Chapter 7

(1) $X = R$ loading impedance $4\rho_o c A$

$f = 700\ \text{Hz}$

$$k = \frac{\omega}{c} = \frac{2\pi f}{c} = \frac{2\pi\,(700\,\text{Hz})}{(343\,\text{m/s})} = 12.82$$

$$\frac{Z_{no}}{\rho_o c A} = \frac{\frac{Z_{nL}}{\rho_o c A} + i \tan kL}{1 + i \frac{Z_{nL}}{\rho_o c S} \tan kL}$$

$$= \frac{\frac{4\rho_o c A}{\rho_o c A} + i \tan kL}{1 + i \frac{4\rho_o c A}{\rho_o c A} \tan kL} = \frac{4 + i \tan kL}{1 + i\,4 \tan kL}$$

$$= \frac{(4 + i \tan kL)(1 - i4 \tan kL)}{(1 + i\,4 \tan kL)(1 - i4 \tan kL)}$$

$$= \frac{4 - i\,16 \tan kL + i \tan kL + 4 \tan^2 kL}{1 - i4 \tan kL + i4 \tan kL + 16 \tan^2 kL}$$

$$\frac{Z_{no}}{\rho_o c A} = \frac{4(1 + \tan^2 kL) - i15 \tan kL}{1 + 16 \tan^2 kL}$$

Now $X = R$ $\quad 4(1 + \tan^2 kL) = -15 \tan kL$

$$\tan^2 kL + \frac{15}{4} \tan kL + 1 = 0$$

$x = \tan kL$

$$x = \frac{-15/4 \pm \sqrt{(15/4)^2 - 4\cdot 1\cdot 1}}{2\cdot 1}$$

$$= \frac{-15 \pm \sqrt{15^2 - 4\cdot 4\cdot 4}}{8}$$

$$= \frac{-15 \pm \sqrt{161}}{8}$$

$$= \frac{-27.69}{8},\ \frac{-2.311}{8} = \boxed{\begin{matrix}-3.461 \\ -0.2889\end{matrix}}$$

$kL = \tan^{-1} x$

$$L = \frac{\tan^{-1} x}{k}$$

$$L = \frac{\tan^{-1}(-0.2889)}{12.82} = \boxed{2.19\,\text{cm}}$$

$10.0\,\text{cm}$

(#2)

(4) $L = 1.2\,m$

$a = 6\,cm$

$m_p = 0.02\,kg$

Infinite baffle

$f = 200\,Hz$

$$\frac{Z_{nL}}{\rho_0 c S} = \frac{(ka)^2}{2} + i\,\frac{8}{3}\,\frac{ka}{\pi}$$

$$\frac{Z_{n0}}{\rho_0 c S} = \frac{\frac{Z_{nL}}{\rho_0 c S} + i\tan kL}{1 + i\frac{Z_{nL}}{\rho_0 c S}\tan kL}$$

~~$Z_{n0} = \rho_0 c S \left[\frac{[R + i(\psi + \tan kL)][(1 - \psi\tan kL) + i(R\tan kL)]}{1 + 2iR\tan kL - 2\psi\tan kL - \tan^2 kL\,(R^2 \ldots}\right]$~~

(a) $k = \frac{\omega}{c} = \frac{2\pi f}{c} = \frac{2\pi(200)}{343\,m/s}$

$k = 3.664$

$$\frac{Z_{nL}}{\rho_0 c S} = R + i\psi$$

$$R = \frac{(ka)^2}{2} = \frac{[(3.664)(0.06)]^2}{2}$$

$R = 0.02416$

$\psi = \frac{8}{3}\,\frac{(3.664)(0.06)}{\pi}$

$\psi = 0.1866$

$kL = (3.664)(1.2\,m) = 4.397\ \text{rad}$

$\tan kL = 3.065$

$R^2 + \psi^2 = (0.02416)^2 + (0.1866)^2$

$= 0.03540$

$\rho_0 c S = (1.2\,kg/m^3)(343\,m/s)(\pi)(.06\,m)^2 = 4.655$

$$Z_{n0} = \rho_0 c S \left[\frac{R(1 + \tan^2 kL) - i\,[\psi\tan^2 kL + (\psi^2 + R^2 - 1)\tan kL - \psi]}{(\psi^2 + R^2)\tan^2 kL - 2\psi\tan kL + 1}\right]$$

$$= 4.655\left[\frac{(0.02416)(1 + (3.065)^2) - i\,[0.1866(3.065)^2 + (0.03540 - 1)(3.065) - 0.1866]}{(0.03540)(3.065)^2 - 2(0.1866)(3.065) + 1}\right]$$

$$= 4.655\left[\frac{0.2511 - i\,[\,1.566\ \ (\text{~~0.6113~~}) - 2.956\,]}{0.1887}\right] = 4.655\left[\frac{0.2511 + i\,(1.390)}{0.1887}\right]$$

