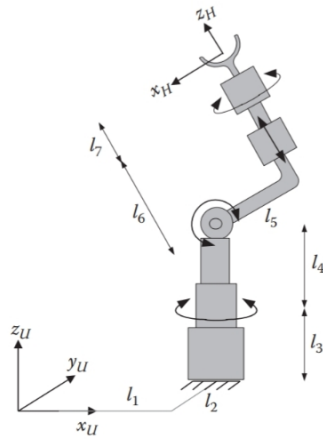
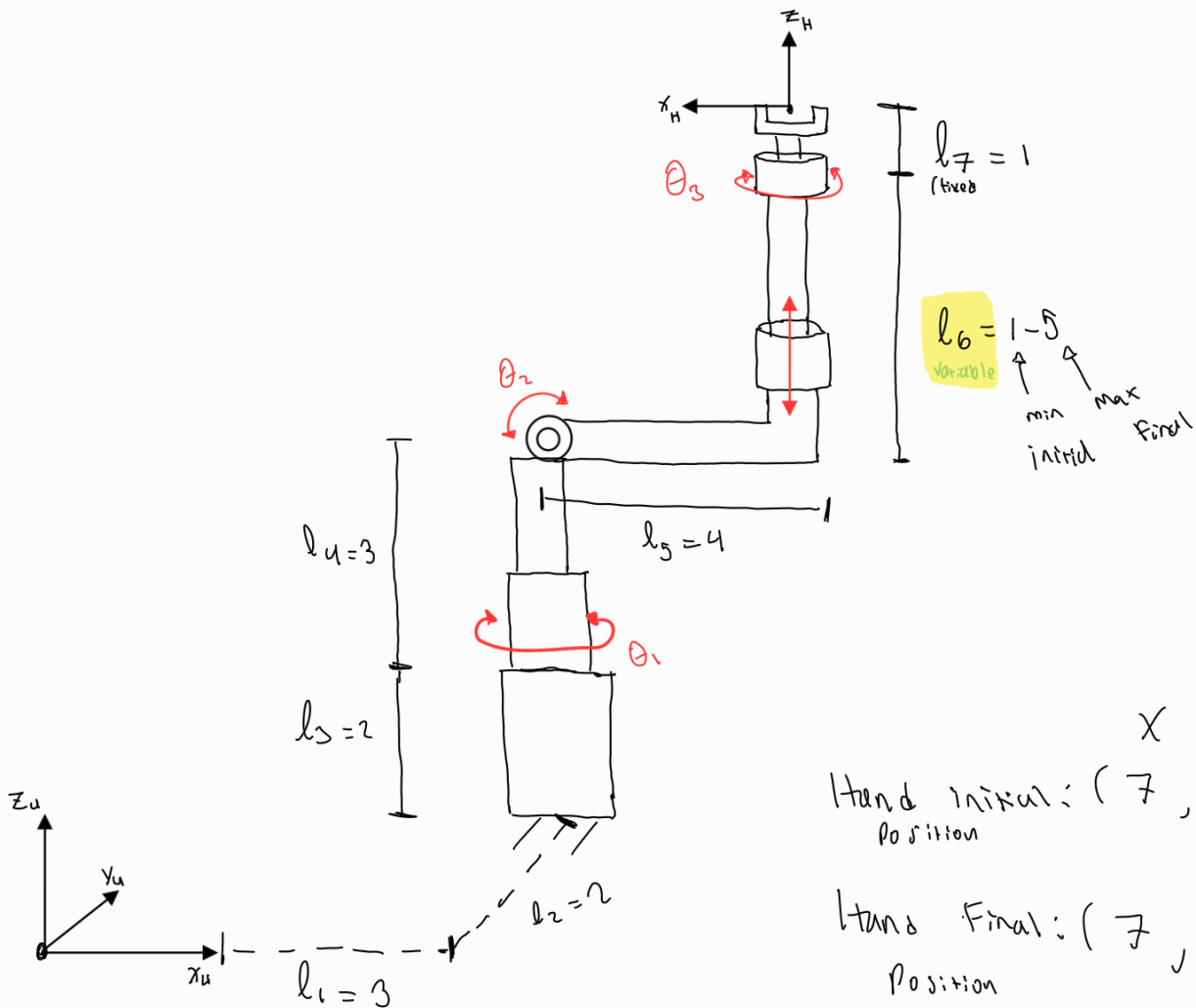


2.40 For the given specialty designed 4-DOF robot:

- Assign appropriate frames for the D-H representation.
- Fill out the parameters table.
- Write an equation in terms of A-matrices that shows how  ${}^U T_H$  can be calculated.



