Unit 5 - Week 3

Assignment 3

The due date for submitting this assignment has passed. **Due on 2020-10-07, 23:59 IST.**
As per our records you have not submitted this assignment.

1) Consider the 3-dof RPP manipulator given below. The tool frame, base frame and the joint axis directions have been marked for you. The values of θ_2, θ_3 are both to be 90° in the given home position *1 point*

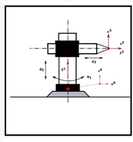

Figure 1: RPP Manipulator

Which of these is the arm matrix of the tool tip w.r.t. the base for the joint variables $(\theta_1, d_2, d_3) = (45°, 200\text{mm}, 150\text{mm})$?

$$\begin{bmatrix} 0.707 & -0.707 & 0 & 141.421 \\ 0.707 & 0.707 & 0 & 141.421 \\ 0 & 0 & 1 & 150 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 0 & 0.707 & 0.707 & 106.066 \\ 0 & -0.707 & 0.707 & 106.066 \\ 1 & 0 & 0 & 200 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 0.707 & 0 & -0.707 & 141.421 \\ 0.707 & 0 & 0.707 & 141.421 \\ 0 & 1 & 0 & 150 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 0 & 0.707 & 0.707 & 141.421 \\ 0 & -0.707 & 0.707 & 141.421 \\ 1 & 0 & 0 & 150 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 0.707 & 0 & -0.707 & 200 \\ 0.707 & 0 & 0.707 & 200 \\ 0 & 1 & 0 & 150 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 0 & 0.707 & 0.707 & 200 \\ 0 & -0.707 & 0.707 & 200 \\ 1 & 0 & 0 & 150 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

No, the answer is incorrect.
Score: 0
Accepted Answers:

$$\begin{bmatrix} 0 & 0.707 & 0.707 & 106.066 \\ 0 & -0.707 & 0.707 & 106.066 \\ 1 & 0 & 0 & 200 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Common data for Q2, Q3 :

The following are the DH parameters of a manipulator.

k	θ_k	d_k	a_k	α_k
1	θ_1	L_{12}	L_{11}	$0°$
2	θ_2	0	L_4	$0°$
3	0	d_3	0	$180°$
4	θ_4	L_4	0	$0°$

2) The arm matrix T^{base}_{tool} is, *1 point*

$$\begin{bmatrix} C_{12+4} & 0 & S_{12+4} & L_4C_{12}+L_{12}C_1 \\ S_{12+4} & 0 & -C_{12+4} & L_4S_{12}+L_{12}S_1 \\ 0 & -1 & 0 & d_3+L_{12}+L_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} C_{12+4} & 0 & S_{12+4} & L_4C_{12}+L_{12}C_1 \\ S_{12+4} & 0 & -C_{12+4} & L_4S_{12}+L_{12}S_1 \\ 0 & 1 & 0 & d_3+L_{12}-L_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} C_{12+4} & -S_{12+4} & 0 & L_4C_{12}+L_{12}C_1 \\ S_{12+4} & C_{12+4} & 0 & L_4S_{12}+L_{12}S_1 \\ 0 & 0 & 1 & d_3+L_{12}-L_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} C_{12+4} & S_{12+4} & 0 & L_4C_{12}+L_{12}C_1 \\ S_{12+4} & -C_{12+4} & 0 & L_4S_{12}+L_{12}S_1 \\ 0 & 0 & -1 & d_3+L_{12}-L_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} -C_{12+4} & S_{12+4} & 0 & L_4C_{12}+L_{12}C_1 \\ S_{12+4} & C_{12+4} & 0 & L_4S_{12}+L_{12}S_1 \\ 0 & 0 & -1 & d_3+L_{12}+L_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

No, the answer is incorrect.
Score: 0
Accepted Answers:

$$\begin{bmatrix} C_{12+4} & S_{12+4} & 0 & L_4C_{12}+L_{12}C_1 \\ S_{12+4} & -C_{12+4} & 0 & L_4S_{12}+L_{12}S_1 \\ 0 & 0 & -1 & d_3+L_{12}-L_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3) Which architecture do you think the manipulator has? *1 point*

