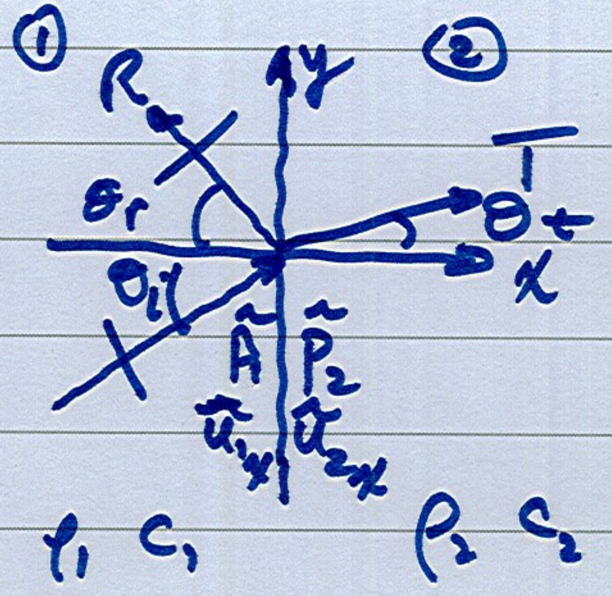
MTE 513 Session 30 10/30/19 1

Book Sections 6.1 - 6.7



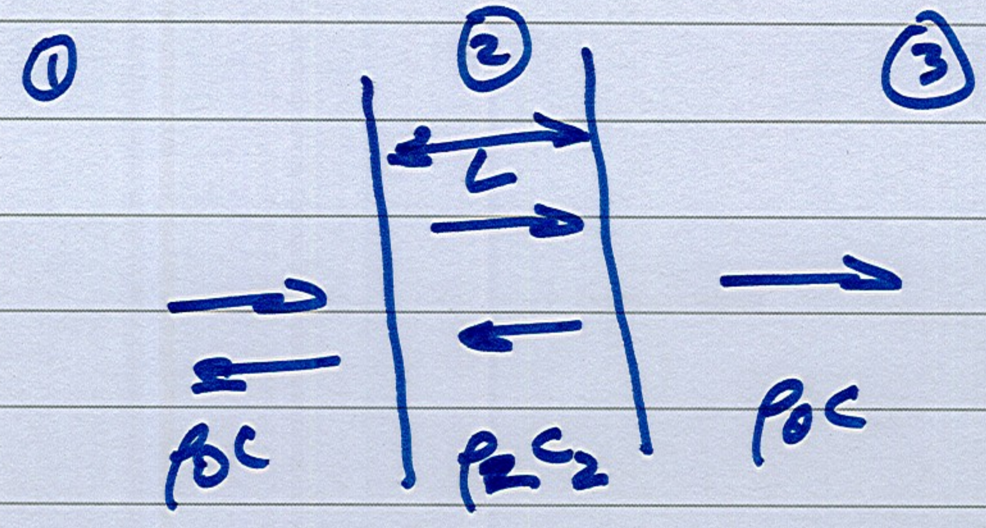
Snell's Law

$\theta_r = \theta_i$

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

$R + T \neq 1$

$R_I + T_I = 1$ Energy Conservation

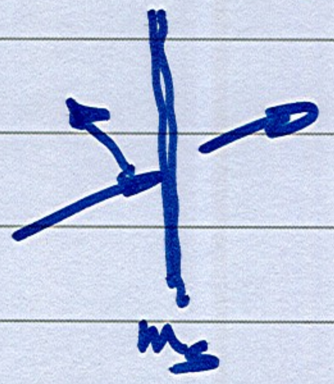


Same medium on both sides

$$L = \frac{n\lambda_2}{2}$$

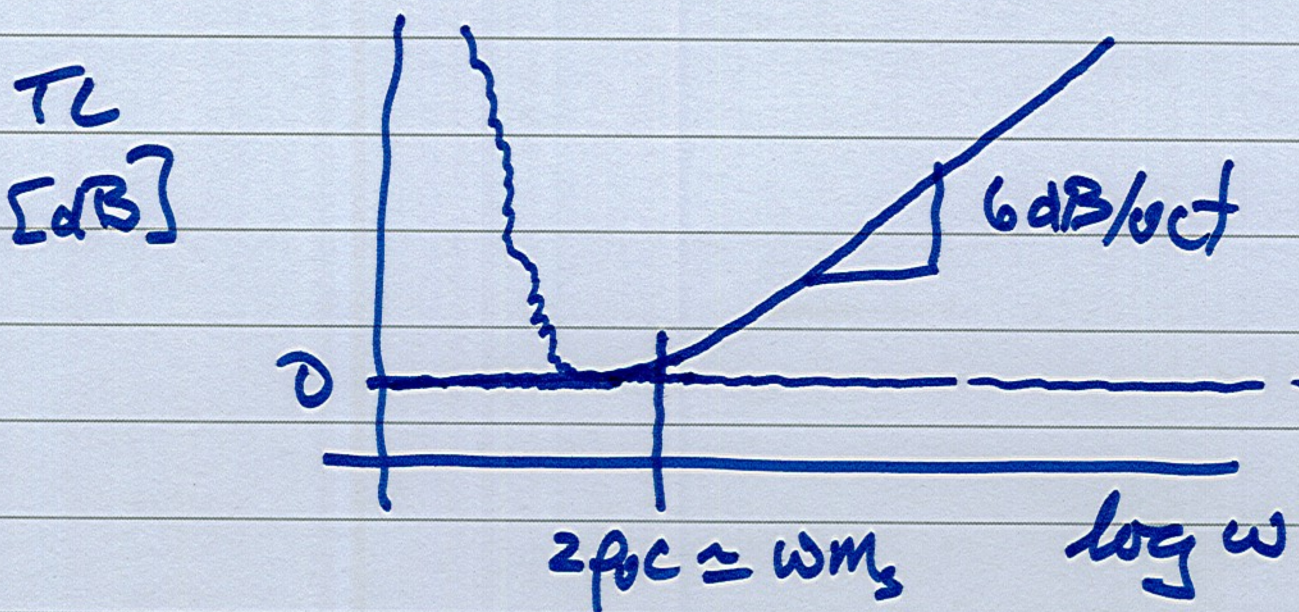
Sonar Dome

Thin limp barrier case

