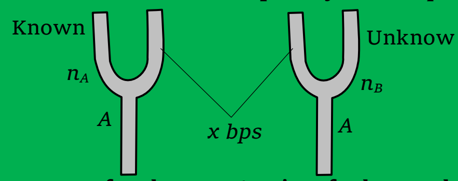
Beats

1. (c) Suppose two tuning forks are named A and B with frequencies $n_A = 256\ Hz$ (known), n_B = ? (unknown), and beat frequency x = 4 *bps*.



Frequency of unknown tuning fork may be

$n_B = 256 + 4 = 260\ Hz$

or $= 256 - 4 = 252\ Hz$

It is given that on sounding waxed fork A (fork of frequency 256 Hz) and fork B, number of beats (beat frequency) increases. It means that with decrease in frequency of A, the difference in new frequency of A and the frequency of B has increased. This is possible only when the frequency of A while decreasing is moving away from the frequency of B.

This is possible only if n_B = 260 Hz.

Alternate method : It is given $n_A = 256\ Hz, n_B = ?$ and x = 4 *bps*

Also after loading A (*i.e.* $n_A \downarrow$), beat frequency (*i.e.* x) increases ($\uparrow$).

Apply these informations in two possibilities to known the frequency of unknown tuning fork.

$n_A \downarrow - n_B = x\uparrow$ ... (i)

$n_B - n_A \downarrow = x\uparrow$ ... (ii)

It is obvious that equation (i) is wrong (ii) is correct so

$n_B = n_A + x = 256 + 4 = 260\ Hz$.

2. (d)

3. (c)

4. (a) Suppose n_A = known frequency = 100 Hz, n_B = ?

x = 2 = Beat frequency, which is decreasing after loading (*i.e.* $x\downarrow$)

Unknown tuning fork is loaded so $n_B\downarrow$

Hence $n_A - n_B\downarrow = x\downarrow$ ... ~~(i)~~ → Wrong

$n_B\downarrow - n_A = x\downarrow$ ... ~~(ii)~~ → Correct

$\Rightarrow n_B = n_A + x = 100 + 2 = 102\ Hz$.

5. (d) n_A = Known frequency = 256, n_B = ?

x = 2 *bps*, which is decreasing after loading (*i.e.* $x\downarrow$) known tuning fork is loaded so $n_A\downarrow$

Hence $n_A\downarrow - n_B = x\downarrow$ ... ~~(i)~~ → Correct

$n_B - n_A\downarrow = x\downarrow$ ... ~~(ii)~~ → Wrong

$\Rightarrow n_B = n_A - x = 256 - 2 = 254\ Hz$.

6. (b) n_A = Known frequency = 256 Hz, n_B = ?

x = 4 *bps*, which is decreasing after loading (*i.e.* $x\downarrow$) also known tuning fork is loaded so $n_A\downarrow$

Hence $n_A\downarrow - n_B = x\downarrow$ ... ~~(i)~~ → Correct

$n_B - n_A\downarrow = x\downarrow$ ... ~~(ii)~~ → Wrong

$\Rightarrow n_B = n_A - x = 256 - 4 = 252\ Hz$.

7. (c) Time interval between two consecutive beats

$$T = \frac{1}{n_1 - n_2} = \frac{1}{260 - 256} = \frac{1}{4}\text{ sec} \quad \text{so,} \quad t = \frac{1}{16} = \frac{T}{4}\text{ sec}$$

By using time difference = $\frac{T}{2\pi} \times$ Phase difference

$\Rightarrow \frac{T}{4} = \frac{T}{2\pi} \times \phi \Rightarrow \phi = \frac{\pi}{2}$

8. (a) The time interval between successive maximum intensities will be $\frac{1}{n_1 \sim n_2} = \frac{1}{454 - 450} = \frac{1}{4}\,\text{sec}$.

9. (d) n_A = Known frequency = 341 Hz, n_B = ?

x = 6 bps, which is decreasing (*i.e.* $x\downarrow$) after loading (from 6 to 1 bps)

Unknown tuning fork is loaded so $n_B\downarrow$

Hence $n_A - n_B\downarrow = x\downarrow$ ... (i) $\longrightarrow$ Wrong

$n_B\downarrow - n_A = x\downarrow$ ... (ii) $\longrightarrow$ Correct

$\Rightarrow n_B = n_A + x = 341 + 6 = 347\ Hz.$

10. (b) $T = \frac{1}{258 - 256} = 0.5\,\text{sec}$

11. (c) Suppose n_A = known frequency = 100 Hz, n_B = ?

x = 5 bps, which remains unchanged after loading

Unknown tuning fork is loaded so $n_B\downarrow$

Hence $n_A - n_B\downarrow = x$ ... (i)

$n_B\downarrow - n_A = x$ ... (ii)

From equation (i), it is clear that as n_B decreases, beat frequency. (*i.e.* $n_A - (n_B)_{\text{new}}$) can never be x again.

