① $\boxed{20.20}$

ⓐ $I_{H_2O} = I_{Air}$ see Eq(18)

$$\frac{(\Delta p_{m,H_2O})^2}{2\rho_{H_2O} V_{H_2O}} = \frac{(\Delta p_{m,Air})^2}{2\rho_{Air} V_{Air}}$$

$$\frac{\Delta p_{m,H_2O}}{\Delta p_{m,Air}} = \sqrt{\frac{\rho_{H_2O} V_{H_2O}}{\rho_{Air} V_{Air}}}$$

$T = 20^\circ C$ $\quad \rho_{H_2O} = 0.998 \cdot 10^3 \ \frac{kg}{m^3}$ p. 379

$V_{H_2O} = 1482 \ m/s$ p. 447

$\rho_{Air} = 1.21 \ kg/m^3$ p 379

$V_{Air} = 343 \ m/s$ p 447

$$\frac{\Delta p_{m,H_2O}}{\Delta p_{m,Air}} = \sqrt{\frac{0.998 \cdot 10^3 \cdot 1482}{1.21 \cdot 343}}$$

$$\boxed{\frac{\Delta p_{m,H_2O}}{\Delta p_{m,Air}} = 59.7}$$

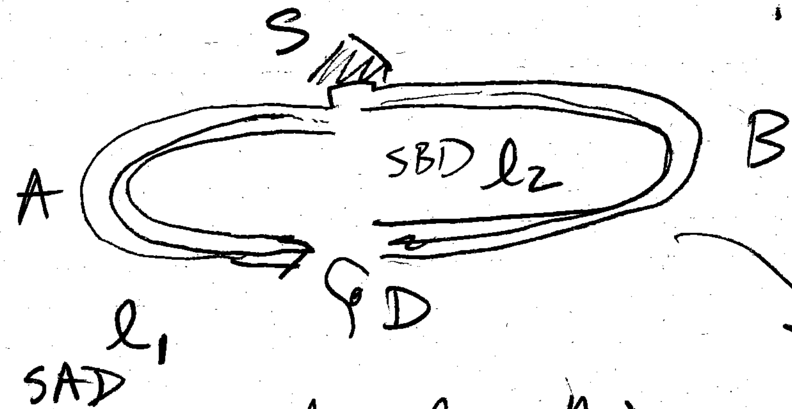
ⓑ $$\frac{I_{H_2O}}{I_{Air}} = \frac{\frac{\cancel{(\Delta p_{m,H_2O})^2}}{2\rho_{H_2O} V_{H_2O}}}{\frac{\cancel{(\Delta p_{m,Air})^2}}{2\rho_{Air} V_{Air}}} = \frac{\rho_{Air} V_{Air}}{\rho_{H_2O} V_{H_2O}}$$

$$\boxed{\frac{I_{H_2O}}{I_{Air}} = \frac{1.21 \cdot 343}{0.998 \cdot 10^3 \cdot 1482} = 2.8 \cdot 10^{-4}}$$

(2) $\boxed{20.23}$ minimum $\rightarrow$ $10\,\mu W/cm^2 = I_{min}$

maximum $\rightarrow$ $90\,\mu W/cm^2 = I_{max}$

$\Delta L = 1.65$ cm



$\rightarrow$ max, change to

minimum: $l_2 - l_1 = \frac{n}{2}\lambda$ $\qquad$ $l_2' - l_1 = m\lambda$

n = odd # $\qquad$ integer.

so $\quad |l_2 - l_2'| = \Delta L = 1.65\,cm = \frac{1}{2}\lambda$

so $\quad \lambda = 3.3\,cm = \frac{v}{\nu}$

$$\nu = \frac{v}{3.3\,cm} = \frac{343\,m/s}{3.3 \cdot 10^{-2}\,m} \text{ (air)}$$

