



**SASTRA**  
SARAJEVO ACADEMY OF SCIENCE, TECHNOLOGY AND RESEARCH UNIVERSITY



School of Mechanical Engg

First CIA Test – Feb 2024

Course Code: MCT309

Course Name: Industrial Manipulators

Duration: 90 minutes

Max Marks: 50

PART -

1)

Part A

20 marks

Answer all the followings:

1. Draw 3 instances of an XYZ-frame wherein Y -axis points outward, X and Z axes only change their relative orientation.
2. If

$$T = \begin{bmatrix} {}^1R_2 & {}^1D_2 \\ 0 & 1 \end{bmatrix}$$

determine the expression for  $T^{-1}$ .

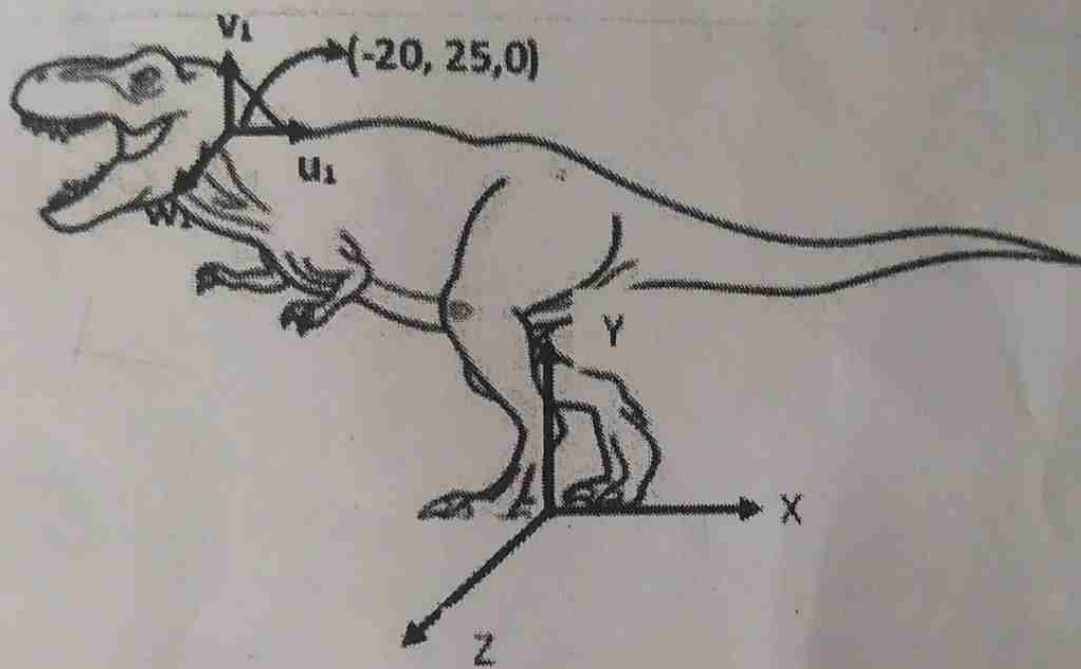
3. A frame undergoes  $90^\circ$  rotation about its Z-axis. Write the corresponding rotation matrix.
4. Two frames-XYZ and uvw are having the same origin. Now, uvw frame rotates about Z axis of XYZ frame. In another case, frame uvw is not having same origin with that of XYZ frame. Frame uvw rotates about Z-axis of XYZ frame. What would be the difference in both cases. Explain with an example. 4 marks
5. In a robotics surgery, transformation matrix of surgical tool with respect to robot base is given. Transformation matrix of patient head w.r.t robot base is also given. Determine the expression of transformation matrix of patient head with respect to surgical tool. 4 marks
6. If physical coordinates of a point are  $[2 \ 3 \ 4]$ , express it in the homogenous coordinates with 3 scaling factors. 2 marks
7. Prove that the transformation matrix obtained after a series of rotations following fixed angle representation is the same following Euler angle representation when the order of rotations is reversed. 4 marks

