Unit 6 - Week 4

Course outline

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Assignment 4

The due date for submitting this assignment has passed.
As per our records you have not submitted this assignment.

Due on 2020-10-14, 23:59 IST.

1) Which of the following are sufficient conditions for the existence of a closed form solution? *1 point*

- Three adjacent joint axes intersecting.
- Three adjacent joint axes perpendicular to one another
- Two adjacent joint axes are mutually perpendicular.
- Three adjacent joint axes parallel to one another

No, the answer is incorrect.
Score: 0
Accepted Answers:
Three adjacent joint axes intersecting.
Three adjacent joint axes parallel to one another

2) The necessary conditions to be satisfied for the inverse kinematics of a manipulator to be solvable is/are: *1 point*

- Tool orientation is such that none of the joint limitations are violated
- The degree of freedom must be less than or equal to 6, to have any arbitrary orientation of tool
- Tool point should be within the workspace
- The degree of freedom must be greater than or equal to 6, to have any arbitrary orientation of tool

No, the answer is incorrect.
Score: 0
Accepted Answers:
Tool orientation is such that none of the joint limitations are violated
Tool point should be within the workspace
The degree of freedom must be greater than or equal to 6, to have any arbitrary orientation of tool

The forward kinematics of the SCARA manipulator derived in assignment 3 is given below:

$$\begin{bmatrix} C_{12-4} & S_{12-4} & 0 & L_2C_{12}+L_{11}C_1 \\ S_{12-4} & -C_{12-4} & 0 & L_2S_{12}+L_{11}S_1 \\ 0 & 0 & -1 & d_3+L_{12}-L_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The links are designed to have $(L_{11}, L_{12}, L_2, L_4) = (1m, 0.2m, 0.8m, 0.4m)$, for what value of $\theta_1(degrees), \theta_2(degrees), d_3(m)$, and $\theta_4(degrees)$ can we position and orient the tool as given below in its matrix form:

$$\begin{bmatrix} 0 & 1 & 0 & 0.1 \\ 1 & 0 & 0 & 0.9\sqrt{3} \\ 0 & 0 & -1 & 0.4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The joint constraints are:

$-90^\circ \leq \theta_1 \leq 90^\circ$
$-90^\circ \leq \theta_2 \leq 90^\circ$
$-150^\circ \leq \theta_4 \leq 150^\circ$
$0.1m \leq d_3 \leq 1m$

3) $\theta_1 =$ ______$^\circ$

No, the answer is incorrect.
Score: 0
Accepted Answers:
(Type: Range) 59,61

1 point

4) $\theta_2 =$ ______$^\circ$

No, the answer is incorrect.
Score: 0
Accepted Answers:
(Type: Range) 59,61

1 point

5) $d_3 =$______ m

No, the answer is incorrect.
Score: 0
Accepted Answers:
(Type: Range) 0.5,0.7

1 point

6) $\theta_4 =$ ______$^\circ$

No, the answer is incorrect.
Score: 0
Accepted Answers:
(Type: Range) 28,32

1 point

Common data for Q4 and Q5:

Given below are the DH parameters of a cartesian robot with a roll wrist (PPP-R)

k	θ_k	d_k	a_k	α_k
1	-90°	d_1	0	-90°
2	-90°	d_2	0	90°
3	0°	d_3	0	0°
4	θ_4	L_4	0	0°

7) Find the jacobian matrix J for the cartesian manipulator. If $L_4 = 5mm$ what would the rank of the Jacobian matrix be for $(d_1, d_2, d_3, \theta_4)$= (10mm, 15mm, 10mm, 60°)?

