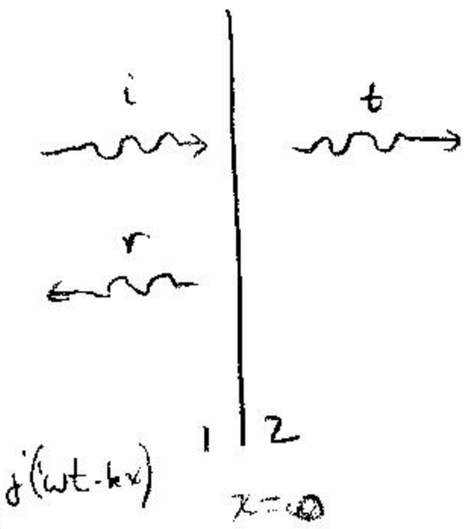
6.3 $p_i = \delta\tilde{p}_i = \delta p_i e^{j(\omega t - kx)}$

6.2.3 $p_r = \delta\tilde{p}_r = \tilde{R}\,\delta p_i e^{j(\omega t + kx)}$

$p_t \quad \delta\tilde{p}_t = \tilde{T}\,\delta p_i e^{j(\omega t - kx)}$



$$u_i = \delta v_i = +\frac{1}{j\omega\rho_1} jk\,\delta p_i e^{j(\omega t - kx)} = \frac{\delta p_i}{\rho_1 c_1} e^{j(\omega t - kx)}$$

$$u_r = \delta v_r = -\frac{\tilde{R}}{\rho_1 c_1}\delta p_i e^{j(\omega t + kx)}$$

$$u_t = \delta v_t = \frac{\tilde{T}\,\delta p_i}{\rho_2 c_2} e^{j(\omega t - kx)}$$

$$\cancel{\delta p_i}(1 + \tilde{R}) = \tilde{T}\,\cancel{\delta p_i}$$

$$\frac{\cancel{\delta p_i}}{\rho_1 c_1}(1 - \tilde{R}) = \tilde{T}\,\frac{\cancel{\delta p_i}}{\rho_2 c}$$

$$\frac{\frac{r_2}{r_1}(1 - \tilde{R})}{1 + \tilde{R}} = \frac{\tilde{T}}{\tilde{T}}$$

$$r_1(1 + \tilde{R}) = r_2(1 - \tilde{R})$$

$$(r_1 + r_2)\tilde{R} = r_2 - r_1$$

$$\tilde{R} = \frac{r_2 - r_1}{r_2 + r_1}$$

$$\tilde{T} = 1 + \tilde{R} = \frac{r_2 + r_1}{r_2 + r_1} + \frac{r_2 - r_1}{r_2 + r_1} = \frac{2r_2}{r_2 + r_1}$$

a. $\rho_1 c_1 = 1.5\times10^6 \frac{Pa\text{-}s}{m} = r_1$

$\rho_2 c_2 = 410 \frac{Pa\text{-}s}{m} = r_2$

$$\tilde{T} = \frac{2(410\ \cancel{Pa\text{-}s/m})}{(1.5\times10^6 + 410)\ \cancel{Pa\text{-}s/m}}$$

$$= \boxed{5.46\times10^{-4}}$$

$$I_i = \frac{\delta p_i^2}{\rho_1 c_1} \qquad I_r = \frac{|\tilde{R}|^2 \delta p_i^2}{\rho_1 c_1} \qquad I_t = \frac{|\tilde{T}|^2 \delta p_i^2}{\rho_2 c_2}$$

$$T_I = \frac{|\tilde{T}|^2 r_1}{r_2} = \frac{(5.46\times10^{-4})^2(1.5\times10^6)}{410} = \boxed{1.09\times10^{-3}}$$

b. $\rho_1 c_1 = 410 \frac{P\text{-}s}{m} = r_1$

$\rho_2 c_2 = 1.5\times10^6 \frac{P\text{-}s}{m} = r_2$

$$\tilde{T} = \frac{2(1.5\times10^6 \frac{P\text{-}s}{m})}{(1.5\times10^6 + 410 \frac{P\text{-}s}{m})} = \boxed{1.99}$$

$$T_I = \frac{(1.99)^2(410 \cancel{\frac{P\text{-}s}{m}})}{1.5\times10^6 \cancel{\frac{P\text{-}s}{m}}} = \boxed{1.09\times10^{-3}}$$

