CAIRO UNIVERSITY
FACULTY OF COMPUTERS AND ARTIFICIAL INTELLIGENCE
MIDTERM EXAM

Examiner : Dr. Mustafa M. Shiple
Subject: Intelligent Autonomous Robotics (AI 441)
Score: 20 Marks

Term: Fall 2023
Exam Time:60 min

ANSWER THE FOLLOWING QUESTIONS:

1. Fill in the spaces [5 marks] [A_q,C_a]
   (a) *True or False:* Proprioception refers to the perception of internal states of a robot.
   (b) *True or False:* Encoders can be used for sensing joint position and speed.
   (c) *True or False:* MEMS capacitive technology Accelerometer has great advantages; PCB mounting and high accuracy.
   (d) *True or False:* Gyroscope is a device used to measure the orientation of objects based on its spinning speed.
   (e) *True or False:* Brushless DC motor is used when high torque is needed.

Solution:
(a) true.
(b) true.
(c) false.
(d) false.
(e) false.

2. Choose only one answer for each question [5 marks] [A_q,C_a]
   (a) Joints with surface contact is called .....
      A. higher pair .
      B. lower pair .
      C. surface pair.
      D. point pair.
   (b) Helical joint is .....
      A. One degree of freedom .
      B. Two degree of freedom .
      C. According to its movement dependencies,its considered as three DOF.
      D. its a false joint with 0 DOF.
   (c) SCARA Robot arm is .

[Total Marks is 20]

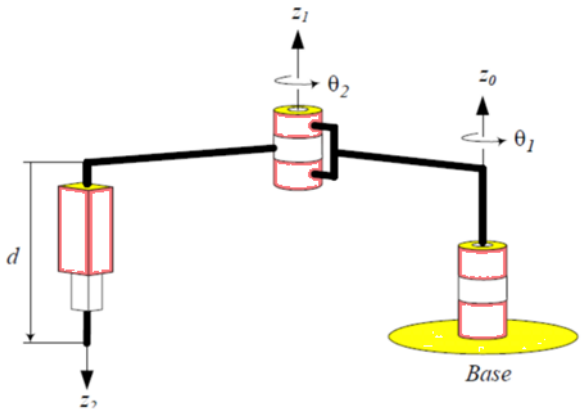
Good Luck

A. R——R——P.

B. R——P——P

C. R——P——P.

D. R——P——R.



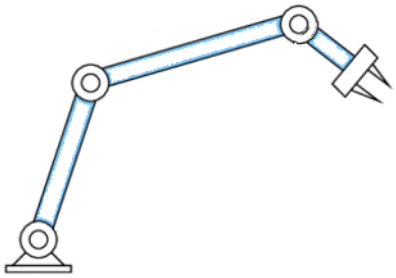
(d) Number of DOF of shown arm robot =.....

A. 1.

B. 2.

C. 3.

D. 4.



(e) The shown transformation represents rotation around=.....

A. x-axis.

B. y-axis.

C. z-axis.

D. moving frame o-axis.

$$ {}^{0}T_{1} = \begin{bmatrix} \cos(q_1) & -\sin(q_1) & 0 & 0 \\ \sin(q_1) & \cos(q_1) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

Solution:

(a) lower pair (B).

(b) One degree of freedom(A)

(c) R——R——P(A).

(d) 4(D).

(e) z-axis (C).

3. A frame ${}^{U}F$ (n-, o-, a-axes) was moved along its own n-axis a distance of 5 units, then rotated about its o-axis an angle of 60°, followed by a rotation of 60° about the z-axis, then translated about its a-axis for 3 units, and finally rotated 45° about the x-axis.

   (a) Calculate the total transformation performed.

   (b) Calculate the total inverse transformation to reallocate the frame to the original position.

[10 marks] [D$_c$]

Solution: $U_{T_B} = Rot(x,45)Rot(z,60)Trans(5,0,0)Rot(o,60)Trans(0,0,3)$

$$U_{T_B} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & cos(45) & -sin(45) & 0 \\ 0 & sin(45) & cos(45) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} cos(45) & -sin(45) & 0 & 0 \\ sin(45) & cos(45) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 0 & 0 & 0 & 5 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\times \begin{bmatrix} cos(45) & 0 & sin(45) & 0 \\ 0 & 0 & 1 & 0 \\ -sin(45) & 0 & cos(45) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

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Answer Q3
Rot(x, 45)Rot(z, 60) =
 [[ 0.5   -0.866  0.     0.   ]
 [ 0.612  0.354 -0.707  0.   ]
 [ 0.612  0.354  0.707  0.   ]
 [ 0.     0.     0.     1.   ]]
Rot(x, 45)Rot(z, 60) trans(5,0,0)=
 [[ 0.5   -0.866  0.     2.5  ]
 [ 0.612  0.354 -0.707  3.062]
 [ 0.612  0.354  0.707  3.062]
 [ 0.     0.     0.     1.   ]]
Rot(x, 45)Rot(z, 60) trans(5,0,0) rot_y(60)=
 [[ 0.25  -0.866  0.433  2.5  ]
 [ 0.919  0.354  0.177  3.062]
 [-0.306  0.354  0.884  3.062]
 [ 0.     0.     0.     1.   ]]
Rot(x, 45)Rot(z, 60) trans(5,0,0) rot_y(60) trans(0,0,3)=
 [[ 0.25  -0.866  0.433  3.799]
 [ 0.919  0.354  0.177  3.592]
 [-0.306  0.354  0.884  5.714]
 [ 0.     0.     0.     1.   ]]
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$$U_{T_B} = \begin{bmatrix} 0.25 & -0.866 & 0.433 & 3.8 \\ 0.918 & 0.354 & 0.177 & 0.359 \\ -0.306 & 0.354 & 0.884 & 5.71 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$