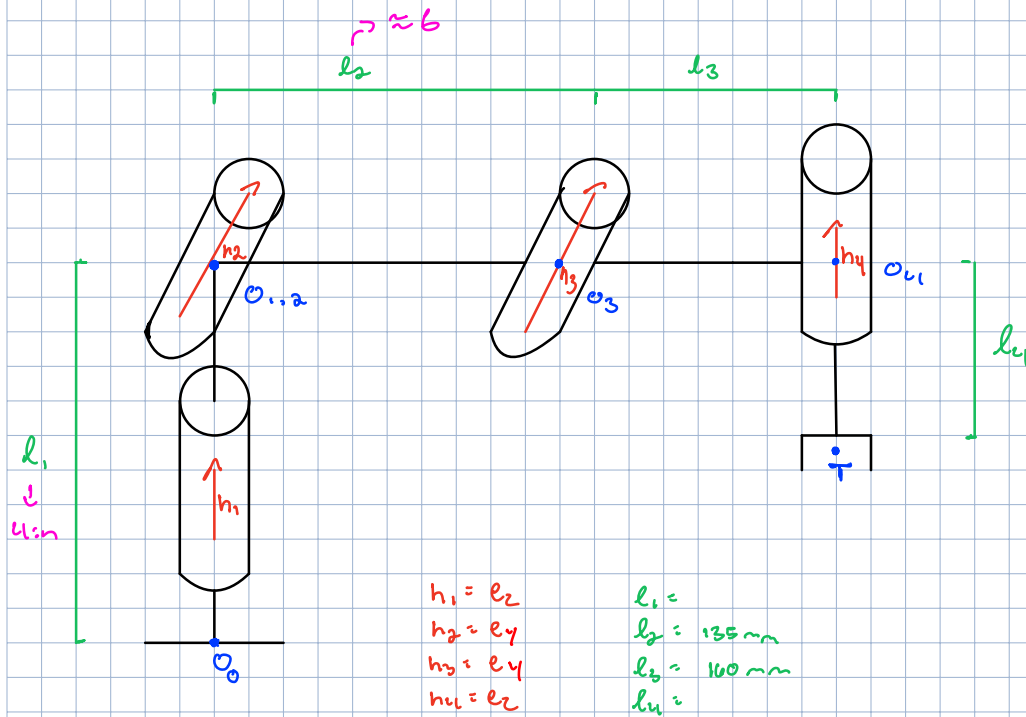
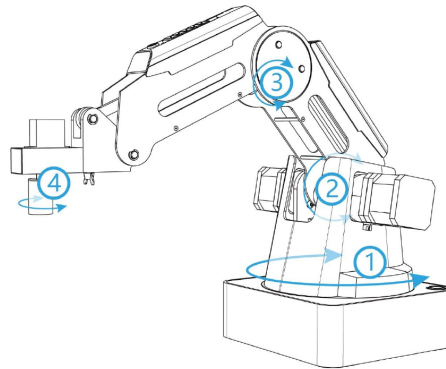


Robot Arm

Joint1
Joint2
Joint3
Joint4



$P_{01} = l_1$ (44 inches)
 $P_{02} = 0$

Joint limitations →

$-125^\circ \leq \text{Joint 1} \leq 135^\circ$
 $-5^\circ \leq \text{Joint 2} \leq 85^\circ$
 $-10^\circ \leq \text{Joint 3} \leq 45^\circ$
 $-90^\circ \leq \text{Joint 4} \leq 90^\circ$

Calibrate arm to final lengths: Do l distances, find angles w/ I_x ,
 l unknown (lengths)
 \rightarrow angles at each point and l eqs.

\hookrightarrow arm lengths
 \hookrightarrow solve!

$$\begin{aligned} \Delta z &= 0 \\ \Delta y &= 0 \\ \Delta x &= \text{dist}_a \end{aligned}$$

$$\begin{aligned} \Delta z &= 0 \\ \Delta y &= 0 \\ \Delta x &= \text{dist}_b \end{aligned}$$

$$P_i = P_1 * R_1 R_2 \dots R_i \quad \rightarrow \quad n: \text{VAR}$$

Inverse kinematics:

$$R_{07} = R_{01} R_{12} R_{23} R_{37} \quad R_{37} = I \text{ (given)}$$

$$R_{07} = R_{01} R_{12} R_{23}$$

$$R_{07} = R_{01}(h_1, q_1) R_{07}(h_2, q_2) R_{07}(h_3, q_3)$$

$$R_{07}^* h_3 = R_{01}(h_1, q_1) R_{07}(h_2, q_2) h_3$$

$$R_{01}(-h_1, q_1) * R_{07}^* h_3 = R_{07}(h_2, q_2) * h_3$$

\rightarrow solve q_1, q_2 with subproblem 2

$$R_{07} = R_{01} R_{12} R_{23}$$

$$R_{07} = R_{01}(h_1, q_1) R_{07}(h_2, q_2) R_{07}(h_3, q_3)$$

$$R_{07}(-h_2, q_2) R_{07}(-h_1, q_1) R_{07} = R_{07}(h_3, q_3)$$

$$R_{07}(-h_2, q_2) R_{07}(-h_1, q_1) R_{07}^* e_x = R_{07}(h_3, q_3)^* e_x$$

\rightarrow solve q_3 with subproblem 1

* $h_3 = e_y$, multiply
 h_1, e_x

\Rightarrow 2 total solutions

Forward Kinematics \rightarrow same as Mini Project 3