~~$= 4.655[$~~ $\boxed{Z_{n0} = 6.194 + i\,34.29}$

(b) $u = \delta\cdot\omega = \delta\, 2\pi f = (0.005\,m)\,2\pi\,(200\,Hz) = 6.283\,m/s$

~~$Z = f/u \quad f = uZ = (6.283\,m/s)(6.194 + i\,34.29) =$~~

$|Z_{n0}| = \sqrt{6.194^2 + 34.29^2} = 34.84$

$f = uZ = (6.283\,m/s)(34.84) = \boxed{218.9\,N}$

(c) $P = \frac{1}{2} R u^2 = \frac{1}{2}(6.194)(6.283\,m/s)^2 = \boxed{122\,W}$

#3

(5) 70 dB (20 μPa)

f = 1000 Hz

$\rho_0 c = (1.2\,kg/m^3)(343\,m/s)$

$= 411.6\ \frac{Pa\,s}{m}$

Air: $\rho_0 c = 411.6\ \frac{Pa\,s}{m}$

medium: $780\ \frac{Pa\,s}{m}$

$$\left|\frac{B}{A}\right| = \frac{\frac{Z_{nL}}{\rho_0 c_S} - 1}{\frac{Z_{nL}}{\rho_0 c_S} + 1} = \frac{\frac{780}{411.6} - 1}{\frac{780}{411.6} + 1} = \frac{0.895}{2.895} = 0.309$$

$$\left|\frac{B}{A}\right|^2 = 0.0956$$

$$L_p = 20 \log\left(\frac{P}{P_0}\right) \Rightarrow \frac{L_p}{20} = \log\left(\frac{P}{P_0}\right) \Rightarrow P = P_0\, 10^{L_p/20}$$

$$P_I = (20\times10^{-6}\,Pa)\, 10^{70/20} = 6.32\times10^{-2}\,Pa$$

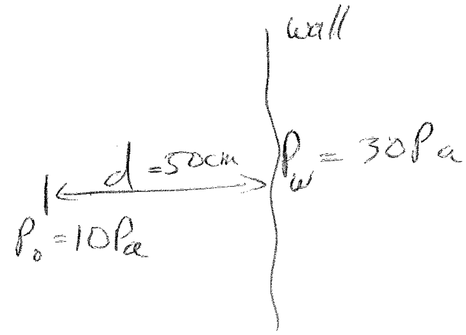
$$P_r = \left|\frac{B}{A}\right|^2 \cdot P_I = (0.0956)(6.32\times10^{-2}\,Pa) = \boxed{6.05\times10^{-3}\,Pa}$$

$$P_t = \left(1 - \left|\frac{B}{A}\right|^2\right) P_I \equiv (0.9044)(6.32\times10^{-2}\,Pa) = \boxed{5.715\times10^{-2}\,Pa}$$

#4 (6)

$c_w = 1480\ m/s$

$f = 2860\ Hz$



$SWR = \frac{30P_a}{10P_a} = 3$

(a) $\frac{B}{A} = \frac{3-1}{3+1} = \frac{2}{4} = \frac{1}{2}$ 2 to 1

$\frac{Z_{nL}}{S} = \rho_0 c \frac{A+B}{A-B} = (1000 kg/m^3)(1480 m/s)\left(\frac{2+1}{2-1}\right)$

$= 4.44 \times 10^6$

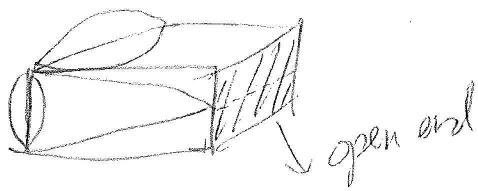
need θ + then

$k = \omega/c = \frac{2\pi f}{c} = \frac{2\pi(2960 Hz)}{1480\ m/s} = 12.57\ rad/m$

$\theta = 2(12.57\ rad/m)(.5m) - \pi = 9.43\ rad$ $\frac{Z_{nL}}{S} = \rho_0 c \frac{A+Be^{i\theta}}{A-Be^{i\theta}}$

---

(10)



---

(11) $c = 344 m/s$

10 eigenfunctions

$6.50 \times 5.65 \times 3.00$

$L_x = 6.50$

$L_y = 5.65$

$L_z = 3.00$

(l, m, n)

(1,0,0) - 26.5 Hz
(0,1,0) - 30.4 Hz
(1,1,0) - 40.3 Hz
(2,0,0) - 52.9 Hz
(0,0,1) - 57.3 Hz
(0,2,0) - 60.9 Hz
(2,1,0) - 61.1 Hz
(1,0,1) - 63.1 Hz
(0,1,1) - 64.9 Hz
(1,2,0) - 66.4 Hz