From equation (ii), as $n_B\downarrow$, beat frequency (*i.e.* $(n_B)_{\text{new}} - n_A$) decreases as long as $(n_B)_{\text{new}}$ remains greater than n_A, If $(n_B)_{\text{new}}$ become lesser than n_A the beat frequency will increase again and will be x. Hence this is correct.

So, $n_B = n_A + x = 100 + 5 = 105\ Hz.$

12. (b) n_A = Known frequency = 256 Hz, n_B = ?

x = 6 bps, which remains the same after loading.

Unknown tuning fork F_2 is loaded so $n_B\downarrow$

Hence $n_A - n_B\downarrow = x$ ... (i) $\longrightarrow$ Wrong

$n_B\downarrow - n_A = x$ ... (ii) $\longrightarrow$ Correct

$\Rightarrow n_B = n_A + x = 256 + 6 = 262\ Hz.$

13. (a) Probable frequencies of tuning fork be $n+4$ or $n-4$

Frequency of sonometer wire $n \propto \frac{1}{l}$

$\therefore \frac{n+4}{n-4} = \frac{100}{95}$ or $95(n+4) = 100(n-4)$

or $95n + 380 = 100n - 400$ or $5n = 780$ or $n = 156$

14. (c) After filling frequency increases, so n_A decreases ($\downarrow$). Also it is given that beat frequency increases (*i.e.*, $x\uparrow$)

Hence $n_A\downarrow - n_B = x\uparrow$ ... (i) $\longrightarrow$ Correct

$n_B - n_A\uparrow = x\uparrow$ ... (ii) $\longrightarrow$ Wrong

$\Rightarrow n_A = n_B + x = 512 + 5 = 517\ Hz.$

15. (c) Intensity $\propto$ (amplitude)^2

as $A_{\max} = 2a_o$ (a_o= amplitude of one source) so $I_{\max} = 4I_o$.

16. (c) Number of beats per second = $n_1 \sim n_2$

$\omega_1 = 2000\,\pi = 2\pi n_1 \Rightarrow n_1 = 1000$

and $\omega_2 = 2008\,\pi = 2\pi n_2 \Rightarrow n_2 = 1004$

Number of beats heard per sec $= 1004 - 1000 = 4$

17. (c) The tuning fork whose frequency is being tested produces 2 beats with oscillator at 514 *Hz*, therefore, frequency of tuning fork may either be 512 or 516. With oscillator frequency 510 it gives 6 *beats/sec*, therefore frequency of tuning fork may be either 516 or 504.

Therefore, the actual frequency is 516 *Hz* which gives 2 *beats/sec* with 514 *Hz* and 6 *beats/sec* with 510 *Hz*.

18. (b) If suppose n_S = frequency of string $= \frac{1}{2l}\sqrt{\frac{T}{m}}$

n_f = Frequency of tuning fork = 480 *Hz*

x = Beats heard per second = 10

as tension T increases, so n_S increases (↑)

Also it is given that number of beats per sec decreases (*i.e.* $x\downarrow$)

Hence $n_S\uparrow - n_f = x\downarrow$ ... (i) $\longrightarrow$ Wrong

$n_f - n_S\uparrow = x\downarrow$ ... (ii) $\longrightarrow$ Correct

$\Rightarrow n_S = n_f - x = 480 - 10 = 470$ *Hz*.

19. (c) It is given that

n_A = Unknown frequency = ?

n_B = Known frequency = 256 *Hz*

x = 3 *bps*, which remains same after loading

Unknown tuning fork A is loaded so $n_A\downarrow$

Hence $n_A\downarrow - n_B = x$ ... (i) $\longrightarrow$ Correct

$n_B - n_A\downarrow = x$ ... (ii) $\longrightarrow$ Wrong

$\Rightarrow n_A = n_B + x = 256 + 3 = 259$ *Hz*.

20. (a) Frequency of the source = 100 ± 5 = 105 *Hz* or 95 *Hz*.

Second harmonic of the source = 210 *Hz* or 190 *Hz*.

As the second harmonic gives 5 *beats/sec* with sound of frequency 205 *Hz*, the second harmonic should be 210 *Hz*.

$\Rightarrow$ Frequency of the source = 105 *Hz*.

21. (d) For producing beats, their must be small difference in frequency.

