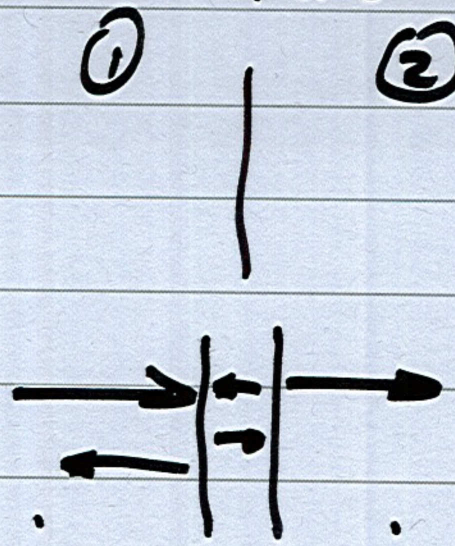
HW3 soln's posted

Nov 1 Mid-term

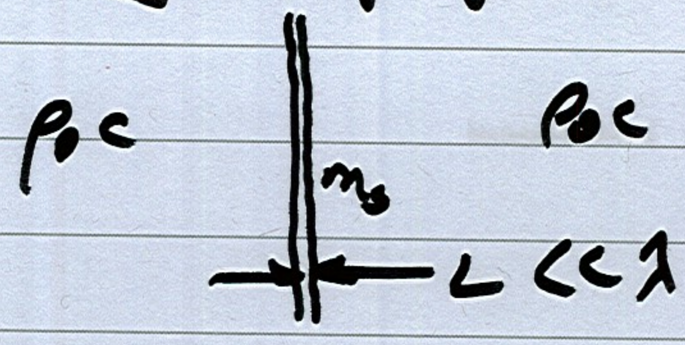
Sections 1 - 3

Reflection & Transmission



Sonar Dome

Thin, heavy lump panel



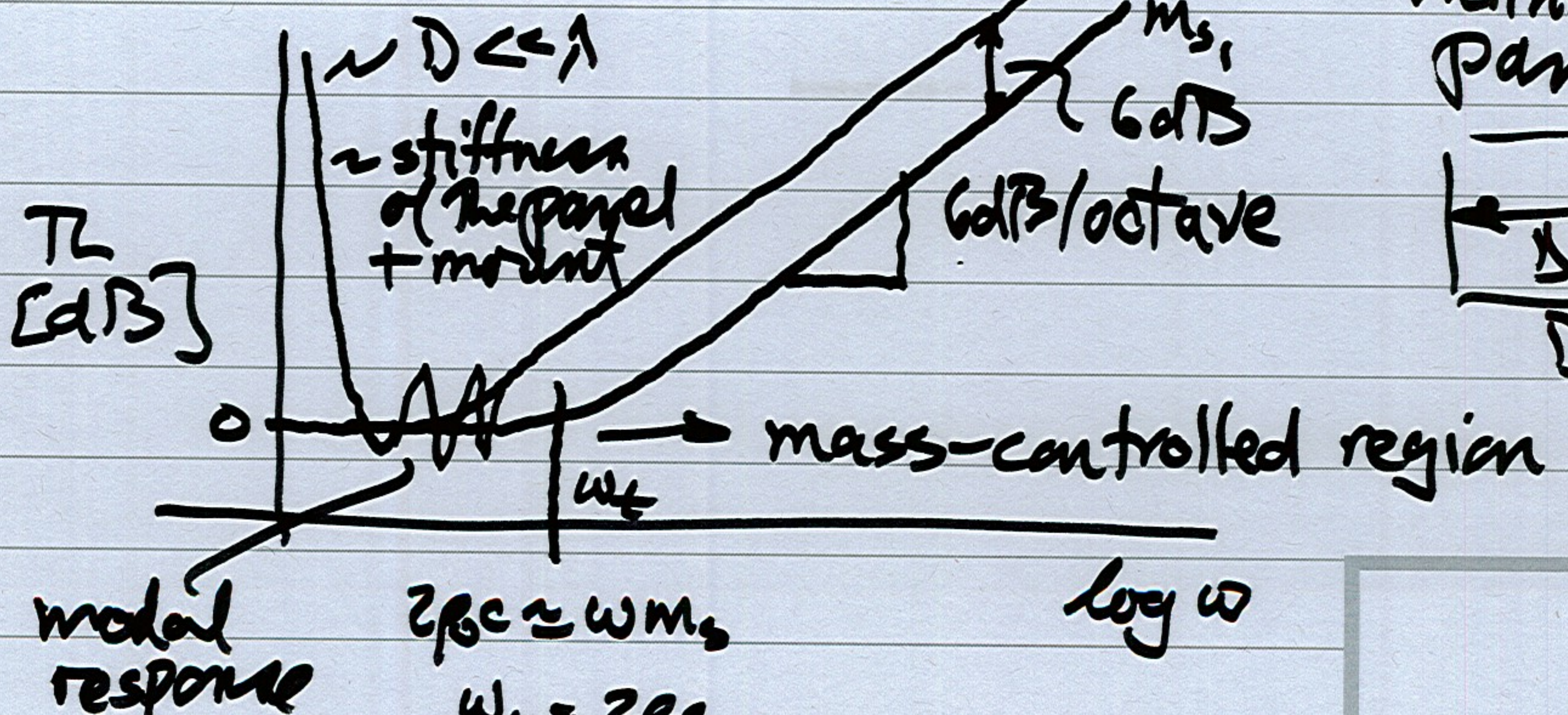
$\rho_2 c_2 \gg \rho_0 c$

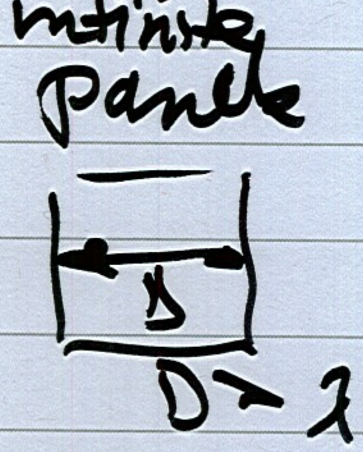
$$T = \frac{2\rho_0 c\, e^{+jkL}}{2\rho_0 c + j\omega m_s}$$

