ME:4140 Modern Robotics & Automation
Homework #6

Due: see ICON

Make sure to upload any supporting documents, e.g., hand work, codes, sketches, etc.

Instructions (READ THESE FIRST!)

- To complete this homework, you can use an **Adobe** pdf reader or **Google Chrome** (after completing make sure to download with changes).
- Answer all questions by typing or selecting radio buttons in this document.
- Upload your completed document and any supporting documents, code, sketches, etc., to ICON.
- Round all values to 3 decimal places.

  Example #1: what is the value of Pi? Answer: 3.142
  Example #2: what is 100/3? Answer: 33.333

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1. A robot has a home configuration given by (5)

$$M = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 200 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

and the following screw axes

$$S = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 1 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & -100 & -150 \\ 0 & 0 & 0 \end{bmatrix}.$$

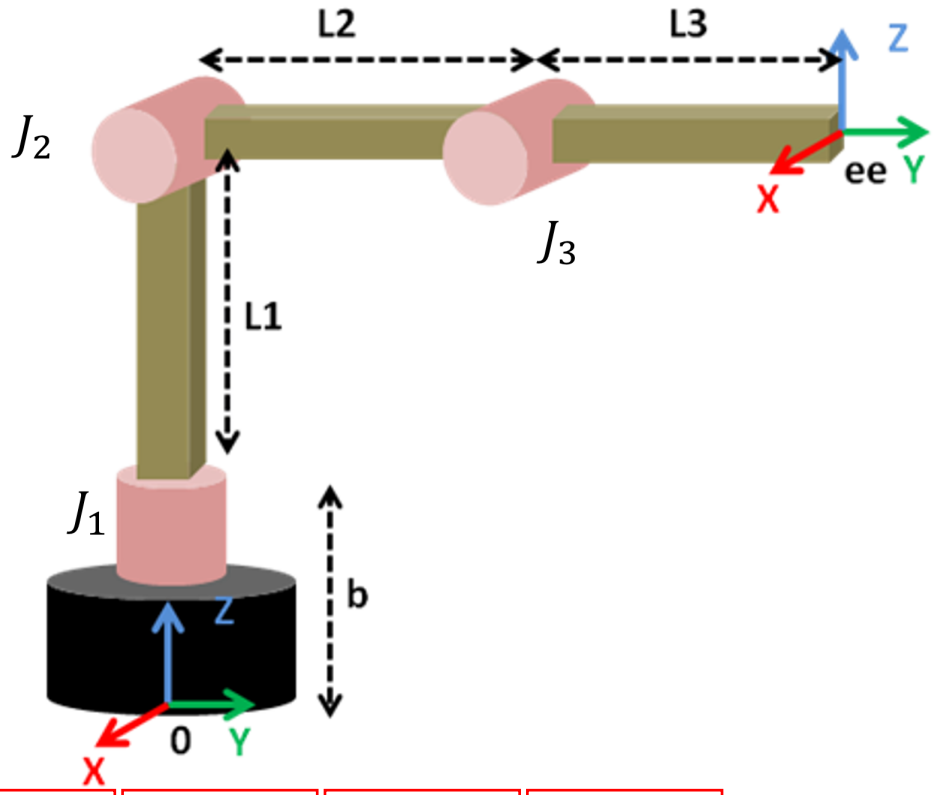
In S, each column represents the screw axis for that joint. For example, the screw axis for joint #1 S_1 is the first column of S.

The end-effector frame is $\{b\}$ and the fixed frame is $\{f\}$. If the robot joint angles are currently $\theta = (30°, 30°, 30°)$, what is the pose and position of the end-effector?

0	0	1	200
0	1	0	-130.9
-1	0	0	0
0	0	0	1

2. The figure below shows a 3R robot arm at its home configuration. The $\{0\}$ frame is at its base and the $\{ee\}$ frame is at its end-effector. The y-z-plane of each frame are coincident (i.e, the x-coordintes are not shifted). Joint 1 rotates about the $\hat{z}_0$-axis and joint 2 and 3 rotate about the $\hat{x}_0$-axis. The relevant dimensions are $b = 50$, $L_1 = L_2 = L_3 = 100$ (all in mm). (20)

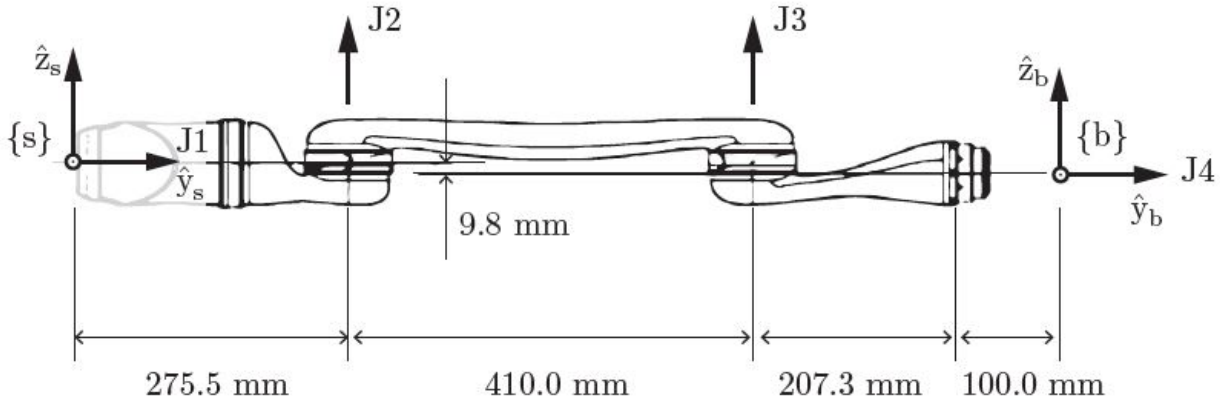
   If the joint angles are $\theta = (45°, 35°, -45°)$, what is the pose and position of the end-effector?



0.707	-0.696	-0.123	-0.128
0.707	0.696	0.123	0.128
0	-0.174	0.985	0.19
0	0	0	1

3. The figure below shows a KINOVA ultra lightweight 4-dof robot arm at its home configuration. The $\{s\}$ frame is at its base and a $\{b\}$ frame is at its end-effector. All the relevant dimensions are shown. The $\hat{y}_b$-axis is offset from the $\hat{y}_s$-axis by 9.8 mm, as shown in the image. Positive rotation about joint axis 1 is about the $\hat{y}_s$-axis (by the right-hand rule, as always) and joint axis 4 is about the $\hat{y}_b$-axis. Joint axes 2 and 3 are also illustrated. (25)

   If the joint angles are $\theta = (45°, 30°, -30°, 35°)$, what is the pose and position of the end-effector?



0.174	0	0.985	-0.152
0	1	0	0.938
-0.985	0	0.174	0.138
0	0	0	1