22. (c) n_A = Known frequency = 256 *Hz*, n_B = ?

x = 4 *beats per sec* which is decreasing (4 *bps* to $\frac{5}{2}bps$) after loading (*i.e.* $x\downarrow$)

Unknown tuning fork B, is loaded so $n_B\downarrow$

Hence $n_A - n_B\downarrow = x\downarrow$ ... (i) $\longrightarrow$ Wrong

$n_B\downarrow - n_A = x\downarrow$ ... (ii) $\longrightarrow$ Correct

$\Rightarrow n_B = n_A + x = 256 + 4 = 260$ *Hz*.

23. (d) $n_A\downarrow - n_B = x\uparrow$ ... (i) $\longrightarrow$ Wrong

$n_B - n_A\downarrow = x\uparrow$ ... (ii) $\longrightarrow$ Correct

$\Rightarrow n_B = n_A + x = 200 + 5 = 205$ *Hz*.

24. (c) $n_A - n_B\downarrow = x$ (same) ... (i) $\longrightarrow$ Wrong

$n_B\downarrow - n_A = x$ (same) ... (ii) $\longrightarrow$ Correct

$\Rightarrow n_B = n_A + x = 320 + 4 = 324$ *Hz*.

25. (c) Beat period $T = \frac{1}{n_1 \sim n_2} = \frac{1}{384 - 380} = \frac{1}{4}\sec$. Hence minimum time interval between maxima and minima $t = \frac{T}{2} = \frac{1}{8}\sec$.

26. (d) $\frac{I_{\max}}{I_{\min}} = \left(\frac{a_1 + a_2}{a_1 - a_2}\right)^2 = \frac{(5+3)^2}{(5-3)^2} = \frac{16}{1}$

27. (a) $n_1 = \frac{v}{\lambda_1} = \frac{v}{0.50}$ and $n_2 = \frac{v}{\lambda_2} = \frac{v}{0.51}$

$$\Delta n = n_1 - n_2 = v\left[\frac{1}{0.05} - \frac{1}{0.51}\right] = 12$$

$$\Rightarrow v = \frac{12 \times 0.51 \times 0.50}{0.01} = 306 \; m/s$$

28. (c) $n_1 = \frac{316}{2\pi}$ and $n_2 = \frac{310}{2\pi}$ Number of beats heard per second = $n_1 - n_2 = \frac{316}{2\pi} - \frac{310}{2\pi} = \frac{3}{\pi}$

29. (b) Beat frequency = $\frac{2}{0.4} = 5\,Hz$

30. (a) Since source of frequency x gives 8 beats per second with frequency 250 Hz, it's possible frequency are 258 or 242. As source of frequency x gives 12 beats per second with a frequency 270 Hz, it's possible frequencies 282 or 258 Hz. The only possible frequency of x which gives 8 beats with frequency 250 Hz also 12 beats per second with 258 Hz.

31. (c) $n_1 = \frac{1000\,\pi}{2\pi} = 500\,Hz$ and $n_2 = \frac{998\,\pi}{2\pi} = 499 \; Hz$

Hence beat frequency = $n_1 - n_2 = 1$

32. (a) $v_0 = 332 \; m/s$. Velocity sound at $t°C$ is $v_t = (v_0 + 0.61\,t)$

$$\Rightarrow v_{20} = v_0 + 0.61 \times 20 = 344.2 \; m/s$$

$$\Rightarrow \Delta n = v_{20}\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right) = 344.2\left(\frac{100}{50} - \frac{100}{51}\right) = 14$$

33. (a) Persistence of hearing is 10 sec^{-1}.

34. (a)

35. (d) n_A = ?, n_B = 384 Hz

x = 6 bps, which is decreasing (from 6 to 4) *i.e.* $x\downarrow$

Tuning fork A is loaded so $n_A\downarrow$

Hence $n_A\downarrow - n_B = x\downarrow \longrightarrow$ Correct

$n_B - n_A\downarrow = x\downarrow \longrightarrow$ Wrong

$\Rightarrow n_A = n_B + x = 384 + 6 = 390\,Hz$.

36. (b) For hearing beats, difference of frequencies should be approximately 10 Hz.

37. (a) $n \propto \frac{1}{l} \Rightarrow n_1 l_1 = n_2 l_2 \Rightarrow (n+4)49 = (n-4)50 \Rightarrow n = 396$

38. (a) No of beats, $x = \Delta n = \frac{30}{3} = 10\;Hz$

$\Rightarrow$ Also $\Delta n = v\left[\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right] = v\left[\frac{1}{5} - \frac{1}{6}\right] = 10 \Rightarrow v = 300 \; m/s$

39. (a) $\Delta n = v\left[\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right] = 396\left[\frac{1}{0.99} - \frac{1}{1}\right] = 3.96 \approx 4.$

40. (b) n_A = Known frequency = 288 cps, n_B = ?

x = 4 bps, which is decreasing (from 4 to 2) after loading *i.e.* $x\downarrow$

Unknown fork is loaded so $n_B\downarrow$

Hence $n_A - n_B\downarrow = x\downarrow \longrightarrow$ Wrong

$n_B\downarrow - n_A\downarrow = x\downarrow \longrightarrow$ Correct

$\Rightarrow n_B = n_A + x = 288 + 4 = 292\,Hz$.