$T \propto \frac{1}{m_s} \propto \frac{1}{\omega}$ mass law

$$TL = 10\log_{10}\frac{1}{|T|^2} \text{ dB}$$

$$T = \frac{2\rho_0 c\, e^{+ikL}}{2\rho_1 c + j\omega m_s}$$



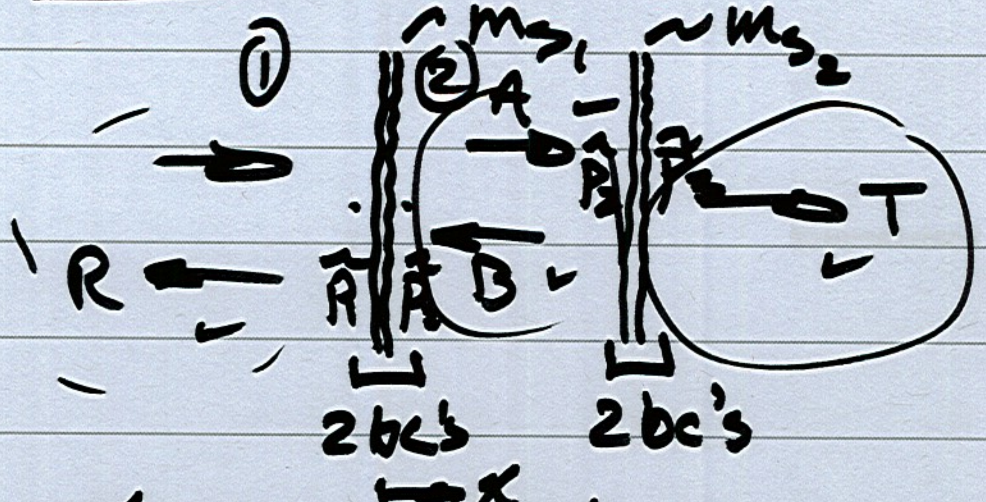


$2\rho_0 c \simeq \omega m_s$

$$\omega_t = \frac{2\rho_0 c}{m_s}$$

- if panels large compared to λ, can be modeled as infinite

Double Panels



b.c.'s

(i) Velocity b.c.

