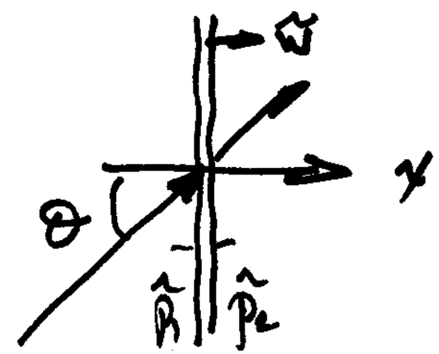
limp panel



$$(\hat{p}_1 - p_2)\big|_{x=0} = m_s \frac{\partial^2 \tilde{w}}{\partial t^2}$$ local reaction

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

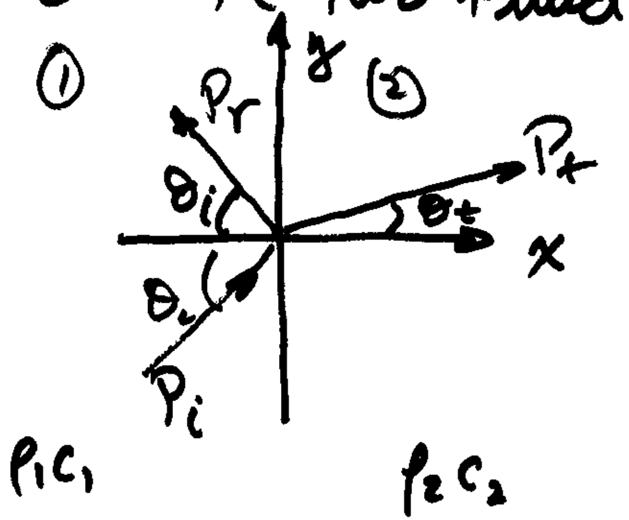
$\theta \to \pi/2$ "grazing"

$T \to 1$

$m_s \to \infty$ $T \to \frac{2\rho_0 c}{\cos\theta}\frac{1}{j\omega m_s}$ mass law

4.4 Reflection coefficient calculations by using the surface normal impedance

Recall the two fluid case



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

at $x = 0$ $\qquad \dfrac{\tilde{p}_1}{\tilde{u}_{1x}} = \dfrac{\tilde{p}_2}{\tilde{u}_{2x}}$ $\qquad$ Impedance is continuous at the boundary

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

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

$$\underbrace{\left.\frac{\tilde{p}_1}{\tilde{u}_{1x}}\right|_{x=0} = z_{2n}}_{\text{impedance b.c.}}$$ known

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

$$\hat{p}_2\big|_{x=0} = P_t e^{-ik_{2y}y}$$

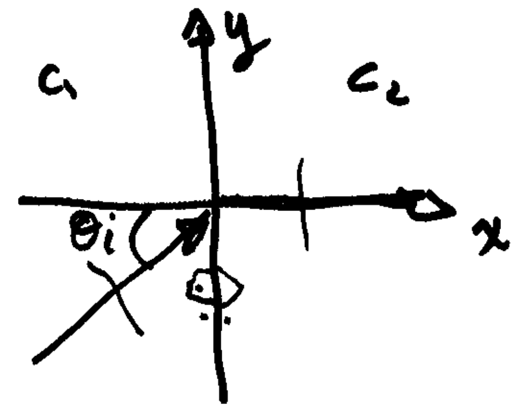
$$\hat{u}_{2x}\big|_{x=0} = \frac{P_t}{\rho_2 c_2}\cos\theta_t \, e^{-ik_{2y}y}$$

$$z_{2n} = \frac{\rho_2 c_2}{\cos\theta_t}$$ — characteristic impedance of region ②

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

specific surface normal impedance for a semi-infinite fluid medium

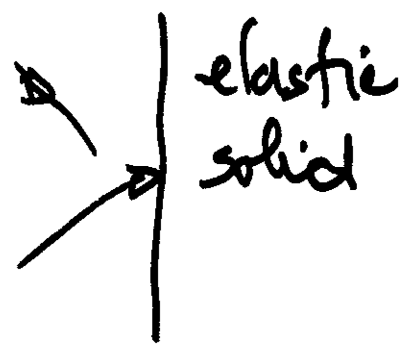
(i) $c_2 << c_1$

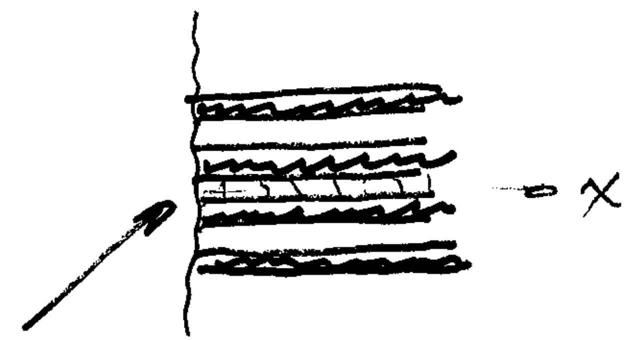


in This case $z_{2n} \simeq \rho_2 c_2$ and is independent of incidence angle

when z_{2n} is independent of θ_i
surface of local reaction

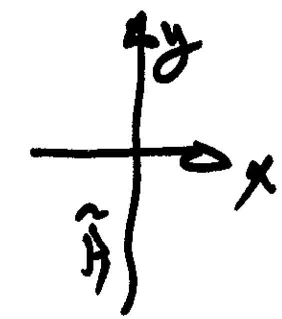
(ii) continuity of surface normal impedance is true regardless of the nature of the second medium





