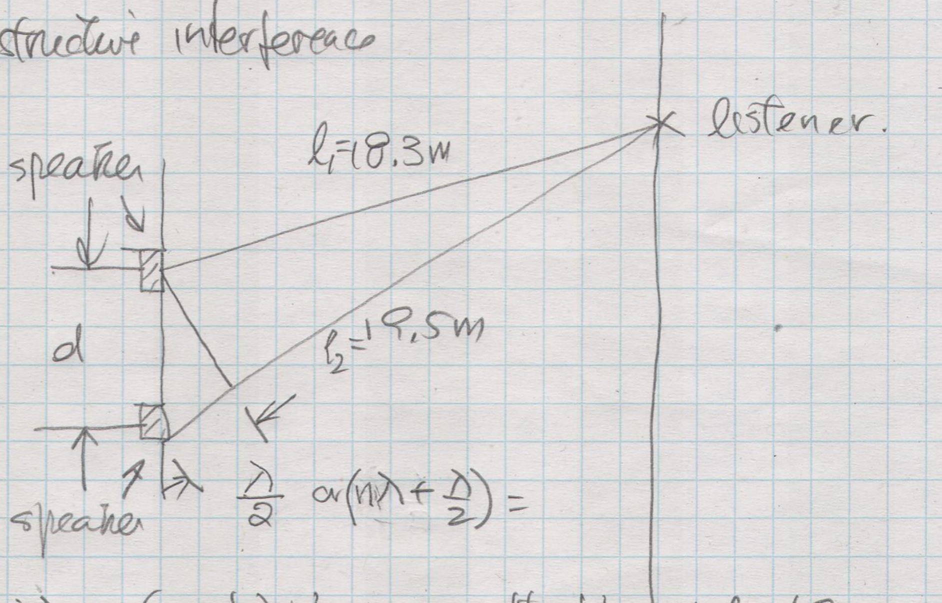
17) #17 Find $f_{min,1}$ for destructive interference



For destructive Inter.
path difference must
be $(n\lambda + \frac{\lambda}{2})$
or $(n + \frac{1}{2})\lambda$.
with n an interge
$n = 0, 1, 2, 3, 4$

$$\Delta l = l_2 - l_1 = (n + \tfrac{1}{2})\lambda = (n + \tfrac{1}{2})\frac{v}{f}$$

with v – vel of sound
f – freq of sound

$$f = (n + \tfrac{1}{2})\frac{v}{\Delta l}.$$

For lowest $f_{min,1}$, $n = 0$.

$$\underline{f_{min,1} = \frac{1}{2}\frac{v}{\Delta l}} = \left(\frac{1}{2}\right)\left(\frac{343\ m/s}{(19.5 - 18.3)m}\right) //$$

$\left(\frac{2n+1}{2}\right)\lambda$.

$n = 1$ $\quad$ $n = 2$

$\frac{3}{2}\lambda$ $\quad$ $\frac{5}{2}\lambda$.

the 2nd lowest $f_{min,2} = (n + \frac{1}{2})\frac{v}{\Delta l} = \left(\frac{2n+1}{2}\right)\frac{v}{\Delta l}$

$$= \frac{3}{2}\left(\frac{v}{\Delta l}\right)$$

$$= 3 f_{min,1} //$$

the 3rd lowest $f_{min,3} = \frac{5}{2}\left(\frac{v}{\Delta l}\right) = 5 f_{min,1}$ //

For $f_{max,1}$, path diff must be $m\lambda$. where $m = 0, 1, 2, 3, 4 \ldots$

$\therefore \Delta l = m\lambda = m\frac{v}{f}$ $\quad$ with v – vel of sound

$f_{max,1} = m\frac{v}{\Delta l} = \frac{v}{\Delta l}$ $\quad$ with $m = 1$

$f_{max,2} = \frac{2v}{\Delta l}$ $\quad$ with $m = 2$. etc.

17 #24 $d_1 = 2\,m$, $d_2 = 3.75\,m$.