Rank= _____

No, the answer is incorrect.
Score: 0
Accepted Answers:
(Type: Range) 3.9,4.1

1 point

8) What force would the joints have to produce if a static load of $(0.3\hat{x} + 0.5\hat{y} + 0.8\hat{z})$N with 0 Nm moment is acting on the tool (F_k is the force applied by joint k and τ_k is the torque produced by joint k)? *1 point*

- $(F_1, F_2, F_3, \tau_4) = (0.3N, 0.5N, 0.8N, 0Nm)$
- $(F_1, F_2, F_3, \tau_4) = (0.5N, 0.3N, 0.8N, (0.3d_2)Nm)$
- $(F_1, F_2, F_3, \tau_4) = (0.8N, 0.3N, 0.5N, 0Nm)$
- $(F_1, F_2, F_3, \tau_4) = (0.8N, 0.3N, 0.5N, (0.3d_2)Nm)$

No, the answer is incorrect.
Score: 0
Accepted Answers:
$(F_1, F_2, F_3, \tau_4) = (0.8N, 0.3N, 0.5N, 0Nm)$

9) determine the linear part of the jacobian matrix for a four-axis SCARA manipulator. Given the positions, $P_x = a_1C_1 + a_2C_{1-2}$ *1 point*
$P_y = a_1S_1 + a_2S_{1-2}$
$P_z = d_1 - d_3 - d_4$

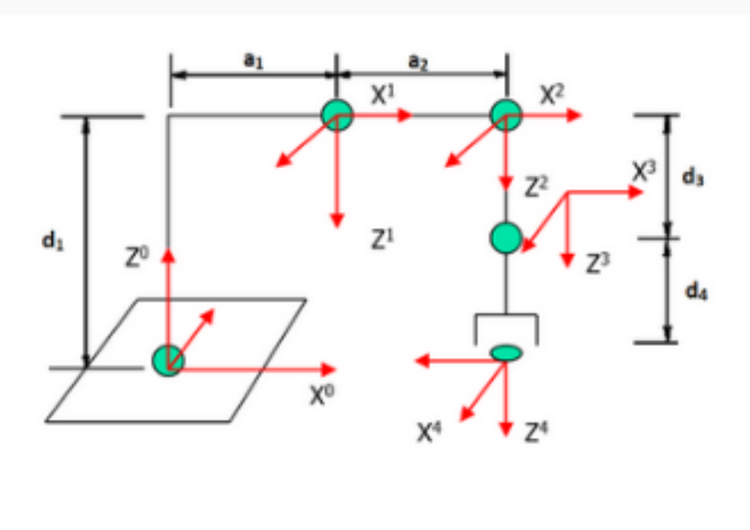


Figure 1: SCARA Manipulator

- $J = \begin{bmatrix} -a_1S_1 - a_2S_{1-2} & -a_2S_{1-2} & 0 & 0 \\ a_1C_1 + a_2C_{1-2} & a_2C_{1-2} & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$
- $J = \begin{bmatrix} -a_1S_1 - a_2S_{1-2} & a_2S_{1-2} & 0 & 0 \\ a_1C_1 + a_2C_{1-2} & -a_2C_{1-2} & 0 & 0 \\ 0 & 0 & -1 & 0 \end{bmatrix}$
- $J = \begin{bmatrix} -a_1S_1 - a_2S_{1-2} & -a_2S_{1-2} & 0 & 0 \\ a_1C_1 + a_2C_{1-2} & a_2C_{1-2} & 0 & 0 \\ 0 & 0 & -1 & 0 \end{bmatrix}$
- $J = \begin{bmatrix} -a_1S_1 - a_2S_{1-2} & a_2S_{1-2} & 0 & 0 \\ a_1C_1 + a_2C_{1-2} & a_2C_{1-2} & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$

No, the answer is incorrect.
Score: 0
Accepted Answers:
$J = \begin{bmatrix} -a_1S_1 - a_2S_{1-2} & a_2S_{1-2} & 0 & 0 \\ a_1C_1 + a_2C_{1-2} & -a_2C_{1-2} & 0 & 0 \\ 0 & 0 & -1 & 0 \end{bmatrix}$

10) The dexterity equation of a robotic manipulator is given as, dex= $a_1a_2S_2$. At what angle θ_2 the manipulator will show boundary singularity? *1 point*

- $0, \pi$
- $\frac{\pi}{2}$
- $-\frac{\pi}{2}$
- $\frac{\pi}{2}, -\frac{\pi}{2}$

