ME 513 Session 27 10/27/15

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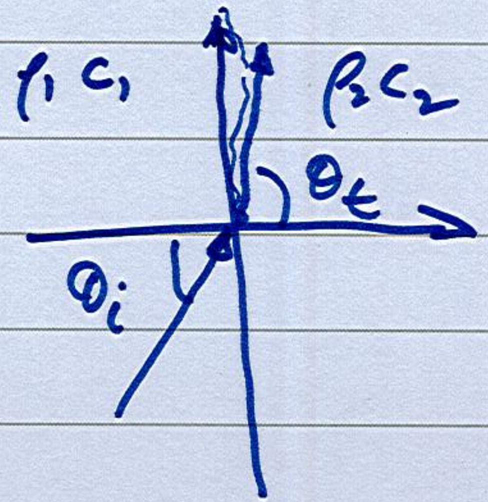
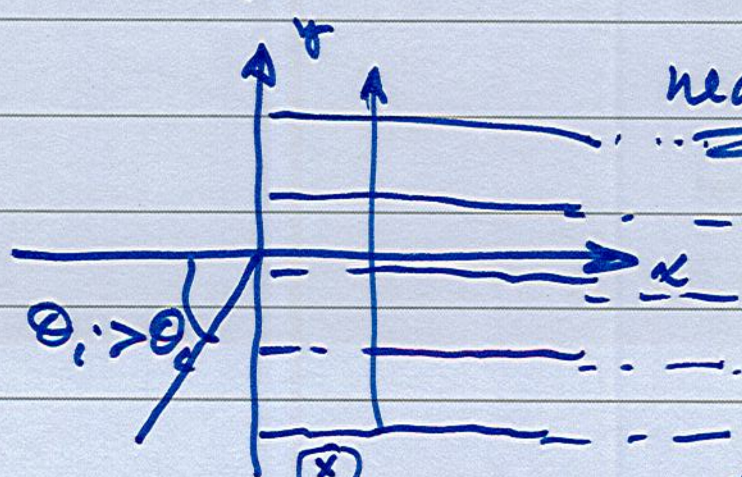


$c_2 > c_1$

$\theta_t > \theta_i$

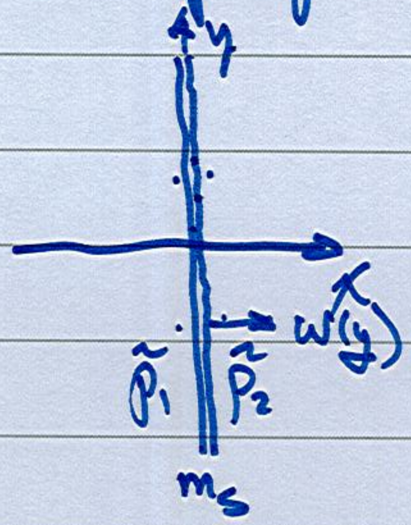
$\theta_i = \theta_c \quad \theta_t \to \frac{\pi}{2}$



nearfield

× → exponential decay

Thin limp panel

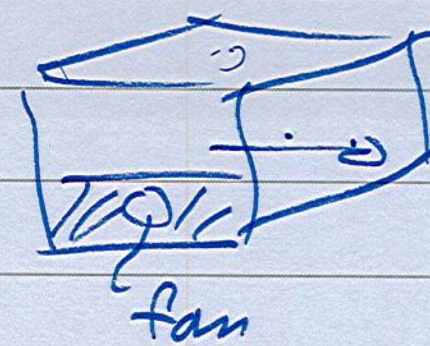


$$(\hat{p}_1 - \hat{p}_2)_{x=0} = m_s \frac{\partial \hat{u}_{1x}}{\partial t}\Big|_{x=0}$$

$$= j\omega m_s \hat{u}_{1x}\big|_{x=0}$$

$$= j\omega m_s \hat{u}_{2x}\big|_{x=0}$$

$$T = \frac{\frac{2\rho_0 c}{\cos\theta}}{\frac{2\rho_0 c}{\cos\theta} + j\omega m_s}$$