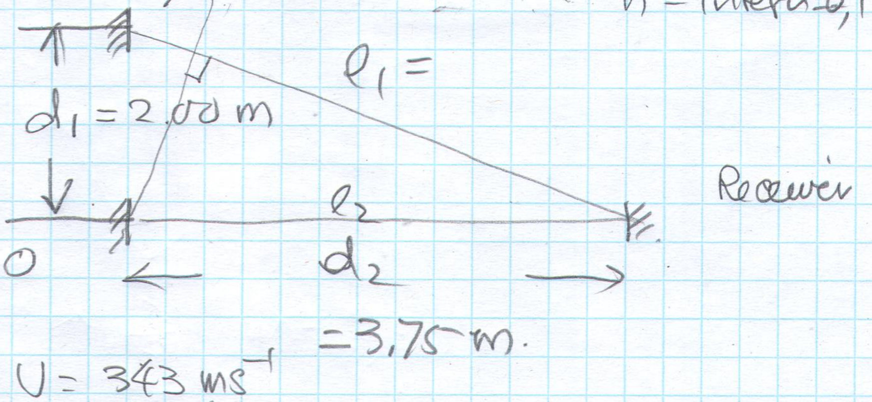
$l_1 = \left(2^2 + (3.75)^2\right)^{1/2}$ m

$l_2 = 3.75\,m$

$\Delta l = (l_1 - l_2)$

$\Delta l = (n+\frac{1}{2})\lambda$ for destructive Int

n - integer $= 0, 1, 2, 3$



$f_{min,1}$ = min freq for destructive Interferen.

$= (n+\frac{1}{2})\frac{V}{\Delta l}$ with $n = 0$

$= \frac{1}{2}\left(\frac{V}{\Delta l}\right)$ with $V = 343\ ms^{-1}$, $\Delta l = l_1 - l_2$

$f_{min,2} = 3\left(\frac{1}{2}\right)\left(\frac{V}{\Delta l}\right) = 3 f_{min,1}$ with $n = 1$.

$f_{min,3} = 5 f_{min,1}$ with $n = 2$

For max signal (constructive Interference)

$\Delta l = m\lambda$ with $m = 1, 2, 3, 4$.

$f_{max,1} = m\left(\frac{V}{\Delta l}\right)$ with $m = 1$.

$f_{max,2} = \frac{2V}{\Delta l}$.

$f_{max,3} = 3\frac{V}{\Delta l}$ //

17#36 Lets assume that the background noise has the same intensity as the conversation. ∴ if the noise level is increased by 5db, the intensity of the conversation must be elevated by the same amount.

Since sound intensity level (db) is defined as

$$\beta = 10\,db \log \frac{I}{I_0}$$

where I_0 is the threshold of hearing, I is the intensity of sound in watt/area.

$$\begin{cases} \beta_i = 10\,db \log \frac{I_i}{I_0} \\ \beta_f = 10\,db \log \frac{I_f}{I_0} \end{cases}$$

when i and f indicate initial and final conversational sound level

$$\beta_f - \beta_i = 10\,db\left(\log\frac{I_f}{I_0} - \log\frac{I_i}{I_0}\right) = 10\,db\left(\log\frac{I_f}{I_0} + \log\frac{I_0}{I_i}\right)$$

$$\Delta\beta = 10\,db \log\left(\frac{I_f}{\cancel{I_0}}\right)\left(\frac{\cancel{I_0}}{I_i}\right)$$

$$5\,db = 10\,db \log\left(\frac{I_f}{I_i}\right)$$

$$\frac{1}{2} = \log\frac{I_f}{I_i} \Rightarrow 10^{1/2} = \frac{I_f}{I_i}$$

Since the sound energy radiates out in 4π direction

$$I(r) = \frac{I(r=0)}{4\pi r^2}$$

$$\frac{I_f}{I_i} = \frac{I(r_f)}{I(r_i)} = \left(\frac{\cancel{I(r=0)}}{\cancel{4\pi} r_f^2}\right)\left(\frac{\cancel{4\pi} r_i^2}{\cancel{I(r=0)}}\right)$$

$$\therefore\ 10^{1/2} = \left(\frac{r_i}{r_f}\right)^2 \quad \text{or} \quad 10^{1/4} = \frac{r_i}{r_f} \quad \text{or} \quad r_f = (r_i)(10^{-1/4}) = (1.2)(10^{-1/4})$$

The new distance must be closer to the source $r_f = \underline{\underline{0.675}}\ m$