c. WATER → AIR

$\Delta SPL = 20 \log(5.46\times10^{-4}) = -65$ dB

$\Delta IL = 10 \log(1.09\times10^{-3}) = -30$ dB

AIR → WATER

$\Delta SPL = 20 \log(1.99) = +5.98$

$\Delta IL = -30$ dB

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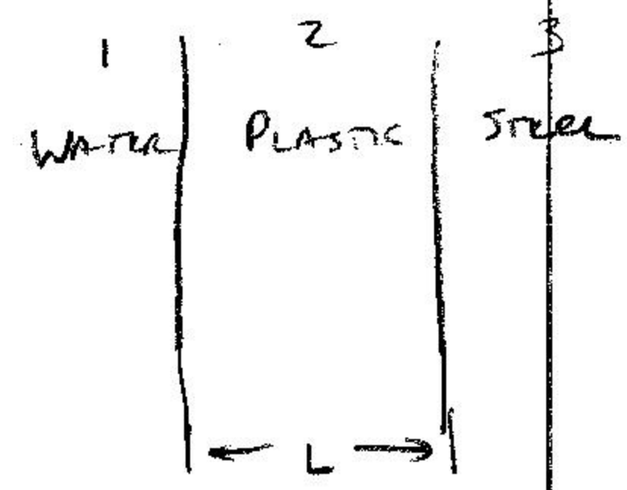
6.4. GIVEN: $R_I = 0$

6.3.2 $\rho_2 = 1500\ kg/m^3$

$f = 20\ kHz$



FIND L, c_2

R_I FOR INFINITE PLASTIC

$$r_2 = \sqrt{r_1 r_3} = \sqrt{(1.5\times10^6)(47\times10^6)}$$

$$r_2 = \sqrt{70.5\times10^{12}} = 8.396\times10^6 = \left(1500\ \frac{kg}{m^3}\right) c_2$$

$$c = \boxed{5600\ m/s}$$

$$f = \frac{c_2}{4L} \Rightarrow L = \frac{c_2}{4f} = \frac{5598\ m/s}{(4)(20\times10^3\ 1/s)}$$

$$\boxed{L = 0.07\ m}$$

$$R_I = |\tilde{R}|^2 = \left(\frac{r_2 - r_1}{r_2 + r_1}\right)^2 = \left(\frac{8.396\times10^6 - 1.5\times10^6}{8.396\times10^6 + 1.5\times10^6}\right)^2$$

$$= \left(\frac{6.896\times10^6}{9.896\times10^6}\right)^2 = \boxed{0.49}$$

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6.7 $\tilde{R} = \dfrac{r_2 - r_1}{r_2 + r_1} = \dfrac{\rho_2 c_2 - \rho_1 c_1}{\rho_2 c_2 + \rho_1 c_1}$ NORMAL

6.4.1

a. $c_2 = c_1 \qquad \rho_2 > \rho_1$

$$\tilde{R} = \frac{\cancel{c}(\rho_2 - \rho_1)}{\cancel{c}(\rho_2 + \rho_1)} = \frac{\rho_2 - \rho_1}{\rho_2 + \rho_1}$$

$\mathrm{Im}(\tilde{R}) = 0, \qquad \phi = 0, \qquad \tilde{R} = \text{CONST}$

OBLIQUE

$$\tilde{R} = \frac{\dfrac{r_2}{\cos\theta_2} - \dfrac{r_1}{\cos\theta_1}}{\dfrac{r_2}{\cos\theta_2} + \dfrac{r_2}{\cos\theta_2}}$$

$$\frac{\sin\theta_i}{c_1} = \frac{\sin\theta_t}{c_2} \Rightarrow \theta_i = \theta_t$$

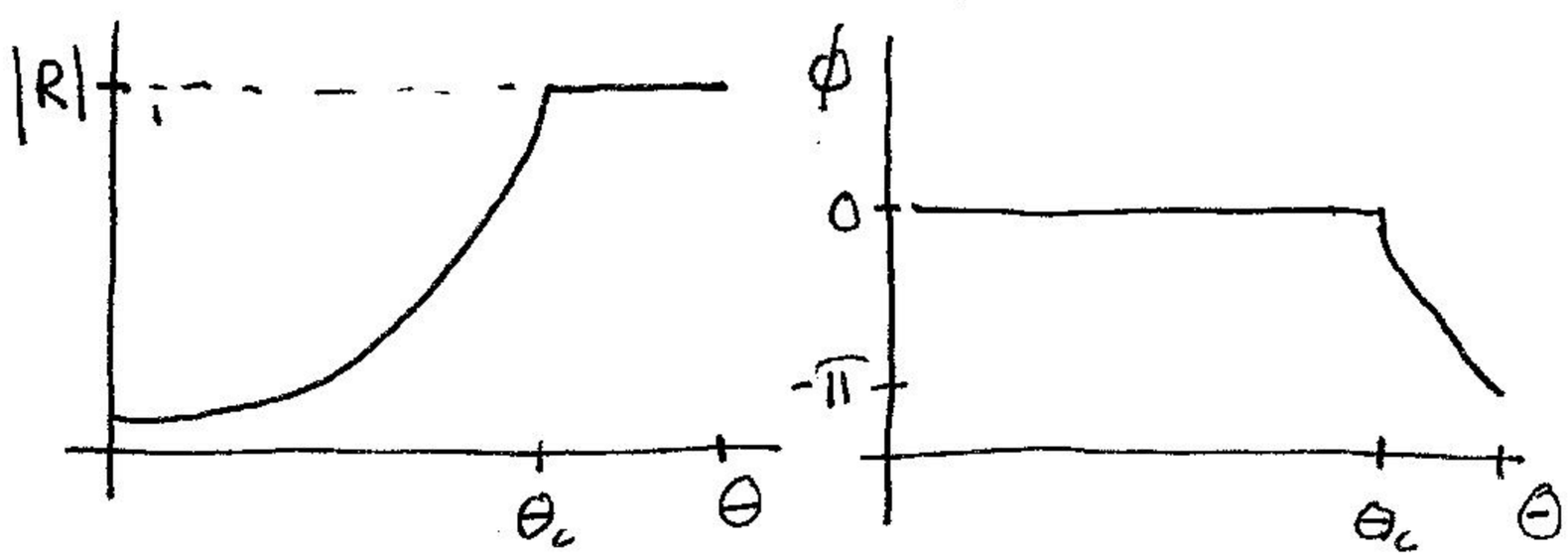
$$\tilde{R} = \frac{\dfrac{\rho_2 c_2}{\cos\theta_2} - \dfrac{\rho_1 c_1}{\cos\theta_1}}{\dfrac{\rho_2 c_2}{\cos\theta_2} + \dfrac{\rho_1 c_1}{\cos\theta_1}} = \boxed{\frac{\rho_2 - \rho_1}{\rho_2 + \rho_1}}$$