$\hat{u}_{1n} = \hat{u}_{2n}$ at $x=0$

(ii) $\hat{p}_1 - \hat{p}_2 = m_s \frac{d\hat{u}_{1n}}{dt}$

$= j\omega m_s \hat{u}_{1n}$

4 eqns 4 unknowns

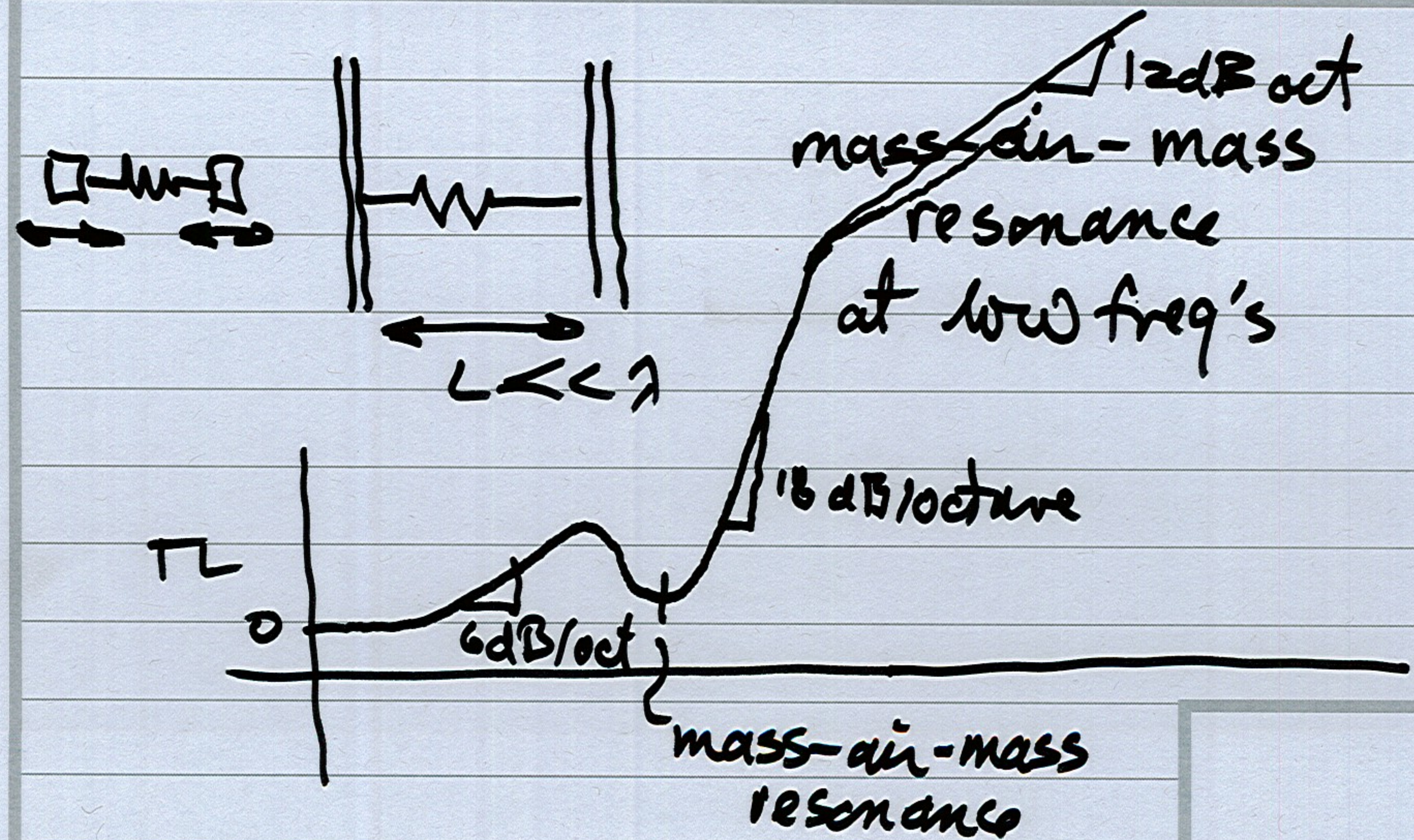
~ absorbing interior layer
– glass fiber

