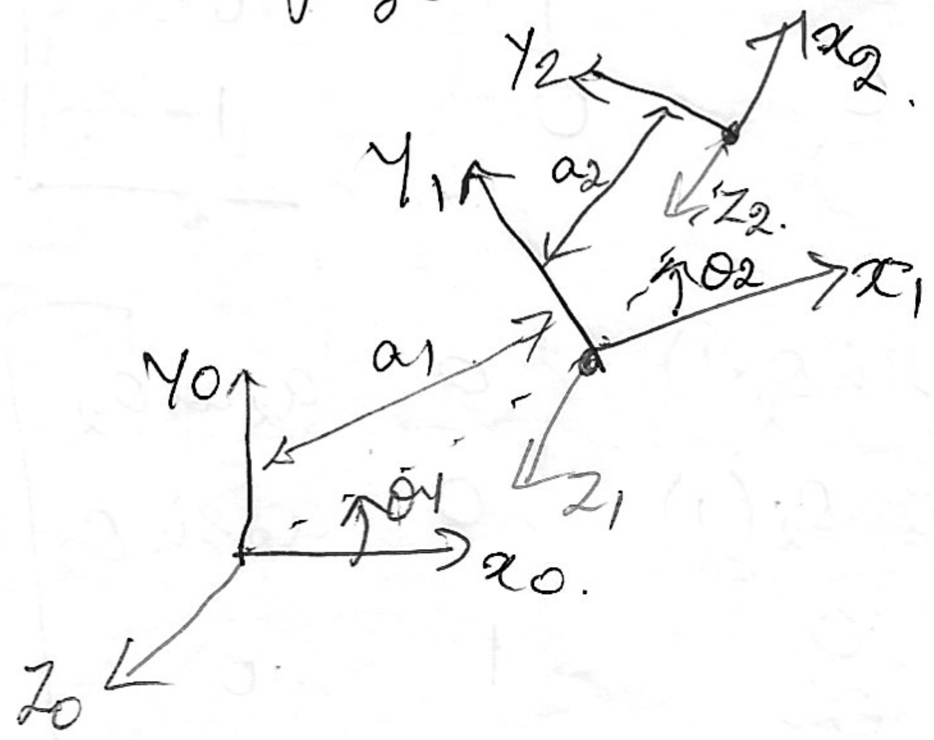
Denavit Hartenberg.

Ex. 2. Consider 2-link planar arm. Z_0 & Z_1 are normal to page. Find the transformation matri



Soln: For the given Framing (frame position

the D-H table is.

Link	θ	α	r	d
1	θ_1	0	a_1	0
2	θ_2	0	a_2	0

$^0H_1 : \rightarrow$

$\theta = \theta_1,\ r = a_1,\ \alpha = d = 0$

$$^0H_1 = \begin{bmatrix} \cos\theta_1 & -\sin\theta_1 \cos(0) & \sin\theta_1 \sin(0) & a_1\mathrm{co} \\ \sin\theta_1 & -\cos\theta_1 \cos(0) & -\cos(\theta_1)\cdot\sin(0) & a_1 s \\ 0 & \sin(0) & \cos(0) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$
{}^{p}H_{\phi} = \begin{bmatrix} \cos\theta_1 & -\sin\theta_1 & 0 & a_1\cos\theta_1 \\ \sin\theta_1 & -\cos\theta_1 & 0 & a_1\sin\theta_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
{}^{1}H_{2} = \begin{bmatrix} \cos\theta_2 & -\sin\theta_2 \times (1) & 0 & a_2\cos\theta_2 \\ \sin\theta_2 & -\cos\theta_2 \cdot (1) & 0 & a_2\sin\theta_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$\theta = \theta_2 \quad \alpha = 0$

