

CHUKA



UNIVERSITY

**UNIVERSITY EXAMINATIONS**

**EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN  
ELECTRICAL AND ELECTRONIC ENGINEERING**

**EENG 444: ROBOTICS I**

**STREAMS: BSC EENG**

**TIME: 2 HOURS**

**DAY/DATE: MONDAY 16/12/2024**

**11.30 A.M – 1.30 P.M.**

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**INSTRUCTIONS:**

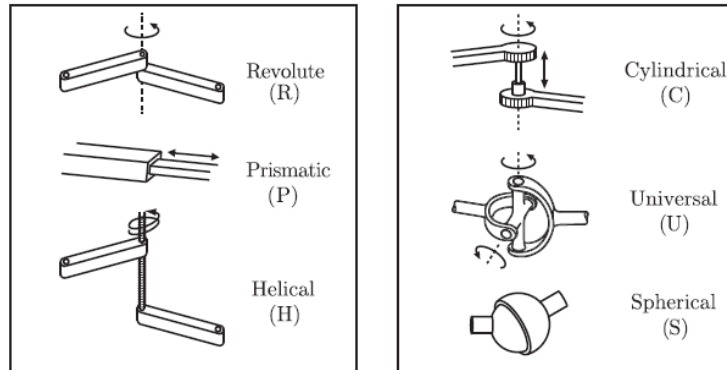
- **Answer question ONE and any other TWO questions.**
- **Do not write on the question paper.**

**QUESTION ONE (30 MARKS)**

- What are the key components of a robotic arm, and how do they work together to achieve precise movements? **(4 marks)**
- Explain the concept of forward kinematics in robotics. **(2 marks)**
- What is inverse kinematics in robotics, and why is it essential? **(2 marks)**
- Describe the advantages and disadvantages of wheeled mobile robots versus legged mobile robots. **(3 marks)**
- How do sensors like LiDAR and cameras contribute to a robot's perception of its environment? **(3 marks)**
- Explain the importance of feedback control systems in robotics. **(3 marks)**
- If a robot arm has three joints, and each joint can move from 0 to 180 degrees, how many possible joint configurations are there? **(3 marks)**
- A robot's manipulator has a reach of 60 centimeters. What is the maximum distance it can extend its end-effector from its base? **(2 marks)**
- The figure above illustrates the basic joints found in typical robots. Every joint connects exactly two links. What are the number of degrees of freedom for each joint? **(6 marks)**

j) What is an articulated robot configuration?

(2 marks)



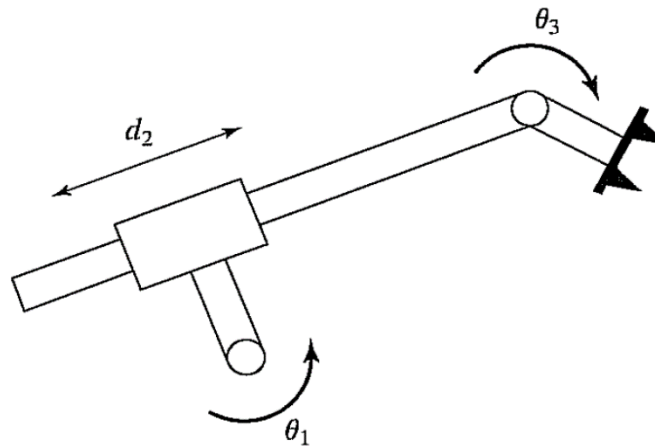
**QUESTION TWO (20 MARKS)**

a) A vector  $AP$  is rotated about  $\hat{Z}_A$  by  $\theta$  degrees and is subsequently rotated about  $\hat{X}_A$  by  $\phi$  degrees. Give the rotation matrix that accomplishes these rotations in the given order.

(3 marks)

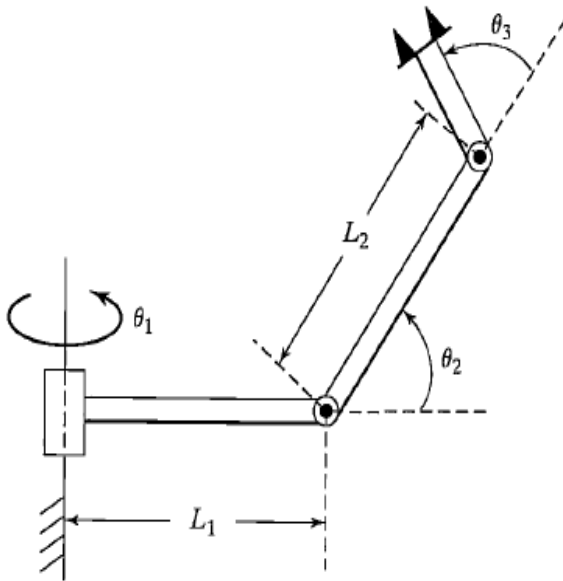
b) Assign link frames to the RPR planar robot shown below, and give the linkage parameters

(5 marks)



c) The arm with three degrees of freedom shown below has a twist of 90 degrees in magnitude between axes 1 and 2. Derive link parameters and the kinematic equations for  $WBT$ . Note that no  $l_3$  need be defined.