PART - B

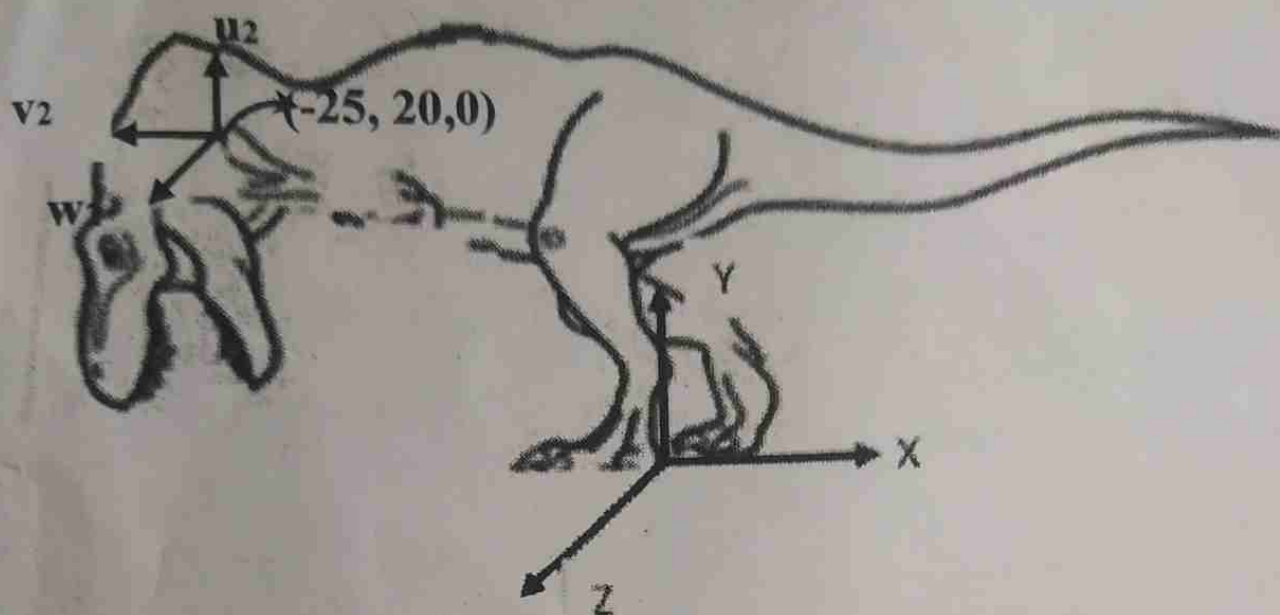
Answer the followings

30 marks

1)



Above figures are two stages of animation of a dinosaur. In bottom fig, the dinosaur's head has undergone a transformation compared to that of above fig. The co-ordinates of the origins of the two frames are also mentioned in the two figures. Determine the transformation matrix of frame  $u_2v_2w_2$  w.r.t. frame XYZ and also write the transformation matrix that the frame  $u_1v_1w_1$  undergoes to reach  $u_2v_2w_2$ .



2. In the bottom figure, X, Y and Z are the end-effector position and the orientation is given by Rx, Ry and Rz (angles following ZYZ Euler angle rotation of the Doosan cobot). Determine the transformation matrix of the end-effector with respect to base frame.

