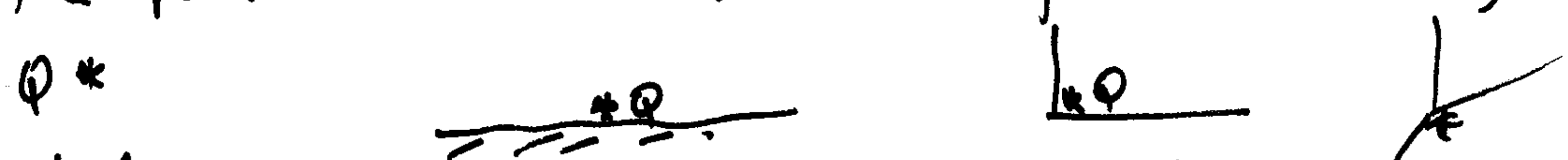
ME 513 Session 34

cancelled

sound power radiated by a source depends on the acoustic environment

free space	hard surface	1 junction	2 junction

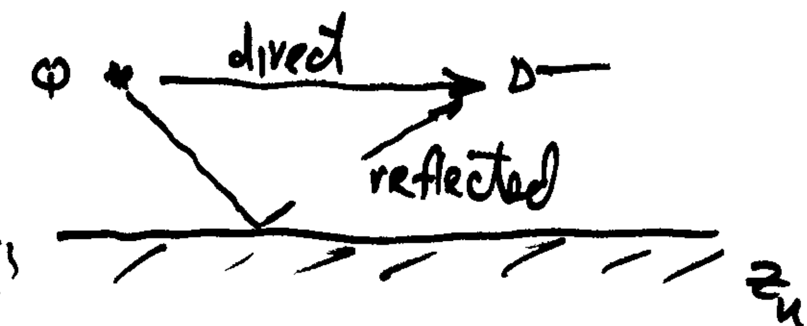


W = 1	W = 2	W = 4	W = 8
	1 image	3 image	7 images

5.3.4 Partially Reflecting surfaces

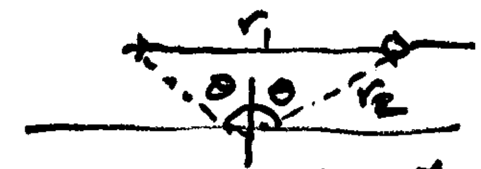
5.3.4.1 Impedance surface

z_n specific impedance specified
surface of local reaction $z_n \neq f(\theta)$



$\frac{p}{u_n} = z_n$

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



Approximate solutions

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

($F(w)$: complicated function)

