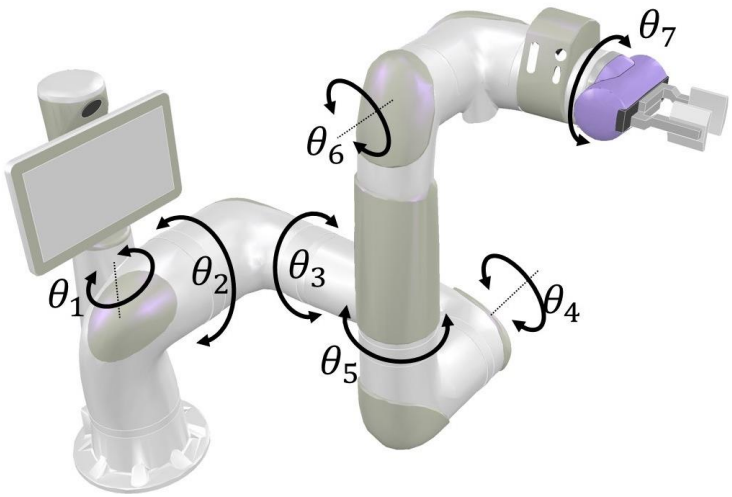
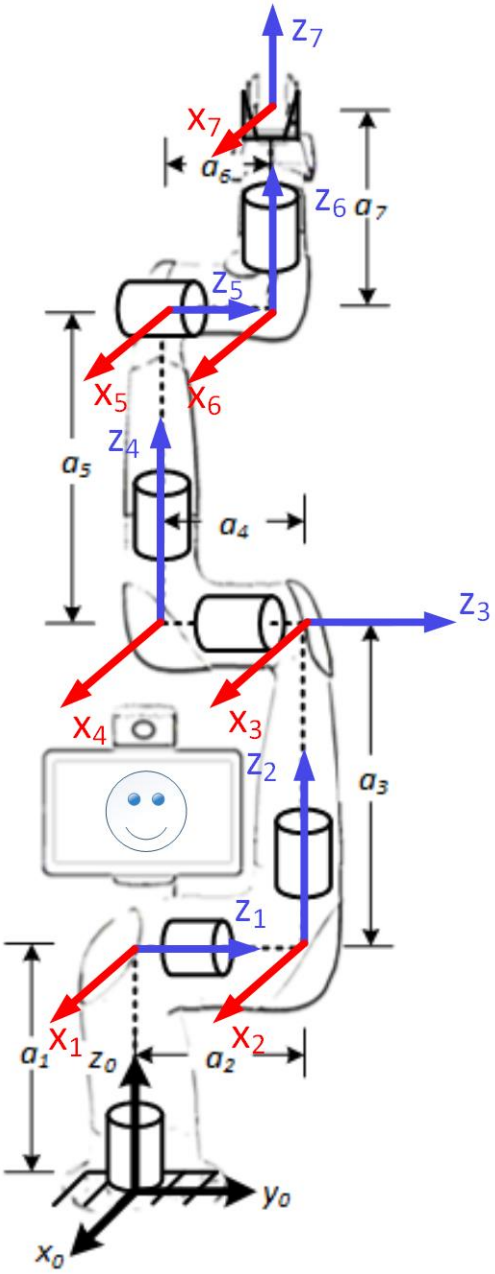
Benha University
Faculty of engineering (Shoubra)

ECE 447: Robotics Engineering
Midterm Exam (Time: **60** min.)

Name: **Model Answer** **Department**: ☐ ECE ☐ CSE

[1] For the shown Sawyer robot, **assign the coordinate frames** on the right projection. **Fill the DH table** below.