17 #46 $V_{sound} = 343\,ms^{-1}$

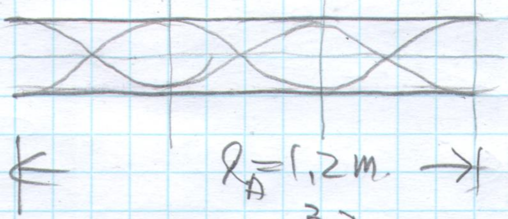
pipe A : the 3rd Harmonic freq

$$f_{A3} = \frac{V}{\lambda_3}$$

and $\lambda_3 = \left(\frac{2}{3} l_A\right)$

$$f_{A3} = \frac{3V}{2 l_A}$$

Pipe A

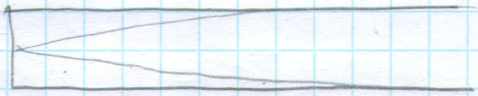


3rd lowest freq

$l_A = 1.2\,m$
$= \frac{3}{2}\lambda_3$

but the 2nd lowest harmonic of pipe B with one end closed $f_{B2} = f_{A3}$

Pipe B



2nd lowest freq

$X=0$ l_B

Relation between f_B and l_B : for pipe with one end closed

$$l_B = n\frac{\lambda_B}{4} = \frac{n}{4}\frac{V}{f_B} \quad \text{with } n = 1, 3, 5$$

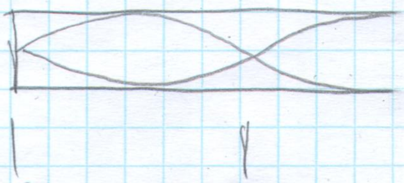
For $n=3$, $l_B = \frac{3}{4}\frac{V}{f_{B2}} = \frac{3}{4}\frac{V}{f_{A3}} = \frac{\cancel{3}}{4_2}\frac{\cancel{V}}{\left(\frac{\cancel{3}}{\cancel{2}}\right)\frac{\cancel{V}}{l_A}} = \frac{l_A}{2} = 0.6\,m$

To find the # of node in pipe B.

$$\lambda_B = \frac{4 l_B}{n} = \left(\frac{4}{3}\right)(\overset{0.2}{\cancel{0.6}})\,m = 0.8\,m$$

there are Two nodes. one at $X=0$ and the 2nd one at $X = 0.4\,m$ from the closed end.

$l_B = 0.6\,m$



pipe B

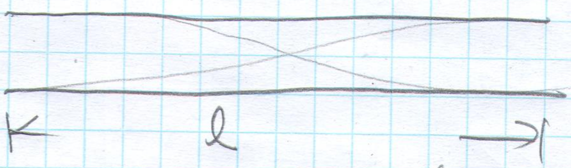
0 0.4m

17 #48 $f_n = 325\,Hz$

$f_{n+1} = 390\,Hz$

Find. f_{m+1} with $f_m = 195\,Hz$.

tube A



For open end tube the harmonic fre f_n is related to l by:

$$l = \frac{\lambda}{2},\ 2\left(\frac{\lambda}{2}\right),\ 3\frac{\lambda}{2} = n\left(\frac{\lambda}{2}\right) \quad n = 1, 2, 3, 4 \cdot \text{integer}$$

$$f_n = \frac{v}{\lambda_n} = \frac{nv}{2l} \quad \text{with } v \text{ - vel. of sound.}$$

Since $f_n = 325$, $f_{n+1} = 390$

$$f_n = \frac{nv}{2l} = 325, \quad f_{n+1} = \frac{(n+1)v}{2l} = 390$$

$$nv = (2l)(325), \quad (n+1)v = (2l)(390)$$

$$v = \frac{2l(325)}{n} \Rightarrow (n+1)\frac{\cancel{2l}(325)}{n} = (\cancel{2l})(390)$$

$$(n+1)(325) = (390)(n)$$

$$n = 5 \text{ and } l = \frac{5v}{2(325)} = \frac{(5)(343)}{(2)(325)} = \underline{2.64}\ m$$