Direct — specular path — ground & surface waves

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

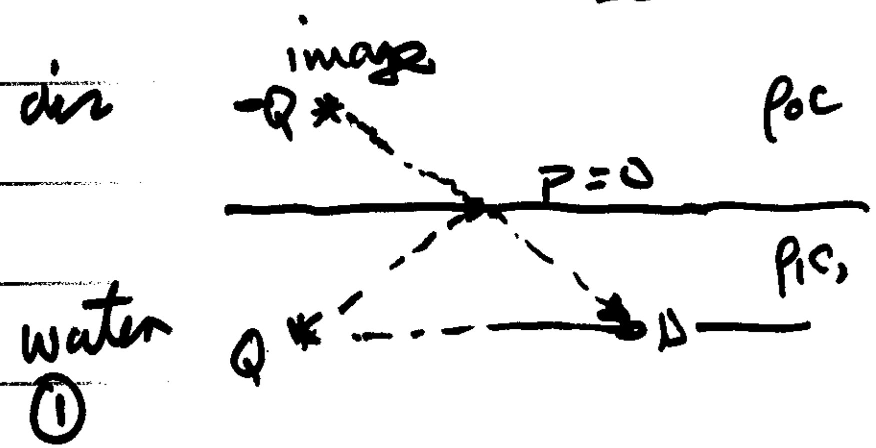
At grazing incidence

$\theta \to \frac{\pi}{2}$ $R \to -1$

when $\theta < 75^\circ$

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

5.3.4.2 Pressure Release Surface



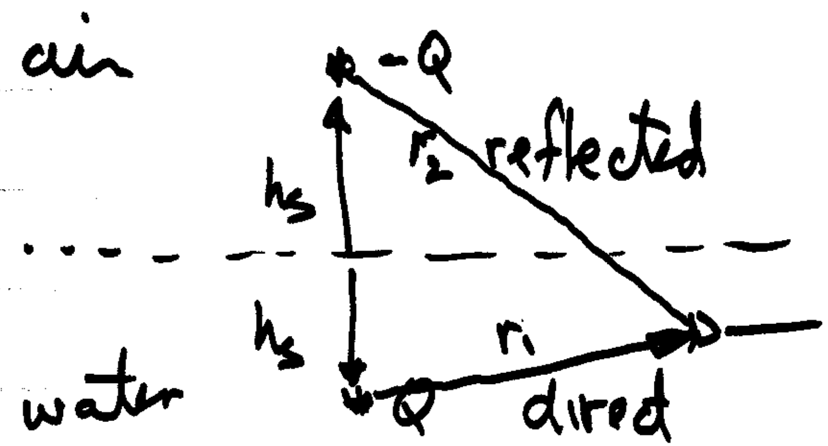
$$\frac{\rho_0 c}{\rho_1 c_1} \ll 1$$

$$\left(\frac{p}{u_n}\right)_1 \simeq 0 \quad \text{pressure release b.c.}$$

$p_1 \simeq 0$ at the surface.

$$R(\theta) = \frac{Z_n \cos\theta - 1}{Z_n \cos\theta + 1}$$

$$\rightarrow -1$$



sound field in the water

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

$k = \frac{\omega}{c}$ c = sound speed in water

Image is "out-of-phase" with the actual source let the source approach the surface