Link	Length
$l_1$	3
$l_2$	2
$l_3$	2
$l_4$	3
$l_5$	4
$l_6$	Variable
$l_7$	1

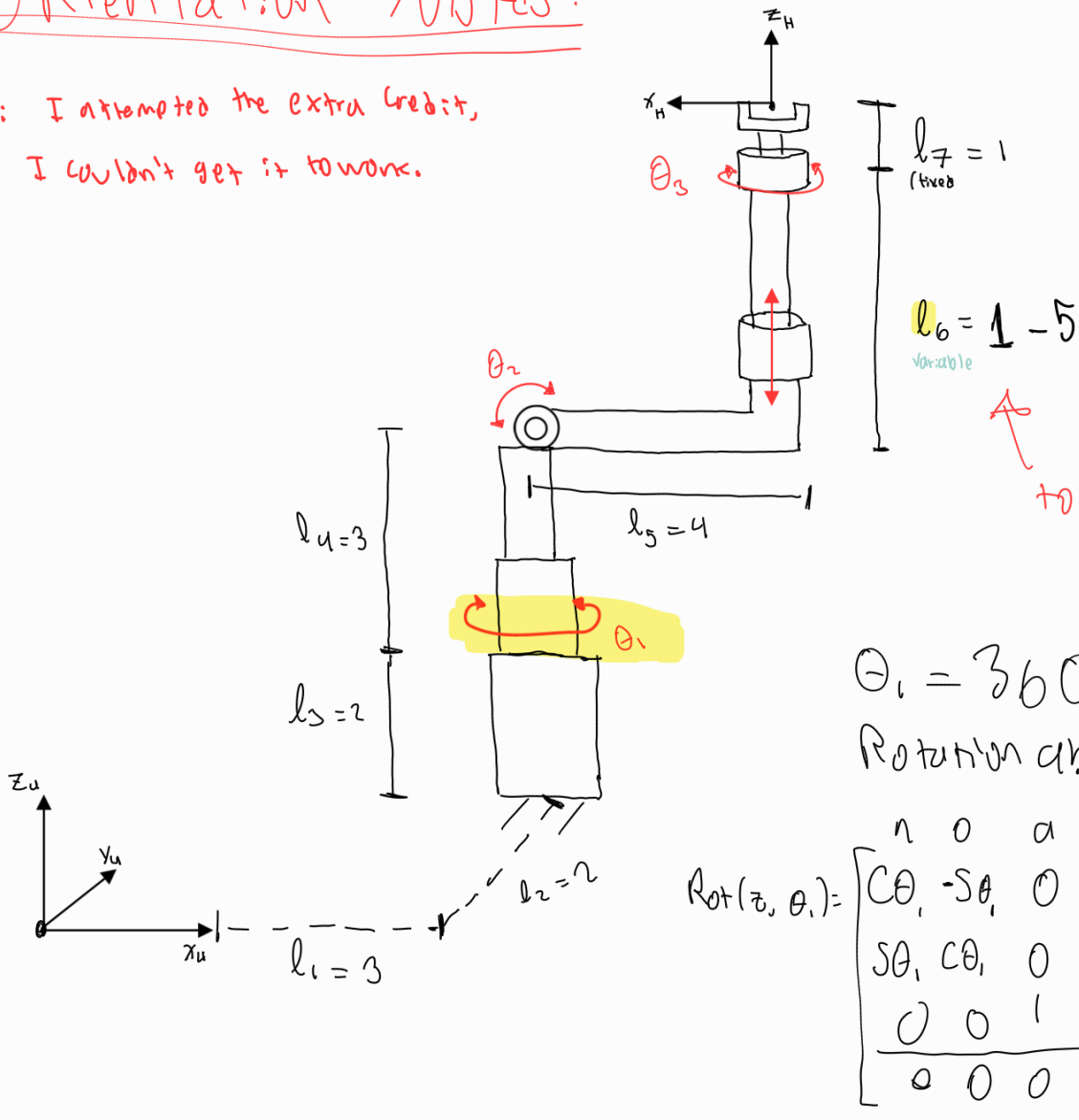


Grouping final hand Trajectory

$$T = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} p_x \\ p_y \\ p_z \\ 1 \end{bmatrix}$$

# Orientation Notes:

Note: I attempted the extra credit, but I couldn't get it to work.