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

11) The DH parameters of a spherical manipulator are given below,

k	θ_k	d_k	a_k	α_k
1	θ_1	L_1	0	90°
2	θ_2	0	0	90°
3	0°	d_3	0	0°

Take $L_1 = 2m$.
If the position vector of the end-effector w.r.t. the base is $(-\frac{\sqrt{2}}{8}, \frac{\sqrt{2}}{8}, \frac{8-\sqrt{3}}{4})$, find the magnitude of d_3(in meters) that achieves this.

d_3=______ meters

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

1 point

12) Consider a Roll-pitch-Roll wrist (the Euler wrist) given below: *1 point*

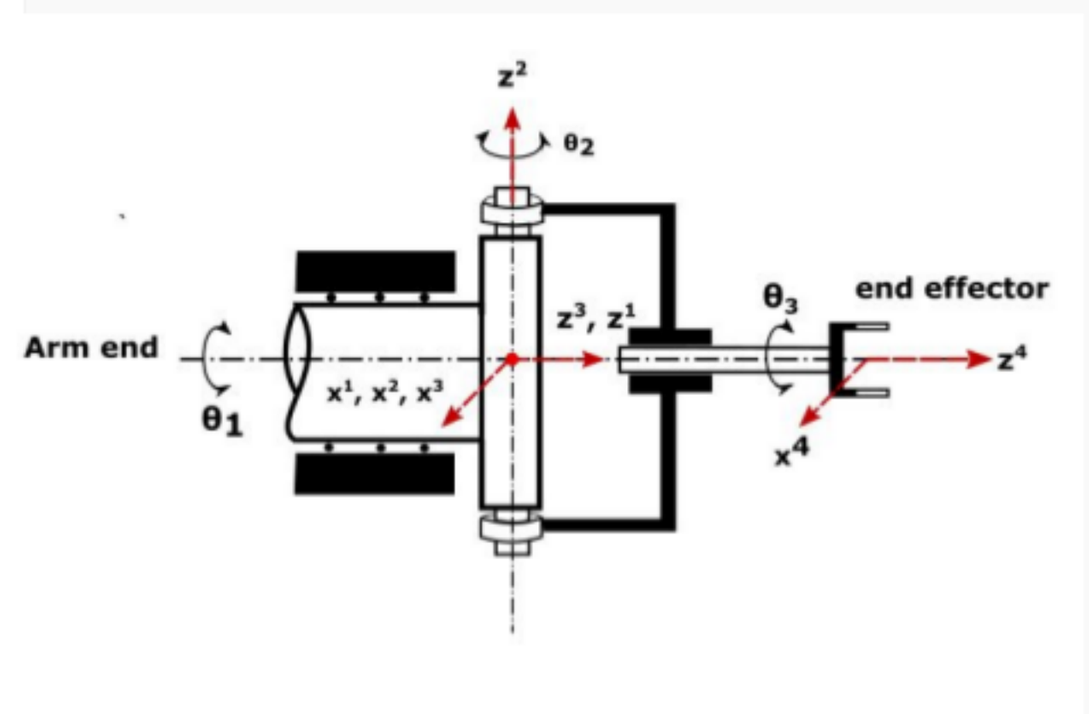


Figure 2: The Euler wrist

Which of the statements are true?

- The wrist has a singularity when $\theta_1 = 0^\circ$
- The wrist has a singularity when $\theta_2 = 0^\circ$
- The wrist has a singularity when $\theta_3 = 0^\circ$
- The wrist has a singularity when $\theta_1 = 90^\circ$
- The wrist does not possess any singularities.