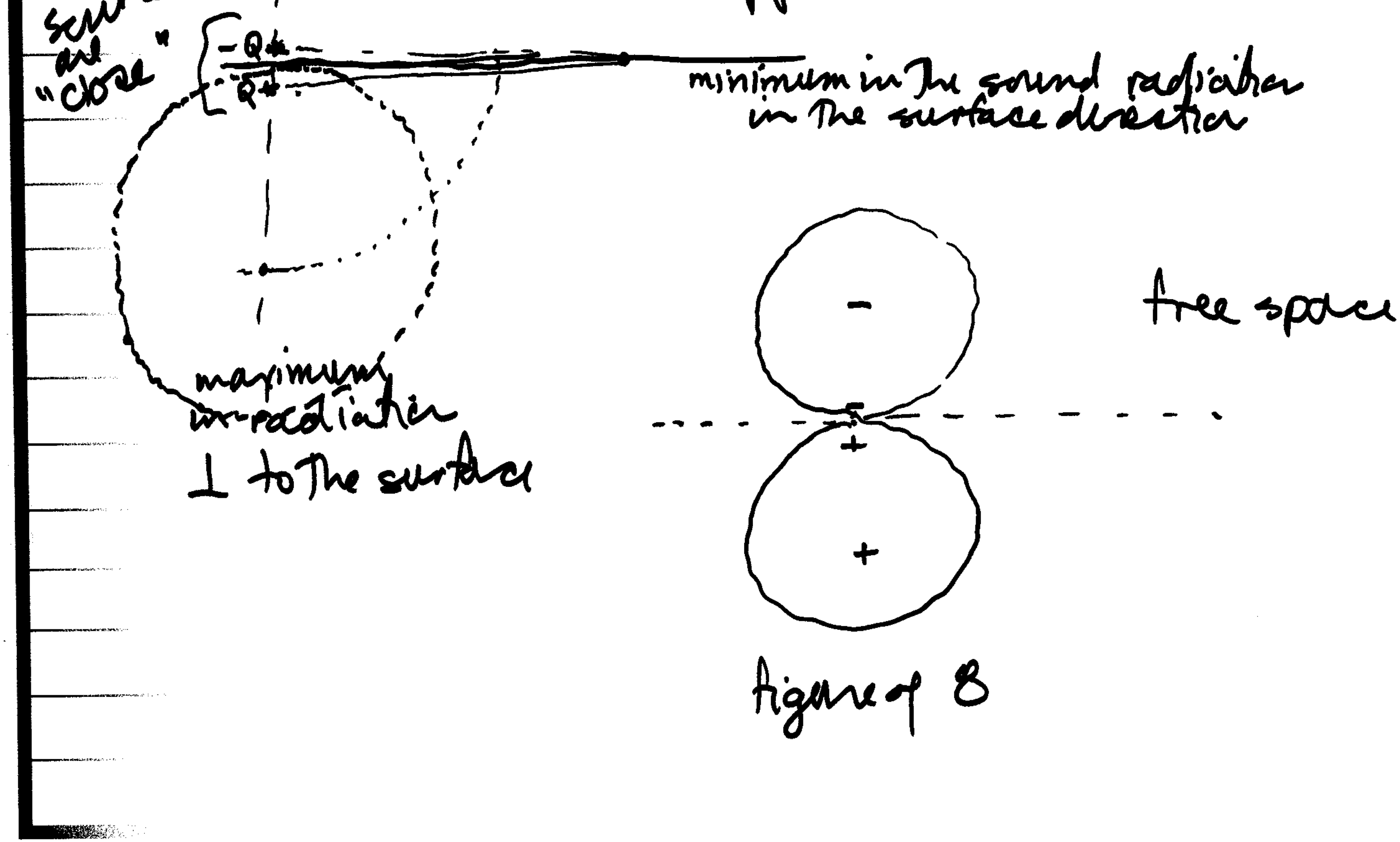
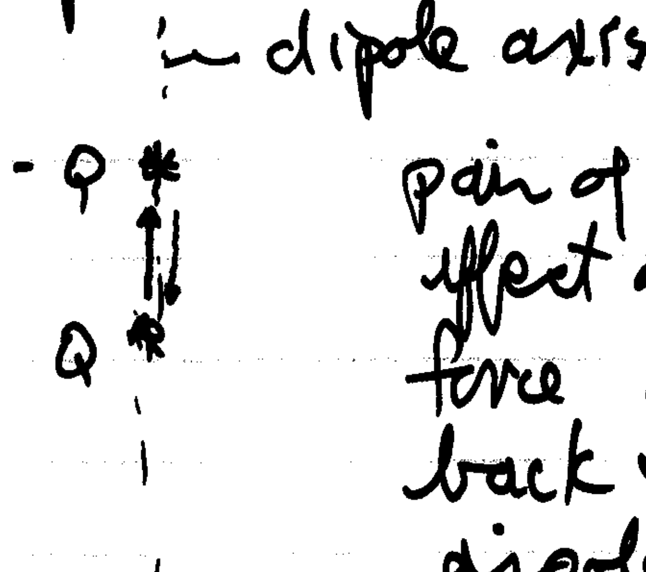


figure of 8

two monopoles - closely spaced & running 180° out-of-phase - create a dipole

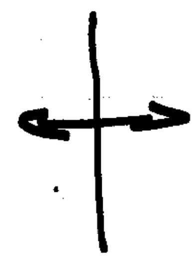


pair of monopoles has the effect of an oscillatory pt force accelerating fluid back & forth along the dipole axis

