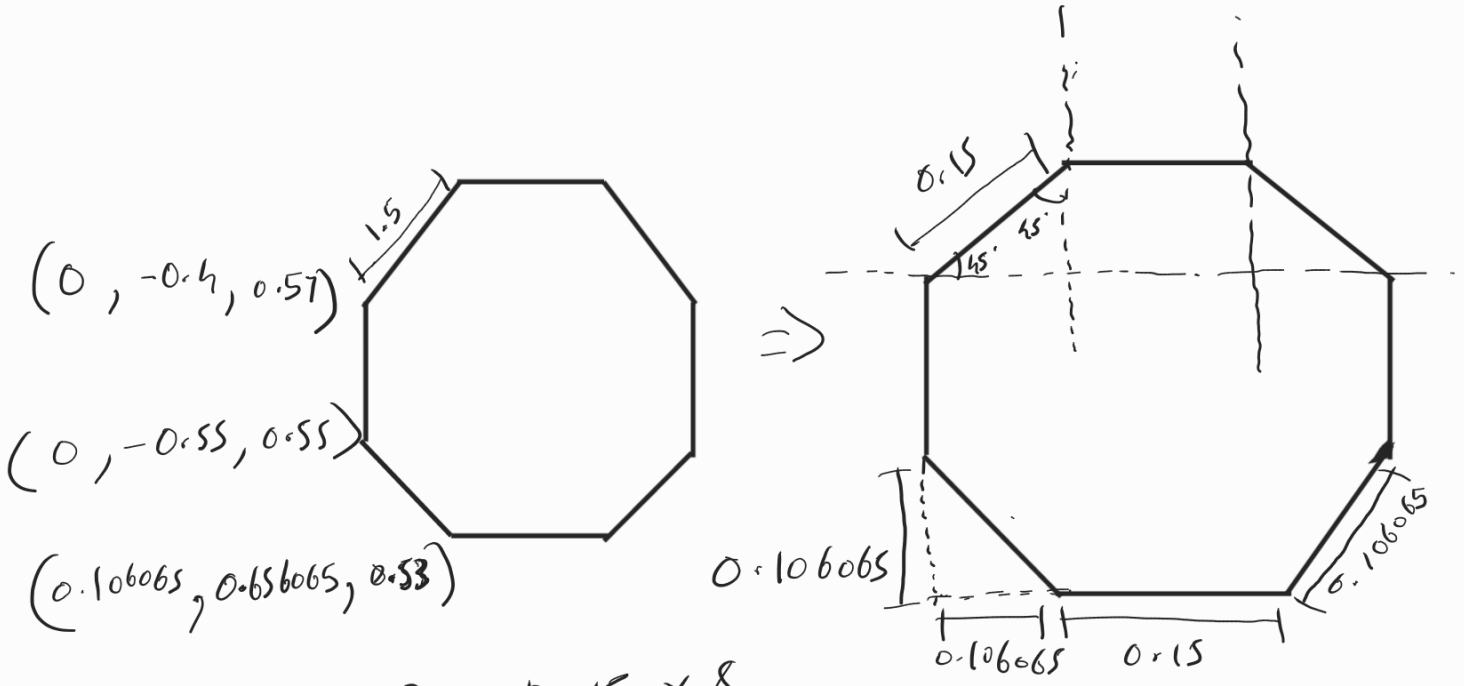
Home Position :

x	y	z
0.77	0	0.6

Waypoints for Hexagon :