No, the answer is incorrect.
Score: 0
Accepted Answers:
The wrist has a singularity when $\theta_2 = 0^\circ$

13) Find the pseudo inverse of $B = \begin{bmatrix} 1 & 0 & 3 \\ 1 & -1 & 0 \end{bmatrix}$ *1 point*

- $B^+ = \frac{1}{19}\begin{bmatrix} 1 & 9 \\ 1 & 10 \\ 6 & -3 \end{bmatrix}$
- $B^+ = \frac{1}{19}\begin{bmatrix} 1 & 9 \\ 1 & -10 \\ 6 & -3 \end{bmatrix}$
- $B^+ = \frac{1}{19}\begin{bmatrix} 1 & 9 \\ 1 & -10 \\ 6 & 3 \end{bmatrix}$
- $B^+ = \frac{1}{19}\begin{bmatrix} 1 & 9 \\ 1 & 10 \\ 6 & 3 \end{bmatrix}$

No, the answer is incorrect.
Score: 0
Accepted Answers:
$B^+ = \frac{1}{19}\begin{bmatrix} 1 & 9 \\ 1 & -10 \\ 6 & -3 \end{bmatrix}$

14) Consider the forward kinematics of the 2-dof, 2 link planar arm given in week-3 lecture 4: $P_x = l_1C_1 + l_2C_{12} P_y = l_1S_1 + l_2S_{12}$ *1 point*
Take $l_1 = 2$ units, $l_2 = 1$ unit.

If all the possible joint velocities are depicted as a unit circle on the $(\dot{\theta}_1, \dot{\theta}_2)$ plane, with the maximum velocity limits on the circle(fig 3)

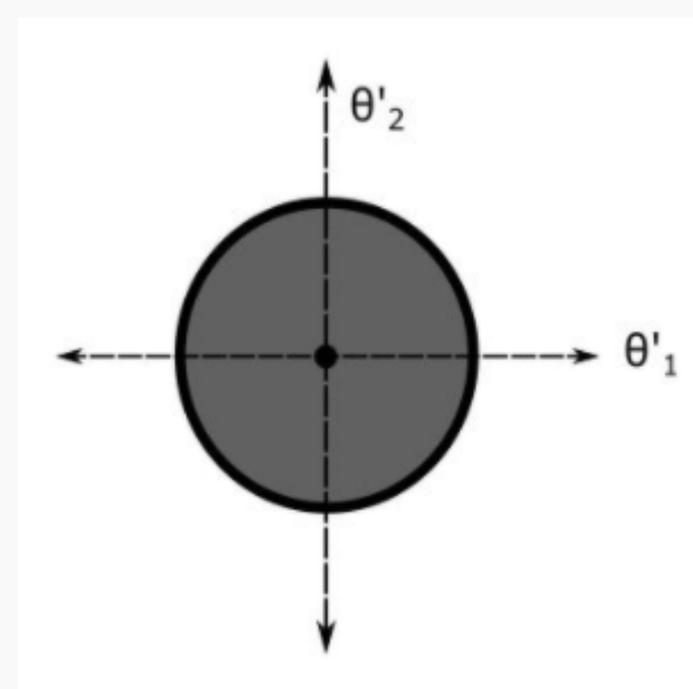


Figure 3 : Joint velocity space

When the arm is in a configuration $(\theta_1, \theta_2) = (0^\circ, 30^\circ)$, the unit circle in the joint space gets mapped as an ellipse in the tool tip velocity space $(\dot{P}_x, \dot{P}_y)$ as given below (fig: 4):