(a) $\boxed{\nu = 10.4\ kHz}$ Book says 5.2 kHz, I think wrong

(b) $$\frac{\text{Destructive}}{\text{Constructive}} = \frac{A_D^2}{A_C^2} = \frac{(a_1 - a_2)^2}{(a_1 + a_2)^2} = \frac{\left(1 - \frac{a_2}{a_1}\right)^2}{\left(1 + \frac{a_2}{a_1}\right)^2}$$

$$\left(\frac{D}{C}\right)^{1/2} = \frac{1 - a_2/a_1}{1 + a_2/a_1}$$

$$\left(1+\frac{a_2}{a_1}\right)\left(\frac{D}{c}\right)^{1/2} = 1-\frac{a_2}{a_1}$$

$$\frac{a_2}{a_1}\left[\left(\frac{D}{c}\right)^{1/2}+1\right] = 1-\left(\frac{D}{c}\right)^{1/2}$$

$$\frac{a_2}{a_1} = \frac{1-\left(\frac{D}{c}\right)^{1/2}}{1+\left(\frac{D}{c}\right)^{1/2}} = \frac{1-\left(\frac{1}{a}\right)^{1/2}}{1+\left(\frac{1}{a}\right)^{1/2}}$$

$$= \frac{1-1/3}{1+1/3} = \frac{2/3}{4/3} = \frac{1}{2}$$

$$\boxed{\frac{a_2}{a_1} = \frac{1}{2}}$$

(c) Perhaps more attenuation along one route.

(3) $\boxed{20.25}$

$$I = \frac{(\Delta p_m)^2}{2\rho v} = \frac{(1.013\cdot 10^5)^2}{2\times 1.2\cdot 343}$$

$$I = 1.25\cdot 10^7 \text{ W/m}^2$$

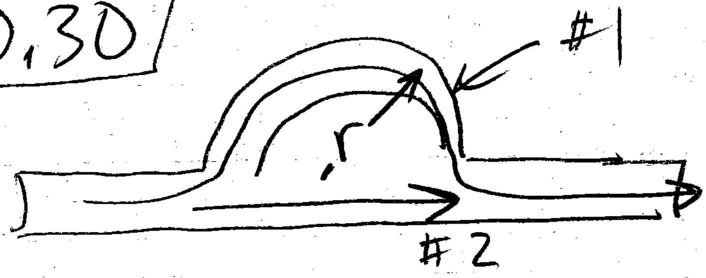
$$SL = 10\log_{10}\frac{1.25\cdot 10^7}{10^{-12}}$$

