

# 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  $\delta$ ,  $\epsilon$ , and  $\zeta$  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}](#).  

$$\begin{equation} \label{eq:xyz} x = \frac{\Delta x (2p_0 - \Delta x) + \delta^2}{2 \delta} \quad y = \frac{\Delta y (2p_0 - \Delta y) + \epsilon^2}{2 \epsilon} \quad z = \frac{\Delta z (2p_0 - \Delta z) + \zeta^2}{2 \zeta} \end{equation}$$

$$\begin{equation} \label{eq:p0_initial} 0 = p_0^2(a_x + a_y + a_z - 1) + p_0(b_x + b_y + b_z) + (c_x + c_y + c_z) \end{equation}$$
 With variable definitions given by [\ref{eq:variable\\_definitions}](#).

$$\begin{equation} \label{eq:variable_definitions} a_x = \left(\frac{\Delta x}{\delta}\right)^2 \quad b_x = \frac{\Delta x}{\delta^2}(\delta^2 - \Delta x^2) \quad c_x = \left(\frac{\Delta x^2 - \delta^2}{2 \delta}\right)^2 \quad a_y = \left(\frac{\Delta y}{\epsilon}\right)^2 \quad b_y = \frac{\Delta y}{\epsilon^2}(\epsilon^2 - \Delta y^2) \quad c_y = \left(\frac{\Delta y^2 - \epsilon^2}{2 \epsilon}\right)^2 \quad a_z = \left(\frac{\Delta z}{\zeta}\right)^2 \quad b_z = \frac{\Delta z}{\zeta^2}(\zeta^2 - \Delta z^2) \quad c_z = \left(\frac{\Delta z^2 - \zeta^2}{2 \zeta}\right)^2 \end{equation}$$

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!

From:

<http://robosub-vm.eecs.wsu.edu/wiki/> - **Palouse RoboSub Technical Documentation**

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<http://robosub-vm.eecs.wsu.edu/wiki/cs/hydrophones/start?rev=1481611375>



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