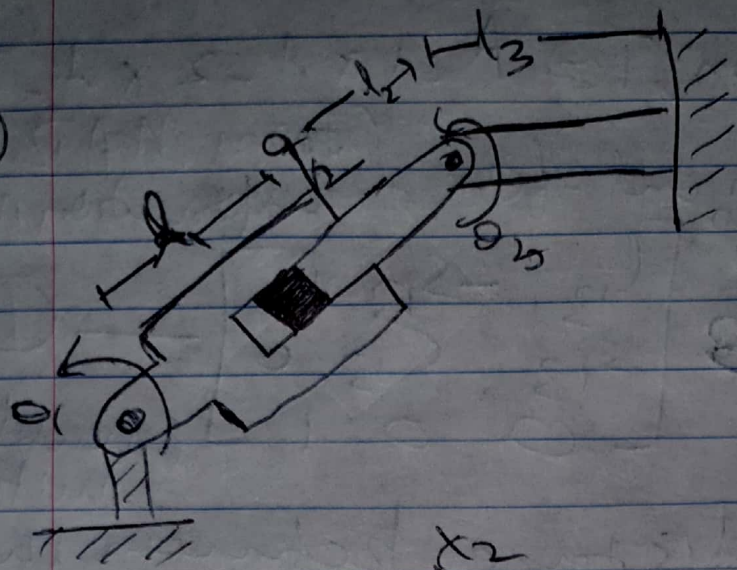
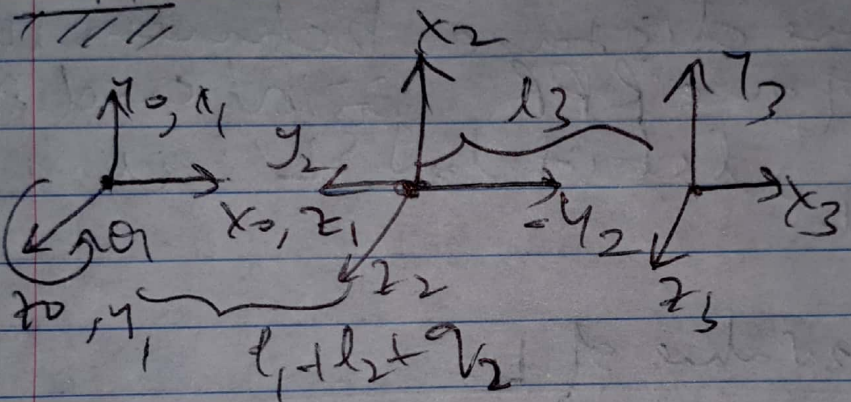
(2)





Writing DH parameters we get,

	θ	d	a	α
0→1	θ_1+90	0	0	90
1→2	0	$l_1+l_2+q_2$	0	-90
2→3	θ_3-90	0	l_3	0

The transformation matrix of this can be seen on MATLAB

This can be written as:

Transformation, $T = A_1 \times A_2 \times A_3$ (from MATLAB)

Taking the Rotation out of the transformation matrix:

$$\Rightarrow {}^{0}_{3}R \begin{bmatrix} C_{13} & -S_{13} & 0 \\ S_{13} & C_{13} & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad \text{---} (1)$$

(mentally multiplying)

Now the distance between the base of the RPR joint and the wall, let it be 'L' is a constant

$\Rightarrow$ This value of L =

$$\boxed{(l_1 + q_2 + l_2)\cos\theta_1 + l_3 = 0} \quad \text{---} (2)$$

This is the constraint to make sure that the link is always normal to the wall

Now from eqn (1)

$$\begin{bmatrix} \cos(\theta_1 + \theta_3) \\ \sin(\theta_1 + \theta_3) \\ 0 \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$$

This RHS to be true become the

link is parallel to the ground.

$\therefore \cos(\theta_1 + \theta_3) = 1$

$\Rightarrow \theta_1 + \theta_3 = 0 \text{ or } \pi \text{ or } 2\pi \ldots$

$= \underline{\underline{n\pi}} \quad \text{---} (3)$

Now the question says that, q_2 has a limited travel.

Let this be between 0 and q_{max}

$$\therefore 0 \leq q_2 \leq q_{max} \quad \text{---} (4)$$

Now, looking at all the constraints

CONSTRAINT-1 →

$$(l_1 + q_2 + l_2)\cos\theta_1 + l_3 = 0$$

If we look at eq (4) we know that the motion of this is limited from

$$(l_1 + l_2)\cos\theta_1 + l_3 \leq (l_1 + q_2 + l_2)\cos\theta_1 + l_3$$

$$\leq (l_1 + q_{max} + l_3)\cos\theta_1 + l_3$$

Hence, this is a HOLONOMIC constraint

Now,

CONSTRAINT 2 →

$$\cos(\theta_1 + \theta_3) = 1$$

$$\rightarrow \theta_1 + \theta_3 = 0^\circ \text{ or } (n\pi), \quad n \in 0, 1, 2 \cdots n$$

This is a indicative of the parallel nature of the joint link at all times, hence, this is also a HOLONOMIC constraint

CONSTRAINT 3 →

$$0 \leq q_2 \leq l_{max}$$

also limits the motion, hence

these constraints are HOLONOMIC IN NATURE