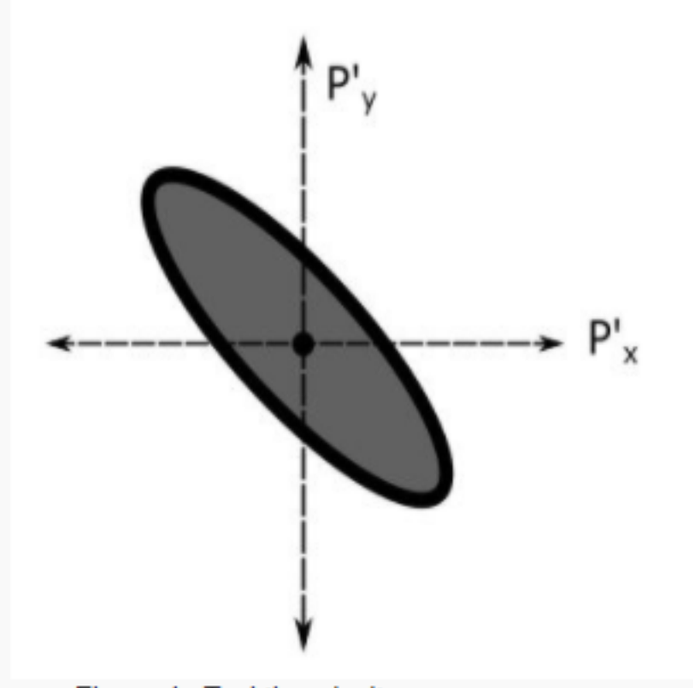
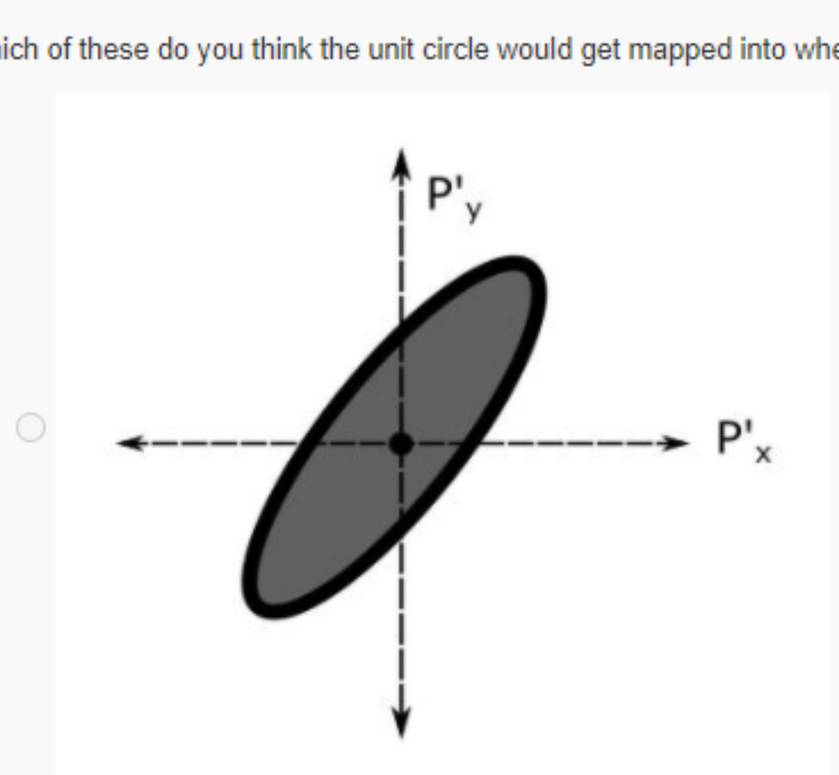
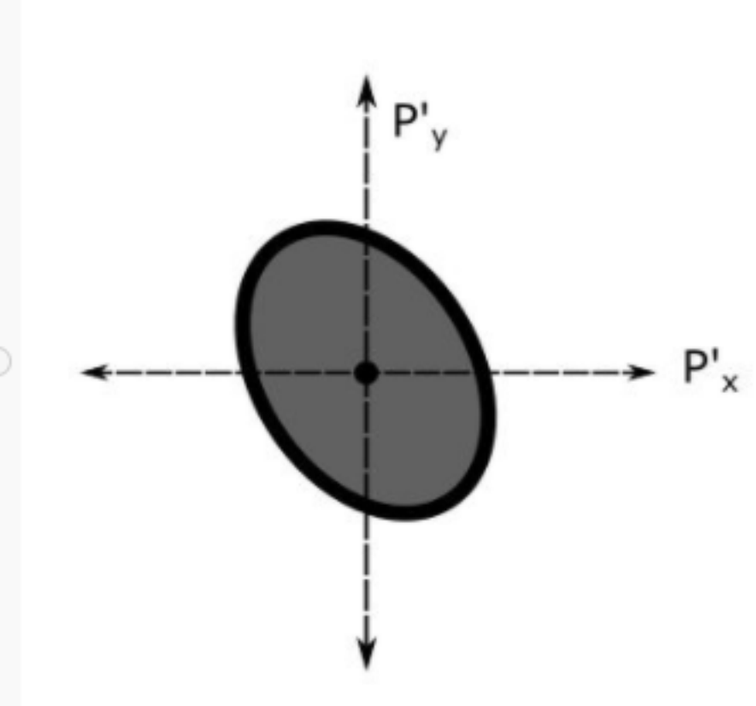
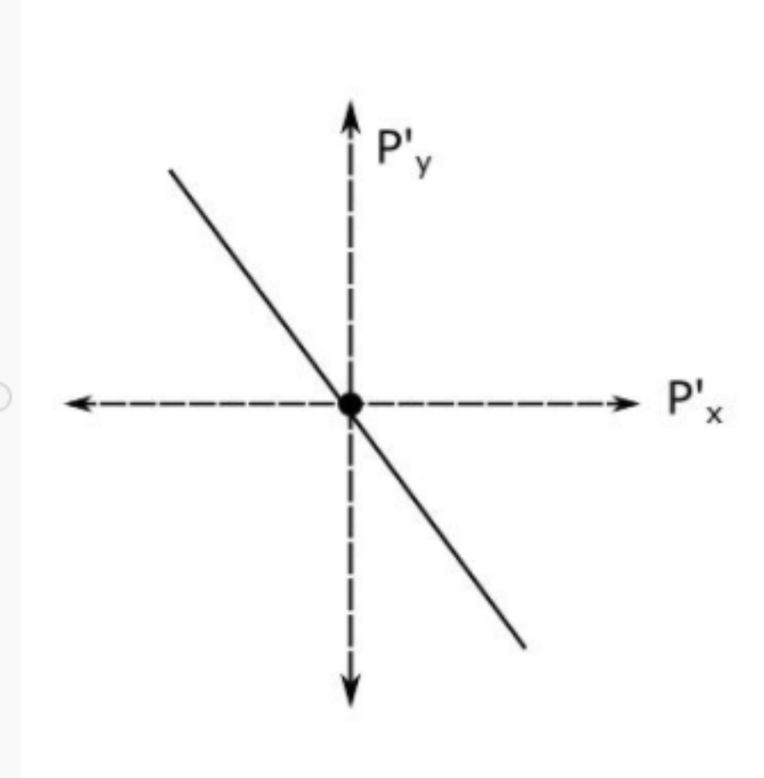


