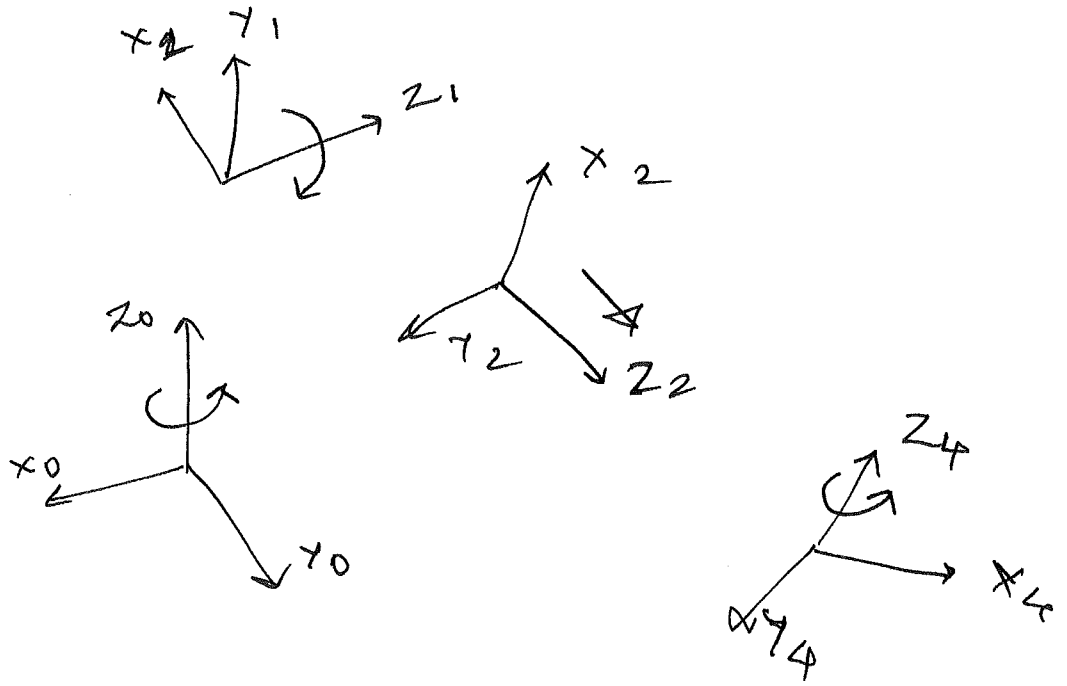
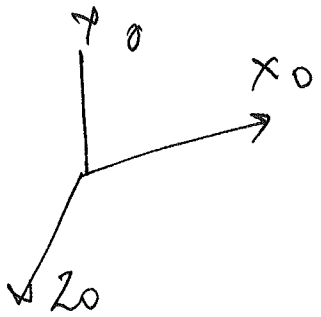
① Find D.H. parameters for the first three joints of the given pose for the Stanford Arm

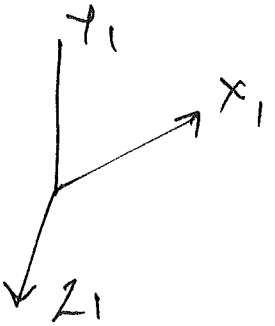
$$pose = [\underbrace{90^\circ, -120^\circ, 22\text{ cm}}_{\text{of interest}}, 0^\circ, 70^\circ, 90^\circ]^T$$

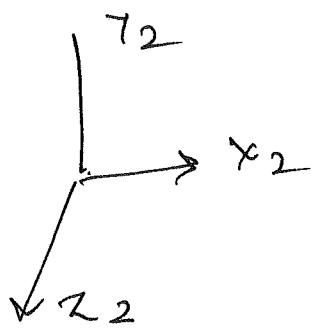


i	a	α	d	θ
1	0	90°	l_1	90°
2	0	90°	l_2	-120°
3	0	~~90°~~	22 cm	90°

2)







All matrices are rotation about "Z" axis.

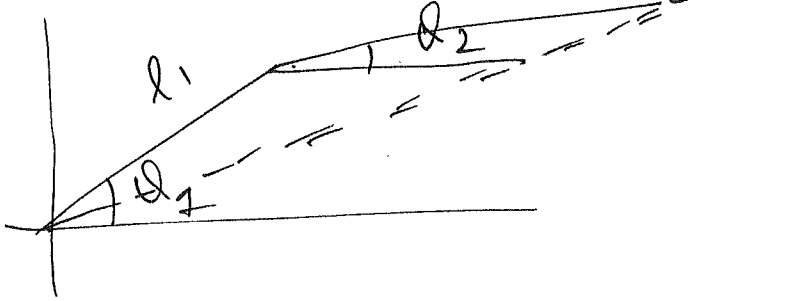
$$ {}^{0}A_1 = \begin{bmatrix} C\theta & -S\theta & 0 & E_1 \\ S\theta & C\theta & 0 & E_2 \\ 0 & 0 & 1 & t_3 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

${}^{1}A_2$ will be of the same form.

Inverse kinematics can be found through either

(a) ~~${}^{0}A_1$~~ ${}^{0}A_1 \, {}^{1}A_2 = [{}^{0}A_2]$ $^{-1}$ [write obvious cannot be solved]

or



$$ \cos\theta_2 = \frac{x^2 + y^2 - l_1^2 - l_2^2}{2 l_1 l_2} $$

$$ \sin\theta_2 = \pm\sqrt{1 - \cos^2\theta} $$

$$ \theta_2 = \tan^{-1}\left(\frac{\sin\theta_2}{\cos\theta_2}\right) $$

$$ \theta_1 = \tan^{-1}\left(\frac{y}{x}\right) - \tan^{-1}\left(\frac{l_2 \sin\theta_2}{l_1 + l_2\cos\theta_2}\right) $$

③ ${}^{0}A_1 = R_{-90,x_1} \; R_{180,z} \; T_{-(a-d)z_1} \; T_{-(c+e)y_1}$

${}^{1}A_2 = [R]_{90,y_2} [R]_{-90,z_2} [T]_{-(a-d),y_1}$

$[T]_{-b,x_2}$

${}^{2}A_3 = [R]_{90,x_2} [R]_{-90,y_2}$

transformations matrices to be determined as above.

${}^{0}A_3 = {}^{0}A_1 \; {}^{1}A_2 \; {}^{2}A_3$