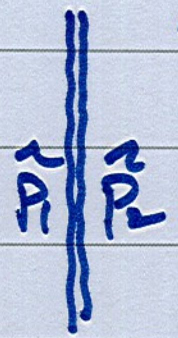
ME 613

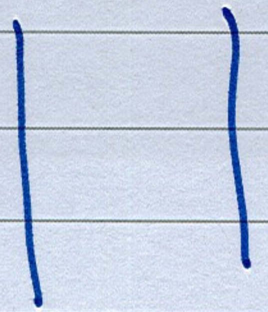
Reflection & Transmission



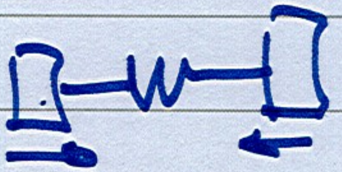
Thin limp panel

- mass law

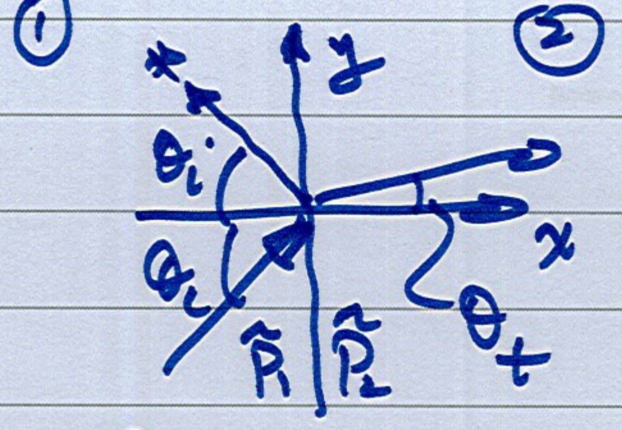
Double Panels



- much more weight efficient
  - mass-air-mass



4.4. Reflection Coefficient → z_n



$$\tilde{P}_1 = \tilde{P}_2$$
$$\tilde{u}_{1x} = \tilde{u}_{2x}$$

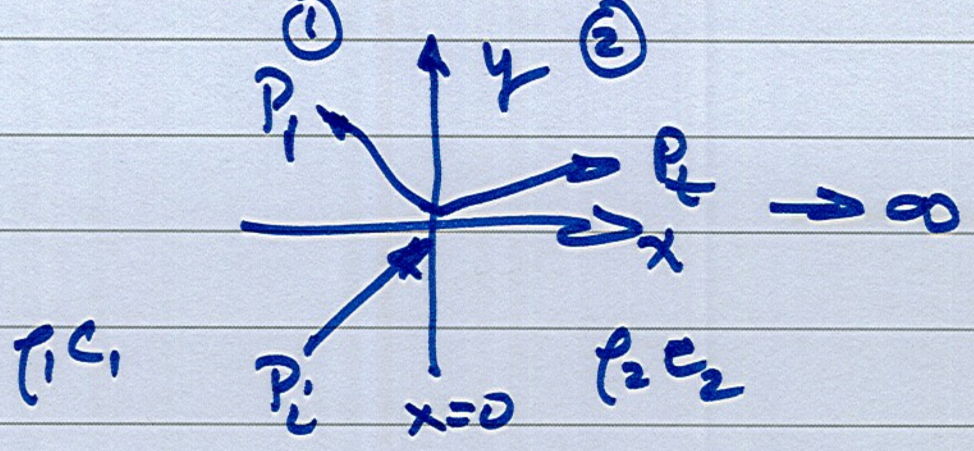
at $x = 0$

$$\frac{\tilde{P}_1}{\tilde{u}_{1x}} = z_{2n}$$

surface specific normal impedance

Impedance B.C.

Example: 2 fluid case - what is z_{2n}?



$$\hat{p}_2\Big|_{x=0} = p_t e^{-jk_{2y}y}$$

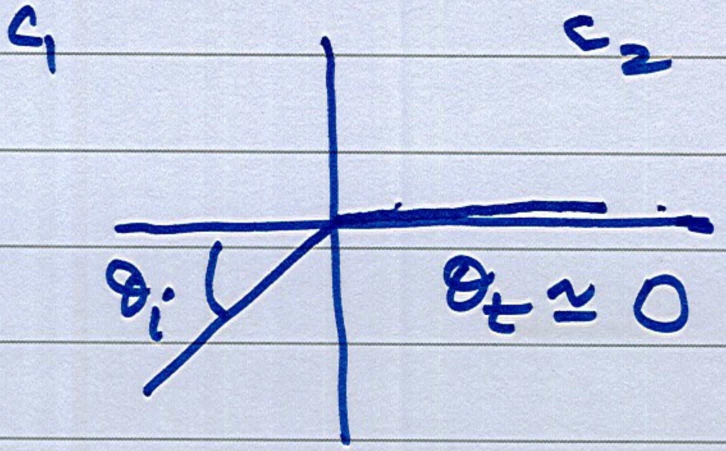
$$\hat{u}_{2x}\Big|_{x=0} = \frac{p_t}{\rho_2 c_2}\cos\theta_t\, e^{-jk_{2y}y}$$

