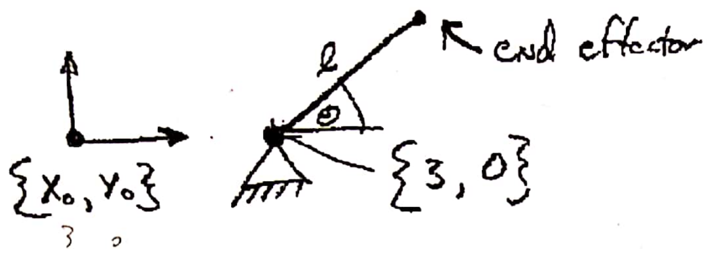
3.1 Forward Manipulator Kinematics I: Link Frame Assignment

3.1.1

For a single link manipulator:



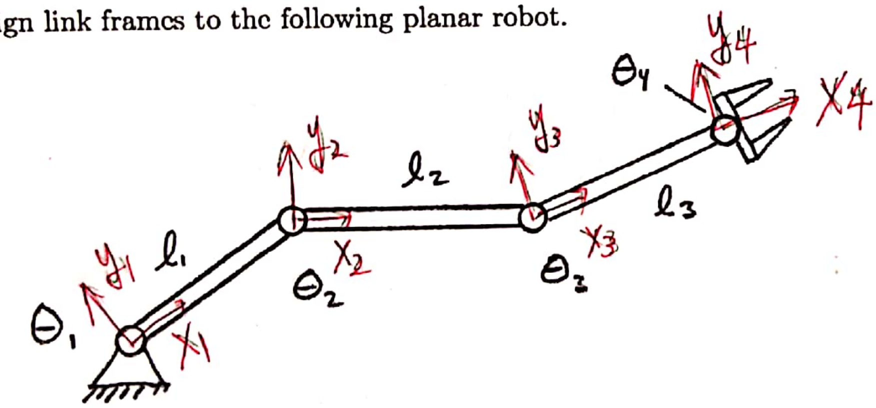
(3+ l cos θ , l sin θ)

(3+ l cos θ , l sin θ)

If the base is located at $x_0 = 3, y_0 = 0$, and the arm length is l, find the position of the end effector in frame 0.

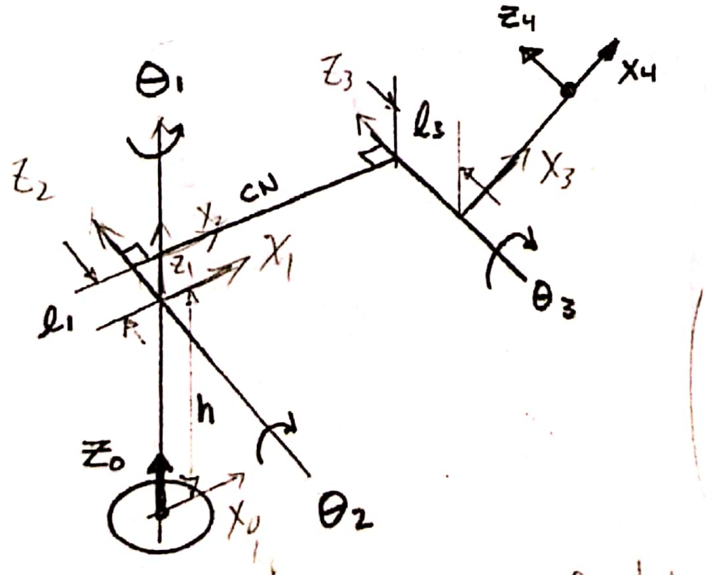
3.1.2

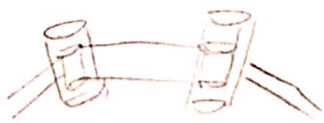
Assign link frames to the following planar robot.



3.1.3

Assign link frames to the following virtual manipulator represented as a stick figure.



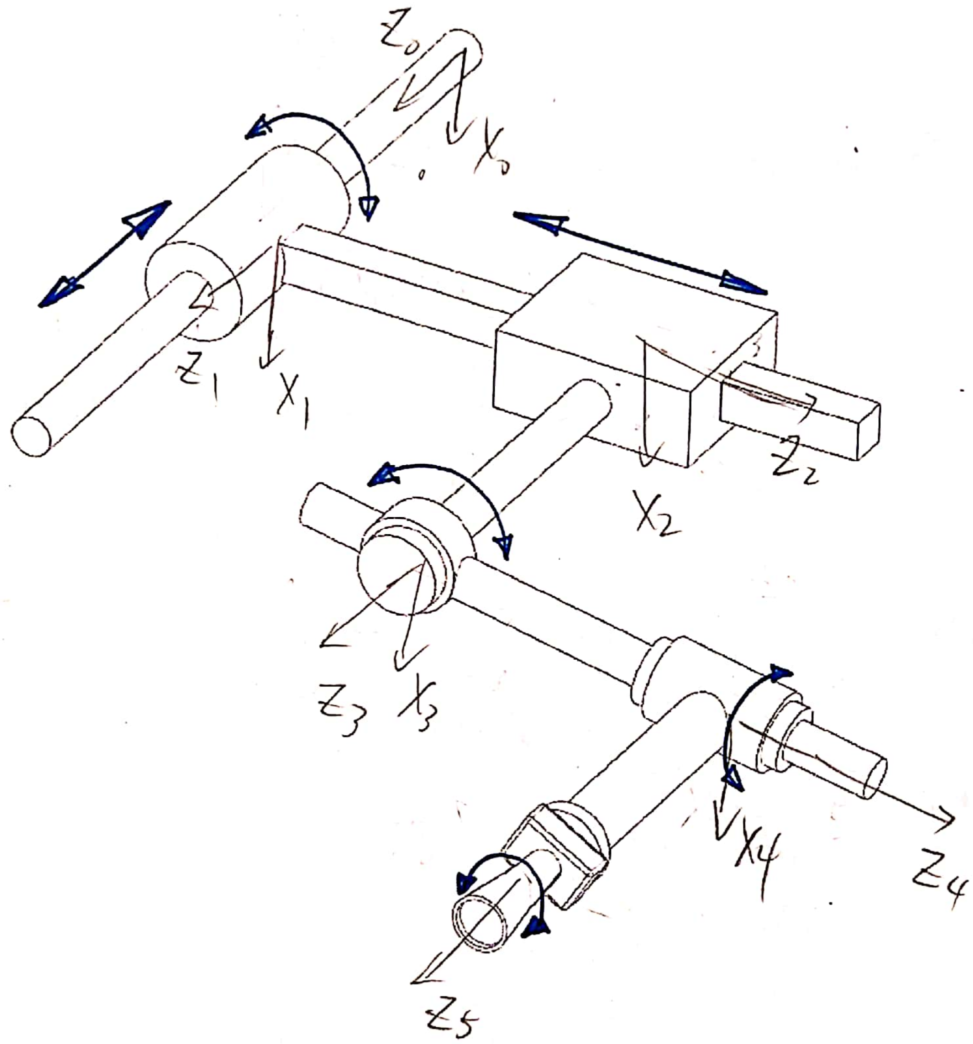


(0 0 h θ1)
(-90 0 l1 θ2)
(0 CN -l3 θ3)
(0 l4 0 0)

(0, 0, θ1, h)
(-90, 0, 0, l1)
(θ3, CN, 0, 0)

3.1.4

Assign link frames to the following manipulator design (Y. Sosnovskaya, EE543 W16)



3.2 Forward Manipulator Kinematics II: DH Parameters and Link Transform

3.2.1

Find the DH parameters of the robot of ICP ~~3.2.~~ 3.1.2

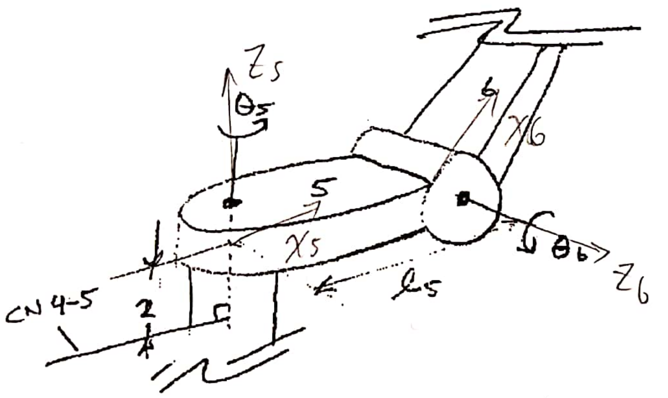
$(0, 0, \theta_1, 0)$
$(l_1, 0, \theta_2, 0)$
$(l_3, 0, \theta_3, 0)$
$(l_4, 0, \theta_4, 0)$

3.2.2

Find the DH parameters of the robot of ICP ~~3.3.~~ 3.1.3

3.2.3

Here is part of a robot manipulator. Assign link frames and derive the Denavit Hartenberg parameters for link 5. If any parameters are unlabeled in this drawing, identify them. Assume axis 6 is rotated by 90° from axis 5 around the common normal.



~~α_4 a_4 d_5 θ_5~~

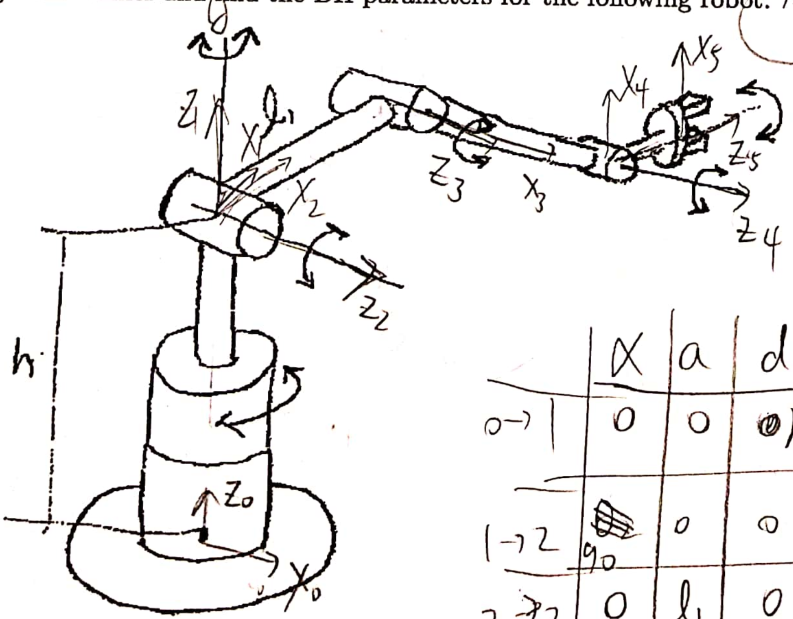
a

~~α_4 a_4 d_5 θ_5~~
~~2 0~~

~~α_5 a_5 d_6 θ_6~~
$90°$ l_5 0 θ_6

3.2.4

Assign link frames and find the DH parameters for the following robot.



	α	a	d	θ
0→1	0	0	h	θ_1
1→2	90	0	0	θ_2
2→3	0	l_1	0	θ_3
3→4	0	l_3	0	θ_4
4→5	90	l_4	0	θ_5

3.2.5

Given the following DH parameters, compute the forward kinematic equations:

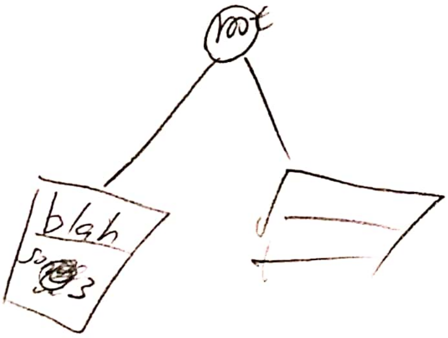
N	α_{N-1}	a_{N-1}	d_N	θ_N
1	$\pi/2$	0	l_1	θ_1
2	0	l_2	d_2	0
3	$-\pi/2$	0	0	θ_3

3.2.6

ROS Hands-on session during class on Tuesday 1/29. Please bring a laptop to class and we'll give more details in cl

You will be submitting your results by the end of the class. And they will be graded as part of ICP3.

(So also remember to have ROS installed and ready for use before 1/29's class. The instructions can be found in HW



$$ {}^0_1T = \begin{bmatrix} \cos\theta_1 & -\sin\theta_1 & 0 & 0 \\ \sin\theta_1 \cos\frac{\pi}{2} & \cos\theta_1 \cos\frac{\pi}{2} & -\sin\frac{\pi}{2} & -\sin\frac{\pi}{2} \cdot l_1 \\ \sin\theta_1 \sin\frac{\pi}{2} & \cos\theta_1 \sin\frac{\pi}{2} & \cos\frac{\pi}{2} & \cos\frac{\pi}{2} l_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^1_2T = \begin{bmatrix} \cos 0 & -\sin 0 & 0 & 0 \\ \sin 0 \cos 0 & \cos 0 \cos 0 & -\sin 0 & -\sin 0 \cdot d_2 \\ \sin 0 \cos 0 & \cos 0 \sin 0 & \cos 0 & \cos 0 \cdot d_2 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^0_1T = \begin{bmatrix} \cos\theta_1 & -\sin\theta_1 & 0 & 0 \\ 0 & 0 & -1 & -l_1 \\ \sin\theta_1 & \cos\theta_1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^1_2T = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d_2 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^2_3T = \begin{bmatrix} \cos\theta_3 & -\sin\theta_3 & 0 & 0 \\ \sin\theta_3 \cos\frac{-\pi}{2} & \cos\theta_3 \cos\frac{-\pi}{2} & -\sin\frac{-\pi}{2} & -\sin\frac{-\pi}{2} \cdot 0 \\ \sin\theta_3 \sin\frac{-\pi}{2} & \cos\theta_3 \sin\frac{-\pi}{2} & \cos\frac{-\pi}{2} & \cos\frac{-\pi}{2} \cdot 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^2_3T = \begin{bmatrix} \cos\theta_3 & -\sin\theta_3 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -\sin\theta_3 & -\cos\theta_3 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} $$

$$ {}^0_1T \, {}^1_2T \, {}^2_3T = {}^0_3T $$