$r = a_2 \quad d = 0$

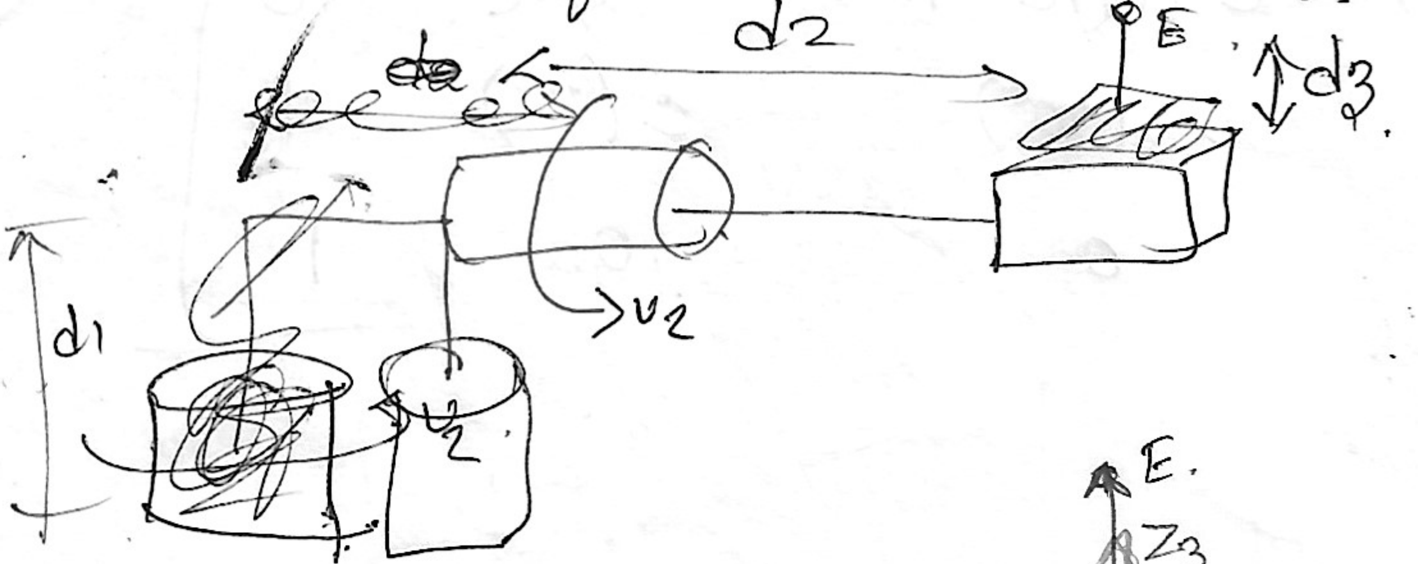
$$
\cancel{{}^{0}H_{2}} = \begin{bmatrix} \cancel{\cos\theta_1 \cdot \cos\theta_2} & \cancel{-\sin\theta_1 \sin\theta_2} \\ \cancel{-\sin\theta_1 \sin\theta_2} & \\ \cancel{0} & \\ \cancel{0} & \end{bmatrix}
$$

$$
\cancel{{}^{0}H_{2} = {}^{0}H_{1} \times {}^{1}H_{2}}
$$

$$
{}^{0}H_{2} = {}^{0}H_{1} \times {}^{1}H_{2}
$$

~~Inverse Kinematics~~

P3) DH - forward Kinematics.