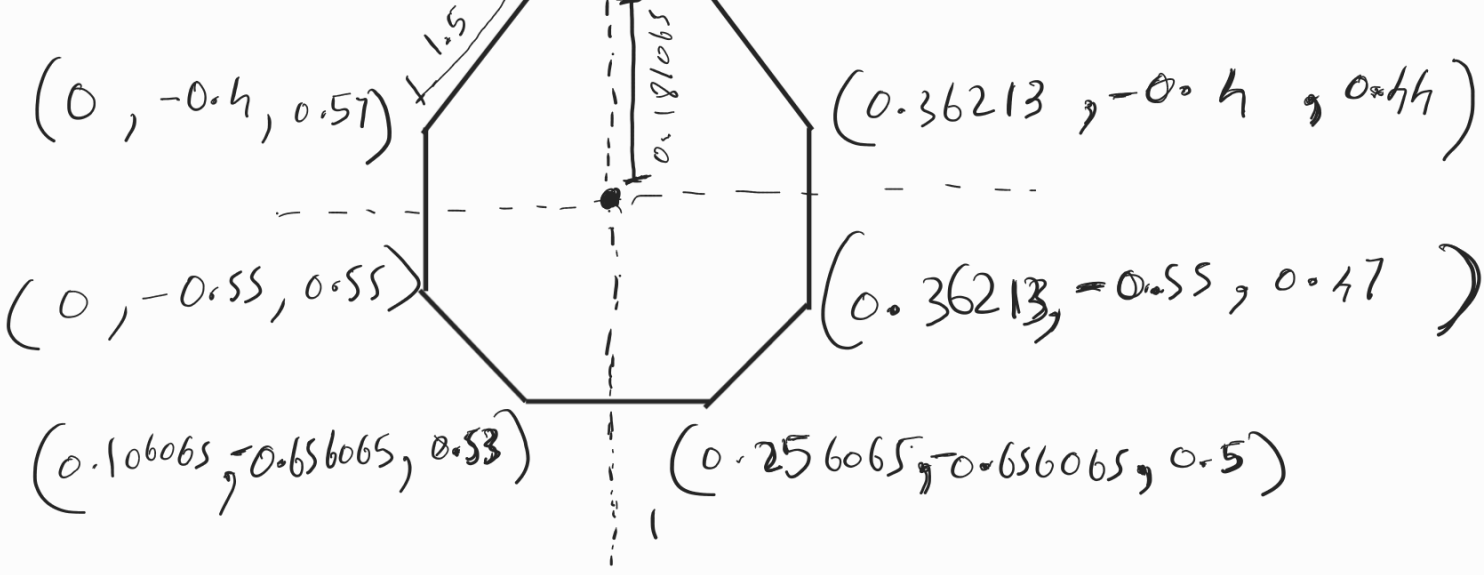
$$P = 0.15 \times 8$$
$$= 1.2\text{m}$$

$$\Rightarrow \sin(45^\circ) = \frac{opp}{hyp} = \frac{opp}{0.15}$$

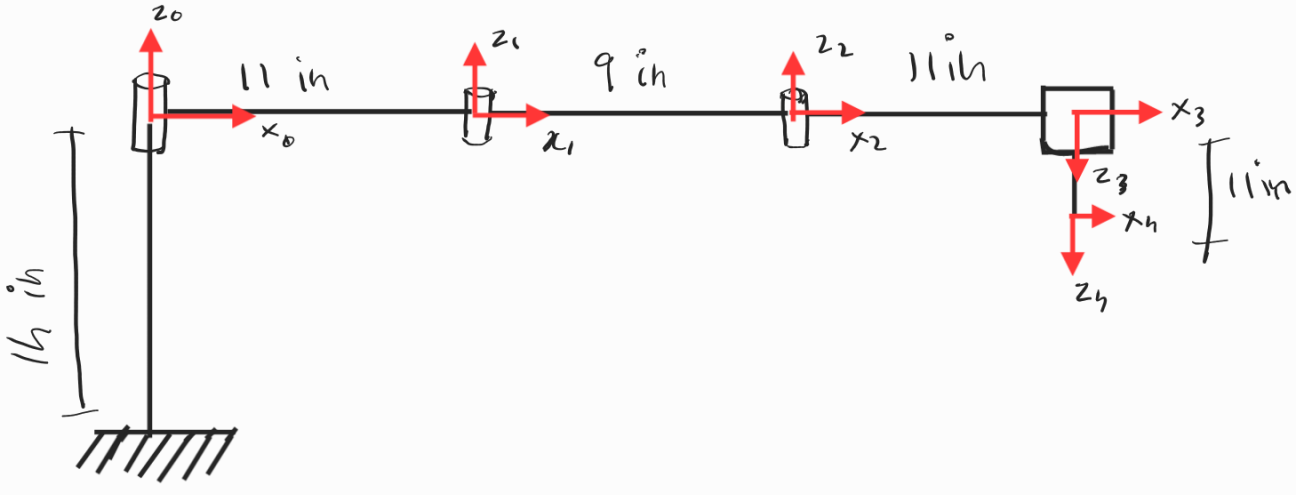
$$\Rightarrow opp = 0.7071 \times 0.15$$
$$= 0.106065$$