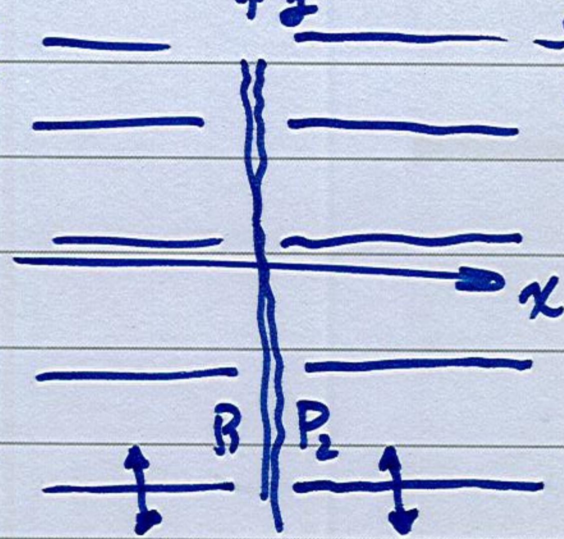


$\underline{m_s \to 0}$ $\quad$ $\underline{T \to 1}$

$m_s \to$ large $\quad T \to \frac{2\rho_0 c}{\cos\theta} \frac{1}{j\omega m_s}$

Grazing Incidence

$\theta_i \to \frac{\pi}{2}$

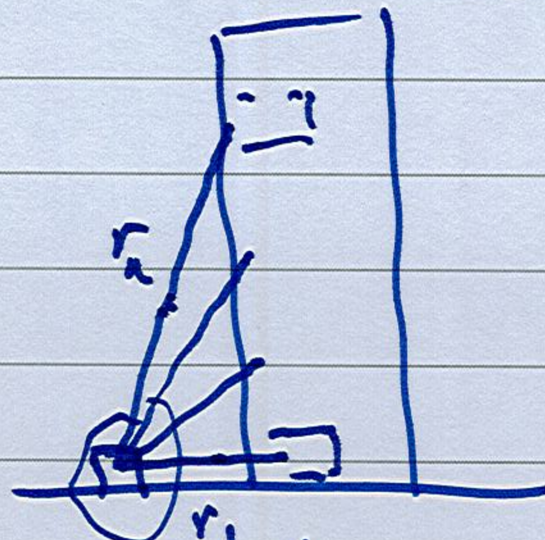


$\cos\theta \to 0$

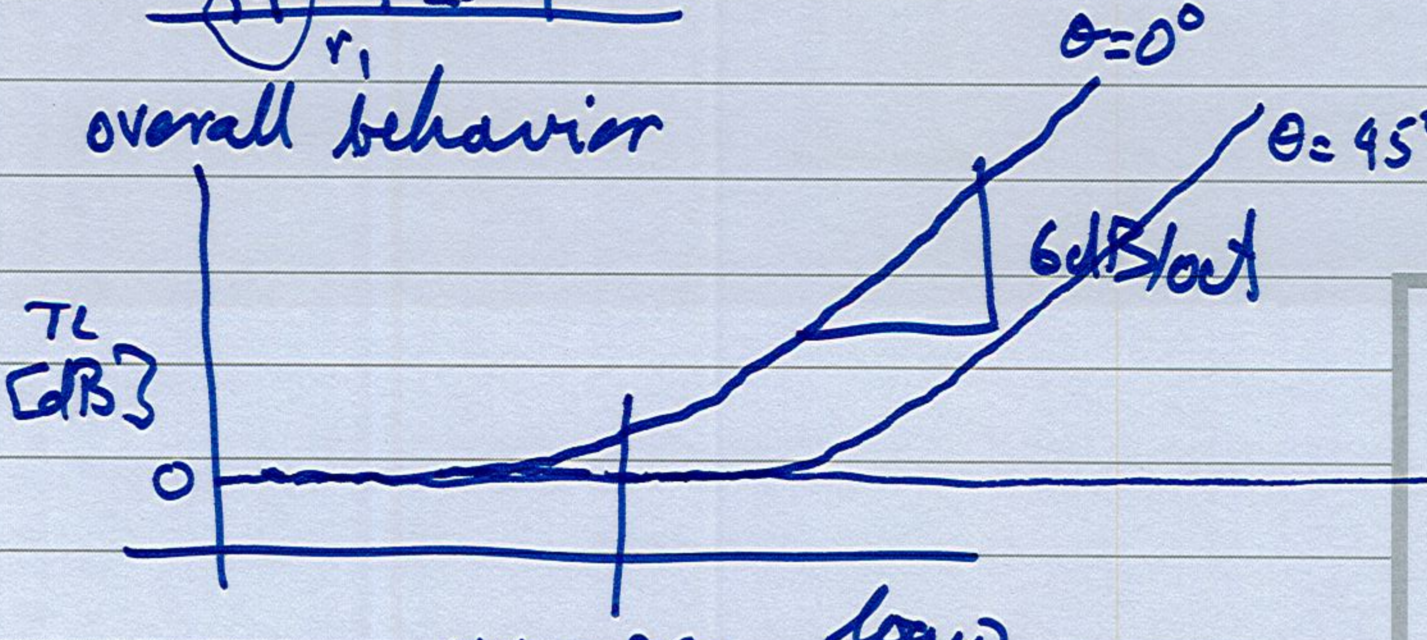
$T \to 1$ $\qquad R \to 0$

$P_1 = P_2$

transmission loss at grazing is always low

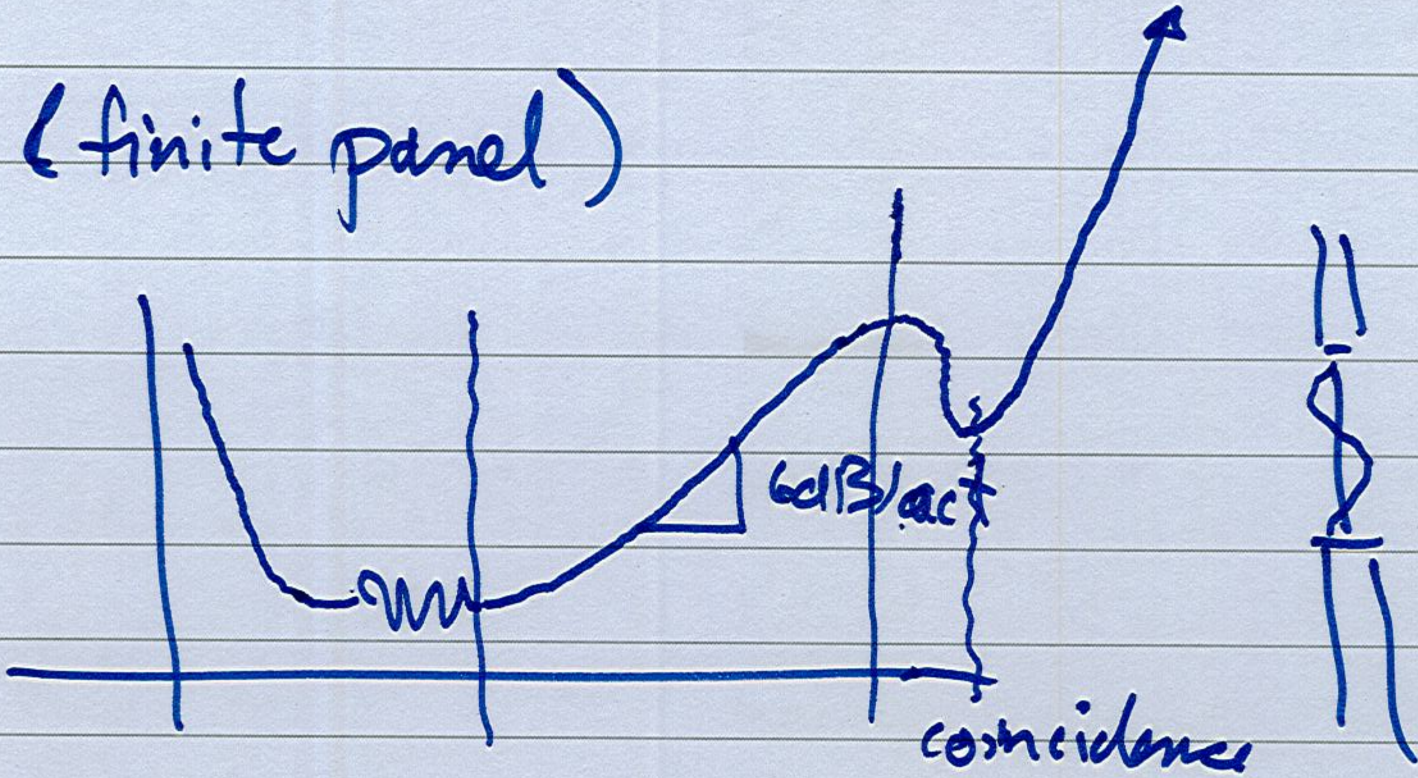


overall behavior



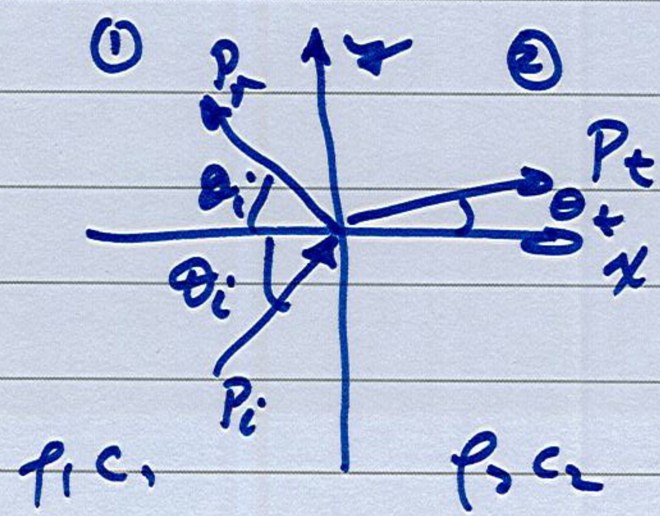
