

# 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 [eq:xyz](#) and [eq:p0\\_initial](#).  

$$\begin{aligned} x &= \frac{\Delta x (2p_0 - \Delta x) + \delta^2}{2\delta} \\ y &= \frac{\Delta y (2p_0 - \Delta y) + \epsilon^2}{2\epsilon} \\ z &= \frac{\Delta z (2p_0 - \Delta z) + \zeta^2}{2\zeta} \end{aligned}$$
 With variable definitions given by [eq:variable\\_definitions](#).

$$\begin{aligned} a_x &= \left(\frac{\Delta x}{\delta}\right)^2 \\ b_x &= \frac{\Delta x}{\delta} \left(\frac{\Delta x}{\delta} - \Delta x\right)^2 \\ c_x &= \left(\frac{\Delta x}{\delta}\right)^2 \\ a_y &= \left(\frac{\Delta y}{\epsilon}\right)^2 \\ b_y &= \frac{\Delta y}{\epsilon} \left(\frac{\Delta y}{\epsilon} - \Delta y\right)^2 \\ c_y &= \left(\frac{\Delta y}{\epsilon}\right)^2 \\ a_z &= \left(\frac{\Delta z}{\zeta}\right)^2 \\ b_z &= \frac{\Delta z}{\zeta} \left(\frac{\Delta z}{\zeta} - \Delta z\right)^2 \\ c_z &= \left(\frac{\Delta z}{\zeta}\right)^2 \end{aligned}$$
 Let us simplify eq. [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. [eq:p0\\_initial\\_simple](#), which is an ordinary quadratic equation.  

$$0 = p_0^2 a + p_0 b + c$$
 Applying the quadratic formula to eq. [eq:p0\\_initial\\_simple](#), we can solve for  $p_0$ .

$$p_0 = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

This will give us two possible solutions for  $p_0$ . We can combine this result with eq. [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:

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

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