Hydrophones

Before reading this page, make sure to check out the **Problem Setup** section of this page.

This page is a summary of how we use the hydrophones to figure out our position.

Note that δ, ϵ, and ζ are defined as:

h_0 is at location $(0,0,0)$
h_x is at location $(\delta,0,0)$
h_y is at location $(0,\epsilon,0)$
h_z is at location $(0,0,\zeta)$

The primary results from this derivation are equations $\ref{eq:xyz}$ and $\ref{eq:p0_initial}$. $$ \begin{equation} \label{eq:xyz} x = \frac{\Delta x (2p_0 - \Delta x) + \delta^2}{2 \delta} \\ y = \frac{\Delta y (2p_0 - \Delta y) + \epsilon^2}{2 \epsilon} \\ z = \frac{\Delta z (2p_0 - \Delta z) + \zeta^2}{2 \zeta} \end{equation}$$ $$ \begin{equation}\label{eq:p0_initial} 0 = p_0^2(a_x + a_y + a_z - 1) + p_0(b_x + b_y + b_z) + (c_x+c_y+c_z) \end{equation} $$ With variable definitions given by $\ref{eq:variable_definitions}$.

$$ \begin{equation} \label{eq:variable_definitions} a_x = \left(\frac{\Delta x}{\delta}\right)^2 \qquad b_x = \frac{\Delta x}{\delta^2}(\delta^2 +\Delta x^2) \qquad c_x = \left(\frac{\Delta x^2 - \delta^2}{2 \delta}\right)^2 \\ a_y = \left(\frac{\Delta y}{\epsilon}\right)^2 \qquad b_y = \frac{\Delta y}{\epsilon^2}(\epsilon^2 +\Delta y^2) \qquad c_y = \left(\frac{\Delta y^2 - \epsilon^2}{2 \epsilon}\right)^2 \\ a_z = \left(\frac{\Delta z}{\zeta}\right)^2 \qquad b_z = \frac{\Delta z}{\zeta^2}(\zeta^2 +\Delta z^2) \qquad c_z = \left(\frac{\Delta z^2 - \zeta^2}{2 \zeta}\right)^2 \end{equation} $$ Let us simplify eq. $\ref{eq:p0_initial}$ using the following substitution: $$ a = (a_x + a_y + a_z - 1) \\ b = (b_x + b_y + b_z) \\ c = (c_x+c_y+c_z) $$

This gives us eq. $\ref{eq:p0_initial_simple}$, which is an ordinary quadratic equation. $$ \begin{equation}\label{eq:p0_initial_simple} 0 = p_0^2 a + p_0 b + c \end{equation} $$ Applying the quadratic formula to eq. $\ref{eq:p0_initial_simple}$, we can solve for p_0.

$$ \begin{equation}\label{eq:p0_solved} p_0 = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \end{equation} $$

This will give us two possible solutions for p_0. We can combine this result with eq. $\ref{eq:xyz}$ to solve for x, y, and z.

Reversing the Problem

Here we describe how the simulator takes the position of the sub and calculates fake hydrophone timing data.

Need figure this part out!