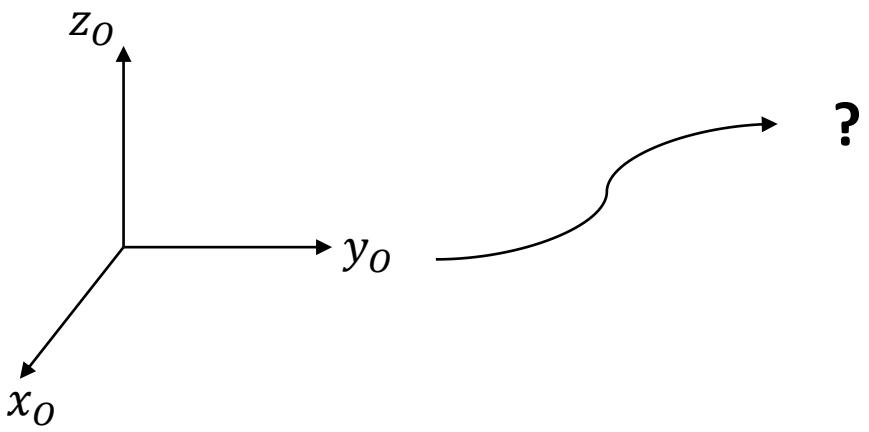
H.W.

❖ **Submit *a pdf file* via email by next Monday 6 p.m.**

1. There is a base frame. Compute a rotation matrix. Also, sketch a final rotated frame as well as the base frame.
   1) Rotate $-90^{\circ}, 90^{\circ}, \text{and } -90^{\circ}$ about *x*, *y*, and *z*, respectively, using Roll-Pitch-Yaw rotation.

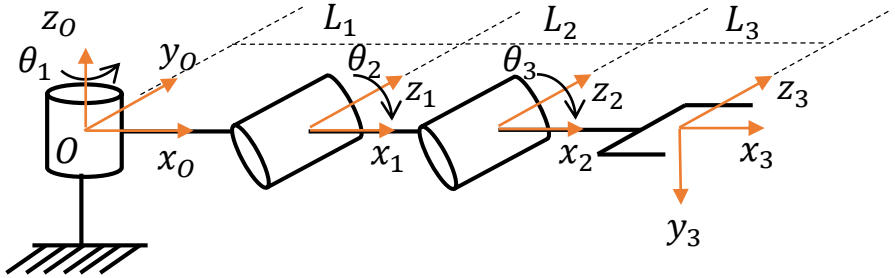
   2) Rotate $90^{\circ}, 90^{\circ}, \text{and } -90^{\circ}$ about *x*, *y*, and *z*, respectively, using Z-Y-X Euler angles rotation.

   3) Rotate $90^{\circ}, -90^{\circ}, \text{and } 90^{\circ}$ about *z*, *y*, and *z*, respectively, using Z-Y-Z Euler angles rotation.



H.W.

2. Consider a three revolute joints (3R) manipulator. It is represented by standard DH notation.



i	θ_i	α_i	a_i	d_i
1	θ_1	-90°	L_1	0
2	θ_2	0°	L_2	0
3	θ_3	0°	L_3	0

1) ${}^{O}A_1 = ?$

2) ${}^{1}A_2 = ?$

3) ${}^{2}A_3 = ?$

4) ${}^{O}A_1 \ {}^{1}A_2 \ {}^{2}A_3 = ?$

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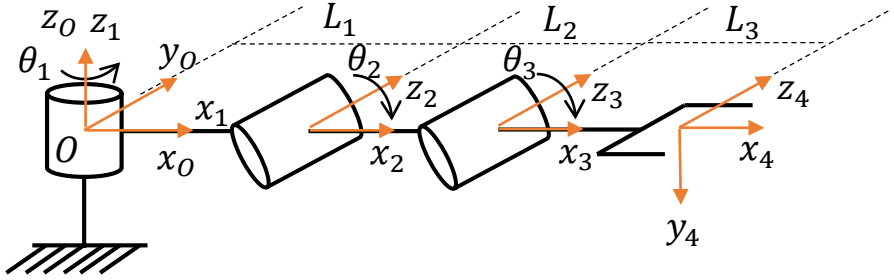
3. Consider a 3R manipulator again. It is represented by modified DH notation.



i	θ_i	α_{i-1}	a_{i-1}	d_i
1	θ_1	0	0	0
2	θ_2	-90°	L_1	0
3	θ_3	0°	L_2	0
4	0	0°	L_3	0

1) ${}^{O}A_1 = ?$

2) ${}^{1}A_2 = ?$

3) ${}^{2}A_3 = ?$

4) ${}^{3}A_4 = ?$

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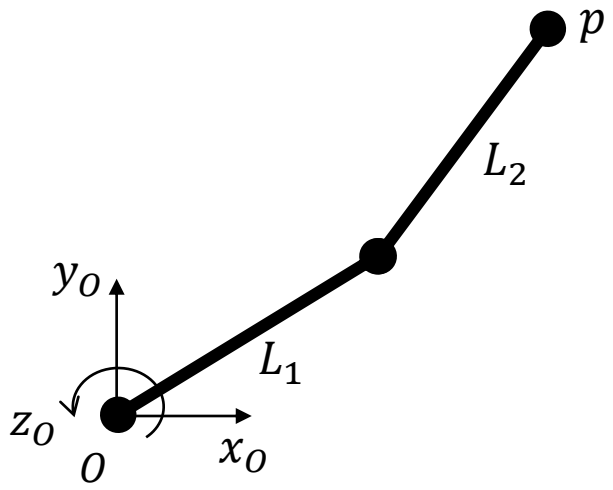
4. There is a 2R planar manipulator. The $p, L_1, and\ L_2$ are tip of the manipulator, link 1 length and link 2 length, respectively.
    1) Sketch coordinate frames and DH parameters using ***standard*** DH notation.
    2) Make a DH parameters table.
    3) What are the ***A*** matrices?
    4) What is the product of ***A*** matrices called ***T*** matrix?
    5) Get the position of tip, p, using DH parameters.



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5. Make a code which a manipulator moves as the following motion sequentially whenever an orange button is pressed.
    1) Link 1 : 45°, and Link 2 : 0°
    2) Link 1 : 45° (keep current angle) , and Link 2 : 45°
    3) Link 1 : 135°, and Link 2 : 45°
    4) Link 1 : 180°, and Link 2 : 0°

    * **Submit a source code with a video clip link like a youtube link or cloud link, or a compressed video clip file.**