BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(MID SEMESTER EXAMINATION SP2023)

CLASS: BTECH **SEMESTER : VI**
BRANCH: MECHANICAL **SESSION : SP2023**

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 vector ${}^{A}\mathrm{P}$ is rotated about $\hat{Z}_A$ by an angle θ and is subsequently rotated about $\hat{X}_A$ by an angle ϕ. Evaluate the rotational matrix that accomplishes these rotations in the given order.	[2]	1	Evaluate
Q.1(b)	Two frames {A} and {B} are related by the following matrix: ${}^{A}_{B}T = \begin{bmatrix} 0 & 1 & 0 & 15 \\ -1 & 0 & 0 & 20 \\ 0 & 0 & 1 & -9 \\ 0 & 0 & 0 & 1 \end{bmatrix}$. If the orientation vector of a parameter is given in frame {B} as ${}^{B}V = \begin{Bmatrix} 10 \\ 10 \\ 10 \end{Bmatrix}$, what is its orientation in {A}? Also, sketch frame {B} relative to frame {A}.	[3]	1	Sketch
Q.2	{A} and {B} are frames differing only in orientation. {B} is attained as follows: starting coinciding with {A}, {B} is rotated by θ radians about unit vector $\hat{K}, i.e.,$ ${}^{A}_{B}R = {}^{A}_{B}R_k(\theta)$. Show that ${}^{A}_{B}R = e^{K\theta}$, where $K = \begin{bmatrix} 0 & -k_z & k_y \\ k_z & 0 & -k_x \\ -k_y & k_x & 0 \end{bmatrix}$.	[5]	1	Evaluate
Q.3(a)	Write the name of the point where the tool frame should be affixed.	[1]	1	Write
Q.3(b)	Show the attachment of the link frames and derive the DH-parameter of the manipulator shown in Fig. Q.3(b).	[4]	1	Derive

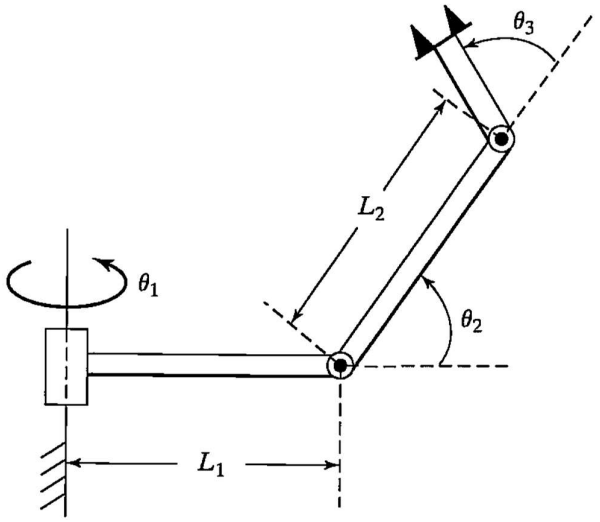

Fig. Q.3(b)

PTO

Q.4(a)	Define repeatability and accuracy.	[2]	2	Define
Q.4(b)	Derive inverse-kinematics solution for d_2 and d_3 shown in Fig. Q.4(b).	[3]	2	Derive

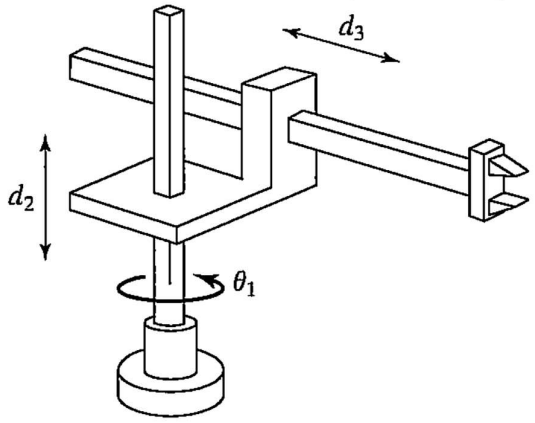

Fig. Q.4(b)

Q.5(a)	For a manipulator derive Jacobian in force domain.	[2]	2	Derive
Q.5(b)	The two-link manipulator (shown in Fig. Q.5(b)) 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.	[3]	2	Find

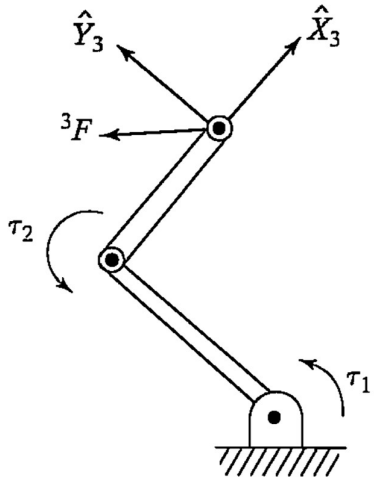

Fig. Q.5(b)

Hint:

$$R_K(\theta) = \begin{bmatrix} k_x k_x v\theta + c\theta & k_x k_y v\theta - k_z s\theta & k_x k_z v\theta + k_y s\theta \\ k_x k_y v\theta + k_z s\theta & k_y k_y v\theta + c\theta & k_y k_z v\theta - k_x s\theta \\ k_x k_z v\theta - k_y s\theta & k_y k_z v\theta + k_x s\theta & k_z k_z v\theta + c\theta \end{bmatrix}$$

::::::21/02/2023::::::M