$$z_{2n}\Big|_{x=0} = \frac{\hat{p}_2}{\hat{u}_{2x}}\Big|_{x=0} = \frac{\rho_2 c_2}{\cos\theta_t}$$

$$= \frac{\rho_2 c_2}{\sqrt{1-\left(\frac{c_2}{c_1}\right)^2 \sin^2\theta_i}}$$

specific surface normal impedance for a semi-infinite fluid medium

$c_2 \ll c_1$



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

$$z_{2n} = \frac{\rho_2 c_2}{\sqrt{1 - \underbrace{\left(\frac{c_2}{c_1}\right)^2 \sin^2\theta_i}_{\text{negligible}}}}$$

$z_{2n} \simeq$ independent of angle of incidence

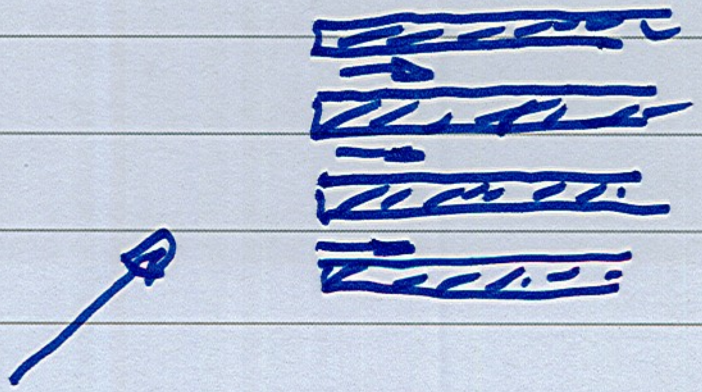
$= \rho_2 c_2$

Definition of a surface of <u>local reaction</u>

Local Reaction

- happens when the second medium is slow $c_2 << c_1$

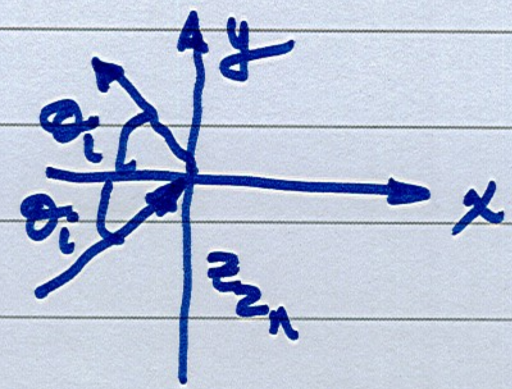
- because of the physical structure of the second medium.



* continuity of surface normal impedance is true regardless of the complexity of the second medium whether or not the medium is locally reacting

can R be found if z_{2n} is known?

$$\left.\frac{\tilde{p}_1}{\tilde{u}_{1x}}\right|_{x=0} = z_{2n}$$



$$\tilde{p}_1\big|_{x=0} = P_i e^{-ik_{1y}y} + P_r e^{-ik_{1y}y}$$

$$\tilde{u}_{1x}\big|_{x=0} = \frac{P_i}{\rho_1 c_1}\cos\theta_i e^{-ik_{1y}y} - \frac{P_r}{\rho_1 c_1}\cos\theta_i e^{-ik_{1y}y}$$

$$z_{1n} = \frac{\tilde{p}_1}{\tilde{u}_{1x}} = \frac{P_i + P_r}{\frac{P_i}{\rho c_1}\cos\theta_i - \frac{P_r}{\rho_1 c}\cos\theta_i} \qquad \div P_i$$

$$\frac{P_r}{P_i} = R$$

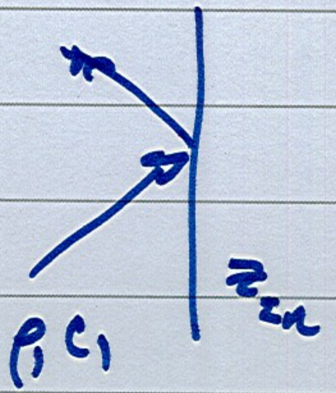
$$= \frac{1 + R}{\frac{\cos\theta_i}{\rho_1 c_1} - R\frac{\cos\theta_i}{\rho_1 c_1}}$$