- Polar, with a roll wrist
- Cylindrical, with a yawing wrist
- SCARA, with a rolling wrist
- Jointed-arm, with a pitching wrist
- Cartesian, with a rolling wrist

No, the answer is incorrect.
Score: 0
Accepted Answers:
SCARA, with a rolling wrist

4) The fundamental operations involved in making $k-1^{th}$ frame coincident with k^{th} frame are: *0 points*

- Rotate L_{k-1} about Z_{k-1} by θ_k
- RotateL_{k-1} about X_{k-1} by θ_k
- Translate L_{k-1} along X_{k-1} by k
- Translate L_{k-1} along X_{k-1} by k
- Translate L_{k-1} along Z_{k-1} by k
- Translate L_{k-1} along X_{k-1} by k
- Rotate L_{k-1} about X_{k-1} by α_kK
- Rotate L_{k-1} about Z_{k-1} by α_k

No, the answer is incorrect.
Score: 0
Accepted Answers:
Rotate L_{k-1} about Z_{k-1} by θ_k
Translate L_{k-1} along X_{k-1} by k
Translate L_{k-1} along X_{k-1} by k
Rotate L_{k-1} about X_{k-1} by α_kK

5) Can we consider the commercial Six-axis articulated arm, INTELLECT 660T as a redundant Manipulator? *1 point*

- Yes
- No

No, the answer is incorrect.
Score: 0
Accepted Answers:
No

6) Select the False statement: *1 point*

- Inverse problems are more difficult than forward problem
- Manipulator tasks are normally formulated in terms of the desired position and orientation
- Multiple solutions exist and unique solutions do not exist for the inverse kinematic problem
- A systematic closed form solution applicable to robots in general is not available

No, the answer is incorrect.
Score: 0
Accepted Answers:
Multiple solutions exist and unique solutions do not exist for the inverse kinematic problem

7) For a homogeneous transformation matrix, *1 point*

$$\begin{bmatrix} C_1C_{23} & -C_1S_{23} & -S_1 & C_1(a_2C_2+a_3C_{23}) \\ S_1C_{23} & -S_1S_{23} & C_1 & S_1(a_2C_2+a_3C_{23}) \\ -S_{23} & -C_{23} & 0 & d_1-a_2S_2-a_3S_{23} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Given the kinematic parameters, $\theta_1 = \theta_2 = 90°, \theta_3 = 45°, a_2 = 177.7, d_1 = 215$ smiπ $d_3 = 129.5$ smiπ. The position coordinates of the wrist with respect to the base of the robotic arm would be:

$$\begin{bmatrix} 0 \\ 125.7 \\ 88.35 \end{bmatrix}$$

$$\begin{bmatrix} 0 \\ 125.7 \\ -88.35 \end{bmatrix}$$

$$\begin{bmatrix} 0 \\ -125.7 \\ -88.35 \end{bmatrix}$$

$$\begin{bmatrix} 0 \\ -125.7 \\ 88.35 \end{bmatrix}$$

No, the answer is incorrect.
Score: 0
Accepted Answers:

$$\begin{bmatrix} 0 \\ -125.7 \\ -88.35 \end{bmatrix}$$

8) Find the values of joint distance and link length of the Rhino XR-3 robot *1 point*

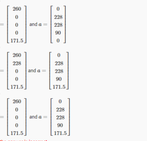

Figure 2: Rhino: XR-3

$$d = \begin{bmatrix} 260 \\ 228 \\ 0 \\ 0 \\ 171.5 \end{bmatrix} \text{ and } a = \begin{bmatrix} 0 \\ 228 \\ 228 \\ 90 \\ 0 \end{bmatrix}$$

$$d = \begin{bmatrix} 260 \\ 0 \\ 0 \\ 0 \\ 171.5 \end{bmatrix} \text{ and } a = \begin{bmatrix} 0 \\ 228 \\ 228 \\ 90 \\ 0 \end{bmatrix}$$

$$d = \begin{bmatrix} 260 \\ 228 \\ 0 \\ 0 \\ 171.5 \end{bmatrix} \text{ and } a = \begin{bmatrix} 0 \\ 228 \\ 228 \\ 90 \\ 171.5 \end{bmatrix}$$

$$d = \begin{bmatrix} 260 \\ 0 \\ 0 \\ 0 \\ 171.5 \end{bmatrix} \text{ and } a = \begin{bmatrix} 0 \\ 228 \\ 228 \\ 90 \\ 171.5 \end{bmatrix}$$