$$= 10\log_{10} 1.25\cdot 10^{19}$$

$$\boxed{SL = 191 \text{ dB}}$$

TOPS

4 $\boxed{20.30}$

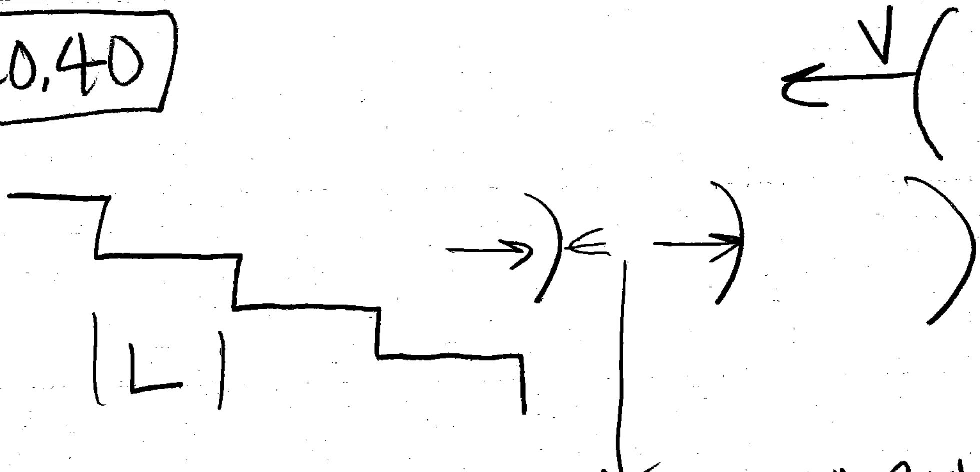


$$\text{path } 1 = \text{path } 2 + \tfrac{1}{2}(2\pi r) - 2r$$
$$= \text{path } 2 + (\pi - 2)r$$
$$\Delta\text{path} = (\pi-2)r = \frac{\lambda}{2} \quad (\text{minimum}$$
$$r = \frac{\lambda}{2(\pi-2)} = \frac{42}{2\cdot(\pi-2)}\text{ cm}$$
$$\boxed{r = 18.4\text{ cm}}$$

5 $\boxed{20.38}$

$$\nu = 7.20\text{ Hz}$$
$$\rho = 1.20\text{ kg/m}^3$$
$$B = 1.41\cdot 10^5\text{ Pa}$$
$$v = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{1.41\cdot 10^5}{1.2}} = 343\text{ m/s}$$
$$\lambda = 4L \quad (\text{one end closed, one open})$$
$$\nu\lambda = v, \quad \text{so } 4L = \frac{v}{\nu}$$
$$\boxed{L = \frac{v}{4\nu} = \frac{343}{4\cdot 7.20} = 11.9\text{ m}}$$

6 $\boxed{20.40}$



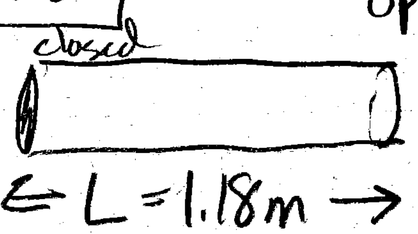
$\lambda = L = 0.914\,m$

$\nu = \dfrac{v}{L} = \dfrac{343\ m/s}{0.914\ m}$

$\boxed{\nu = 375\ Hz}$

7 $\boxed{20.48}$

a



$\lambda = 4L$

$\nu = \dfrac{v}{\lambda} = \dfrac{v}{4L}$

$= \dfrac{343\ m/s}{4 \cdot 1.18}$

$\boxed{\nu = 72.7\ Hz}$

b $\lambda = 2L$, so $\nu = \dfrac{v}{2L} = \dfrac{1}{2L}\sqrt{\dfrac{F}{\mu}}$

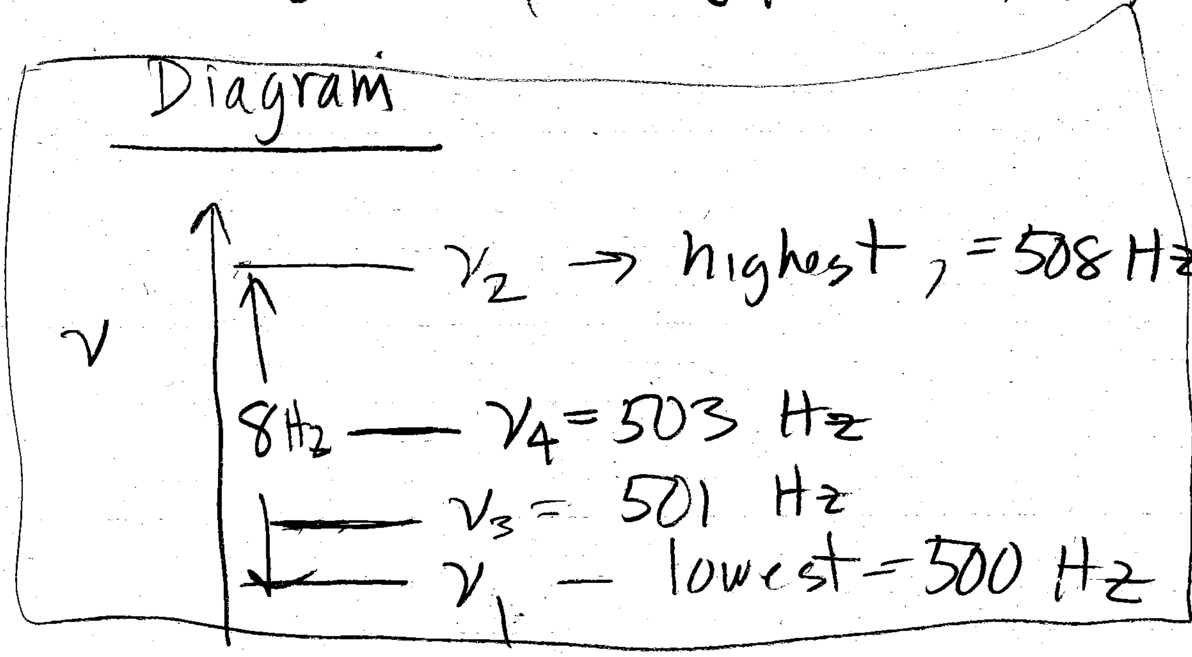
$= \dfrac{1}{2L}\sqrt{\dfrac{F}{m/L}} = \nu$