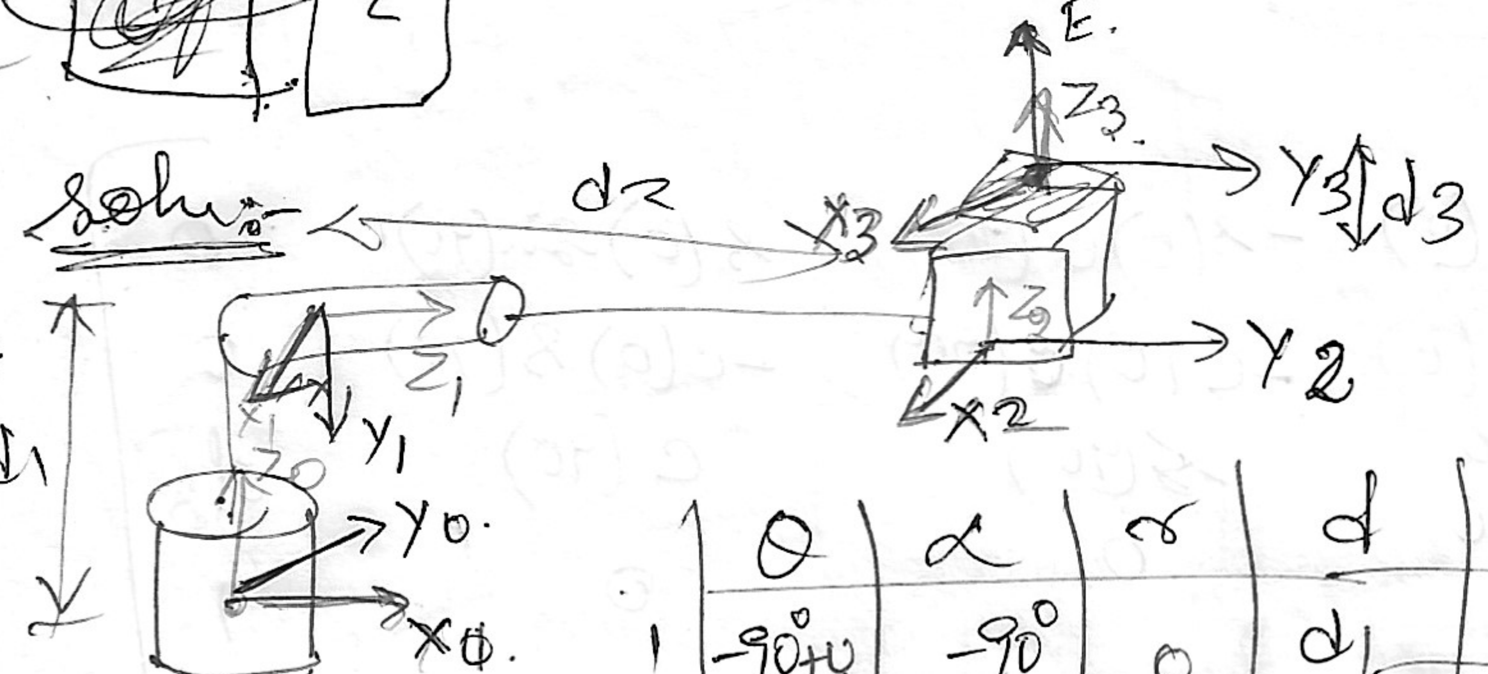
Joints = 3

Frames = 4

Rows = 3

Soln

Step1



Step 2

	θ	α	r	d
1	$-90^\circ + v_1$	-90°	0	d_1
2	v_2	90	0	d_2
3	0	0	0	d_3

Step3

$$ {}^{n-1}H_n = \begin{bmatrix} c(\theta_n) & -s(\theta_n)C(\alpha_n) & s(\theta_n)s(\alpha_n) & r_n c(\theta_n) \\ s(\theta_n) & -c(\theta_n).c(\alpha_n) & -c(\theta_n)s(\alpha_n) & r_n s(\theta_n) \\ 0 & s(\theta_n) & c(\alpha_n) & d_n \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

