BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(MID SEMESTER EXAMINATION SP/2025)

CLASS: BTECH **SEMESTER: VI**
BRANCH: MECHANICAL ENGINEERING **SESSION: SP/2025**

SUBJECT: ME307 ROBOTICS ENGINEERING

TIME: 02 Hours **FULL MARKS: 25**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 5 marks and total 25 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Tables/Data handbook/Graph paper etc., if applicable, will be supplied to the candidates**

			CO	BL
Q.1(a)	A frame {*B*} is located initially coincident with a frame {*A*}. We rotate {*B*} about Z_B by 30 degrees, and then we rotate the resulting frame about X_B by 45 degrees. Give the rotation matrix that will change the description of vectors from ${}^{B}p$ to ${}^{A}p$.	[2]	1	3
Q.1(b)	Imagine two unit vectors, v_1 and v_2, embedded in a rigid body. Note that, no matter how the body is rotated, the geometric angle between these two vectors is preserved (i.e., rigid-body rotation is an "angle-preserving" operation). Use this fact to give a concise (four- or five-line) proof that the inverse of a rotation matrix must equal its transpose and that a rotation matrix is orthonormal.	[3]	1	5
Q.2(a)	Prove that the determinant of any rotation matrix is always equal to 1.	[1]	1	5
Q.2(b)	Referring to Fig. Q.2(b), write the transformation matrix ${}^{A}_{C}\mathbf{T}$. Additionally, find coordinate of a point P in {A} if its coordinate in {C} is $\begin{Bmatrix}\mathbf{0}\\\mathbf{0}\\\mathbf{10}\end{Bmatrix}$.	[4]	1	3

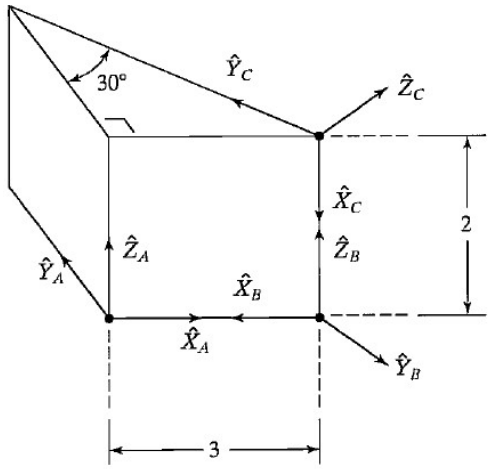

Fig. Q.2(b)

Q.3(a)	Define joint space and configuration/Cartesian space.	[1]	1	1
Q.3(b)	Determine the DH- parameter table for the manipulator depicted in Fig. Q.3(b). Note that the axes of prismatic throws d_2 and d_3 are not intersecting.	[4]	1	3

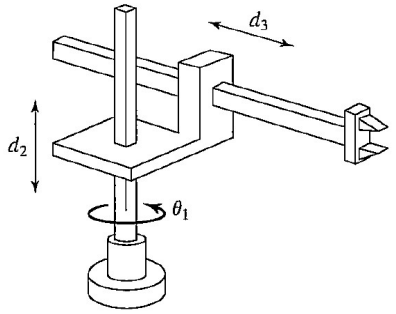

Fig. Q.3(b)

PTO

Q.4(a)	Discuss the concept of taught point and computed point. Provide examples and explain how these two points differ in terms of their determination and practical implications in robot control and manipulation.	[1]	2	2
Q.4(b)	Analyze the inverse kinematics of the 3R non-planar manipulator shown in Fig.Q.4(b).	[4]	2	4

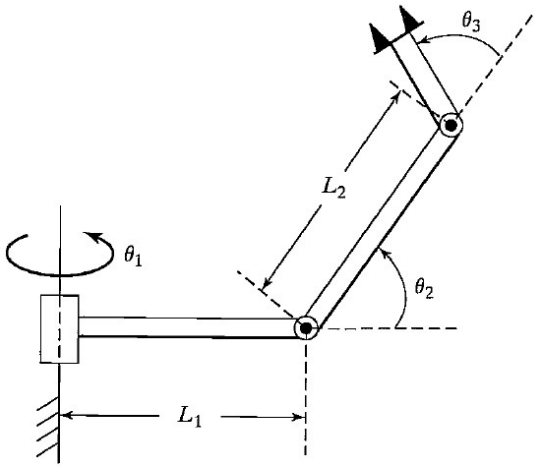

Fig. Q.4(b)

Hint:

$$ {}^{i-1}_{i}T = \begin{bmatrix} c\theta_i & -s\theta_i & 0 & a_{i-1} \\ s\theta_i c\alpha_{i-1} & c\theta_i c\alpha_{i-1} & -s\alpha_{i-1} & -s\alpha_{i-1}d_i \\ s\theta_i s\alpha_{i-1} & c\theta_i s\alpha_{i-1} & c\alpha_{i-1} & c\alpha_{i-1}d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}. $$

Q.5	The two-link manipulator shown in Fig. Q.5 is applying a force vector ${}^3F$ with its end-effector. Consider this force to be acting at the origin of {3}. Find the required joint torques as a function of configuration and of the applied force.	[5]	2	3

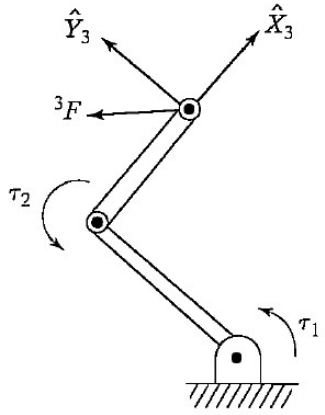

Fig. Q.5

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