30 dB + 30 dB + 6 dB

De-coupled

Double panel $TL \simeq TL_1 + TL_2 + 6\,dB$

single panel – double the mass 30 dB → 36 dB



L << λ
TL
0
6dB/oct
18 dB/octave
12dB oct
mass-air-mass resonance at low freq's
mass-air-mass resonance

4.2.3 Relation to Acoustic Intensity

Pressure: $R = \frac{P_r}{P_i} = \frac{\zeta_{21} - 1}{\zeta_{21} + 1}$ $\quad \zeta_{21} = \frac{\rho_2 c_2}{\rho_1 c_1}$

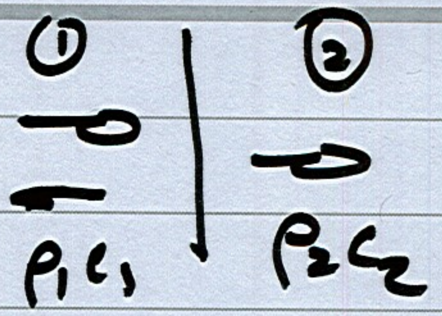
$$T = \frac{P_t}{P_i} = \frac{2\zeta_{21}}{\zeta_{21} + 1}$$

Intensity coefficients $R_I = \frac{I_r}{I_i}$ $\quad T_I = \frac{I_t}{I_i}$

plane waves freely propagating $\quad I = \frac{P_{rms}^2}{\rho c}$

Harmonic case $P_{rms}^2 = \frac{\tilde{P}\tilde{P}^*}{2} = \frac{|\hat{P}|^2}{2}$

Two Fluid Case



$$R_I = \frac{I_r}{I_i} = \frac{\dfrac{(p^2_{rms})_r}{\rho_1 c_1}}{\dfrac{(p^2_{rms})_i}{\rho_1 c_1}} = \frac{(p^2_{rms})_r}{(p^2_{rms})_i} = |R|^2 = R_I$$

$$T_I = \frac{I_t}{I_i} = \frac{\dfrac{(p^2_{rms})_t}{\rho_2 c_2}}{\dfrac{(p^2_{rms})_i}{\rho_1 c_1}} = \frac{\rho_1 c_1}{\rho_2 c_2} |T|^2$$

$$= \frac{1}{\zeta_{21}} |T|^2 = T_I$$

$$\zeta_{21} = \frac{\rho_2 c_2}{\rho_1 c_1}$$

Air ① | Water ②

$P_i \rightarrow$ | $\rightarrow P_t$ T

$P_r \leftarrow$ R

$\rho_2 c_2 >> \rho_1 c_1$ $\quad \zeta_{21} \rightarrow \infty$

$|T| = 2$ $\quad T_I = 0$

$|R| = \frac{1}{3}$ $\quad R_I = \frac{1}{1}$

water | air

$P_i \rightarrow$ | $\rightarrow P_t$

$P_r \leftarrow$ $\quad P = 0$

$\rho_1 c_1 >> \rho_2 c_2$ $\quad \zeta_{21} \rightarrow 0$

$|T| = 0$ $\quad T_I = 0$

$|R| = \frac{1}{1}$ $\quad R_I = \frac{1}{1}$

Hard to transmit acoustic energy across a large impedance difference

$R_I + T_I = 1$

energy conservation statement

Generally $T + R \neq 1$

but it's always true

$$R_I + T_I = 1$$

$$T = \frac{2 S_{21}}{S_{21} + 1} \qquad R = \frac{S_{21} - 1}{S_{21} + 1}$$

$$T_I = \frac{1}{S_{21}} |T|^2 \qquad R_I = |R|^2$$