Find the harmonic freq. next highest after $f_m = 195\,Hz$

$$f_m = \frac{mv}{2l} \quad \text{and} \quad f_{m+1} = \frac{(m+1)v}{2l}$$

$$m = \frac{2l}{v} f_m = \left(\frac{2l}{v}\right)(195) = \frac{(2)(2.64)}{(343)}(195) \quad //$$

$$f_{m+1} = \left[\frac{(2)(2.64)}{343}(195) + 1\right]\frac{v}{2l}.$$

$$= \left[\frac{(2)(2.64)(195)}{343} + 1\right]\left[\frac{343}{(2)(2.64)}\right]$$

$$= \left(\frac{(2)(2.64)(195) + 343}{(2)(2.64)}\right) \quad //$$

17#54 Five tuning forks, closed but diff freq.

f_1, f_2, f_3, f_4, f_5

a) Max number of diff. beat freq. is

$f_1 \& f_2$, $f_1 \& f_3$, $f_1 \& f_4$, $f_1 \& f_5$
$f_2 \& f_3$, $f_2 \& f_4$, $f_2 \& f_5$, $f_3 \& f_4$, $f_3 \& f_5$
and $f_4 \& f_5$

Total # of Beat freq. is 10.

b) If however $f_n = n\Delta f$ .. ie. the freq f is related for 5 tuning fork then

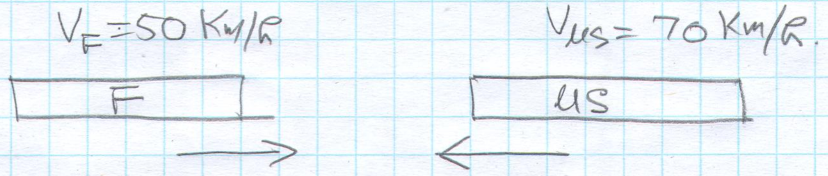
$[f_1 \& f_2, f_2 \& f_3, f_4 \& f_5, f_3 \& f_4]$ produce 1 beat freq. since n is different by 1
$[f_1 \& f_3, f_2 \& f_4, f_3 \& f_5]$ will produce a diff beat freq. since n is differ by 2
$[f_1 \& f_4]$ with $\Delta n = 3$
$[f_1 \& f_5]$ and $\Delta n = 4$

∴ Four different Beats

On the other hand if the beat freq. is more than 10 Hz, our ear may not be able to detect it.
the minimum can be fewer than 4 beats if the difference in freq between tuning fork is > 10 Hz.

17 #59 sound speed V_s , water vel $= 0$

Find the freq seen by an observer at US. sub



$V_{sonar} = 5470$ Km/h. @ 1×10^3 Hz

(a)

$$f'' = f\left(\frac{V_{sonar} + V_{US}}{V_{sonar} - V_f}\right)$$

this is the freq detected by any observer stationary with the US sub or an observer in a separate vessel moving at the same vel as the US sub. this observer also observes the reflected sonar from the US sub (reemitted by the US sub) and

(b) The freq of the reflected sonar is also f'' since the observer and the emitter are moving at the same velocity.

this shift in freq is due to the motions of the two vessels. the reflected sonar has essentially the same shifted frequency.

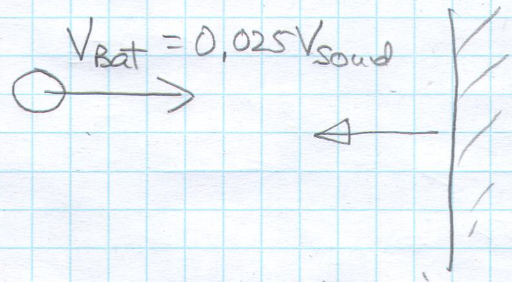
this reflected wave with $f'' = f\left(\frac{V_{sonar} + V_{US}}{V_{sonar} - V_f}\right)$ is now intercepted by a moving French sub travelling in the opposite direction as the reflected sonar. the observed freq on the French sub is "blue shifted" to a shorter freq

$$f''' = f''\left(\frac{V_{sonar}}{V_{sonar} - V_f}\right)$$

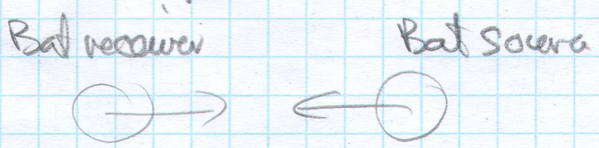
$$= f\left(\frac{V + V_{US}}{V - V_f}\right)\left(\frac{V}{V - V_s}\right)$$

