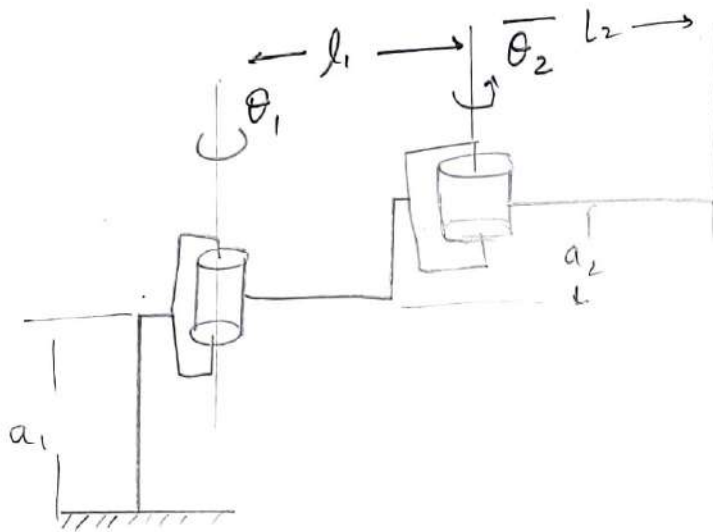


Task 0:



$$l_1 = l_2 = 107 \text{ mm.}$$

$$a_1 = 100$$

$$a_2 = 84$$

Note: \rightarrow During coding in IDE a_1 & a_2 are assumed to be zero to reduce the system to be a planar manipulator.

DH Table after above assumption.

Link	a_i	α	d	θ
1	107	0		θ_1
2	107	0		θ_2

$$A_1 = \begin{bmatrix} C_1 & -S_1 & 0 & a_1 C_1 \\ S_1 & C_1 & 0 & a_1 S_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad A_2 = \begin{bmatrix} C_2 & -S_2 & 0 & a_2 C_2 \\ S_2 & C_2 & 0 & a_2 S_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

T-matrix

$$T_0^1 = A_1 ; \quad T_0^2 = A_1 A_2 = \begin{bmatrix} C_{12} & -S_{12} & 0 & a_1 C_1 + a_2 C_{12} \\ S_{12} & C_{12} & 0 & a_1 S_1 + a_2 S_{12} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Case 1 : $\theta_1 = 45^\circ$ $\theta_2 = 90^\circ$

$$T_0^2 = \begin{bmatrix} -1/\sqrt{2} & -1/\sqrt{2} & 0 & 0 \\ 1/\sqrt{2} & -1/\sqrt{2} & 0 & 151.32 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Case 2 : $\theta_1 = 90^\circ$ $\theta_2 = 45^\circ$

$$T_0^2 = \begin{bmatrix} -1/\sqrt{2} & -1/\sqrt{2} & 0 & -75.66 \\ 1/\sqrt{2} & -1/\sqrt{2} & 0 & 182.66 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

we have,

$$J = [J_v, J_w]$$

where,

$$J_v = \begin{bmatrix} 107 * (-\sin \theta_1) & 107 * (-\sin \theta_2); \\ 107 * \cos \theta_1 & 107 * \cos \theta_2; \\ 0 & 0 \end{bmatrix}$$

$$J_w = \begin{bmatrix} 0 & 0; \\ 0 & 0; \\ 1 & 1 \end{bmatrix}$$

Thus

$$J = \begin{bmatrix} -107 \sin \theta_1 & , & -107 \sin \theta_2 \\ 107 \cos \theta_1 & , & 107 \cos \theta_2 \\ 0 & & 0 \\ 0 & & 0 \\ 1 & & 1 \end{bmatrix}$$

Issue
~~Issue~~ faced in Hardware.

1. Pulleys were slipping during sudden motion.
2. Gear was slipping from shaft of motor 2.
3. Gear of shaft of motor 1 was eccentric.
4. Motor 1 was not moving blew 40 value of PWM and motor 2 was not moving blew 30 value of PWM.

Task I:

- 1- Due to various issues in hardware as mentioned before there were constant vibrations and end effector was not reaching the point 1.

Task 2:

1. We were not able to control the Torque through current sensor. Therefore after reaching the point we gave a constant value of PWM to both motors and recorded the force value ~~and~~ using FSR sensor on a separate arduino.

Task 3:

- 1- ~~we~~ Our proper code of Spring force by using dynamics was not working so we made the End effector oscillate b/w two points.