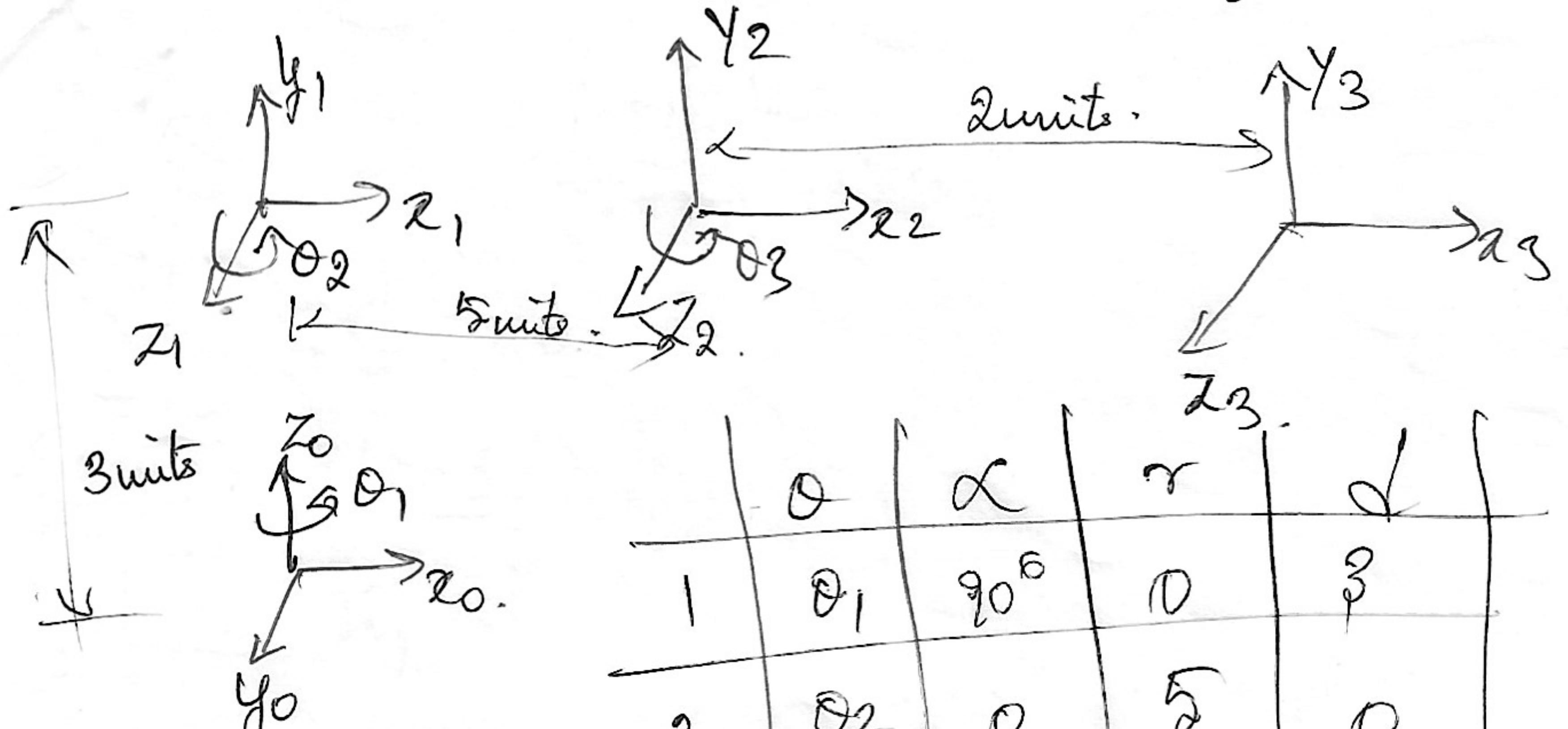
$$ {}^{0}H_{\phi} = \begin{bmatrix} \cos(v_1-90^\circ) & -s(v_1-90^\circ)c(-90^\circ) & s(v_1-90^\circ)s(-90^\circ) & 0 \\ \sin(v_1-90^\circ) & -c(v_1-90^\circ)c(-90^\circ) & -c(v_1-90^\circ)s(-90^\circ) & 0 \\ 0 & s(v_1-90^\circ) & c(-90^\circ) & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$
{}^{1}H_2 = \begin{bmatrix} c(U_2) & -s(U_2)\cos(90^\circ) & s(U_2)s(90^\circ) & 0 \\ s(U_2) & c(U_2)c(90^\circ) & -c(U_2)s(90^\circ) & 0 \\ 0 & s(90^\circ) & c(90^\circ) & d_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
{}^{2}H_3 = \begin{bmatrix} c(0) & -s(0)c(90^\circ) & s(0)\sin(90) & 0 \\ s(0) & -c(0)c(90^\circ) & -c(0)s(90^\circ) & 0 \\ 0 & s(90^\circ) & c(90) & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
{}^{0}H_3 = {}^{0}H_1 \times {}^{1}H_2 \times {}^{2}H_3 .
$$

P4). Find DH matrix & transformation



	θ	α	r	d
1	θ_1	90°	0	3
2	θ_2	0	5	0
3	θ_3	0	2	0

$$
{}^0H_1 = \begin{bmatrix} C\theta_1 & 0 & S\theta_1 & 0 \\ S\theta_1 & 0 & -C\theta_1 & 0 \\ 0 & 1 & 0 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix}
\qquad
{}^1H_2 = \begin{bmatrix} C\theta_2 & -S\theta_2 & 0 & 5C\theta_2 \\ S\theta_2 & C\theta_2 & 0 & 5S\theta_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
{}^2H_3 = \begin{bmatrix} C\theta_3 & -S\theta_3 & 0 & 2C\theta_3 \\ S\theta_3 & C\theta_3 & 0 & 2S\theta_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
{}^0H_3 = {}^0H_1 \times {}^1H_2 \times {}^2H_3 = [\ \cdot\ ][\ \cdot\ ][\ \cdot\ ]
$$