41. (a) Frequency = $\frac{\text{Number of beats}}{\text{Time}} = \frac{2}{0.04} = 50\ Hz$

42. (c) No. of beats = frequency difference = $\frac{4}{0.25} = 16$

43. (d) Suppose n_P = frequency of piano = ? $(n_P \propto \sqrt{T})$

n_f = Frequency of tuning fork $= 256\, Hz$

x = Beat frequency = 5 *bps*, which is decreasing $(5 \to 2)$ after clanging the tension of piano wire

Also, tension of piano wire is increasing so $n_P \downarrow$

Hence $n_P \uparrow - n_f = x \downarrow \longrightarrow$ Wrong

$n_f - n_P \uparrow = x \downarrow \longrightarrow$ Correct

$\Rightarrow n_P = n_f - x = 256 - 5\ Hz$.

44. (b) With temperature rise frequency of tuning fork decreases. Because, the elastic properties are modified when temperature is changed

also, $n_t = n_0(1 - 0.00011\, t)$

where n_t = frequency at $t°C$, n_0 = frequency at $0°C$

45. (a) $n_x = 300\, Hz,\ \ n_y = ?$

x = beat frequency = 4 Hz, which is decreasing $(4 \to 2)$ after increasing the tension of the string y.

Also tension of wire y increasing so $n_y \uparrow$ $(\because n \propto \sqrt{T})$

Hence $n_x - n_y \uparrow = x \downarrow \longrightarrow$ Correct

$n_y \uparrow - n_x = x \downarrow \longrightarrow$ Wrong

$\Rightarrow n_y = n_x - x = 300 - 4 = 296\, Hz$

46. (c) Let n be the frequency of fork C then

$n_A = n + \frac{3n}{100} = \frac{103\, n}{100}$ and $n_B = n - \frac{2n}{100} = \frac{98}{100}$

but $n_A - n_B = 5 \Rightarrow \frac{5n}{100} = 5 \Rightarrow n = 100\ Hz$

$\therefore\ n_A = \frac{(103)(100)}{100} = 103\ Hz$

47. (a)

48. (b) From the given equations of progressive waves $\omega_1 = 500\pi$ and $\omega_2 = 506\pi$ $\therefore$ $n_1 = 250$ and $n_2 = 253$

So beat frequency $= n_2 - n_1 = 253 - 250 = 3$ *beats per sec* $\therefore$ Number of beats per min = 180.

49. (b)

50. (b) Frequency $= \frac{360}{60} \times 60 = 360\, Hz$.

51. (b) $v = n\lambda \Rightarrow \lambda = \frac{v}{n} = \frac{340}{170} \Rightarrow \lambda = 2$

Distance separating the position of minimum intensity = $\frac{\lambda}{2} = \frac{2}{2} = 1\, m$

Doppler's Effect

1. (d)

2. (b) $n' = n\left(\frac{v}{v - v_O}\right) = 450\left(\frac{340}{340 - 34}\right) = 500\ \ cycles\ /\sec$

3. (a) $n' = n\left(\frac{v}{v - v_s}\right) \Rightarrow \lambda' = \lambda\left(\frac{v - v_S}{v}\right)$

$\Rightarrow \lambda' = 120\left(\frac{330 - 60}{330}\right) = 98\ cm.$

4. (b) $n' = n\left(\frac{v}{v - v_S}\right) = 600\left(\frac{330}{300}\right) = 660\ \ cps$

5. (c) Both listeners, hears the same frequencies.

6. (b)

7. (c) $n' = n\left(\frac{v + v_O}{v}\right) \Rightarrow 2n = n\left(\frac{v + v_0}{v}\right) \Rightarrow \frac{v + v_0}{v} = 2$

$\Rightarrow\ v_O = v = 332\ m/sec$

8. (b) Apparent frequency in this case $n' = \frac{n(v + v_O)}{v}$

$\because\ \frac{v + v_0}{v} > 1 \Rightarrow \frac{n'}{n} > 1\ \ i.e.\ \ n' > n$.