$$\frac{\omega m_s}{\xi} = \frac{2\rho c}{\cos\theta}$$

(finite panel)



4.4 Reflection coefficient calculations by using surface normal impedance.

Recall the two fluid case



- assume solutions
- two b.c.'s
  - pressure
  - velocity

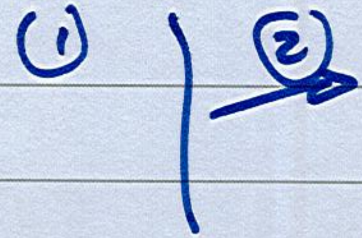
at $x = 0$ $\quad \dfrac{\hat{p}_1}{\hat{u}_{1x}} = \dfrac{\hat{p}_2}{\hat{u}_{2x}}$ Impedance is continuous

Define $\left.\frac{\tilde{p}_1}{\tilde{u}_{1x}}\right|_{x=0} = z_{1n}$ specific surface <u>normal</u> <u>impedance</u>

$$= z_{2n} = \left.\frac{\tilde{p}_2}{\tilde{u}_{2x}}\right|_{x=0}$$

$$\underbrace{\left.\frac{\hat{p}_1}{\tilde{u}_{1x}}\right|_{x=0} = z_{2n} \text{ known}}_{\text{Impedance B.C}}$$

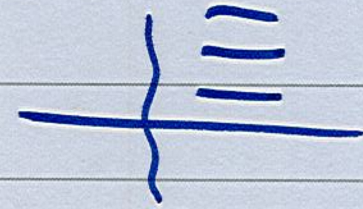
Example: two-fluid case - what is z_{2n}?



$$\tilde{p}_2\big|_{x=0} = P_t e^{-jk_{ty}y}$$

$$\tilde{u}_{2x}\big|_{x=0} = \frac{P_t}{\rho_2 c_2}\cos\theta_t e^{-jk_{ty}y}$$

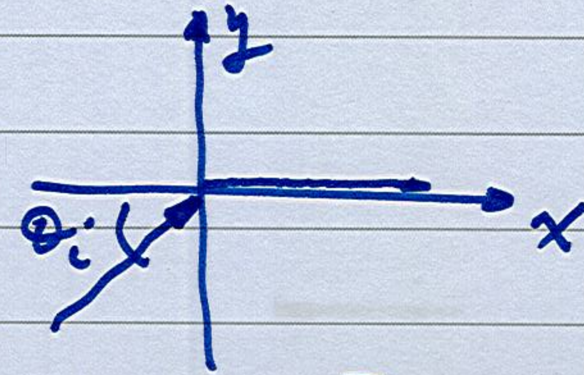
$$z_{2n} = \frac{\rho_2 c_2}{\cos\theta_t}$$



