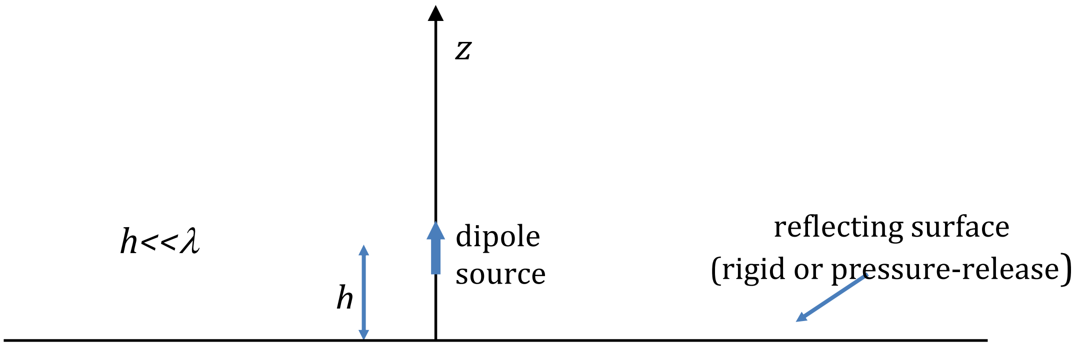


The complex pressure amplitude at frequency ω radiated from a point dipole source aligned with the z axis can be expressed the form

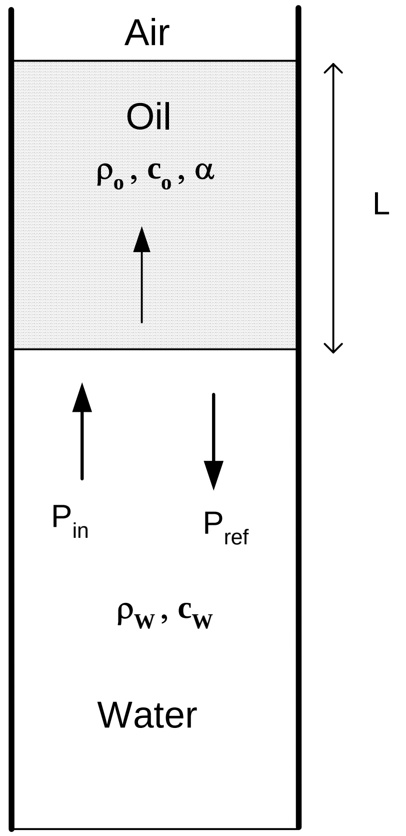
$$\hat{p}(r) = \frac{\hat{d}\cos\theta}{r} e^{ikr} \qquad (1)$$

where $k=\omega/c$ and θ is the angle between the observation point $\vec{r}$ and the z axis. .

1. Find an expression for the complex pressure amplitude in the far field in terms of the variables of Eq. 1 if the source is located at $z=h$ $(h<<\lambda)$ and there is a pressure release reflector in the $z=0$ plane . What is the total power radiated into the half-space $z>0$?
2. Find an expression for the complex pressure amplitude in the far field (in terms of the variables of Eq. 1 if the source is located at $z=h$ $(h<<\lambda)$ and there is a rigid reflector located in the $z=0$ plane . What is the total power radiated into the half-space $z>0$? How does it compare to the power radiated for the pressure reflector case?
3. If instead of being aligned with the z- axis the source was perpendicular to the z –axis, would the total radiated power be greater for the rigid reflector case or the pressure release reflector case? (You needn't derive anything, but you must justify your answer)

Consider pressure waves normally incident at water – oil interface in a tube where an oil layer of thickness L is floating over water, and it is terminated with air at the top. The water (c_w =1500 m/s, ρ_w=1000 kg/m^3) can be considered lossless, whereas the oil (c_o =1450 m/s, ρ_o=960 kg/m^3) has an absorption coefficient, α = 2 dB/cm measured at 4MHz, with f^2 frequency dependence, typical of viscous attenuation.

a) Find an expression for the characteristic impedance of plane acoustic waves in oil, considering the viscous losses.
b) Find the expressions for reflection and transmission coefficients at this interface. You can assume that the speed of sound in oil is not affected by the attenuation in oil. Please justify any other assumptions you make.
c) What should be the distance L so that when a tone burst pressure signal at 2MHz is incident from water, only 1% of the incident acoustic energy is reflected back to water after a single reflection from the oil-air interface.



A plane circular piston in an infinite baffle operates into ethyl alcohol ($c = 1150$ m/s; $\rho_0 = 790$ kg/m^3). The radius of the piston is 1 m. At frequency of $6/\pi$ kHz, the sound pressure level on axis at 1 km is 39 dB (*re* 20 μPa). Assume you know $j_{11} = 3.83$ for the Bessel Function of the first kind, $J_m(j_{mn}) = 0$.

a) Knowing: $p(r,\theta,t) = j\rho_0 c \frac{U_0}{\lambda} \int_S \frac{1}{r'} e\, e^{j(\omega t - kr')} dS$; find the rms speed of the piston.

b) What is the smallest angle at which the pressure amplitude in the far field is equal to zero?

c) If the frequency were doubled while keeping the velocity amplitude of the piston constant, what would be the dB change in sound pressure level on the axis at 1 km?