1. Fill in the table of Denavit-Hartenburg parameters for the three-link spherical robot shown below.

Joint	θ_i	d_i	a_i	α_i
1	θ_1	d_1	0	90°
2	θ_2	0	0	90°
3	90°	d_3	0	90°

2. Use the results from the table above and the D-H matrix given on page 18 of your notes to write the three Denavit-Hartenburg transformation matrices (one for each joint) for the spherical robot shown below.

$$A1 := \begin{bmatrix} c_1 & 0 & s_1 & 0 \\ s_1 & 0 & -c_1 & 0 \\ 0 & 1 & 0 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad A2 := \begin{bmatrix} c_2 & 0 & s_2 & 0 \\ s_2 & 0 & -c_2 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A3 := \begin{bmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

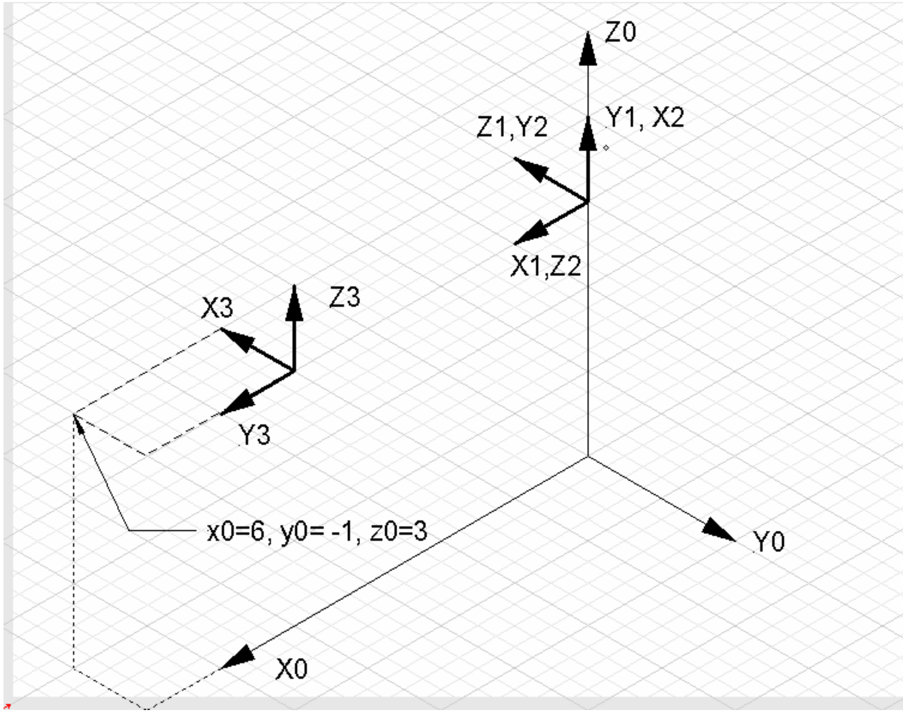
3. Find the overall transformation matrix which relates the final coordinates ($x_3y_3z_3$) to the "base" coordinates ($x_0y_0z_0$) for the spherical robot shown below.

$$T03 := \begin{bmatrix} s_1 & c_1 s_2 & c_1 c_2 & c_1 s_2 d_3 \\ -c_1 & s_1 s_2 & s_1 c_2 & s_1 s_2 d_3 \\ 0 & -c_2 & s_2 & -c_2 d_3 + d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

4. Check the spherical robot in the following configurations and end-effector location

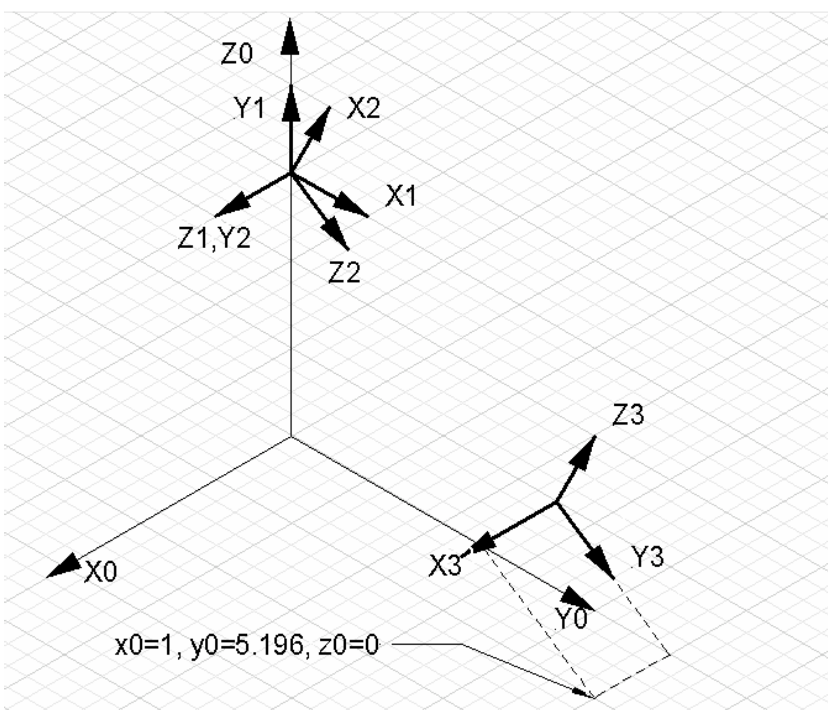
a) $\theta_1 = 0°$, $d_1 = 3$, $\theta_2 = 90°$, $d_3 = 4$

A1*A2*A3 =	A1*A2*A3*[1; 2; 0; 1] =
-0.0000 1.0000 0.0000 4.0000	6.0000
-1.0000 -0.0000 0.0000 -0.0000	-1.0000
0.0000 -0.0000 1.0000 3.0000	3.0000
0 0 0 1.0000	1.0000



b) $\theta_1 = 90°$, $d_1 = 3$, $\theta_2=60°$, $d_3 = 4$

A1*A2*A3 =				A1*A2*A3*[1; 2; 0; 1] =
1.0000	0.0000	-0.0000	0.0000	1.0000
-0.0000	0.8660	0.5000	3.4641	5.1962
0.0000	-0.5000	0.8660	1.0000	-0.0000
0	0	0	1.0000	1.0000



c) $\theta_1 = 45°$, $d_1 = 3$, $\theta_2=120°$, $d_3 = 4$

A1*A2*A3 =	A1*A2*A3*[1; 2; 0; 1] =
0.7071 0.6124 -0.3536 2.4495	4.3813
-0.7071 0.6124 -0.3536 2.4495	2.9671
0.0000 0.5000 0.8660 5.0000	6.0000
0 0 0 1.0000	1.0000