9. (a) Wave number = $\frac{1}{\lambda}$ but $\frac{1}{\lambda'} = \frac{1}{\lambda}\left(\frac{v}{v - v_s}\right)$ and $v_S = \frac{v}{3}$

$\therefore$ (W.N.)' = (W.N.) $\left(\frac{v}{v - v/3}\right) = 256 \times \frac{v}{2v/3}$

$= \frac{3}{2} \times 256 = 384$

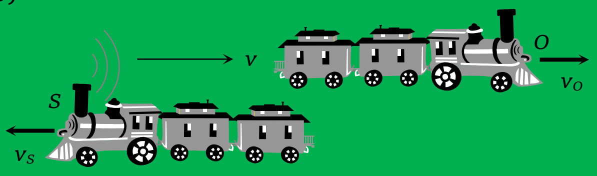
10. (a) By Doppler's formula $n' = \frac{nv}{(v - v_S)}$

Since, source is moving towards the listener so $n' > n$.

If n = 100 then n' = 102.5

$\Rightarrow 102.5 = \frac{100 \times 320}{(320 - v_S)} \Rightarrow v_s = 8\ \ m/\sec$

11. (b)

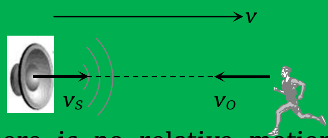


$n' = n\left(\frac{v - v_O}{v + v_S}\right) = 750\left(\frac{330 - 180 \times \frac{5}{18}}{330 + 108 \times \frac{5}{18}}\right) = 625\ \ Hz$

12. (a) By using $n' = n\left(\frac{v}{v - v_S}\right)$

$2n = n\left(\frac{v - v_O}{v - 0}\right) \Rightarrow v_O = -v = -$ (Speed of sound)

Negative sign indicates that observer is moving opposite to the direction of velocity of sound, as shown



13. (d) Since there is no relative motion between observer and source, therefore there is no apparent change in frequency.

14. (c)

15. (b)

16. (a) $n' = n\left(\frac{v}{v - v_S}\right) \Rightarrow \frac{n'}{n} = \frac{v}{v - v_S} \Rightarrow \frac{v}{v - v_S} = 3 \Rightarrow v_s = \frac{2v}{3}$

17. (a) $n' = n\left(\frac{v}{v - v_S}\right) = n\left(\frac{v}{v - v/10}\right) \Rightarrow \frac{n'}{n} = \frac{10}{9}$

18. (c) $n' = n\left(\frac{v}{v - v_S}\right) = 1200 \times \left(\frac{350}{350 - 50}\right) = 1400\ cps$

19. (d) $n' = n\left(\frac{v}{v - v_S}\right) = 1200\left(\frac{400}{400 - 100}\right) = 1600\ Hz$

20. (a) $n' = \frac{v}{v - v_S} \times n = \left(\frac{330}{330 - 110}\right) \times 150 = 225\ Hz$

21. (d) Doppler's effect is applicable for both light and sound waves.

22. (a) When source is approaching the observer, the frequency heard

$$n_a = \left(\frac{v}{v - v_S}\right) \times n = \left(\frac{340}{340 - 20}\right) \times 1000 = 1063\ Hz$$

When source is receding, the frequency heard $n_r = \left(\frac{v}{v + v_S}\right) \times n = \frac{340}{340 + 20} \times 1000 = 944$

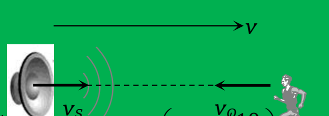
$\Rightarrow n_a : n_r = 9 : 8$

Short tricks : $\frac{n_a}{n_r} = \frac{v + v_S}{v - v_S} = \frac{340 + 20}{340 - 20} = \frac{9}{8}$.

23. (a) By using $\frac{n_{\text{approaching}}}{n_{\text{receding}}} = \frac{v + v_s}{v - v_s}$

$\Rightarrow \frac{1000}{n_r} = \frac{350 + 50}{350 - 50} \Rightarrow n_r = 750\ Hz.$

24. (b) When source and listener both are moving towards each other then, the frequency heard



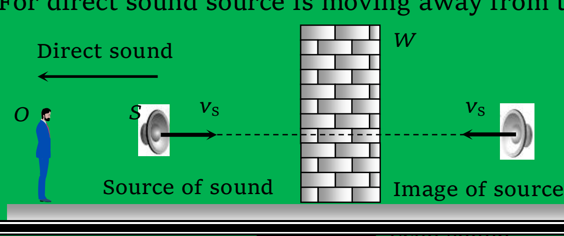
$n' = n\left(\frac{v + v_O}{v - v_S}\right) \Rightarrow n' = f\left(\frac{v + v/10}{v - v/10}\right) = 1.22\ f.$

