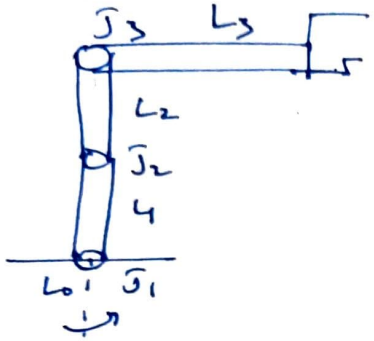
122009154

Industrial Robotics

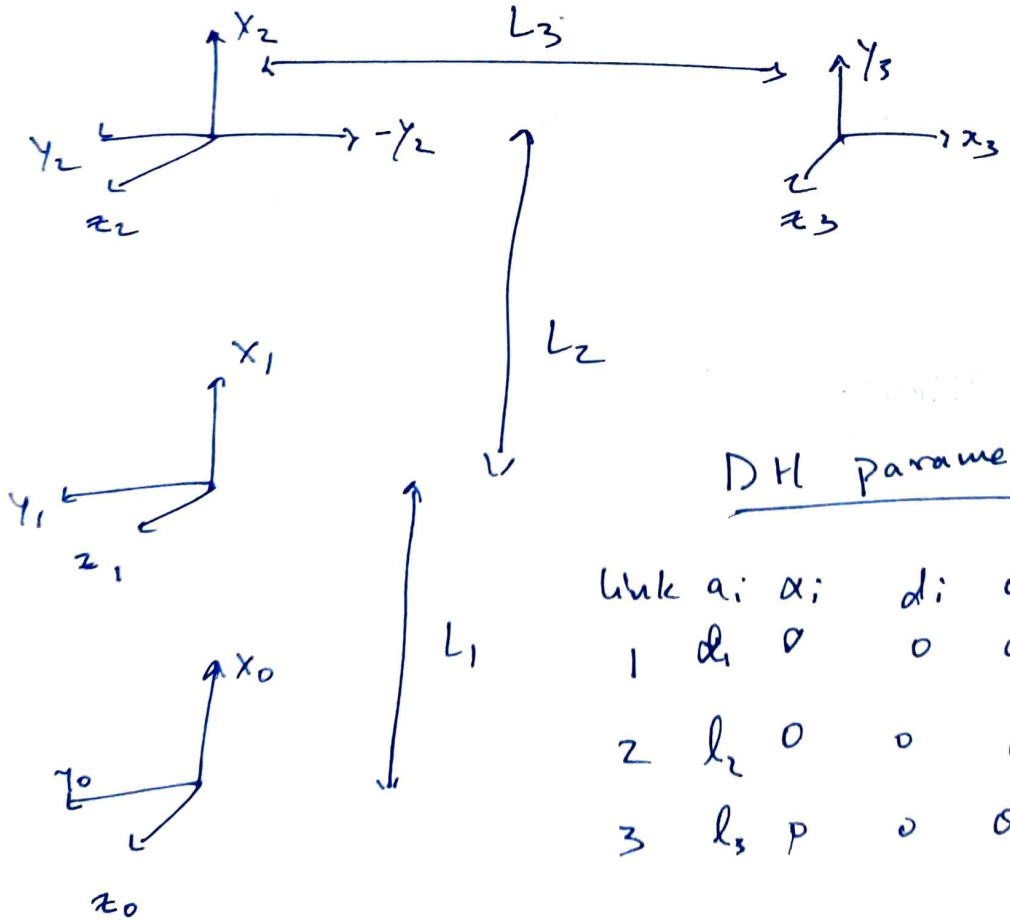
Naimish Mani B

Team: Pravin A (122009184)
Shyam Ganesh R (122009228)

Line diagram:



Forward kinematics:



DH parameters:-

Link	a_i	α_i	d_i	θ_i	Joint var.
1	l_1	0	0	θ_1	θ_1
2	l_2	0	0	θ_2	θ_2
3	l_3	p	0	$\theta_3 - 90$	θ_3

Derivation:

$$
{}^{i-1}T_i = \begin{bmatrix} C\theta_i & -S\theta_i C\alpha_i & S\theta_i S\alpha_i & a_i C\theta_i \\ S\theta_i & C\theta_i C\alpha_i & \cos\theta_i(-\sin\alpha_i) & a_i S\theta_i \\ 0 & S\alpha_i & C\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
{}^{0}T_1 = \begin{bmatrix} C_1 & -S_1 & 0 & l_1 C_1 \\ S_1 & C_1 & 0 & l_1 S_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
{}^{1}T_2 = \begin{bmatrix} C_2 & -S_2 & 0 & l_2 S_2 \\ S_2 & C_2 & 0 & l_2 C_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
{}^{2}T_3 = \begin{bmatrix} S_3 & C_3 & 0 & l_3 S_3 \\ -C_3 & S_3 & 0 & -l_3 C_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
{}^{0}T_3 : {}^{0}T_1 \times {}^{1}T_2 \times {}^{2}T_3
$$

$$
{}^{0}T_1 \times {}^{1}T_2 = \begin{bmatrix} -C_1 & S_1 & 0 & l_1 C_1 \\ S_1 & C_1 & 0 & l_1 S_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} C_2 & -S_2 & 0 & l_2 S_2 \\ S_2 & C_2 & 0 & l_2 S_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