Joint			Task
J1	0.00	X	-566.39
J2	-29.41	Y	0.00
J3	-51.75	Z	254.02
J4	0.00	Rx	0.00
J5	-95.25	Ry	179.47
J6	0.00	Rz	0.00





**SASTRA**  
SARAJITHA ARUNACHAL THIRU ARUNACHAL UNIVERSITY



School of Mechanical Engg

2<sup>nd</sup> CIA Test – Apr 2024

Course Code: MCT309

Course Name: Industrial Manipulators

Duration: 90 minutes

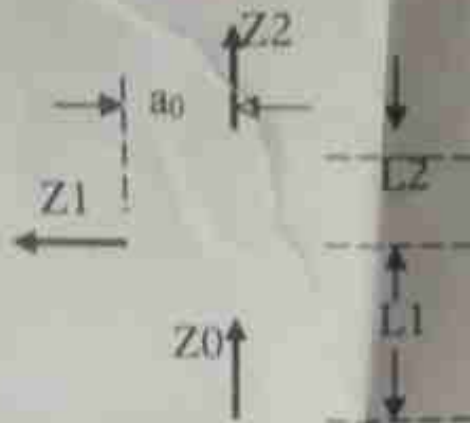
Max Marks: 50

**Part A**

**20 marks**

Answer all the followings:

1. What purpose DH parameters solve in relation to industrial manipulators?
2. In the following fig, locate the origin of frame 1 and draw X1.



3. In the above fig (of que no 2), locate the origin of frame 2 and draw X2.
4. Determine the DH parameters of link 1 and link 2 in the fig of que no 2. 4 marks
5. Draw the workspace of 3-DOF cartesian manipulator.
6. While doing inverse kinematics, why should we give preference to  $\tan^{-1}$  than  $\sin^{-1}$  or  $\cos^{-1}$ ? Explain with an example.
7. Draw an approximate manipulator befitting to frames given in que no 2. Assume frame 2 as the last but 2<sup>nd</sup> frame. 4 marks.
8. With the help of  $a_i$ ,  $\alpha_i$ ,  $d_i$  and  $\theta_i$  what do we do? How is it helpful for forward kinematics of a manipulator?

**PART - B**

Answer the following


30 marks

1. Fix the frames and determine the DH parameters for the following 6-DOF manipulator.



Draw the manipulator in home config  
then draw the frames

12.06.2024

 <b>SASTRA</b> <small>SARAJITHA ANNA SASTRI</small>	<b>School of Mechanical Engg</b> <b>Third CIA Test – Apr 2024</b> Course Code: MCT309 Course Name: Industrial Manipulators Duration: 90 minutes      Max Marks: 50
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**Part A** Answer the following:

10 marks

1. What will be the size of the Jacobian matrix for the Cobot in TDC? What does the last column of the Jacobian matrix imply?
2. What is Robot centered layout?
3. What happens when a Cobot hits a human being? What is the safety feature given in the Cobot in this connection?
4. Give applications of Joint space and cartesian space trajectory planning.
5. What do the top three rows and bottom three rows of Jacobian matrix imply?

**Part B** Answer any two of the followings

2x15=30 marks

6. The forward kinematics model of the SCARA, 4-DOF (RRPR) manipulator is given below. Determine the top three rows of the Jacobian matrix.

$${}^0T_4 = \begin{bmatrix} C_{124} & S_{124} & 0 & L_2 C_{12} + L_1 C_1 \\ S_{124} & -C_{124} & 0 & L_2 S_{12} + L_1 S_1 \\ 0 & 0 & -1 & L_{12} + d_3 - L_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

7. The first joint of a 3-DOF manipulator rotates from  $45^\circ$  to  $-25^\circ$  in 5 sec. Design a cubic spline trajectory for the joint for a pick and place task.
8. Write short notes on the following
  - (i) Lead through and textual programming
  - (ii) Digital twin

**Part C**

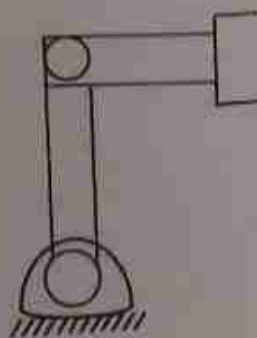
10 marks

9. For the Home configuration 1, derive the Jacobian matrix.

If the home configuration changes to 'Home configuration-2' as shown below, will there be any change in the Jacobian matrix?



Home configuration-1



Home configuration-2