25. (c) For source $v_S = r\omega = 0.70 \times 2\pi \times 5 = 22\ m/sec$

Minimum frequency is heard when the source is receding the man. It is given by $n_{\min} = n\frac{v}{v + v_S}$

$= 1000 \times \frac{352}{352 + 22} = 941\ Hz$

26. (b) For direct sound source is moving away from the observes so frequency heard in this case



$$n_1 = n\left(\frac{v}{v+v_s}\right) = 500\left(\frac{332}{332+2}\right) = 500\left(\frac{332}{334}\right)Hz$$

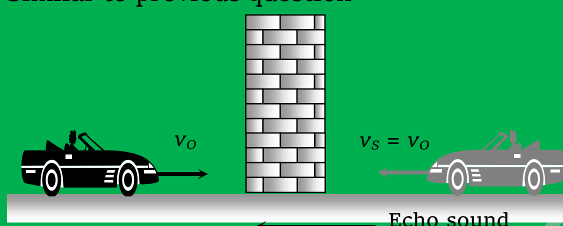
The other sound is echo, reaching the observer from the wall and can be regarded as coming from the image of source formed by reflection at the wall. This image is approaching the observer in the direction of sound.

Hence for reflected sound, frequency heard by the observer is

$$n_2 = n\left(\frac{v}{v-v_S}\right) = 500\left(\frac{332}{332-2}\right) = 500\left(\frac{332}{330}\right)Hz$$

Beats frequency $= n_2 - n_1 = 500 \times 332\left(\frac{1}{330} - \frac{1}{334}\right) = 6.$

27. (c) Similar to previous question



The frequency of reflected sound heard by the driver

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

$$= 124\left[\frac{330+(72\times 5/18)}{330-(72\times 5/18)}\right] = 140 \; vibration/sec.$$

28. (d) By using $n' = n\dfrac{v}{v-v_S} \Rightarrow \dfrac{n_1}{n} = \left(\dfrac{V}{V-S}\right)$

29. (b) In this case Doppler's effect is not applicable.

30. (d) The apparent frequency heard by the observer is given by

$$n' = \frac{v}{v-v_S}n = \frac{330}{330-33}\times 450 = \frac{330}{297}\times 450 = 500 \;\; Hz$$

31. (a) $n' = n\left(\dfrac{v-v_O}{v}\right) = \left(\dfrac{330-33}{330}\right)\times 100 = 90 \;\; Hz$

32. (c) When train is approaching frequency heard by the observer is

$$n_a = n\left(\frac{v}{v-v_S}\right) \Rightarrow 219 = n\left(\frac{340}{340-v_S}\right) \qquad ...(i)$$

when train is receding (goes away), frequency heard by the observer is

$$n_r = n\left(\frac{v}{v+v_S}\right) \Rightarrow 184 = n\left(\frac{340}{340+v_S}\right) \qquad ...(ii)$$

On solving equation (i) and (ii) we get $n = 200\,Hz$

and $v_S = 29.5 m/s.$

33. (d) Frequency is decreasing (becomes half), it means source is going away from the observes. In this case frequency observed by the observer is

$$n' = n\left(\frac{v}{v+v_S}\right) \Rightarrow \frac{n}{2} = n\left(\frac{v}{v+v_S}\right) \Rightarrow v_S = v$$

34. (d) Observer hears two frequencies

(i) n_1 which is coming from the source directly

(ii) n_2 which is coming from the reflection image of source

so, $n_1 = 680\left(\frac{340}{340-1}\right)$ and $n_2 = 680\left(\frac{340}{340+1}\right)$

$\Rightarrow \quad n_1 - n_2 = 4 \ beats$

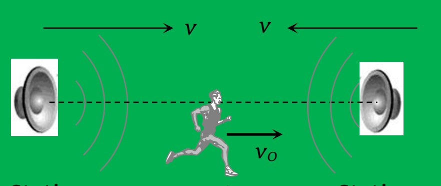
35. (a) From the figure, it is clear that

Frequency of reflected sound heard by the driver.

$$n' = n\left[\frac{v-(-v_o)}{v-v_s}\right] = n\left[\frac{v+v_o}{v-v_s}\right] = n\left[\frac{v+v_{car}}{v-v_{car}}\right]$$

$$= 600\left[\frac{330+30}{330-30}\right] = 720 \ Hz.$$

36. (b) Observer is moving away from siren 1 and towards the siren 2.