$\sqrt{\dfrac{F}{mL}} = 2\nu$

$\boxed{F = 4\nu^2 \cdot mL = 66.9N}$ $= 4(72.7)^2 \cdot .00954; 33.$

$\boxed{8\ 20.52}$ $\nu_1, \nu_2, \nu_3, \nu_4$

need to get... $|\nu_i - \nu_j| = 1, 2, 3, 5, 7, 8$



make $|\nu_1 - \nu_2| = 8$ Hz

ν_3, ν_4 must be "inside"

make $\nu_3 = 501$ Hz (could be 507 Hz)

→ now have $|\nu_2 - \nu_3| = 7$ Hz

$\nu_3 = 501$ Hz $|\nu_3 - \nu_1| = 1$ Hz

→ now have $|\nu_4 - \nu_3| = 2$ Hz

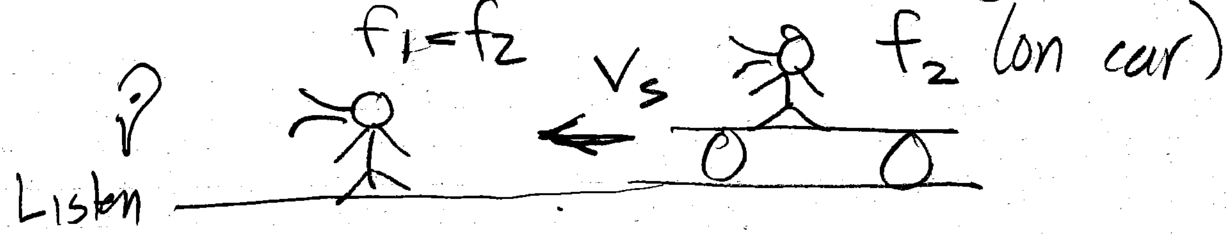
$\nu_4 = 503$ Hz $|\nu_4 - \nu_1| = 3$ Hz

$|\nu_4 - \nu_2| = 5$ Hz

$\nu_3 = 507$ Hz

+ $\nu_4 = 505$ Hz Another Solution

$\boxed{9\ 20.58}$ Moving Source ...
(assume listener on ground)



$$f_2' = f_2 \cdot \frac{V}{V - V_s}$$ ← toward, higher frequency

Beats:

$$|f_2' - f_1| = f_2 \cdot \frac{V}{V - V_s} - f_2$$

$$= f_2 \left[\frac{V}{V - V_s} - \frac{V - V_s}{V - V_s} \right]$$

$$\Delta f = \frac{V_s}{V - V_s} f_2$$

$$\frac{\Delta f}{f_2} = \frac{V_s}{V - V_s}$$

$$\left(\frac{\Delta f}{f_2}\right)(V - V_s) = V_s$$

$$\left(\frac{\Delta f}{f_2}\right) \cdot V = V_s \left(1 + \frac{\Delta f}{f_2}\right)$$

$$\boxed{V_s = \frac{\Delta f / f_2}{1 + \Delta f / f_2} V = \frac{4/440}{1 + 4/440} \cdot 343 = 3.09\ \text{m/s}}$$