(0.106065, -0.293935, 0.37)

(0.256065, -0.293935, 0.4)



midpoint = (0.181065, -0.475, 0.16)



DH - Parameters:

Link	a	α_i	di	θ_i
1	11	0	0	-20
2	9	0	0	-70
3	11	π	0	-70
4	0	0	11	0

$$\begin{bmatrix} C\theta_i & -S\theta_i C\alpha_i & S\theta_i S\alpha_i & a_i C\theta_i \\ S\theta_i & C\theta_i C\alpha_i & -C\theta_i S\alpha_i & a_i S\theta_i \\ 0 & S\alpha_i & C\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$${}^0_1T = \begin{bmatrix} 0.9397 & 0.3420 & 0 & 10.3366 \\ -0.3420 & 0.9397 & 0 & -3.7622 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$${}^1_2T = \begin{bmatrix} 0.3420 & 0.9397 & 0 & -3.0782 \\ -0.9397 & 0.3420 & 0 & -8.4572 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$${}^2_3T = \begin{bmatrix} 0.3420 & -0.9397 & 0 & -3.7622 \\ -0.9397 & -0.3420 & 0 & -10.3366 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$${}^3_4T = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 8 \end{bmatrix}$$

$$\begin{bmatrix} 0 & 0 & 0 & \end{bmatrix}$$

$${}^{0}_{4}T = \begin{bmatrix} -0.9397 & -0.3420 & 0 & 0 \\ -0.3420 & 0.9397 & 0 & -16.5244 \\ 0 & 0 & -1 & -8 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$X = -16.5244 \text{ in} = -41.311 \text{ cm} = \boxed{-0.41 \text{ m}}$

$Z = -8$ (Prismatic)

Jacobian matrix

Prismatic

linear $R_{0,i-1}\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

Rotation $\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$

Revolute: → w.r.t radial distance

$R_{0,i-1}\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \times (O_n - O_{0,i-1})$

n = no. of links

$R_{0,i-1}\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$ i = current one.

Jacobian matrix for finding velocity.

$$
\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{z} \\ w_x \\ w_y \\ w_z \end{bmatrix} = \begin{bmatrix} \times & \times & \times & \times \\ \times & \times & \times & \times \\ \times & \times & \times & \times \\ \times & \times & \times & \times \\ \times & \times & \times & \times \\ \times & \times & \times & \times \end{bmatrix}_{6\times 4} \begin{bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ d_1 \end{bmatrix}
$$

$$
\left[\begin{array}{ccc|c} R_0^0 \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \times (O_4^0 - O_0^0) & R_1^0 \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} (O_4^0 - O_1^0) & R_2^0 \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \times (O_4 - O_2^0) & R_3^0 \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \\ \hline R_0^0 \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} & R_1^0 \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} & R_2^0 \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} & \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \end{array}\right]
$$

$$
J = \begin{bmatrix} J_w \\ J_v \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 \\ 16.5244 & 12.7622 & 3.7622 & 0 \\ 0 & -10.3366 & -10.3366 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}
$$