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

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



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

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

$$Z_{in} = \frac{\tilde{P}_1}{\tilde{u}_{1x}}\bigg|_{x=0} = \frac{P_i + P_r}{\frac{P_i \cos\theta_i}{\rho_1 c_1} - \frac{P_r}{\rho_1 c_1}\cos\theta_i}$$

$\div$ above and below by P_i

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

$$= \frac{1 + R}{\frac{\cos\theta_i}{\rho c}(1 - R)} = Z_{2n}$$

assumed known

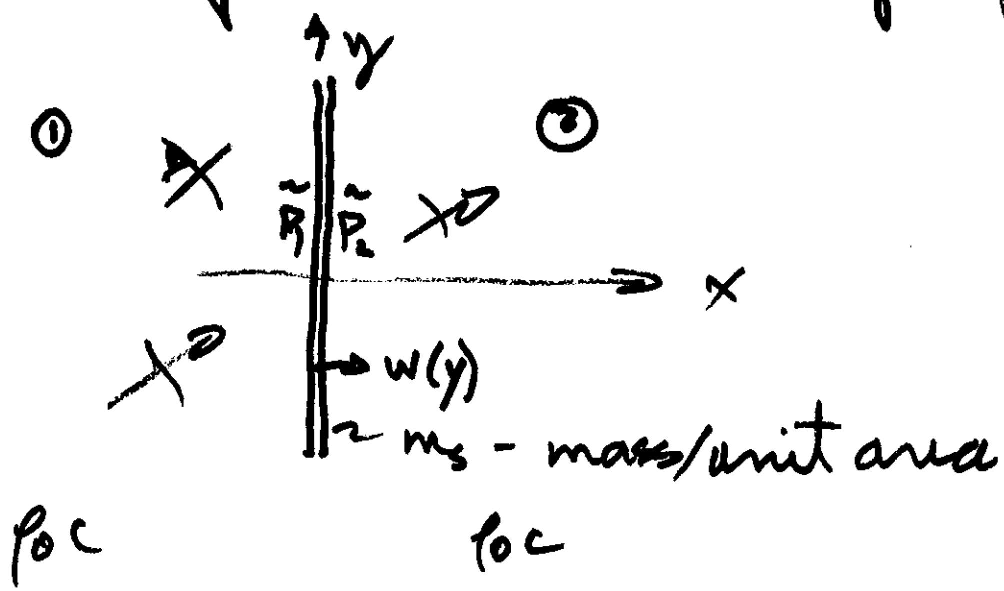
Solve for R in terms of Z_{2n}

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

plane wave reflection coefficient for a surface having a surface normal impedance of Z_{2n}

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

Example: Thin limp panel



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

harmonic case $(x=0)$

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

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

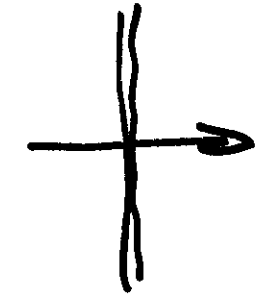
$$\tilde{p}_1 - \tilde{p}_2 = -\omega^2 m_s \hat{w}$$

$$\tilde{p}_1 = (j\omega)\underbrace{(j\omega)\hat{w}}_{\tilde{u}_{1x}} m_s + \tilde{p}_2$$

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

$$\frac{\tilde{p}_1}{\hat{u}_{1x}}\Bigg|_{x=0} = j\omega m_s + \underbrace{\frac{\tilde{p}_2}{\hat{u}_{1x}}\Bigg|_{x=0}}_{=\ \hat{u}_{2x}\text{ at } x=0}$$

$$\left.\frac{\tilde{p}_1}{\tilde{u}_{1x}}\right|_{x=0} = \underbrace{j\omega m_s}_{z_p} + \underbrace{\left.\frac{\tilde{p}_2}{\tilde{u}_{2x}}\right|_{x=0}}_{z_b}$$



in vacuo specific mechanical impedance of the panel

specific surface normal impedance of the backing space

$$z_{2n} = z_p + z_b$$

<u>series addition</u>

So then

$$R(\theta_i) = \frac{\zeta_{2n} \cos\theta_i - 1}{\zeta_{2n} \cos\theta_i + 1} \qquad \zeta_{2n} = \frac{Z_{2n}}{\rho_1 c_1}$$

$$\alpha(\theta_i) = 1 - |R(\theta_i)|^2$$