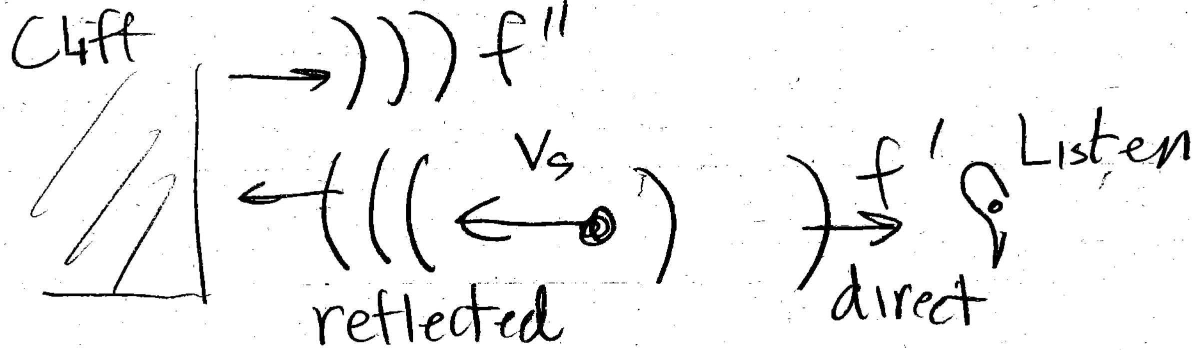
10 20.68

(a) Moving source -- $v = 343$ m/s

away $f' = \dfrac{f}{1 + v_s/v} = \dfrac{1000\ \text{Hz}}{1 + 10/343}$

$\boxed{f' = 971.7\ \text{Hz}}$

(b) Seems like reflected sound comes from a siren coming toward you..



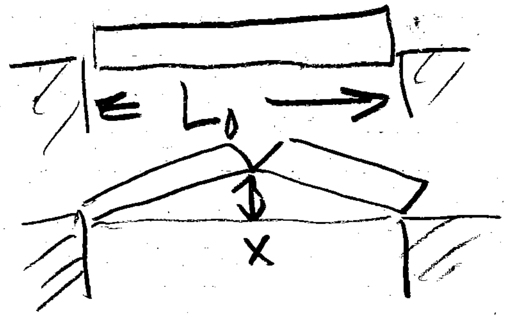
$f'' = \dfrac{f}{1 - v_s/v} = \dfrac{1000}{1 - 10/343}$

$= 1030$ Hz

(c) $\Delta f = |f'' - f'| = 58.4$ Hz

Yes, could hear

11 22.28



$$\frac{L}{2} = \sqrt{\left(\frac{L_0}{2}\right)^2 + x^2} = \frac{L_0}{2}\left(1 + \alpha \Delta T\right)$$

$$\cancel{\left(\frac{L_0}{2}\right)^2} + x^2 = \left(\frac{L_0}{2}\right)^2\left(\cancel{1} + 2\alpha\Delta T + \alpha^2 \Delta T^2\right)$$

$$\boxed{x = \sqrt{2\alpha\Delta T + \alpha^2 \Delta T^2}\left(\frac{L_0}{2}\right)}$$