(7 marks)



- d) Why would one desire a cylindrical configured robot over a Cartesian configured robot? **(2 marks)**
- e) Illustrate diagrammatically the difference between open chain and closed chain kinematics. **(3 marks)**

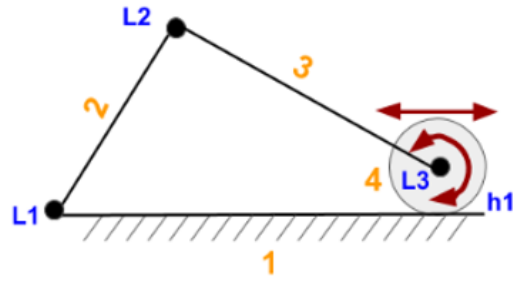
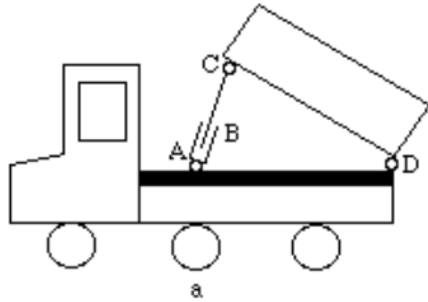
**QUESTION THREE (20 MARKS)**

- a) Discuss briefly any 3 types of gripper mechanism. **(3 marks)**
- b) A single cubic trajectory is given by **(5 marks)**

$$\theta(t) = 10 + 90t^2 - 60t^3$$

and is used over the time interval from  $t = 0$  to  $t = 1$ . What are the starting and final positions, velocities, and accelerations?

- c) Outline any two criteria used for selection of grippers. **(4 marks)**
- d) Using Grubler's formula, calculate the number of degrees of freedom in the figures below. **(6 marks)**



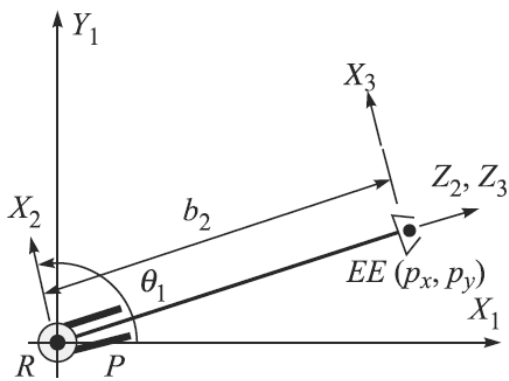
e) How can we measure the performance of a robot? (2 marks)

**QUESTION FOUR (20 MARKS)**

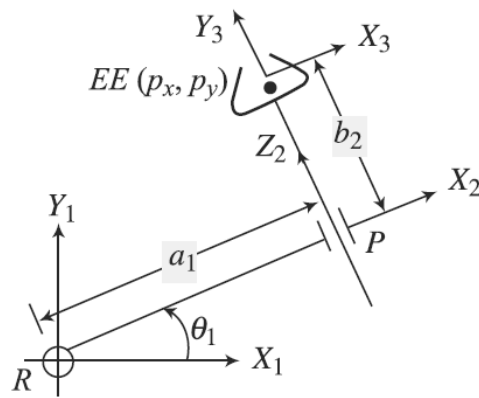
a) What does an ADC do in robots? (2 marks)

b) Discuss the motion subsystems of a robot system. (4 marks)

c) Referring to two Revolute-Prismatic (RP) planar arms below, where the revolute and prismatic joints are indicated as R and P, respectively, find the DH parameters (8 marks)



(a) Intersecting joint axes



(b) Non-intersecting joint axes

d) Consider the parallel SCARA robot shown in Figure 2.6. The robot is controlled by two rotational motors located in the base, and one rotational and one prismatic motor at the end effector. Assume each of the links of the parallel mechanism are length 1 m, the prismatic joint has a maximum travel of 1 m, and the separation distance of the base motors is 0.5 m. Assume no collisions between the links and that the end effector y-coordinate is constrained to be greater than zero. (6 marks)

- (a) Sketch the workspace of the end effector.
- (b) What are some benefits and drawbacks of making a parallel rather than a SCARA robot?

