ME 573 Session 22 10/11/19

Decibels

$$L_p = 10\log_{10}\frac{p_{rms}^2}{p_{ref}^2} \quad \text{dB re } 20\,\mu Pa$$

$$= 20\log_{10}\frac{p_{rms}}{p_{ref}}$$

$$L_I = 10\log_{10}\frac{I}{I_{ref}} \qquad 1\times10^{-12}\ W/m^2$$

$$L_W = 10\log_{10}\frac{W}{W_{ref}} \qquad W_{ref} \quad 1\times10^{-12}\ \text{Watts}$$

$$70 + 70 \neq 140$$

<u>Adding decibels</u>

- add the corresponding mean square pressures (or Intensities or Sound Powers)
  - under the assumption the signals are statistically uncorrelated

1 L_{p_1}

2 L_{p_2}

$$L_p = 10 \log_{10} \frac{p_{rms}^2}{p_{ref}^2}$$

$$(p_{rms}^2)_1 = p_{ref}^2 \, 10^{L_{p_1}/10}$$

$$(p_{rms}^2)_2 = p_{ref}^2 \, 10^{L_{p_2}/10}$$

$\vdots$

$$(p_{rms}^2)_{total} = (p_{rms_1}^2) + (p_{rms_2}^2) + \ldots\ldots$$

$$L_{p_{total}} = 10\log_{10} \frac{(P^2_{rms})_{total}}{P^2_{ref}}$$

$L_{p_1} = 70\ dB$

$+$

$L_{p_2} = 55\ dB$

≈ 70

$$\begin{array}{r} 73 \\ 72 \\ \hline 75 \end{array}$$

<u>Section 3</u>

Development of The wave eqn

- assumptions - linear

eqn of state
eqn of continuity
<u>eqn of motion</u>

2nd order PDE

linearized momentum eqn

pressure field → particle velocity

One-dimensional solutions

- plane waves $|p| \neq f(x)$
- cylindrical $|p| \propto \frac{1}{r^{1/2}}$
- spherical $|p| \propto \frac{1}{r}$

specific Acoustic Impedance

$\tilde{z} = \frac{\tilde{p}}{\tilde{u}}$ $\hat{u} = \frac{\tilde{p}}{\tilde{z}}$

Intensity - direction & magnitude

- time-averaged product of
$\tilde{p}$ & $\tilde{u}$

$\bar{I} = \frac{1}{2} Re\{\tilde{p}\, \tilde{\vec{u}}^*\}$ W/m^2

integrate over an area

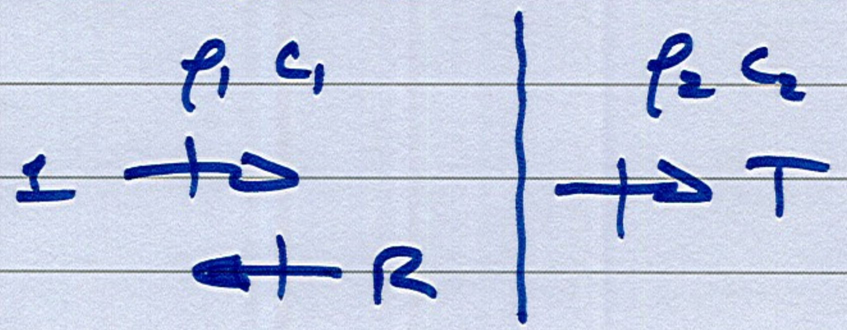
W - sound power

4.0 Fundamentals of Reflection + Transmission

Chapter 6

4.1 Introduction

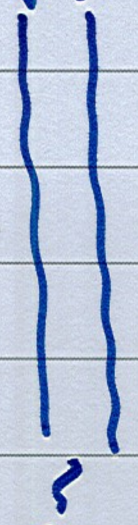
① sound in a semi-infinite medium hitting a second semi-infinite medium



Finite depth intermediate layer

(2)