$\alpha = 25 \cdot 10^{-6}$ $\quad \Delta T = 32$

$$x = \sqrt{2\underbrace{\left(25 \cdot 10^{-6} \cdot 32\right)}_{8 \cdot 10^{-4}} + \underbrace{\left(25 \cdot 10^{-6} \cdot 32\right)^2}_{64 \cdot 10^{-8}}} \cdot \frac{3.77}{2}$$

negligible actually

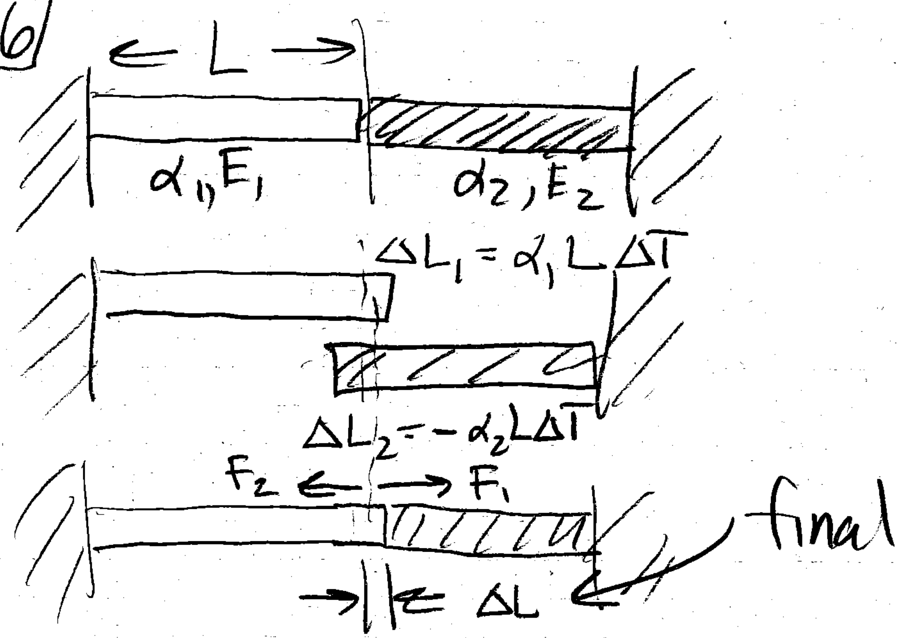
$$= .04 \cdot \frac{3.77}{2}$$

$$\boxed{\begin{aligned} x &= 0.0754 \text{ m} \\ &= 7.54 \text{ cm} \end{aligned}}$$

12 22.46

IF NOT MEETING AT CENTE

STUFF TOGETR



$$\frac{F_1}{A} = E_1 \frac{(\Delta L_1 - \Delta L)}{L} \qquad \frac{F_2}{A} = E_2 \frac{(\Delta L_2 - \Delta L)}{L}$$

equilibrium: $F_1 = -F_2$

so $$E_1(\Delta L_1 - \Delta L) = -E_2(\Delta L_2 - \Delta L)$$

$$E_1 \Delta L_1 + E_2 \Delta L_2 = \Delta L(E_1 + E_2)$$

$$E_1 \alpha_1 L \Delta T - E_2 \alpha_2 L \Delta T = \Delta L(E_1 + E_2)$$

(a) so $$\Delta L = \left(\frac{E_1\alpha_1 - E_2\alpha_2}{E_1 + E_2}\right) L \Delta T$$

(b) $$\frac{F_1}{A} = \frac{E_1}{\cancel{L}} \cdot \left(\alpha_1 \cancel{L} \Delta T - \left(\frac{E_1\alpha_1 - E_2\alpha_2}{E_1 + E_2}\right) \cancel{L} \Delta T\right)$$

$$\boxed{\frac{F_1}{A} = E_1\left(\frac{\cancel{\alpha_1 E_1} + \alpha_1 E_2 - \cancel{\alpha_1 E_1} + \alpha_2 E_2}{E_1 + E_2}\right)\Delta T = \frac{E_1 E_2}{E_1 + E_2}(\alpha_1 + \alpha_2)\Delta T}$$