Problems of Ch. 12

(1) $f = 1.0 \times 10^5\ Hz$, $T = 15^\circ c$, $\lambda = ?$

$\lambda = \frac{V}{f}$, We need V at $T = 15^\circ c + 273 = 288\ k$

$$V = V_0 \sqrt{\frac{T}{T_0}} = 330 \sqrt{\frac{288}{273}} = 338.9\ m/s$$

$$\Rightarrow \lambda = \frac{V}{f} = \frac{338.9\ m/s}{1.0 \times 10^5\ Hz} = 0.0034\ m = \boxed{3.4\ mm}$$

(10) t = time = 8.2 s = time for thunder to be heard

$T = 12^\circ c = 12 + 273 = 285\ k$

a) $$V = V_0 \sqrt{\frac{T}{T_0}} = 330 \sqrt{\frac{285}{273}} = \boxed{338\ m/s}$$

b) $$x = Vt = (338)(8.2) \approx 2800\ m = \boxed{2.8\ km}$$

(12) $\beta = 71\ dB \Rightarrow \beta = 10 \log \frac{I}{I_0} \Rightarrow 71 = 10 \log \frac{I}{I_0}$

$$\Rightarrow 7.1 = \log \frac{I}{I_0} \Rightarrow \frac{I}{I_0} = 10^{7.1} = 1.26 \times 10^7 \Rightarrow$$

$$I = (10^{-12})(1.26 \times 10^7) = 1.26 \times 10^{-5}\ W/m^2$$

$$P = IA = (1.26 \times 10^{-5})(4\pi \times 25^2) = \boxed{0.099\ W}$$

(14) $\beta_1 = 98\ dB = \beta_2 = \cdots = \beta_8$

$\beta_{total} = ?$

Use $\beta_1 = 10 \log \frac{I_1}{I_0} \rightarrow 98 = 10 \log \frac{I_1}{I_0} \rightarrow$

$$I_1 = I_0 (10)^{9.8} = (10^{-12})(10)^{9.8} = 6.3 \times 10^{-3}\ W/m^2$$

$$I_{TOTAL} = I_1 + \cdots + I_8 = 8(6.3 \times 10^{-3}) = 0.051\ W/m^2$$

$$\beta = 10 \log \frac{I}{I_0} = 10 \log \frac{0.051}{10^{-12}} = \boxed{107\ dB}$$

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(18) $A_{final} = A_{initial} + 0.5\ A_{initial} = 1.5\ A_{initial}$

a) $I \propto A^2 \Rightarrow I_{final} = 2.25\ I_{initial}$

$$\frac{\Delta I}{I} = \frac{I_{final} - I_{initial}}{I_{initial}} = \frac{2.25\ I_{initial} - I_{initial}}{I_{initial}} = 1.25$$

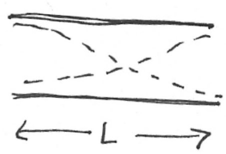
$$\Rightarrow \frac{\Delta I}{I} = 1.25 = 125\%$$

b) $\beta_i = 10 \log \frac{I_i}{I_0}$, $\beta_F = 10 \log \frac{I_f}{I_0} \Rightarrow$

$$\Delta\beta = 10 \left[\log \frac{I_f}{I_0} - \log \frac{I_i}{I_0}\right] = 10 \log \frac{I_f}{I_i} = 10 \log 2..$$

$$\boxed{\Delta\beta = 3.52\ dB}$$

(19)



$$L = \frac{\lambda}{4} + \frac{\lambda}{4} = \frac{\lambda}{2}$$

To find L we need λ.

Using $\lambda = \frac{V}{f} \Rightarrow \lambda = \frac{343 \text{ m/s}}{20 \text{ kHz}} = 0.017 \text{ m}$

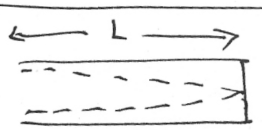
$L = \frac{\lambda}{2} \rightarrow L = \frac{0.017}{2} = 0.00858 \text{ m}$

$= \boxed{8.58 \text{ mm}}$

Note: The longest wavelength corresponds to the lowest frequency in the range of 20 – 40

In this case, this frequency = 20 kHz.

(20)

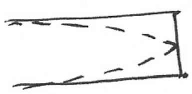


= fundamental

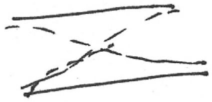
$L = \frac{\lambda}{4}$ but $\lambda = \frac{V}{f} = \frac{343}{261.5} = 1.3 \text{ m}$

$\Rightarrow L = \frac{1.3 \text{ m}}{4} = 0.328 \text{ m} = \boxed{32.8 \text{ cm}}$

(2b)

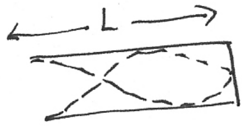


A



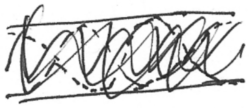
B

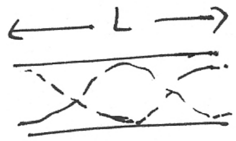
= fundamental



next to lowest for A

$\downarrow$





next to lowest for B

$$L = \frac{3}{4}\lambda_A \qquad\qquad L = \lambda_B$$

$$\Rightarrow \lambda_A = \frac{4L}{3} \qquad\qquad \lambda_B = L$$

$$\frac{\lambda_A}{\lambda_B} = \frac{4/3\, \cancel{L}}{\cancel{L}} = 4/3$$

But $\lambda_A = \dfrac{v}{f_A}$ $\qquad \lambda_B = \dfrac{v}{f_B}$

$$\frac{\lambda_A}{\lambda_B} = \frac{f_B}{f_A} = 4/3 \Rightarrow \boxed{\frac{f_A}{f_B} = 3/4}$$

(36) $f_s = 500\ Hz$ $\quad V_o = 85\ km/h = 23.6\ m/s$

$$f_i = \left(1+\frac{V_o}{V}\right)f_s = \left(1+\frac{23.6}{343}\right)500 = 534.4\ Hz$$

$$f_f = \left(1 - \frac{V_o}{V}\right)f_s = \left(1-\frac{23.6}{343}\right)500 = 465.6\ Hz$$

$$\Delta f = 534.4 - 465.6 = \boxed{68.8\ Hz}$$

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(38) $f_s = 1.0\ kHz$ $\quad V_s = 0.5 \times 343 = 171.5\ m/s$

a) $f_o = ?$ $\quad f_o = \dfrac{1}{1 - V_s/V} f_s$

$$f_o = \frac{1}{1 - \frac{171.5}{343}}(1.0\times10^3\ Hz) = 2\times10^3\ Hz = 2\ kHz$$

b)

$$f_o = \frac{1}{1+\frac{171.5}{343}}(1.0\times10^3\ Hz) = 670\ Hz$$

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(44)

$$f_{o_1} = \frac{1}{1-\frac{V_s}{V}} f_s, \quad f_{o_2} = \frac{1}{1+\frac{V_s}{V}} f_s$$

$$f_{o_2} = 0.75\, f_{o_1} \Rightarrow \frac{1}{1+\frac{V_s}{V}}\cancel{f_s} = 0.75\frac{1}{1-\frac{V_s}{V}}\cancel{f_s}$$

$$\Rightarrow 1+\frac{V_s}{V} = \frac{1}{0.75}\left(1-\frac{V_s}{V}\right) \Rightarrow \boxed{V_s = 49\ m/s}$$