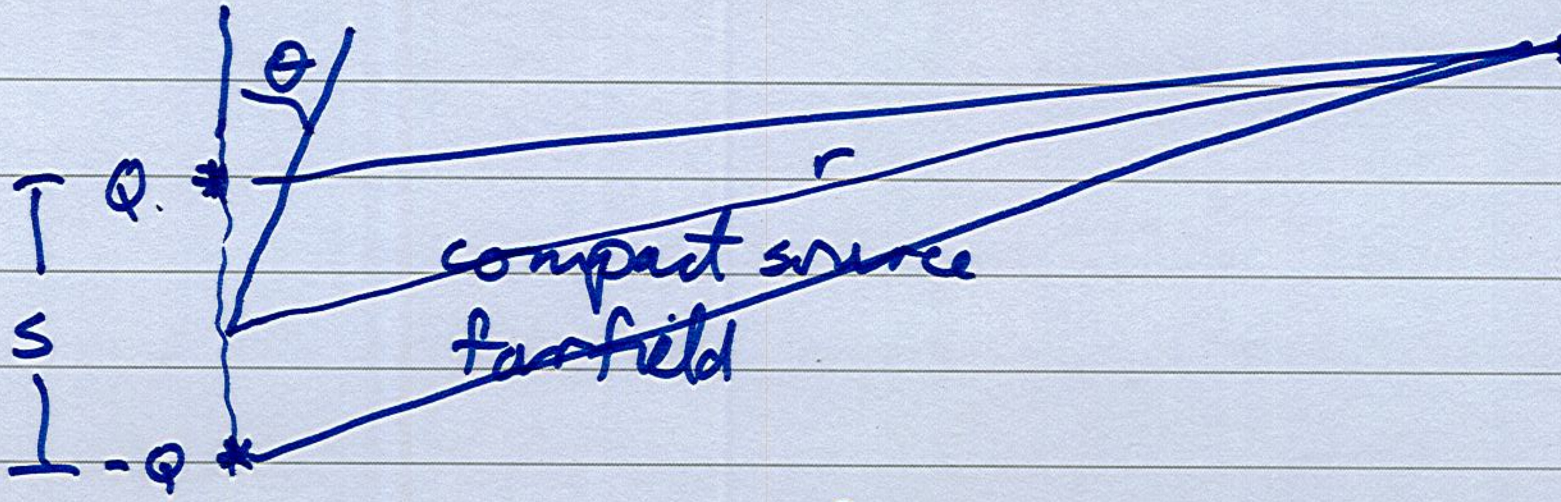
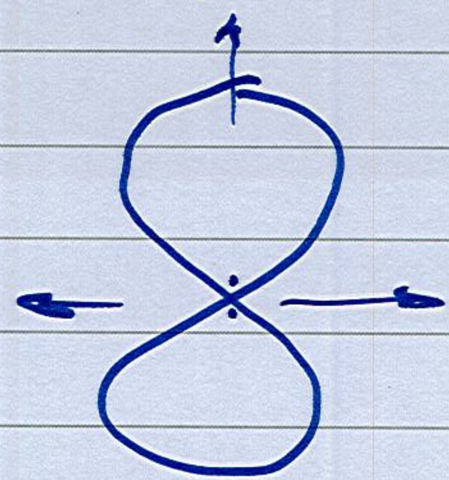
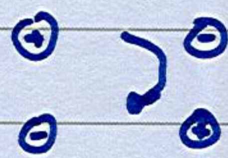


$$\tilde{p}(r) = -\rho_0 c k^2 \overset{D}{(Qs)} \frac{e^{-ikr}}{4\pi r} \cos\theta$$



