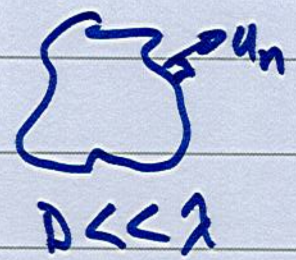
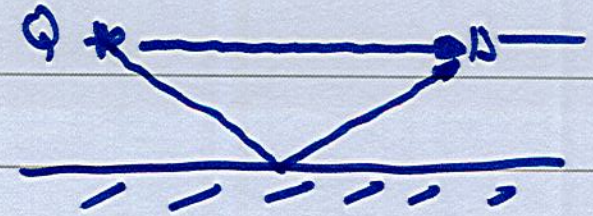
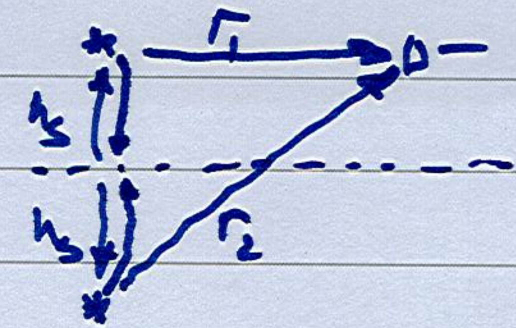
MR 513 Session 33 11/11/15

<u>si/ixa</u>

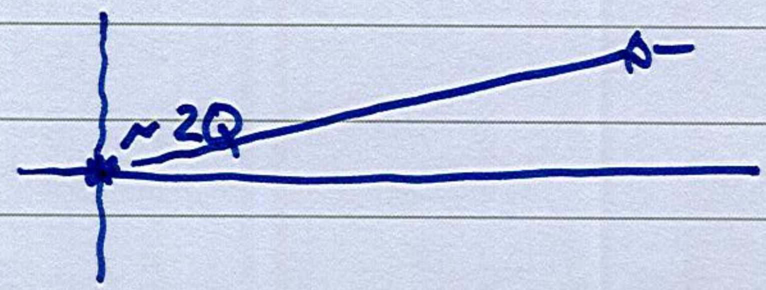


$Q = \int u_n dS \longrightarrow$ monopole





$$\hat{P}_t = j\rho_0 c \frac{kQ}{4\pi r_1} e^{-jkr_1} \left[1 + \left(\frac{r_1}{r_2}\right) e^{-jk(r_2 - r_1)} \right]$$



$h_s = 0$

true source & image source coalesce at the surface.

$r_1 = r_2 = r$

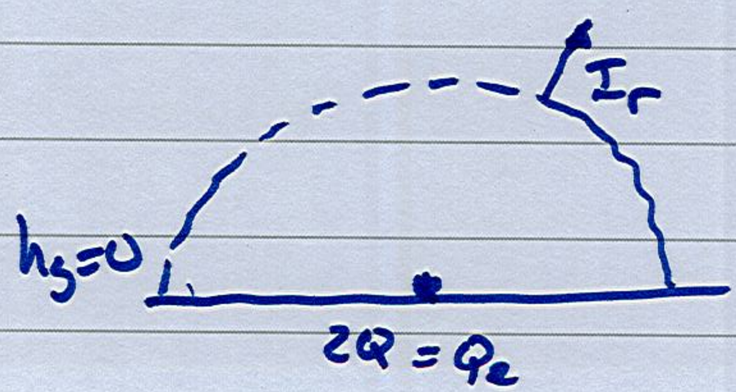
$$\tilde{p}(r) = j\rho_0 c \frac{kQ}{4\pi r} e^{-jkr} \Big[\underbrace{1 + \left(\frac{r}{r_2}\right)}_{1} \overbrace{e^{-jk(r-r_2)}}^{1} \Big]$$