monopole → mass or volume source

dipole → force source

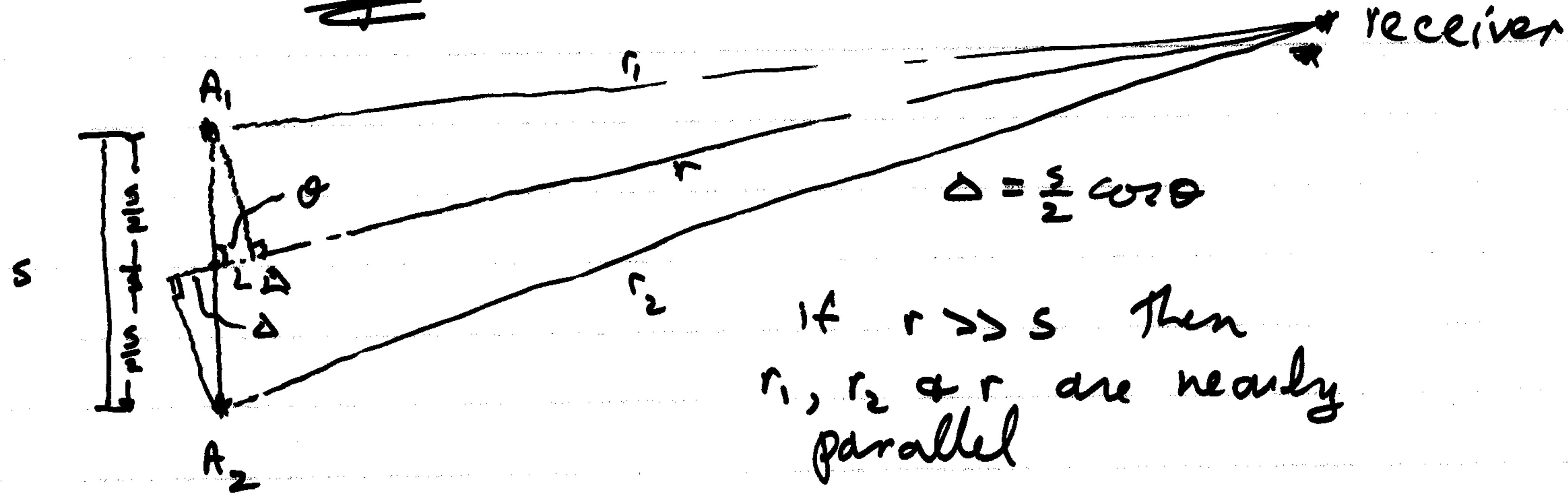
unbaffled l/s



small
axial
fan

fluid-structure
interaction
case

5.3.5 Dipole



$\Delta = \frac{s}{2}\cos\theta$

if $r \gg s$ then r_1, r_2 & r are nearly parallel

two ~~[illegible]~~ monopoles strengths A_1 & A_2

$$r_1 \simeq r - \Delta = r - \frac{s}{2}\cos\theta$$

$$r_2 \simeq r + \Delta = r + \frac{s}{2}\cos\theta$$

θ is the angle from the dipole axis

$$\tilde{p}(r) = A_1 \frac{e^{-jkr}}{r_1} + A_2 \frac{e^{-jkr_2}}{r_2}$$

Assumed $\quad r \gg s$

$$A_2 = -A_1$$

$$A_1 = A$$

$$\hat{p}(r) = A\left\{ \frac{e^{-jk(r-\Delta)}}{r-\Delta} - \frac{e^{-jk(r+\Delta)}}{r+\Delta} \right\}$$

$$= A\,e^{-jkr}\left\{ \frac{r\,(e^{+jk\Delta} - e^{-jk\Delta}) + \cancelto{0}{\Delta\,(e^{+jk\Delta} + e^{-jk\Delta})}}{r^2 - \cancelto{0}{\Delta^2}} \right\}$$

$r \gg s \;\therefore\; \Delta \ll r$

$$\hat{p}(r) \simeq A\frac{e^{-jkr}}{r}\left(e^{+jk\Delta} - e^{-jk\Delta}\right)$$

$$\simeq 2j\,A\frac{e^{-jkr}}{r}\sin k\Delta$$