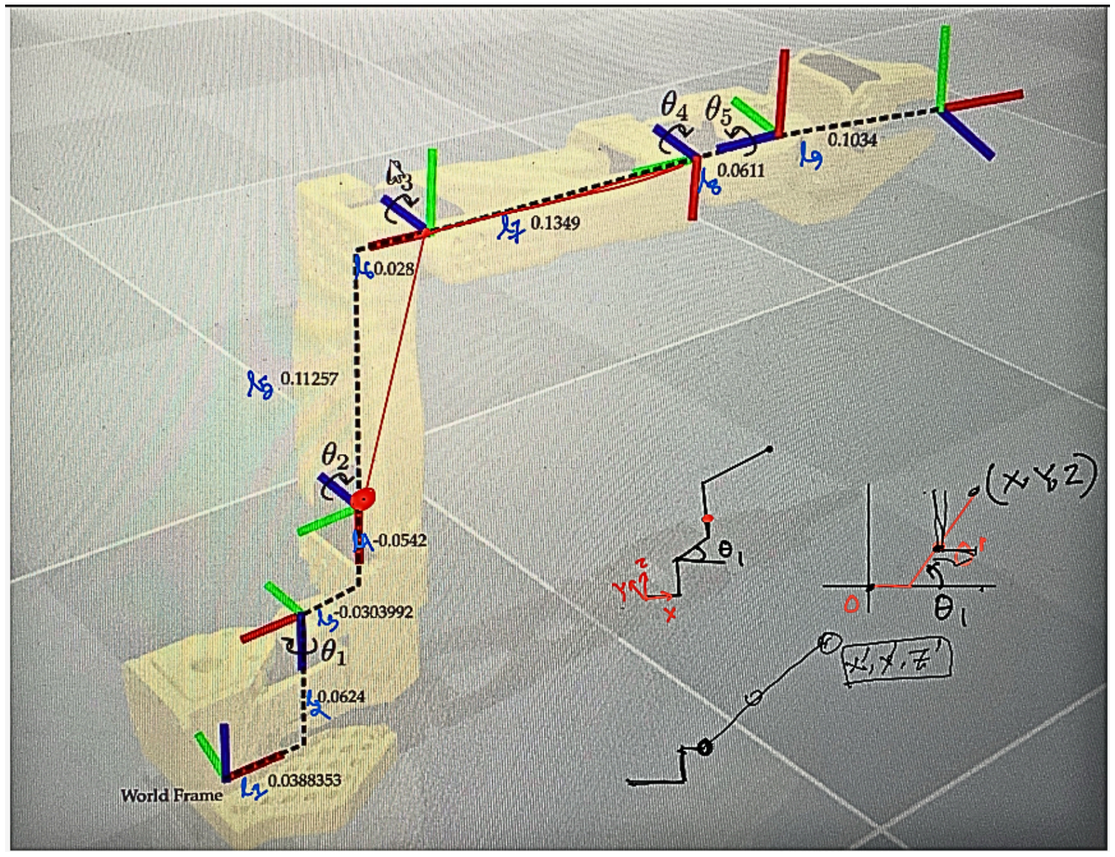
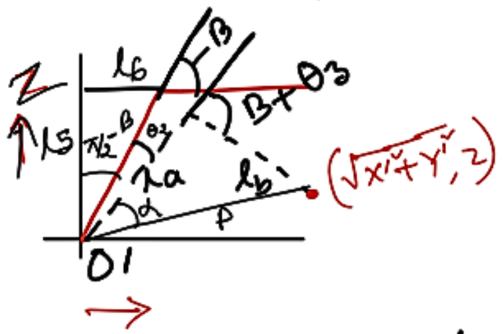


θ2, θ3 Calculation



For O'

$x' = X - l_4 - l_3\cos\theta_1$

$y' = Y - l_3\sin\theta_1$

$z' = Z - l_2 - l_4 + l_8 + l_9$

$$D2 = \frac{l_a^2 + p^2 - l_b^2}{2 l_a p}$$

$$\pi/2 - (\pi/2 - \beta) - \cos^{-1} D2 - \tan^{-1}\frac{z}{\sqrt{x'^2 + y'^2}} = \theta_2$$

$l_a = \sqrt{l_5^2 + l_6^2}$

$l_b = l_7, \beta = \arctan(l_5, l_6)$

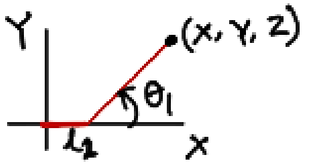
$p = \sqrt{x'^2 + y'^2 + z'^2}$

$l_a^2 + l_b^2 - 2 l_a l_b \cos(\pi - (\beta + \theta_3)) = p^2$

$l_a^2 + l_b^2 + 2 l_a l_b \cos(\beta + \theta_3) = p$

$$\cos(\beta + \theta_3) = \frac{p^2 - l_a^2 - l_b^2}{2 l_a l_b}$$

θ1 Calculation:



$$\theta_1 = \text{arctan2}(Y,\ x - l_1)$$

θ4 Calculation

get $H_4^0 = A_1 A_2 A_3 A_4$ [Forward Kinematics]

↳ Hs Y-axis needs to be opposite of world Z axis

$$\theta_4 = \pi - \text{acos}(H_4^0[1,1])$$