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

specific surface normal impedance of a semi-infinite fluid medium

$c_2 << c_1$



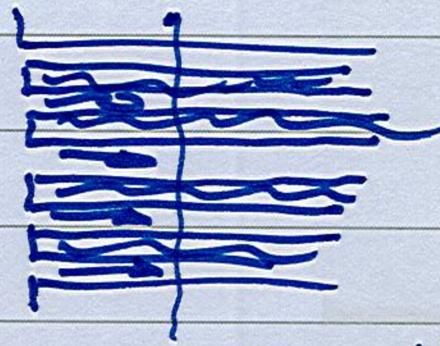
$$Z_{2n} = \frac{\rho_2 c_2}{\sqrt{1 - \underbrace{\left(\frac{c_2}{c_1}\right)^2 \sin^2\theta_i}_{\text{always small when } c_2 << c_1}}}$$

Z_{2n} is independent of incidence angle

$= \rho_2 c_2$

a definition of a surface of local reaction

happens if second medium is slow



surface is <u>locally reacting</u> because of its physical structure.

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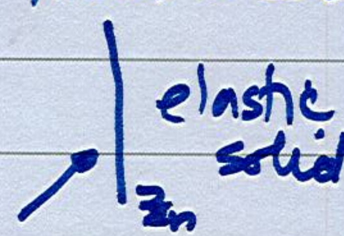
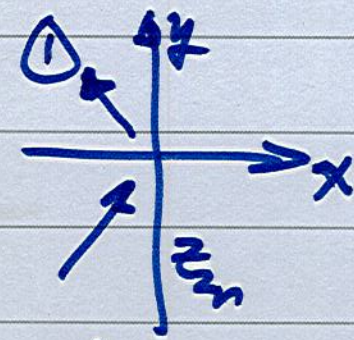
continuity of surface normal impedance is true regardless of the nature of the second medium (if the first medium is a fluid)



can R be found if Z_{2n} is known

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



$$p_1\big|_{x=0} = P_i e^{-ik_{1y}y} + P_r e^{-ik_{1y}y}$$

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

$$z_{1n} = \frac{\tilde{p}_1}{\hat{u}_{1x}}\bigg|_{x=0} = \frac{P_i + P_r}{\frac{P_i \cos\theta_i}{\rho_1 c_1} - \frac{P_r \cos\theta_i}{\rho_1 c_1}} \qquad \div P_i$$

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

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

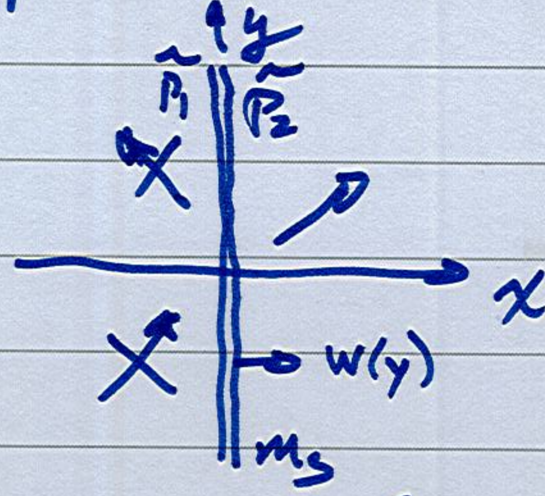
solve for R in terms of z_{2n}

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

$$\zeta_{2n} = \frac{z_{2n}}{\rho_1 c_1}$$

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

Example: Thin limp panel



$\rho_0 c$ $\rho_0 c$

at $x = 0$ $\quad \hat{p}_1 - \hat{p}_2 = m_s \dfrac{\partial^2 \hat{w}}{\partial t^2}$

harmonic case $e^{j\omega t}$

$$\hat{p}_1 - \hat{p}_2 = -\omega^2 m_s \hat{w}$$

$$= (j\omega)\underbrace{(j\omega)}_{\hat{u}_{1x}} m_s \hat{w}$$

$$j\omega\hat{w} = \hat{u}_{1x}\big|_{x=0} = \hat{u}_{2x}\big|_{x=0}$$

$$\hat{p}_1 = j\omega m_s \hat{u}_{1x} + \hat{p}_2 \qquad x = 0$$

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

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

$$= j\omega m_s + z_b$$

$$= z_p + z_b$$