17#61 $f_0 = 39{,}000\,Hz$

The bat is moving in
the opposite direction as
the reflected sound

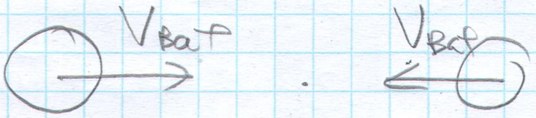


the source of the reflected
sound is the bat itself



The reflected sound is shifted
due to the motion of the bat.

The freq of the reflected sound is further modified by
the motion of the receiver (bat itself) moving toward
the sound source (bat the emitter)



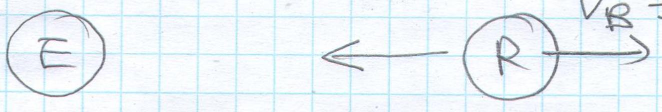
$$f'' = f_0\left(\frac{V+V_B}{V-V_B}\right)$$

$$= f_0\,\frac{\cancel{V}(1+0{,}025)}{\cancel{V}(1-0{,}025)} = f_0\left(\frac{1{,}025}{0{,}975}\right)$$

17#63

$f' = f_0\left(\frac{V - V_B}{V \pm V_E}\right)$ $\quad V_E = 0$

$f_0 = 28\ kHz$ $\quad f'$



$V_B = 0.95 ms^{-1}$

$V = 343 ms^{-1}$

$= f_0\left(\frac{V - V_B}{V}\right)$

$Beat = |f_0 - f'|$

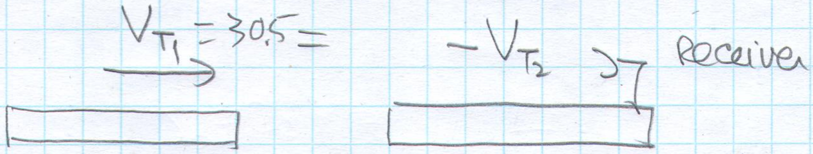
$= f_0 - f_0\left(\frac{V - V_B}{V}\right)$

$= f_0\left(1 - \frac{V - V_B}{V}\right)$

$= f_0\left(\frac{V_B}{V}\right)$

$= (28)\left(\frac{0.95}{343}\right)$ $\quad = \underline{2.77\times10^{-3}}\ kHz \quad = 2.\underline{\underline{77}}\ Hz$

17# 66



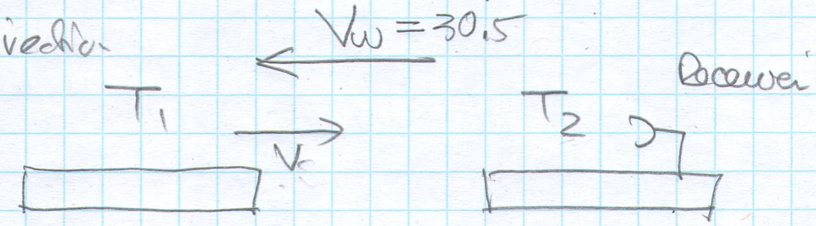
(a) Air still

observer in T_2 detect f'' $\qquad f_0 = 500\,Hz$

$$f'' = f_0\left(\frac{V + V_R}{V - V_E}\right) = (500)\left(\frac{343 + 30.5}{343 - 30.5}\right) //$$

(b) wind blowing at 30.5 m/s toward Train T_1

Since the wind move in opp direction as the sound speed, the sound speed is reduced due to motion of medium (for sound).



The effective sound speed is $V - V_W$

$$f'' = f_0\left(\frac{V - V_W + V_R}{V - V_W - V_E}\right)$$

$$= (500)\left(\frac{343}{343 - 61}\right)$$

(c) If the wind direction is reversed. the

$$f'' = f_0\left(\frac{V + V_W + V_R}{V + V_W - V_E}\right) \qquad |V_W| = |V_R| = |V_E|$$

$$= f_0\left(\frac{V + 2V_R}{V}\right) = (500)\left(\frac{343 + 61}{343}\right) //$$