No, the answer is incorrect.
Score: 0
Accepted Answers:

$$d = \begin{bmatrix} 260 \\ 0 \\ 0 \\ 0 \\ 171.5 \end{bmatrix} \text{ and } a = \begin{bmatrix} 0 \\ 228 \\ 228 \\ 90 \\ 0 \end{bmatrix}$$

Common data for Q9, Q10, Q11:

The manipulator shown below is the Stanford Arm 6-dof (RRP-RRR) configuration. The base frame (x^0, y^0, z^0), the tool frame (x^6, y^6, z^6), the joints and their respective joint axes/joint directions have been marked for you in red. Assign the coordinate frames, and make sure to assign all the intermediate x-axes such that all the joint angles θ_i are set to zero in the home position given in the diagram. (Hint: Google what an Euler wrist is)

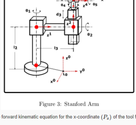

Figure 3: Standard Arm

9) What would the forward kinematic equation for the x-coordinate (P_x) of the tool frame be w.r.t. the base frame be in the arm matrix? *1 point*

$-S_1C_2C_4S_5S_6 + C_1S_4S_5S_6 - S_2C_4C_5S_6 + 1_2C_1 + S_1S_2d_3$

$-C_1C_2C_4S_5S_6 - S_1S_4S_5S_6 - C_1S_2C_4C_5S_6 + C_1S_2d_3 + S_1l_2$

$S_1C_2C_4S_5S_6 + C_1S_4S_5S_6 + S_1S_2C_4C_5S_6 + 1_2C_1 + S_1S_2d_3$

$C_1C_2C_4S_5S_6 - S_1S_4S_5S_6 + C_1S_2C_4C_5S_6 + C_1S_2d_3 - S_1l_2$

$-S_2C_4S_5S_6 + C_2C_5S_6 + l_1 + C_2d_3$

No, the answer is incorrect.
Score: 0
Accepted Answers:
$C_1C_2C_4S_5S_6 - S_1S_4S_5S_6 + C_1S_2C_4C_5S_6 + C_1S_2d_3 - S_1l_2$

What would be the approach vector components w.r.t. the base frame if $(l_1, l_2, l_3) = (1\text{m}, 0.5\text{m}, 2\text{m})$ and the joint variables $(\theta_1, \theta_2, d_3, \theta_4, \theta_5, \theta_6) = (90°, 45°, 0.8\text{m}, 90°, 45°, 135°)$ (rounded off to 2 decimal places)

10) $a_x =$ _____

No, the answer is incorrect.
Score: 0
Accepted Answers:
(Type: Range) -0.75,-0.65

1 point

11) $a_y =$ _____

No, the answer is incorrect.
Score: 0
Accepted Answers:
(Type: Range) 0.45,0.55

1 point

12) $a_z =$ _____

No, the answer is incorrect.
Score: 0
Accepted Answers:
(Type: Range) 0.45,0.55

1 point

13) Which of the following statements is/are **FALSE**? *1 point*

- The manipulator is holonomic
- The manipulator is non-holonomic as it lacks a yaw joint
- The position of the tool frame w.r.t. the base frame is dependent on the values of $\theta_1, \theta_2, d_3, \theta_4, \theta_5$, and θ_6
- The locus of the tool tip, when the value of θ_2 is held constant at ° , and we vary the other 2 joint variables (θ_1, d_3), is a spherical shell

No, the answer is incorrect.
Score: 0
Accepted Answers:
The manipulator is non-holonomic as it lacks a yaw joint
The position of the tool frame w.r.t. the base frame is dependent on the values of $\theta_1, \theta_2, d_3, \theta_4, \theta_5$, and θ_6
The locus of the tool tip, when the value of θ_2 is held constant at ° , and we vary the other 2 joint variables (θ_1, d_3), is a spherical shell