_2 - \ell_1)$
$V = 2\times800(31.25 - 9.75)$ cm
$V = 1600(21.25) \times 10^{-2}$
$V = 344$ m/s

PART - II

1. Motor cycle has travelled a distance s. Its velocity at that point
$v = \sqrt{2as}$
The observed frequency
$f' = f\ \frac{330 - v}{330}$
$\Rightarrow$ $0.94 = \frac{330-v}{330}$
$\Rightarrow$ $v = 0.06 \times 330$ m/s
$= 19.8$ m/s
$s = \frac{v^2}{2a} = \frac{19.8^2}{2 \times 2} = 9.9^2 = 98$ m

2. Number of beats proudcd = 1

3. $f_{\text{before crossing}} = f_0\left(\frac{c}{c - v_S}\right) = 1000\left(\frac{320}{320-20}\right)$ $\Rightarrow$ $f_{\text{after crossing}} = f_0\left(\frac{c}{c+v_S}\right) = 1000\left(\frac{320}{320+20}\right)$

$\Delta f = f_0\left(\frac{2cv_s}{c^2 - v_s^2}\right)$ $\Rightarrow$ $\frac{\Delta f}{f} \times 100\% = \frac{2 \times 320 \times 20}{300 \times 340} \times 100 = 12.54\% \approx 12\%$

4. Open organ pipe
$f = \frac{V}{2\ell}$ ...(i)
For closed organ pipe
$f' = \frac{V}{4\left(\frac{\ell}{2}\right)} = \frac{V}{2\ell} = f$ **Ans. (3)**

5. $\nu' = \nu\sqrt{\dfrac{1+\frac{v}{c}}{1-\frac{v}{c}}}$

$\Rightarrow$ $\nu' = \nu\sqrt{\dfrac{1+\frac{1}{2}}{1-\frac{1}{2}}} = \sqrt{3}\nu$

ν' = 10 × 1.73 = 17.3 GHz

6. $f_0 = \dfrac{1}{2\ell}\sqrt{\dfrac{Y}{\rho}} = \dfrac{1}{2(0.6)}\sqrt{\dfrac{9.27\times10^{10}}{2.7\times10^{3}}}$ = 4.9 × 10^3Hz ≃ 5 kHz

7. $f = \dfrac{V}{L} = \dfrac{330}{1/2} = 660$

V_0 = 10 km/h = 25/9 m/s

$f' = f\left(\dfrac{V+V_0}{V}\right) = 660\left(\dfrac{330+25}{330}\right)$ = 665.55 ≈ 666 Hz

8. $f_1 = \left(\dfrac{340}{340-34}\right)f$

$\Rightarrow$ $f_2 = \left(\dfrac{340}{340-17}\right)f$

$\Rightarrow$ $\dfrac{f_1}{f_2} = \left(\dfrac{340-17}{340-34}\right) = \dfrac{19}{18}$

9. $\dfrac{\lambda_1}{4}$ = 11 cm. + e

$\Rightarrow$ $\dfrac{v}{512\times4}$ = 11 cm. + e ...(1)

$\dfrac{\lambda_2}{4}$ = 27 cm. + e

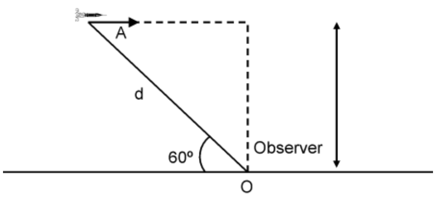
$\Rightarrow$ $\dfrac{v}{256\times4}$ = 27 cm + e ...(2)

equation (2) – (1)

$\dfrac{v}{256\times4}\times\dfrac{1}{2}$ = 0.16

v = 0.16 × 2 × 4 × 256 = 327.68 m/s ≈ 328 m/s.

10.



$\dfrac{d}{V_s} = \dfrac{d\cos60^\circ}{V_a}$

$V_a = \dfrac{V_s}{2} = \dfrac{V}{2}$