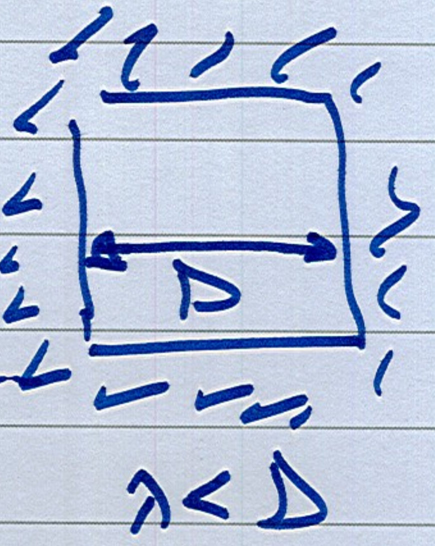


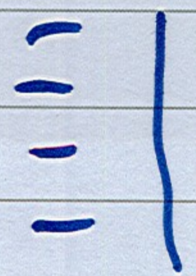
mass law

$T \propto \frac{1}{m_s}$ $\quad$ $T \propto \frac{1}{f}$

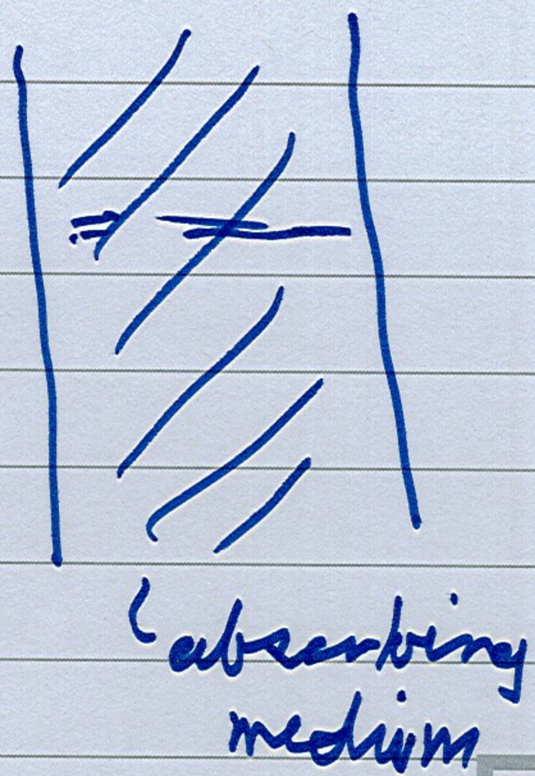


$2\rho_0 c \simeq \omega m_s$





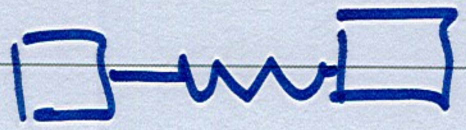
Double Panel



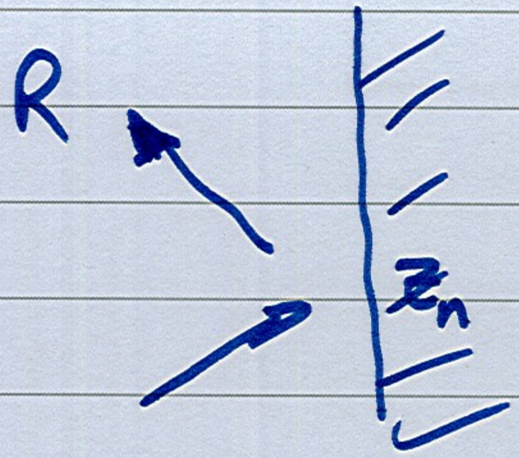
$TL \simeq TL_1 + TL_2 + 6\,dB$

if there is adequate decoupling

- mass-~~x~~air-mass



surface normal impedance B.C.