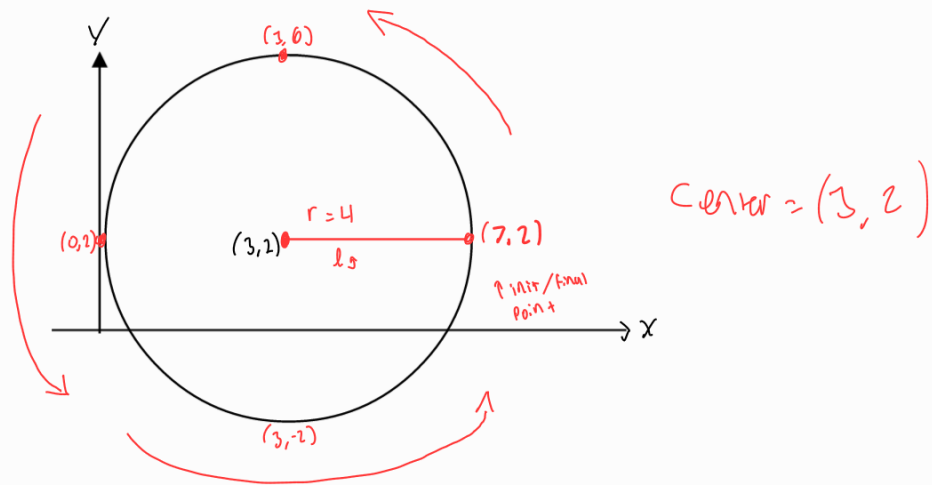


$\theta_1 = 360^\circ$   
Rotation about Z-axis

we are rotating about (3, 2, 2)

$$Rot(z, \theta_1) = \begin{bmatrix} c\theta & -s\theta & 0 & p_x \\ s\theta & c\theta & 0 & p_y \\ 0 & 0 & 1 & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{matrix} x \\ y \\ z \end{matrix}$$

Plot should be on X-Y plane: should look like this



## 2 link Planar

Forward:

$${}^0T_H = A_1 A_2 = \begin{bmatrix} C_{12} & -S_{12} & 0 & L_2 C_{12} + L_1 C_1 \\ S_{12} & C_{12} & 0 & L_2 S_{12} + L_1 S_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{matrix} \text{From} \\ \text{base} \rightarrow \text{hand} \end{matrix} \quad \begin{matrix} \text{X actual} \\ \text{Y actual} \end{matrix}$$

Inverse:

$$T = A_1 A_2$$

$$\underbrace{A_1^{-1} T}_{\text{LHS}} = \underbrace{A_2}_{\text{RHS}}$$

$$T_{\text{known}} = \begin{bmatrix} n_x & o_x & a_x & p_x \\ n_y & o_y & a_y & p_y \\ n_z & o_z & a_z & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\text{LHS} = \begin{bmatrix} n_x C_1 - n_y S_1 & o_x C_1 - o_y S_1 & a_x C_1 - a_y S_1 & L_1 C_1 + p_x C_1 - p_y S_1 \\ n_y C_1 + n_x S_1 & o_y C_1 + o_x S_1 & a_y C_1 + a_x S_1 & L_1 S_1 + p_y C_1 + p_x S_1 \\ n_z & o_z & a_z & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\text{RHS} = \begin{bmatrix} C_2 & -S_2 & 0 & L_2 C_2 \\ S_2 & C_2 & 0 & L_2 S_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Find  $\theta_1, \theta_2$

$$\theta_2 = \arctan2(S_2, C_2);$$

$$C_2 = \frac{1 - (L_1^2 + L_2^2)}{2 L_1 L_2}$$