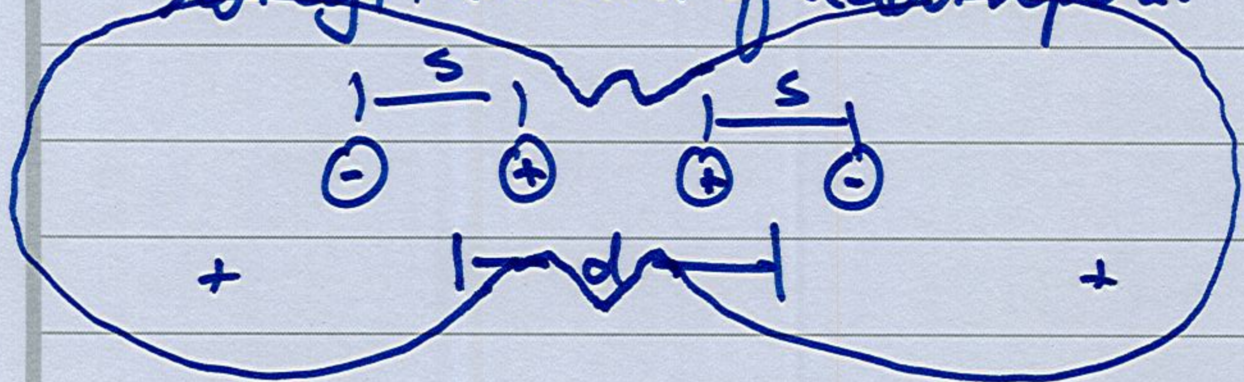
fan



quadrupole - pt moment -
sound radiation from turbulence

- turbulent interaction with a hard surface
  - dipole-like

longitudinal quadrupole.



$ks \ll 1$

$kd \ll d$

compact sources

- special types of compact sources
  - simple sources
    - monopole - volume
    - dipole - force
    - quadrupole - moment

radiation efficiency drops

per unit source strength

$|p_{monopole}| \gg |p_{dipole}| \gg |p_{quadrupole}|$

<u>Multipole Decomposition</u>

Equivalent source methods (ESM)