$$= \frac{1 + R}{\frac{\cos\theta}{\rho_1 c_1}(1 - R)} = z_{2n}$$

← assumed known

solve for R

$$R = \frac{\zeta_{2n}\cos\theta_i - 1}{\zeta_{2n}\cos\theta_i + 1}$$



$$\zeta_{2n} = \frac{Z_{2n}}{\rho c_1}$$

plane wave reflection coefficient of a surface having known Z_{2n}

$$\alpha = 1 - |R|^2$$

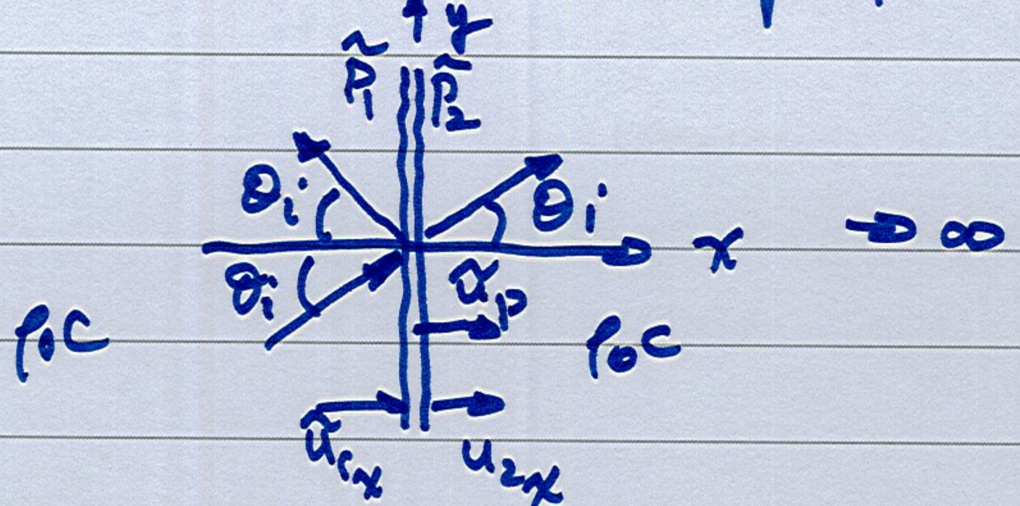
Absorption Coefficient

- Fraction of the incident energy absorbed at a surface

Z_{2n}:

- experiment
- ~~the~~ Theory
- numerically

Example: Thin limp panel



at $x=0$ $\quad \tilde{p}_1 - \tilde{p}_2 = j\omega m_s \tilde{u}_p$ $\quad$ harmonic case

$$\tilde{u}_p = \tilde{u}_{1x}\big|_{x=0}$$

$$= \tilde{u}_{2x}\big|_{x=0}$$

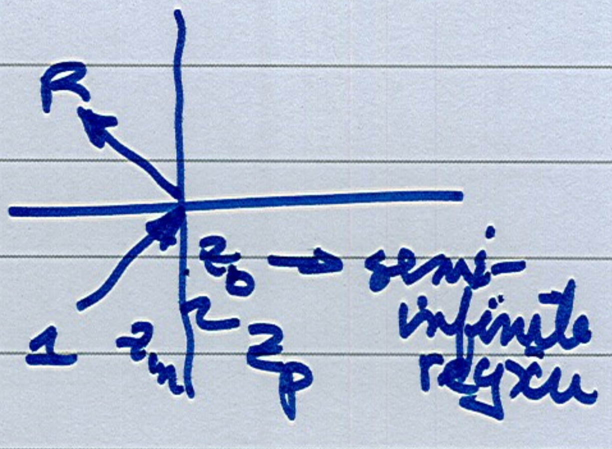
$$\tilde{p}_1 = j\omega m_s \tilde{u}_{1x} + \tilde{p}_2$$

$\div \tilde{u}_{1x}$

$$\frac{\tilde{p}_1}{\tilde{u}_{1x}} = j\omega m_s + \frac{\tilde{p}_2}{\tilde{u}_{2x}}$$

$$= j\omega m_s + z_b$$

$$= z_p + z_b$$ series addition of impedances



z_p = $\frac{\tilde{p}_1 - \tilde{p}_2}{\tilde{u}_p}$ = in vacuo specific mechanical transfer impedance of the panel

z_b = specific surface normal impedance of the backing space

* Add z's in series – because particle velocity is shared

Notes:

(i) For ~~complex~~ complex systems, z_n can be found by measurement or <u>Theory</u>

(ii) When z_n is independent of angle of incidence – surface of "local reaction"

- occurs when $c_2 << c_1$ or when θ_t is forced to be 0 by physical nature of surface

(iii). z_n is normally complex $z_n = r_n + i x_n$