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

section 5: <u>Sound Generation + Radiation</u>

Chapter 7

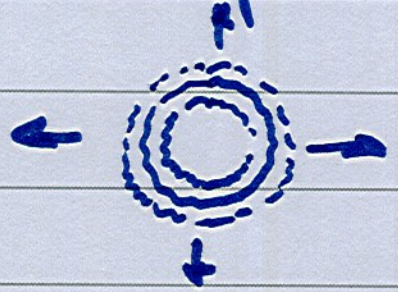
<u>Compact Sources</u>: small compared to a wavelength

- loudspeakers at low frequency
- exhaust pipe

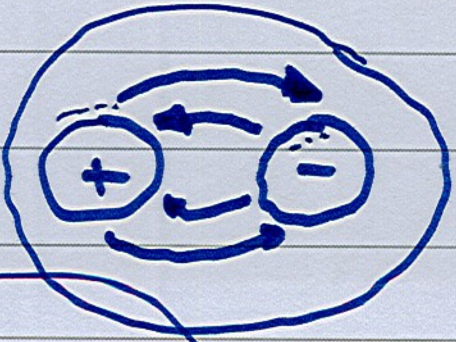
$D << \lambda$

"simple" Sources

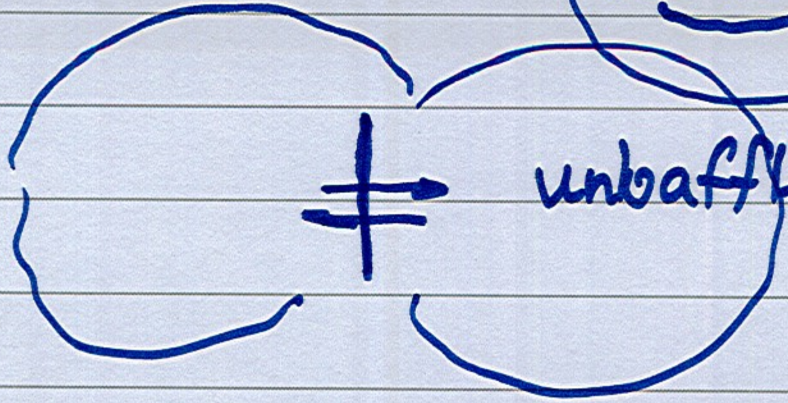
- monopole - volume velocity sources



- dipole



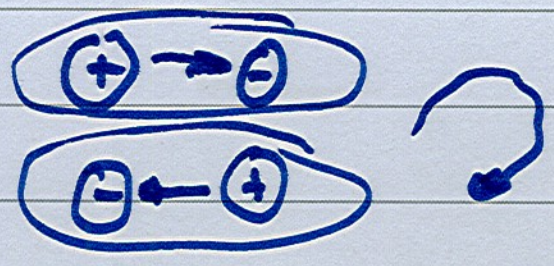
- point force applied to the fluid



unbaffled l/s

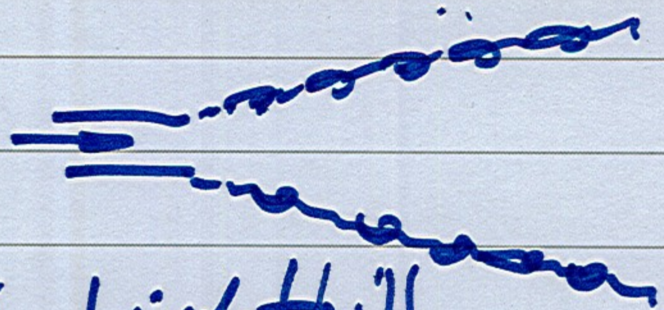
Axial fans

· <u>Quadrupole</u>



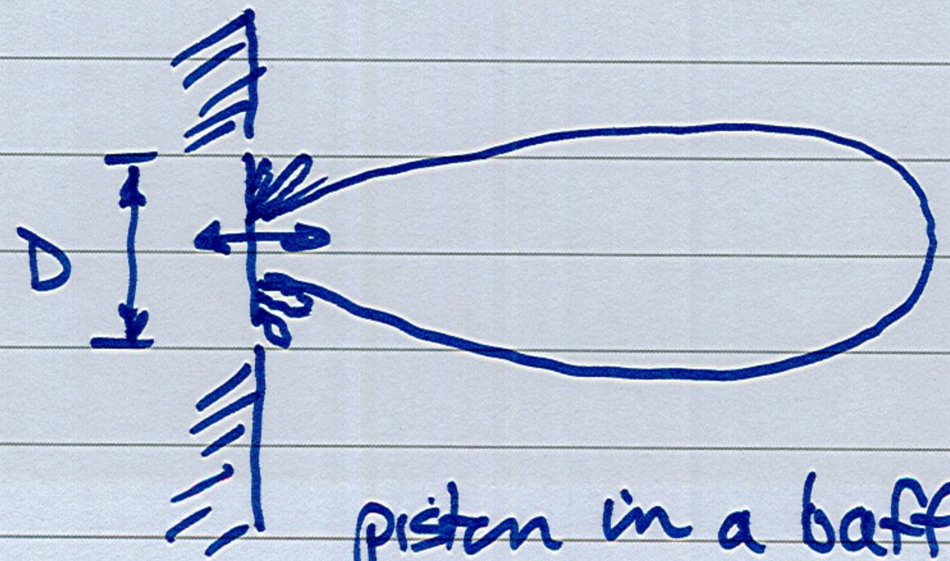
- an oscillatory moment applied to fluid

- turbulence jet



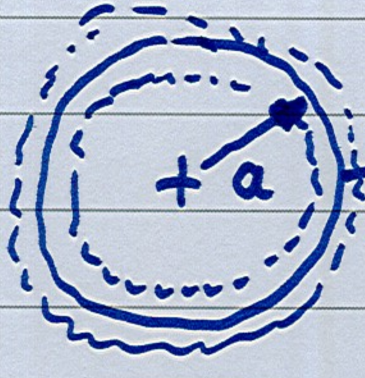
M. J. Lighthill
1951

Non-compact
- not small compared to λ
- extended sources



piston in a baffle

5.2 Sound Radiation from a pulsating sphere



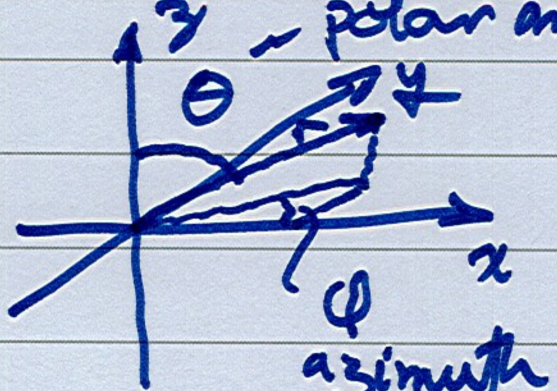
$\rightarrow u_0 e^{j\omega t}$

purely radial velocity

Write:
- wave eqn
- assume a solution
- apply a b.c at $r=a$

spherically symmetric

Volume velocity source



