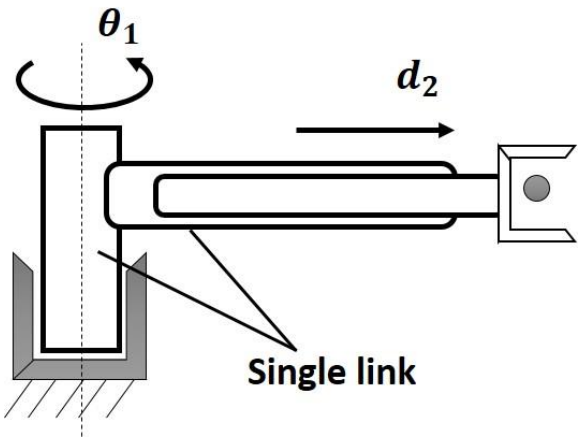
BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
HYDERABAD CAMPUS
First Semester (2022-23)
BITS F441: Robotics
Mid Semester Test **3rd November 2022**
Time: 1.30 PM – 3.00 PM **Closed Book** **Max. Marks: 50**

Q1. A frame $\{j\}$ is rotated about $Z-axis$ in frame $\{i\}$ by 33^0 CCW (2M). Determine the Coordinates of the Point $\boldsymbol{Q}$ in frame $\{i\}$ (2M), if the coordinates of point $\boldsymbol{Q}$ in frame $\{j\}$ are $[15,\ 8, 12]^T$ (1M). Draw a free hand diagram of the two frames and show point $\boldsymbol{Q}$ (2M). What will be the rotation matrix, if frame $\{i\}$ is rotated by 33^0 CCW with respect to frame $\{j\}$ (1M)? **8 M**

Q2. For a 2 degree of freedom manipulator shown in figure, draw an equivalent line diagram (1.5 M), number the links (0.5 M), number the joints (0.5 M) and identify the type of joints (0.5 M). Assign frames to this robotic arm (5 M) and determine the link joint parameters for each link (2+2 = 4 M). **12 M**



Q3. For a three degree of freedom manipulator link joint parameter table is given below. Determine $[0T_1]$, $[1T_2]$, $[2T_3]$, $[0T_2]$ and $[0T_3]$. **18 M**

Link	a_i	α_i	d_i	θ_i
1	$0.30\ m$	0	0	θ_1
2	$0.25\ m$	0	0	$(\theta_2 - 90)$
3	$0.10\ m$	0	0	θ_3

If the joint space vector $[q] = \begin{bmatrix}\theta_1\\ \theta_2\\ \theta_3\end{bmatrix} = \begin{bmatrix}60\\ 45\\ 30\end{bmatrix}$ determine the Tool matrix is $[T_E]$

I222, J107 and J115

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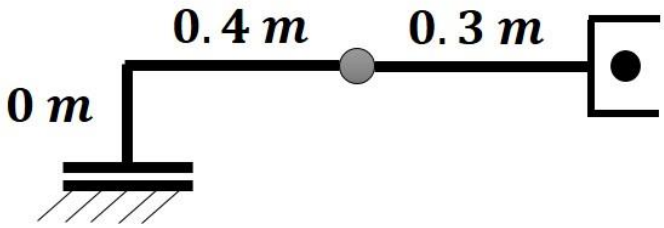
Q4. Given in picture below is a manipulator arm with two revolute joints. The link joint parameter table is also given for this manipulator arm. Determine individual link transformation matrices and hence the manipulator arm transformation matrix (3 *2 =6 M). Write all possible kinematic equations (2 M). Hence determine the joint space vector for the given Cartesian space vector. (4 M) **12 M**



Link	a_i	α_i	θ_i	d_i
1	0.4 m	90	θ_1	0
2	0.3 m	0	θ_2	0

$$[T_E] = \begin{bmatrix} 0.7424 & -0.5198 & 0.4226 & 0.5852 \\ 0.3462 & -0.2424 & -0.9063 & 0.2729 \\ 0.5736 & 0.8192 & 0 & 0.1721 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

All The Best

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