REAL

$|R| = \text{CONST}$

$\phi = 0$

b. $\rho_2 = \rho_1 \qquad c_2 > c_1 \qquad r_2 > r_1$



$\rho c_1 = 1.5 \times 10^6 \frac{Pa\text{-}s}{m}$

6.10 $\delta P_{rms} = 100\ Pa$ $\rho_1 = 1000\ kg/m^3$, $c_1 = 1500\ m/s$

6.4.4 $\theta_i = 45°$ $\rho_2 = 2000\ kg/m^3$, $c_2 = 1000\ m/s$

$\rho_2 c_2 = 2 \times 10^6 \frac{Pa\text{-}s}{m}$

F. θ_t, $\delta P_{t\,peak}$, $\delta P_{r\,peak}$, R_Π

a. $$\frac{\sin\theta_i}{c_1} = \frac{\sin\theta_t}{c_2}$$

$$\frac{c_2}{c_1}\sin\theta_i = \frac{\cancel{1000}^{\,2}}{\cancel{1500}_{\,3}}\sin 45 = \sin\theta_t = .4714$$

$$\theta_t = \boxed{28.1°}$$

b. $$\tilde{R} = \frac{\frac{r_2}{\cos\theta_i} - \frac{r_1}{\cos\theta_t}}{\frac{r_2}{\cos\theta_2} + \frac{r_t}{\cos\theta_1}} = \frac{\frac{2\times\cancel{10^6}}{\cos 28.1} - \frac{1.5\times\cancel{10^6}}{\cos 45}}{\frac{2\times\cancel{10^6}}{\cos 28.1} + \frac{1.5\times\cancel{10^6}}{\cos 45}}$$

$$= \frac{2.267 - 2.122}{2.267 + 2.122} = \frac{.145}{4.389} = .033$$

$$\tilde{R} + 1 = \tilde{T} = 1.033$$

$$\delta\tilde{P}_t = 1.033 \quad 100\ Pa = \boxed{103.3\ Pa}$$

c. $$\delta P_{r\,peak} = .033 \quad 100\ Pa = \boxed{3.3\ Pa}$$

d $$R_\Pi = |\tilde{R}|^2 = \boxed{.00109}$$

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6.11 $\delta P_{RMS} = 100\ Pa$ $\rho_2 = 2000\ kg/m^3$

6.4.5 NORMAL INC $c_2 = 2000\ m/s$

$r_2 = 4 \times 10^6\ \frac{Pa \cdot s}{m}$

F: δP_r, δP_t, R_π, θ_{min} – ALL ENERGY REF.

$$\tilde{R} = \frac{r_2 - r_1}{r_2 + r_1} = \frac{4 - 1.5}{4 + 1.5} = \frac{2.5}{5.5} = .45\overline{45}$$

$$P_r = \delta P_r = \boxed{45.45\ Pa}$$

$$\tilde{T} = 1 + \tilde{R} = 1.4545$$

$$P_t = \delta P_t = \boxed{145.45\ Pa}$$

$$R_\pi = |R|^2 = \boxed{.2066}$$

$$\frac{\sin\theta_1}{c_1} = \frac{\cancel{\sin\theta_2}^{\,1}}{c_2}$$

$$\sin\theta_1 = \frac{c_1}{c_2} = \frac{1500}{2000} = \frac{3}{4}$$

$$\theta_1 = \boxed{48.6^\circ}$$

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