$\tilde{p}(r) = \sum$ monopoles

$+ \sum$ dipole

$+ \sum$ quadrupoles

$+ \sum$ octopoles

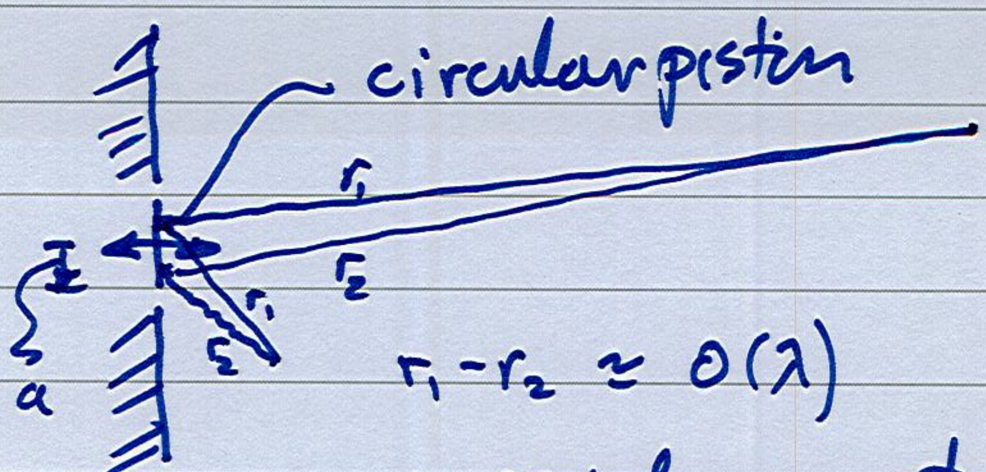
arbitrary source

5.4 Sound radiation from extended sources

- finite extent

$D = O(\lambda)$

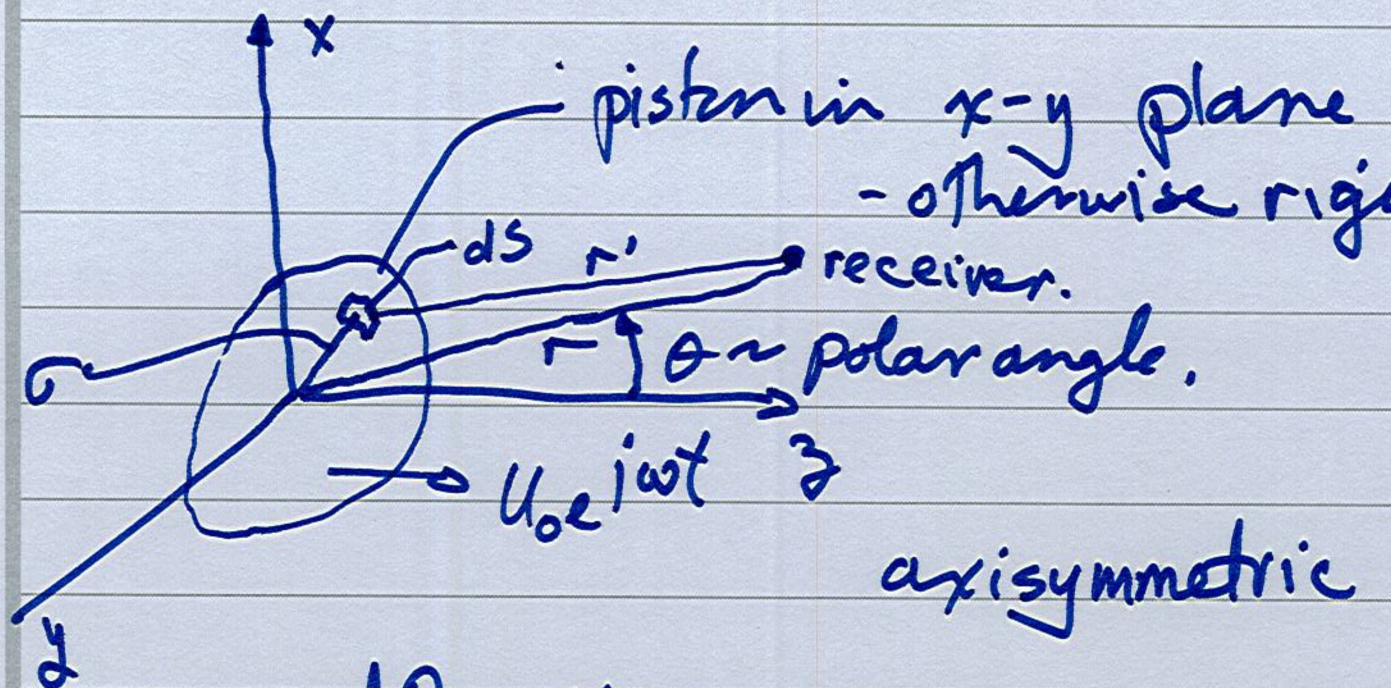
5.4.1 Piston in a Baffle



$r_1 - r_2 \simeq O(\lambda)$

$a = O(\lambda)$

reinforcement & cancellation is possible.



axisymmetric

$$dQ = u_0 dS$$

contribution from the incremental source dS

$$d\tilde{p} = j\rho_0 c\, k\, (dQ)\, \frac{e^{-jkr'}}{2\pi r'}$$

$$dQ = u_0\, dS$$

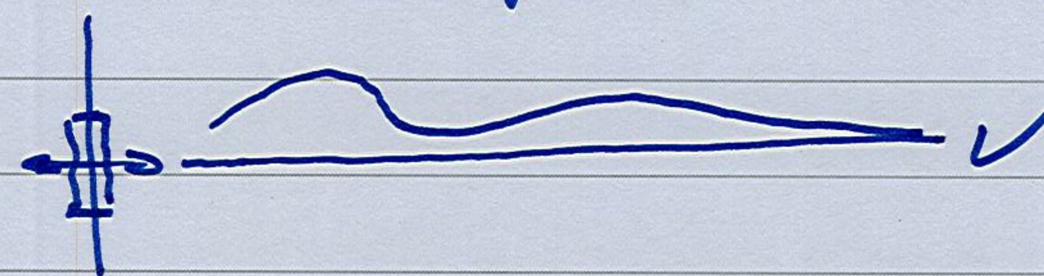
monopole on a hard surface.

Integrate over the surface of the source

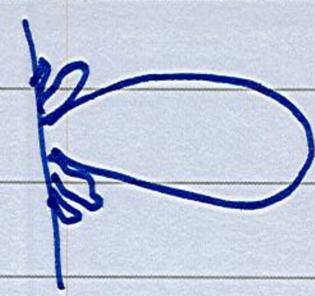
$$\tilde{p}(r,\theta) = j \rho_0 c \frac{u_0 k}{2\pi} \int_{S_2} \frac{e^{-jkr'}}{r'}\, dS$$