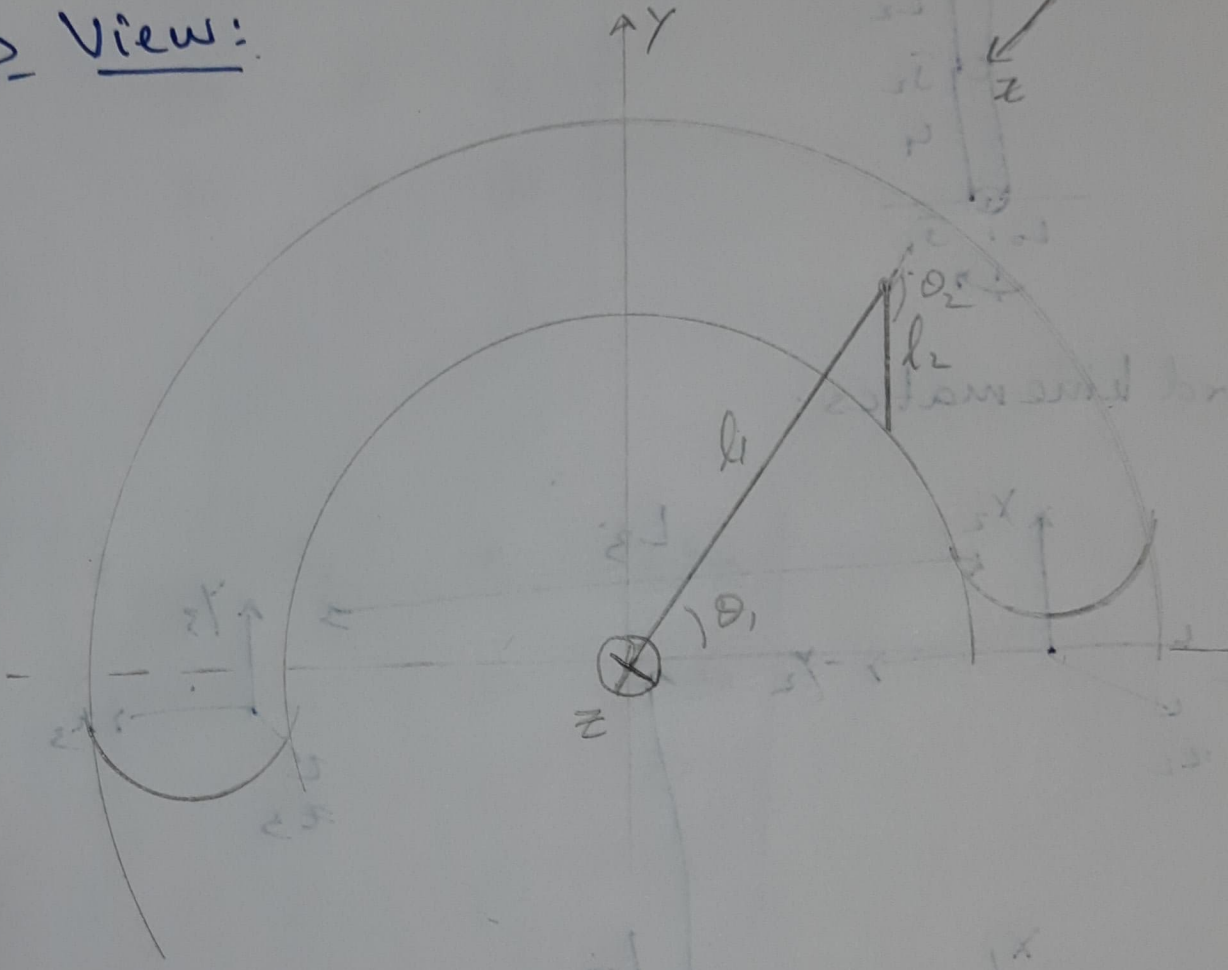
$$
{}^{0}T_2 = \begin{bmatrix} C_1C_2 - S_1S_2 & -C_1S_2 - S_1C_2 & 0 & C_1C_2l_2 - S_1S_2l_2 + l_1C_1 \\ S_1C_2 + C_1S_2 & -S_1S_2 + C_1C_2 & 0 & S_1C_2l_2 + C_1S_2l_2 + l_1S_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
{}^{0}T_2 \times {}^{2}T_3 = \begin{bmatrix} C_{12} & -S_{12} & 0 & C_1C_2l_2 - S_1S_2l_2 + l_1C_1 \\ S_{12} & C_{12} & 0 & S_1C_1l_2 + C_1S_2l_2 + l_1S_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} S_3 & C_3 & 0 & l_3S_3 \\ -C_3 & S_3 & 0 & -l_3C_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
\Rightarrow {}^{0}T_3 = \begin{bmatrix} C_{12}S_3 + S_{12}C_3 & C_{12}C_3 - S_{12}S_3 & 0 & C_{12}l_3S_3 + S_{12}l_3C_3 + \\ & & & C_1C_2l_2 - S_1S_2l_2 + l_1C_1 \\ S_{12}S_3 - C_{12}C_3 & S_{12}C_3 + C_{12}S_3 & 0 & S_{12}l_3S_3 - C_{12}C_3l_3 \\ & & & + S_1C_2l_2 + C_1S_2l_2 + l_1S_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

Workspace diagram:

Top View:



Side View: