University of Notre Dame
Aerospace and Mechanical Engineering

AME 469: Introduction to Robotics
Homework 3 Solutions

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1. (Craig, 3.4)
   Following the usual rules for affixing frames to manipulators results in the frames illustrated in Figure 1.

   Consulting the figure, the following link parameters are apparent:

i	α_{i-1}	a_{i-1}	d_i	θ_i
1	0	0	0	θ_1
2	$\frac{\pi}{2}$	0	0	θ_2
3	0	L_3	0	θ_3

   Determining ${}^0_1T$,${}^1_2T$ and ${}^2_3T$ is now a simple matter of substituting these values into Equation 3.6.

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

$$
{}^1_2T = \begin{bmatrix} \cos\theta_2 & -\sin\theta_2 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ \sin\theta_2 & \cos\theta_2 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
{}^2_3T = \begin{bmatrix} \cos\theta_3 & -\sin\theta_3 & 0 & L_3 \\ \sin\theta_3 & \cos\theta_3 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

2. (Craig, 3.17)
   Following the usual rules for affixing frames to manipulators results in the frames illustrated in Figure 2.

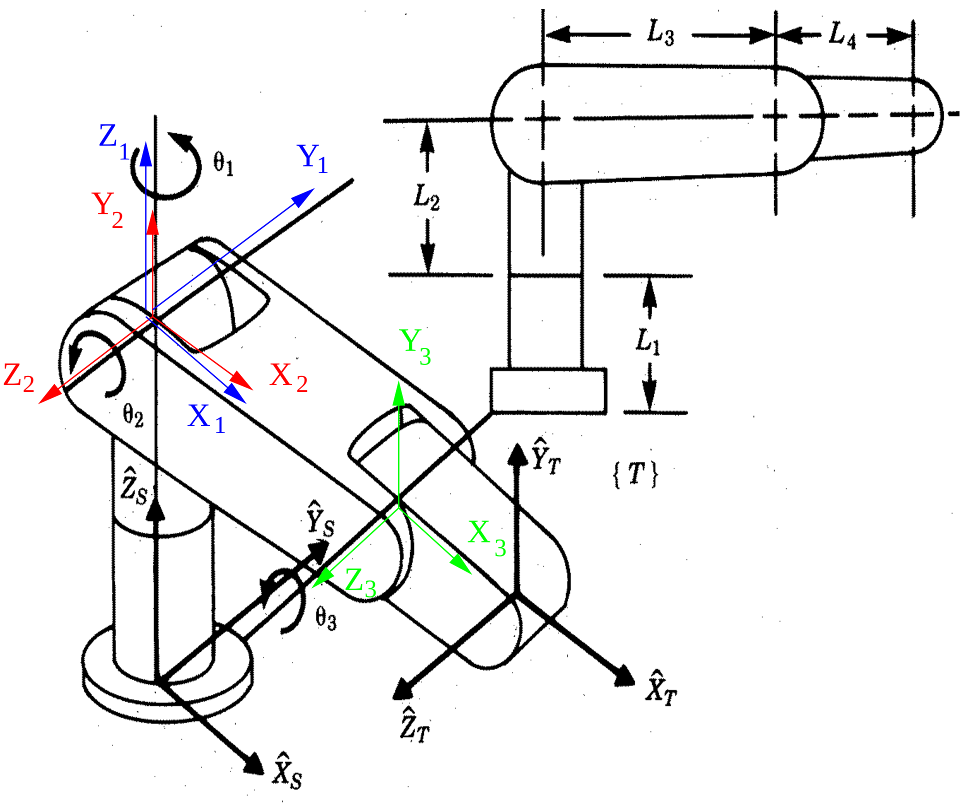

Figure 1. Frames for problem 1.

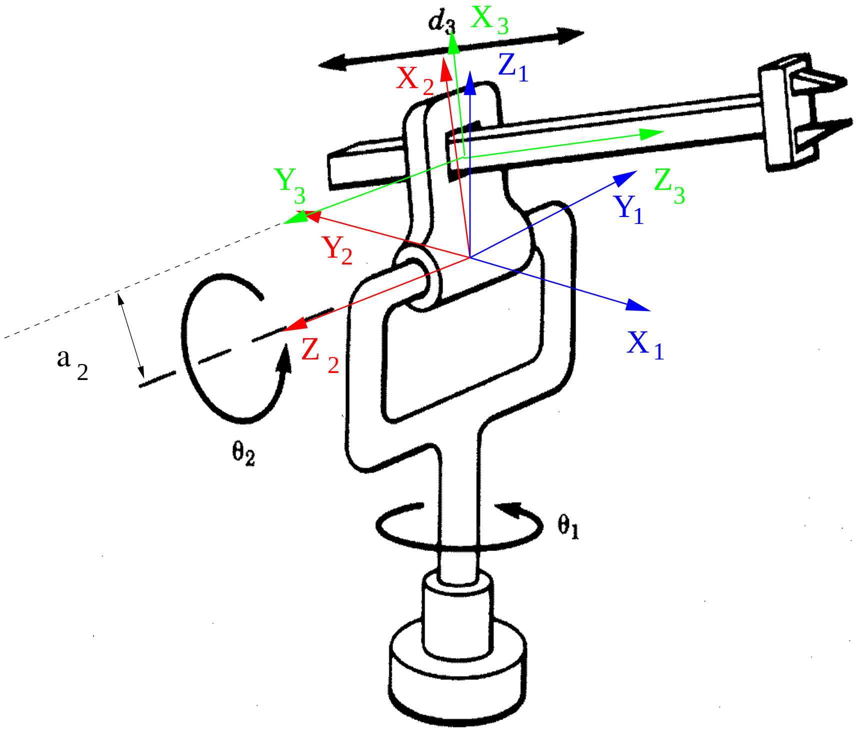

Figure 2. Frames for problem 2.

Consulting the figure, and naming the distance a_2, the following link parameters are apparent:

i	α_{i-1}	a_{i-1}	d_i	θ_i
1	0	0	0	θ_1
2	$\frac{\pi}{2}$	0	0	θ_2
3	$\frac{\pi}{2}$	a_2	d_3	0