$$= j\rho_0 c \frac{k2Q}{4\pi r} e^{-jkr} \underbrace{}_{2}$$

pressure at the receiver location is doubled wrt a single monopole in free space

Recall monopole in free space

$$I_r = \frac{\rho_0 c}{2} \frac{k^2 Q^2}{(4\pi r)^2}$$



$$W = \int I_r \, dS$$

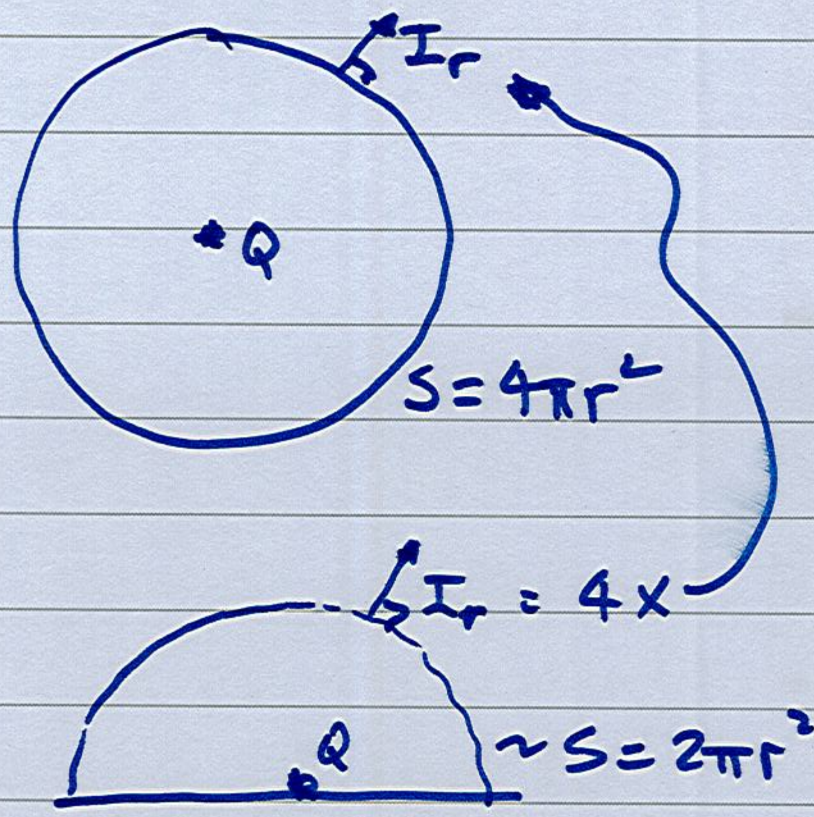
= 2 × free space value

$$I_r = \frac{\rho_0 c}{2} \frac{k^2 Q_e^2}{(4\pi r)^2}$$

$$= 2 \rho_0 c \frac{k^2 Q^2}{(4\pi r)^2}$$

sound power is ~~d~~ doubled

hard surface has increased the intensity (on a surface of radius r centered on the source) by a factor of 4 compared to the same source in a free field



$$W = \int I_r dS = \rho_0 c \frac{k^2 Q^2}{8\pi}$$

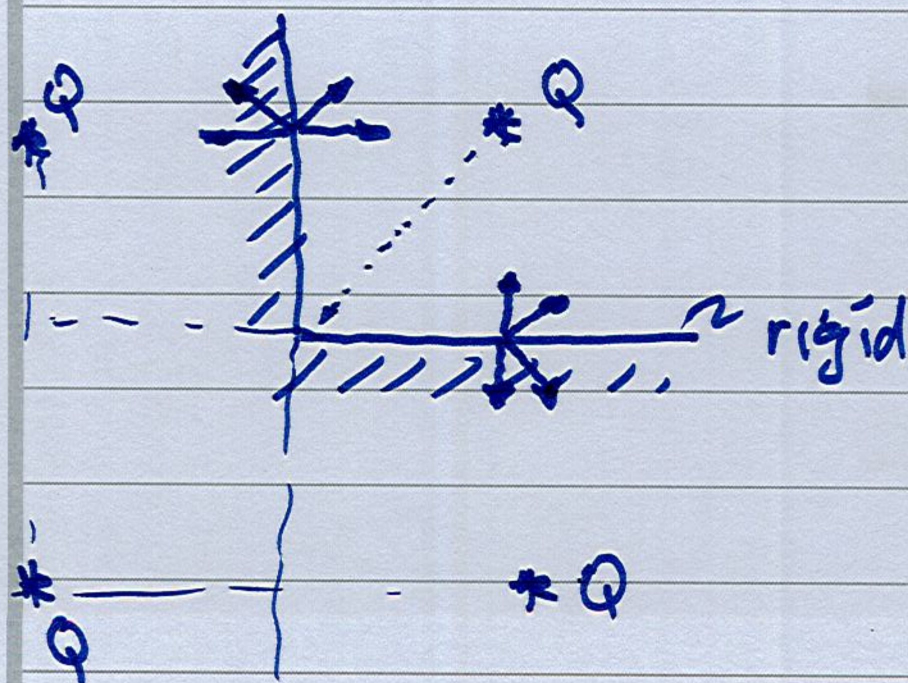
$$W = \int I_r dS = \rho_0 c \frac{k^2 Q^2}{4\pi}$$

Simply by putting a monopole on a hard surface – radiated sound power is doubled – assuming that Q is independent of load.