no variation in ϕ or θ

$\tilde{p}(r)$

scalar Helmholtz Eqn harmonic

$$\nabla^2 \tilde{p} + k^2 \tilde{p} = 0$$

$$p(r,t) = \hat{p}(r) e^{j\omega t}$$

$$k = \frac{\omega}{c}$$

$$\nabla^2 \longrightarrow \left. \frac{\partial^2}{\partial r^2} + \frac{2}{r}\frac{\partial}{\partial r} \right]$$

Due to the spherical symmetry

$$\frac{\partial}{\partial \phi} \quad \frac{\partial}{\partial \theta} \longrightarrow 0$$

$$\frac{d^2 \tilde{p}}{dr^2} + \frac{2}{r}\frac{d\tilde{p}}{dr} + k^2 \tilde{p} = 0$$

$$\frac{d^2(r\tilde{p})}{dr^2} + k^2(r\tilde{p}) = 0$$

$$\tilde{p} = \underbrace{\left(\frac{A}{r}\right)e^{-ikr}}_{\text{outward -going}} + \cancel{\underbrace{\left(\frac{B}{r}\right)e^{+ikr}}_{\text{inward -going}}} \to \text{neglect}$$

Free - space - no reflecting surfaces

outward going wave only.

5.2.2 Boundary Conditions

set radial particle velocity
at $r = a$ to $U_0 e^{j\omega t}$

$$\underbrace{\tilde{u}_r(a)}_{\text{fluid velocity}} = \underbrace{U_0}_{\text{surface velocity}}$$

$$\tilde{u}_r = -\frac{1}{j\omega\rho_0}\nabla^2 \tilde{p}$$

- no pressure grads in θ or ϕ dir