S_2 total piston area

(i) On-axis

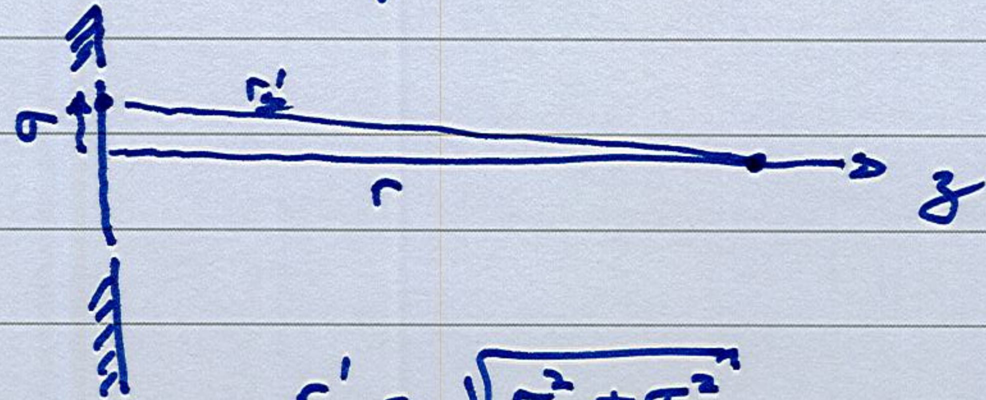


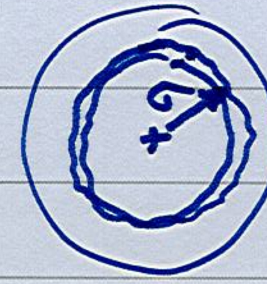
(ii) Farfield



Evaluate The pressure on-axis

$\hat{p}(r,0)$

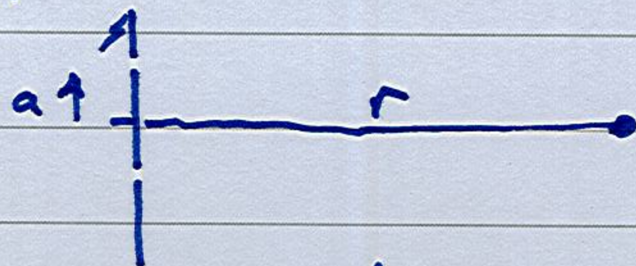




$$r' = \sqrt{r^2+\sigma^2}$$

$$\hat{p}(r,0) = j\frac{\rho_0 c k U_0}{2\pi}\int_0^{a}\frac{e^{-ik(r^2+\sigma^2)^{1/2}}}{(r^2+\sigma^2)^{1/2}}\,2\pi\sigma\,d\sigma$$

$$\tilde{p}(r,0) = j\rho_0 c U_0 e^{-jkr} \underbrace{e^{-j\frac{kr}{2}\left[\sqrt{1+\frac{a^2}{r^2}}-1\right]}}_{\text{phase}} \underbrace{2j\sin\left[\frac{kr}{2}\left[\sqrt{1+\frac{a^2}{r^2}}-1\right]\right]}_{\text{oscillatory function of position}}$$



special case

$ka \ll 1$ (compact source)

farfield $\frac{a}{r} \ll 1$

should reduce to a monopole on a hard surface.

farfield

$\sqrt{1+\frac{a^2}{r^2}}$ $\quad \frac{a^2}{r^2} \ll 1$ $\quad (1+x)^{1/2}$

$= 1 + \frac{a^2}{2r^2}$ $\quad \simeq \underbrace{1 + \frac{x}{2}}$ $+ \cancel{\frac{x^2}{3} \cdots}$.

$\sin\frac{kr}{2}\left[\cancel{1} + \frac{1}{2}\frac{a^2}{r^2} - \cancel{1}\right]$

$\sin\left(\frac{ka}{4}\left(\frac{a}{r}\right)\right)$ $\quad ka \ll 1$ compact

$\frac{a}{r} \ll 1$ farfield

$\simeq \frac{ka}{4}\left(\frac{a}{r}\right)$ substitute into the complete & take the magnitude