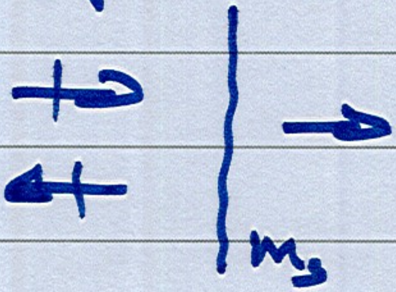
$\rho_1 c_1$



$\rho_3 c_3$

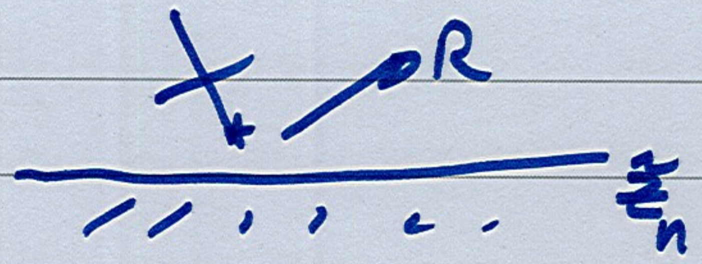
$\rho_2 c_2$

(3) Sound transmission through a limp barrier



- mass law

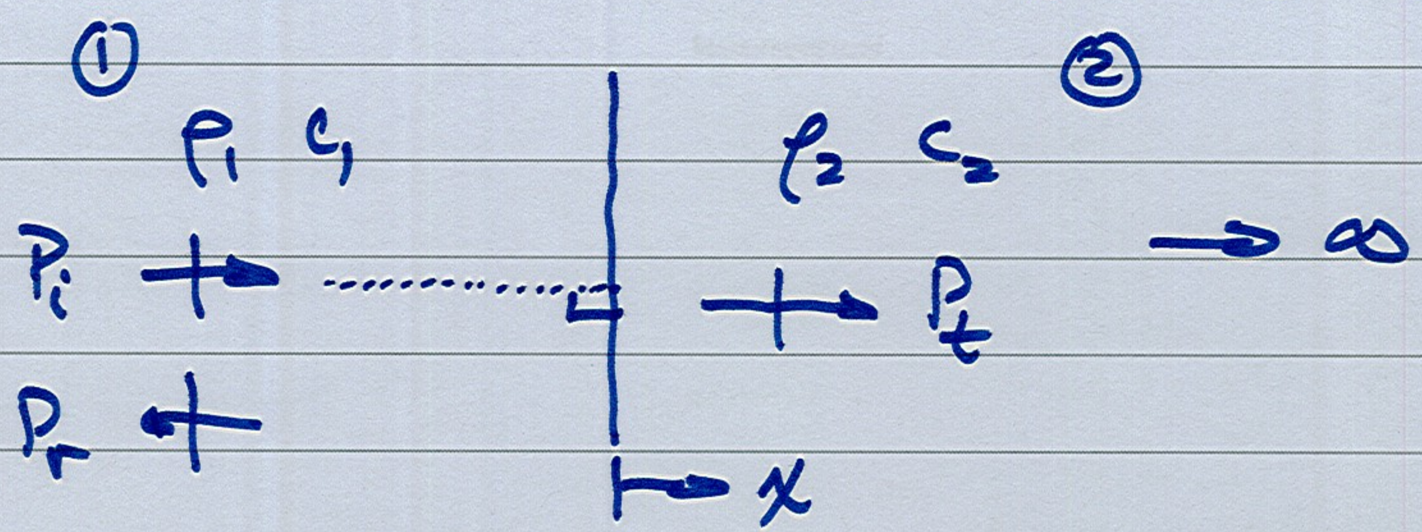
4 Sound reflection from an impedance surface



<u>Applications</u>

- transmission
    - aircraft fuselage
    - ships
    - walls
    - control rooms
    - dash panels

4.2 Normal Incidence Reflection and Transmission (two fluid)



$\nabla^2 \hat{p}_1 + k_1^2 \hat{p}_1 = 0$ $\qquad$ $\nabla^2 \hat{p}_2 + k_2^2 \hat{p}_2 = 0$

$k_1 = \dfrac{\omega}{c_1}$ $\qquad$ $k_2 = \dfrac{\omega}{c_2}$

$\hat{p}_1 = P_i e^{-ik_1 x} + P_r e^{+ik_1 x}$

$\hat{p}_2 = P_t e^{-ik_2 x}$

$$\tilde{u}_1 = \frac{P_i}{\rho_1 c_1} e^{-ik_1 x} - \frac{P_r}{\rho_1 c_1} e^{+ik_1 x}$$

$$\tilde{u}_2 = \frac{P_t}{\rho_2 c_2} e^{-ik_2 x}$$

3 constants P_i, P_r, P_t — 2 b.c.'s

normalize wrt P_i

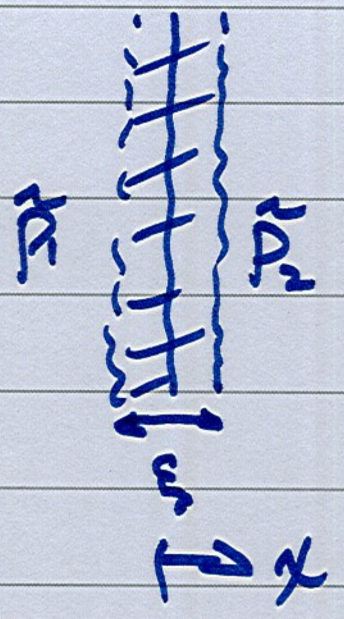
$$\frac{P_r}{P_i} = R \qquad \frac{P_t}{P_i} = T$$

plane wave pressure reflection coefficient

plane wave pressure transmission coef.

(i) <u>Pressure Continuity Eqn</u>

①



② $m_s = \rho_1 \frac{\xi}{2} + \rho_2 \frac{\xi}{2}$

$$\tilde{p}_1 - \tilde{p}_2 = m_s \tilde{a}$$

m_s: mass/unit area of fluid layer of depth ξ

$$\tilde{a} = \frac{\tilde{p}_1 - \tilde{p}_2}{m_s}$$

let $\xi \to 0$ $\quad m_s \to 0$

$\underline{\tilde{p}_1 = \tilde{p}_2}$ avoids infinite accelerations