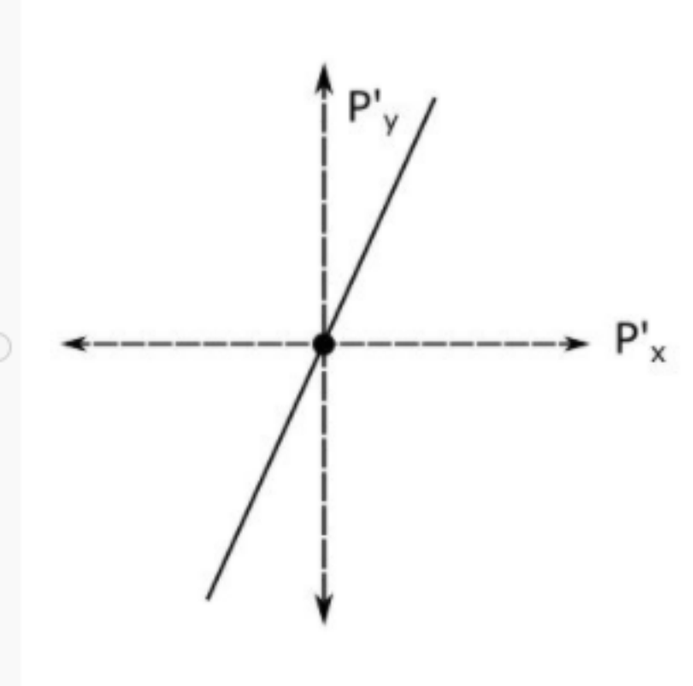
Figure 4 : Tool tip velocity space

Which of these do you think the unit circle would get mapped into when $(\theta_1, \theta_2) = (30^\circ, 0^\circ)$?

- 

- 

- 

- 

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