If a source is mounted in an infinite rigid baffle - Then a high impedance acoustic source radiates twice The sound power That it would in free space

(because The loading - radiation resistance is increased)

5.3.3.2 Multiple Reflections



place a source close to the junction of two infinite planes

$\bar{u} \cdot \bar{n} = 0$

3 image sources are required to satisfy the hard-wall b.c.

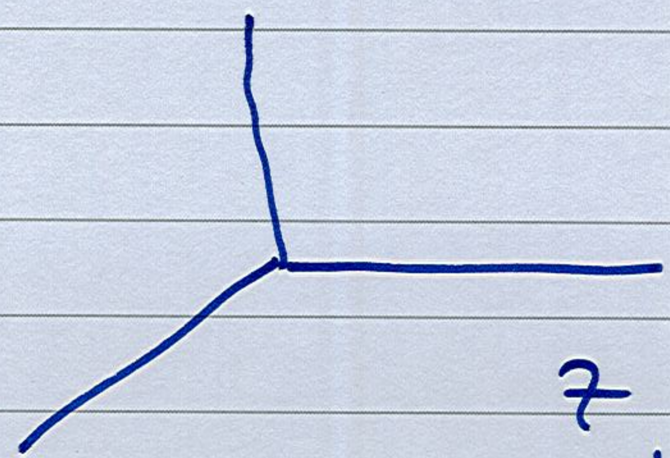
if the source is moved to the corner

$Q_c = 4Q$

Intensity increases by a factor of 16

Sound is radiating into a quarter sphere

W increases by a factor of 4



3 walls

7 images are required to satisfy b.c.

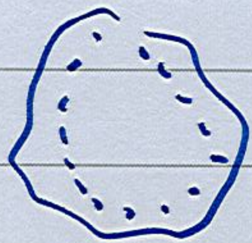
Source → corner $Q_e \to 8Q$

Intensity increases by a factor of 64

Radiating into 1/8th of a sphere

Sound power increases by 8 X

- monopoles – represent "small" sources (compact)

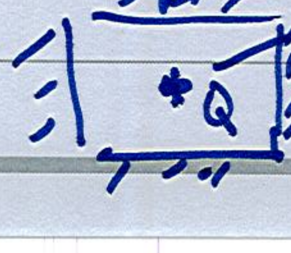


$ka << 1$ source is small compared to a wavelength

– that exhibit oscillatory volume changes.

- assumed that Q is independent of acoustic loading

* sound power of a source is ~~affected~~ affected by the environment

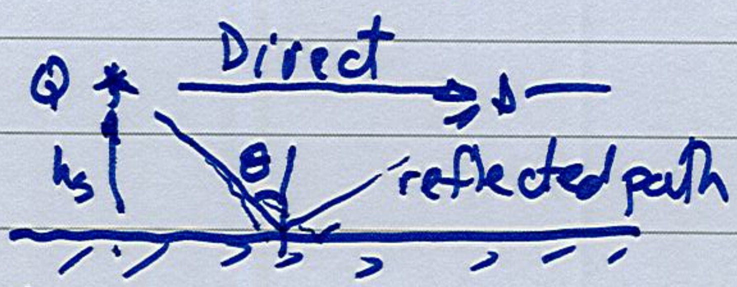


$W = 0$

closed box with rigid walls

5.3.4 Partially Reflecting Surfaces

5.3.4.1 Impedance Surface



$$\left.\frac{p}{v_n}\right|_{\text{surface}} = Z_n$$

"fuzzy" image source not a point

locally reacting

$Z_n \neq f(\theta)$

Impedance b.c. cannot be satisfied by a simple point image

Approximate Solution

$$\tilde{p}(r) = A\left\{ \frac{e^{-jkr_1}}{r_1} + R(\theta)\frac{e^{-jkr_2}}{r_2} + \left[1 - R(\theta)\right] F(w) \frac{e^{-jkr_2}}{r_2} \right\}$$

direct — Reflected (specular) — complicated: ground & surface waves

$$R(\theta) = \frac{Z_n \cos\theta - \rho_0 c}{Z_n \cos\theta + \rho_0 c}$$

At grazing incidence

$\theta \to \pi/2 \quad R \to -1$

near grazing only the ground & surface waves contribute when $\theta < 75^\circ$

$$\hat{p}(r) = A\left\{\frac{e^{-ikr_1}}{r_1} + R(\theta)\frac{e^{-ikr_2}}{r_2}\right\}$$

5.3.4.2 Pressure Release Surface