

# 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

The primary results from [this derivation](#) are equations [\ref{eq:xyz}](#) and [\ref{eq:p0\\_initial}](#).  

$$\begin{aligned} x &= \frac{\Delta x (2p_0 - \Delta x) + \delta^2}{2\delta} \\ y &= \frac{\Delta y (2p_0 - \Delta y) + \epsilon^2}{2\epsilon} \\ z &= \frac{\Delta z (2p_0 - \Delta z) + \zeta^2}{2\zeta} \end{aligned}$$

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

$$\begin{aligned} a_x &= \left(\frac{\Delta x}{\delta}\right)^2 \\ b_x &= \frac{\Delta x}{\delta^2}(\delta^2 + \Delta x^2) \\ c_x &= \left(\frac{\Delta x^2 - \delta^2}{2\delta}\right)^2 \\ a_y &= \left(\frac{\Delta y}{\epsilon}\right)^2 \\ b_y &= \frac{\Delta y}{\epsilon^2}(\epsilon^2 + \Delta y^2) \\ c_y &= \left(\frac{\Delta y^2 - \epsilon^2}{2\epsilon}\right)^2 \\ a_z &= \left(\frac{\Delta z}{\zeta}\right)^2 \\ b_z &= \frac{\Delta z}{\zeta^2}(\zeta^2 + \Delta z^2) \\ c_z &= \left(\frac{\Delta z^2 - \zeta^2}{2\zeta}\right)^2 \end{aligned}$$

$h_0$  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  $(0,0,\zeta)$

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.  

$$0 = p_0^2 a + p_0 b + c$$
 Applying the quadratic formula to eq. [\ref{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. [\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-old.eecs.wsu.edu/wiki/> - **Palouse RoboSub Technical Documentation**

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