Hearing frequency of sound emitted by siren 1

$$n_1 = n\left(\frac{v-v_0}{v}\right) = 330\left(\frac{330-2}{330}\right) = 328 \, Hz$$

Hearing frequency of sound emitted by siren 2

$$n_2 = n\left(\frac{v+v_O}{v}\right) = 330\left(\frac{330+2}{330}\right) = 332 \, Hz$$

Hence, beat frequency $= n_2 - n_1 = 332 - 328 = 4.$

37. (c) $n' = n\left(\frac{v}{v-v_S}\right) = \frac{2000 \times 1220}{(1220-40)} = 2068 \ Hz$

38. (d) $n' = n\left(\frac{v+v_O}{v-v_S}\right) n \Rightarrow 400 = n\left(\frac{360+40}{360-40}\right) \Rightarrow n = 320 \ cps$

39. (a) $n' = n\left(\frac{v}{v+v_S}\right) = 500 \times \left(\frac{330}{300+50}\right) = 434.2 Hz$

40. (c) Since there is no relative motion between the listener and source, hence actual frequency will be heard by listener.

41. (a) $n' = n\left(\frac{v}{v-v_S}\right) \Rightarrow n' = 500\left(\frac{330}{330-30}\right) = 550 \ Hz.$

42. (c) $n' = n\left(\frac{v}{v-v_S}\right) = 90\left(\frac{v}{v-\frac{v}{10}}\right) = 100 \frac{Vibration}{sec}$

43. (a) The linear velocity of Whistle

$$v_S = r\omega = 1.2 \times 2\pi \frac{400}{60} = 50\ m/s$$

When Whistle approaches the listener, heard frequency will be maximum and when listener recedes away, heard frequency will be minimum

So, $n_{\max} = n\left(\frac{v}{v - v_S}\right) = 500\left(\frac{340}{290}\right) = 586\ Hz$

$$n_{\min} = n\left(\frac{v}{v + v_S}\right) = 500\left(\frac{340}{390}\right) = 436\ Hz$$

44. (d) By using $n' = n\left(\frac{v}{v - v_S}\right)$

$$\Rightarrow f_1 = n\left(\frac{v}{v - v_S}\right) = n\left(\frac{340}{340 - 34}\right) = \frac{340}{306}n$$

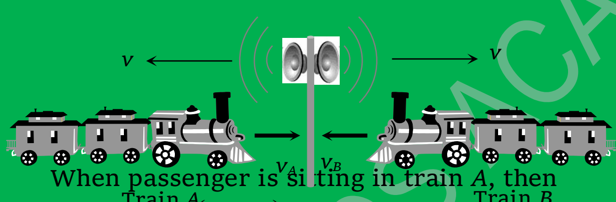
and $f_2 = n\left(\frac{340}{340 - 17}\right) = n\left(\frac{340}{323}\right) \Rightarrow \frac{f_1}{f_2} = \frac{323}{306} = \frac{19}{18}$

45. (d) No change in frequency.

46. (b) $n' = n\left(\frac{v - v_O}{v + v_S}\right) = n\left(\frac{340 - 10}{340 + 10}\right) = 1950 \Rightarrow n = 2068\ Hz$

47. (b) $n' = n\left(\frac{v + v_O}{v - v_S}\right) = 240\left(\frac{340 + 20}{340 - 20}\right) = 270\ Hz$.

48. (b) In both the cases observer is moving towards, the source. Hence by using $n' = n\left(\frac{v + v_0}{v}\right)$



When passenger is sitting in train A, then

$$5.5 = 5\left(\frac{v + v_A}{v}\right) \quad \text{...(i)}$$

when passenger is sitting in train B, then

$$6 = 5\left(\frac{v + v_B}{v}\right) \quad \text{...(ii)}$$

On solving equation (i) and (ii) we get $\frac{v_B}{v_A} = 2$

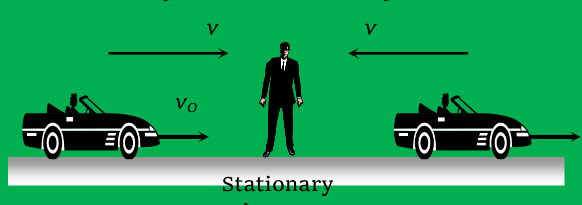
49. (b) Minimum frequency will be heard, when whistle moves away from the listener.

$n_{\min} = n\left(\frac{v}{v + v_s}\right)$ where $v = r\omega = 0.5 \times 10 = 1\ m/s$

$$\Rightarrow n_{\min} = 385\left(\frac{340}{340 + 10}\right) = 374\ Hz.$$

50. (a) $n' = n\left(\frac{v}{v + v_S}\right) = 800\left(\frac{330}{330 + 30}\right) = 733.33\ Hz$.