$$Q = \pi a^2 u_0$$

$$|\tilde{p}(r,0)| \simeq \rho_0 c \frac{u_0}{2} (ka) \frac{a}{r}$$

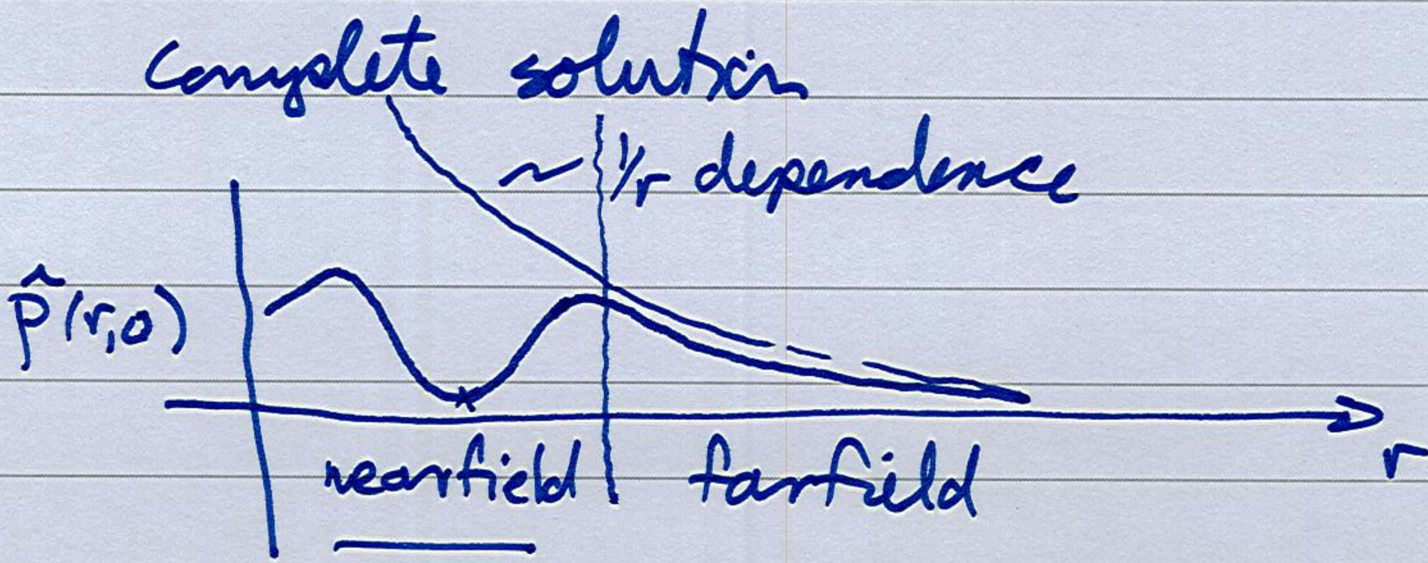
$$\simeq \underline{\underline{\rho_0 c \frac{kQ}{2\pi r}}}$$

exactly the same as the monopole on a hard surface.

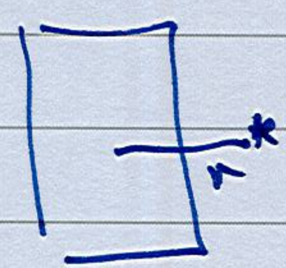
Piston in a baffle
loudspeaker flush mounted in a wall

if $ka << 1$

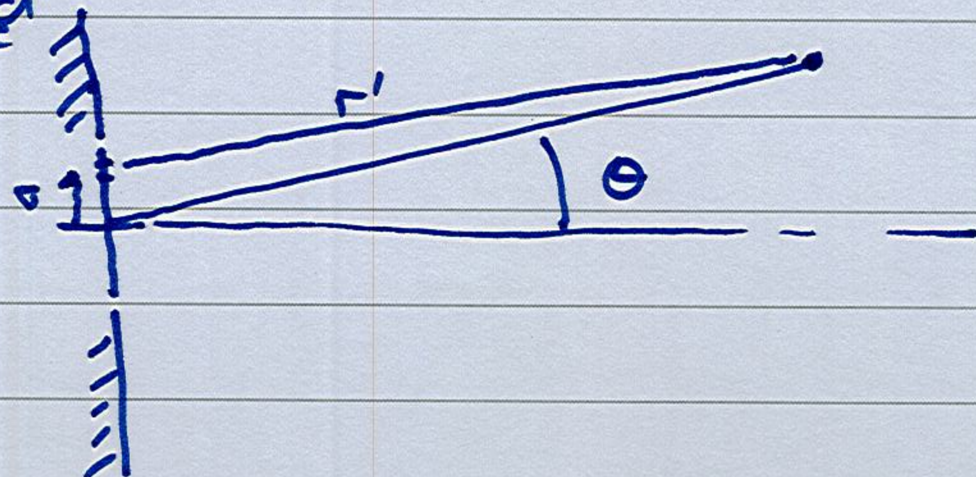
The l/s can be modeled as a pt. monopole on a hard surface.



oscillatory sound field that can both increase & decrease



farfield



$\frac{a}{r} \ll 1$

farfield

- replace r' by r
- replace r' by $\boxed{r + \delta r}$ $\sim r - a\sin\theta\cos\phi$

$$\tilde{p}(r,\theta) = \underbrace{j\frac{\rho_0 c}{2} U_0 \left(\frac{a}{r}\right) e^{-ikr}}_{\text{monopole}} \underbrace{\left[2\,\frac{J_1(ka\sin\theta)}{ka\sin\theta}\right]}_{\text{Directivity factor}}$$