Link	a_i	α_i	d_i	θ_i
1	0	-90	a_1	θ_1^*
2	0	+90	a_2	θ_2^*
3	0	-90	a_3	θ_3^*
4	0	+90	a_4	θ_4^*
5	0	-90	a_5	θ_5^*
6	0	+90	a_6	θ_6^*
7	0	0	a_7	θ_7^*

DH Table

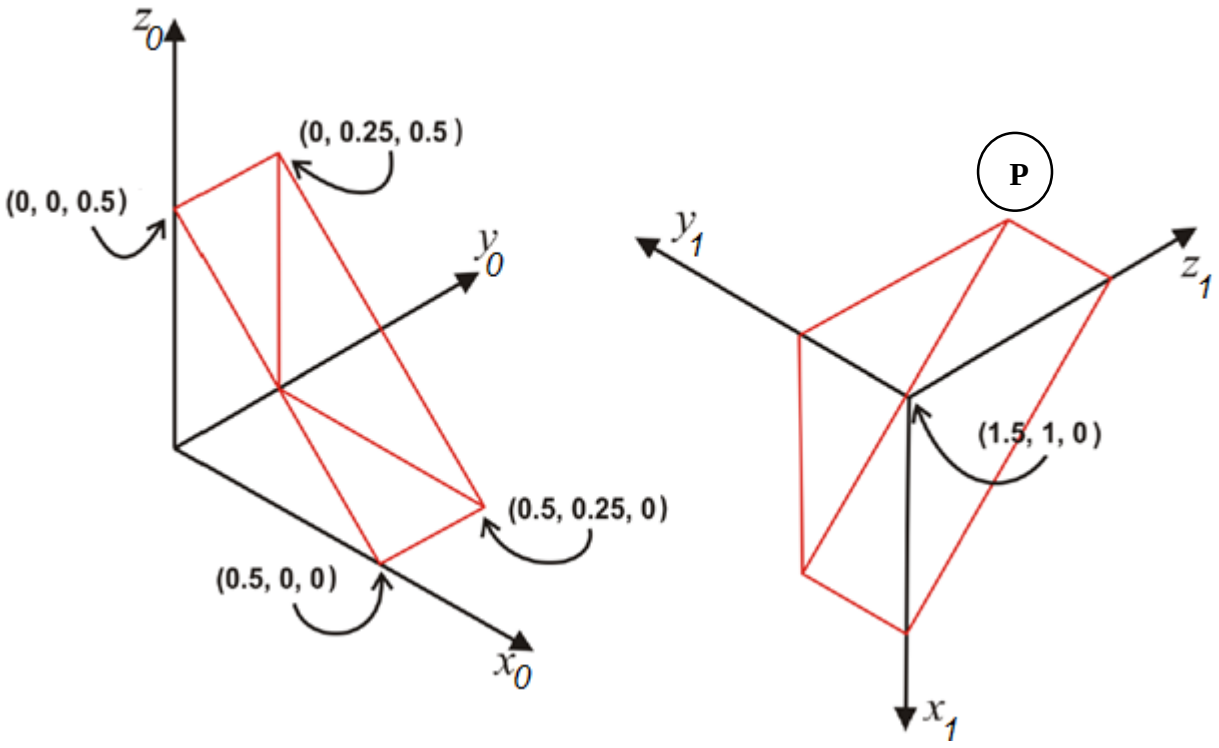
DH terms:

1. a_i: link length, distance between z_{i-1} and z_i (along x_i).
2. α_i: link twist, angle between z_{i-1} and z_i (measured around x_i)
3. d_i: link offset, distance between o_{i-1} and intersection of z_{i-1} and x_i (along z_{i-1})
4. θ_i: joint angle, between x_{i-1} and x_i (measured around z_{i-1})

[2] Consider the wedge-shaped object in the following drawing,

a) Obtain the transformation that should be applied to take it from the origin (left) to its final location (right).

b) Compute the coordinates of the point ***P*** of the translated and rotated wedge with respect to the original frame.



$$T_1^0 = \left[\begin{array}{ccc|c} 0 & -1 & 0 & 1.5 \\ 0 & 0 & 1 & 1 \\ -1 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 1 \end{array}\right]$$

$$P^0 = T_1^0 \, P^1$$

$$P^0 = \left[\begin{array}{ccc|c} 0 & -1 & 0 & 1.5 \\ 0 & 0 & 1 & 1 \\ -1 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 1 \end{array}\right] * \begin{bmatrix} 0 \\ 0.25 \\ 0.5 \\ 1 \end{bmatrix}$$

$$P^0 = \begin{bmatrix} 1.25 \\ 1.5 \\ 0 \\ 1 \end{bmatrix}$$

With my best wishes, Dr. Haitham El-Hussieny