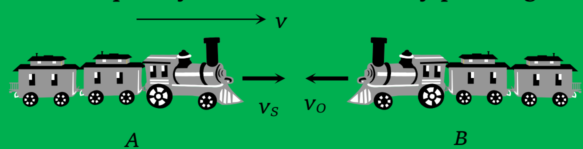
51. (a) $n_{Before} = \frac{v}{v - v_c}n$ and $n_{After} = \frac{v}{v + v_c}.n$



$$\frac{n_{Before}}{n_{After}} = \frac{11}{9} = \left(\frac{v+v_c}{v-v_c}\right) \Rightarrow v_c \Rightarrow \frac{v}{10}$$

52. (c) By using $n' = \left(\frac{v}{v-v_S}\right) \Rightarrow 2n = n\left(\frac{v}{v-v_S}\right) \Rightarrow v_S = \frac{v}{2}$

53. (d) The frequency of whistle heard by passenger in the train B, is



$$n' = n\left(\frac{v+v_0}{v-v_s}\right) = 600\left(\frac{340+15}{340-20}\right) \approx 666\ Hz$$

54. (b) At point A, source is moving away from observer so apparent frequency $n_1 < n$ (actual frequency) At point B source is coming towards observer so apparent frequency $n_2 > n$ and point C source is moving perpendicular to observer so $n_3 = n$

Hence $n_2 > n_3 > n_1$

55. (a) $n' = n\left[\frac{v+v_O}{v-v_S}\right]$; Here $v = 332\ m/s$ and $v_0 = v_s = 50\ m/s$

$$\Rightarrow 435 = n\left[\frac{332+50}{332-50}\right] \Rightarrow n = 321.12\ sec^{-1} \approx 320\ sec^{1}$$

56. (c) Since apparent frequency is lesser than the actual frequency, hence the relative separation between source and listener should be increasing.

57. (c)

58. (d) $n' = n\left(\frac{v+v_0}{v-v_s}\right) = n\left(\frac{v+v/2}{v-v/2}\right) = 3n$

59. (c) When engine approaches towards observer $n' = n\left(\frac{v}{v-v_S}\right)$

when engine going away from observer $n'' = \left(\frac{v}{v+v_S}\right)n$

$$\therefore\ \frac{n'}{n''} = \frac{v+v_S}{v-v_S} \Rightarrow \frac{5}{3} = \frac{340+v_S}{340-v_S} \Rightarrow v_S = 85\ m/s.$$

60. (a) Frequency heard by the observer

$$n' = n\left(\frac{v+v_0}{v}\right) = 240\left(\frac{330+11}{330}\right) = 248\ Hz.$$

61. (c) According the concept of sound image

$$n' = \frac{v+v_{\text{person}}}{v-v_{\text{person}}}.272 = \frac{345+5}{345-5}\times 272 = 280\ Hz$$

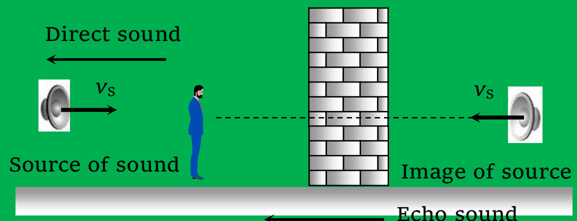
$\Delta n =$ Number of beats $= 280 - 272 = 8\ Hz$

62. (b) According the concept of sound image

$$n' = \frac{v+v_B}{v-v_B}\times n = \frac{355+5}{355-5}\times 165 = 170\ Hz$$

Number of beats $= n' - n = 170 - 165 = 5$

63. (a) The observer will hear two sound, one directly from source and other from reflected image of sound



Hence number of beats heard per second

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

$$= \frac{2nvv_S}{v^2 - v_S^2} = \frac{2 \times 256 \times 330 \times 5}{335 \times 325} = 7.8\ Hz$$

64. (a) When a listener moves towards a stationary source apparent frequency

$$n' = \left(\frac{v + v_O}{v}\right) n = 200 \qquad .....(i)$$

When listener moves away from the same source

$$n'' = \frac{(v - v_O)}{v} n = 160 \qquad .....(ii)$$

From (i) and (ii)

$$\frac{v + v_O}{v - v_O} = \frac{200}{160} \Rightarrow \frac{v + v_O}{v - v_O} = \frac{5}{4} \Rightarrow v = 360\, m / \sec$$

65. (b) When observer moves towards stationary source then apparent frequency

$$n' = \left[\frac{v + v_O}{v}\right] n = \left[\frac{v + v/5}{v}\right] n = \frac{6}{5} n = 1.2n$$

Increment in frequency = 0.2 n so percentage change in frequency = $\frac{0.2n}{n} \times 100$ = 20%.