The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

Study Programme	:	Bachelor of Science Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**DMX7303- Control of Robotics Manipulators**
Academic Year/Semester	:	2023/2024
Date	:	9th February 2025
Time	:	13.30h - 16.30h
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of Five (5) questions on Four (4) pages.
3. **Answer all questions.**
4. All questions carry equal marks.
5. This is a Closed Book Test (CBT).
6. The answer for each question should commence from a new page.
7. Answers should be in clear handwriting.
8. Do not use a **RED** pen.

Question 1

a) What is the definition of robotics, and how does it differ from automation and artificial intelligence? [5 marks]

b) What are the main classifications of robots based on their structure and mobility, and how are they utilized in various applications? [5 marks]

c) What is the current state of research and development in humanoid robotics, and what are the implications of creating robots that resemble humans? [5 marks]

d) What role do machine learning and neural networks play in enhancing the capabilities and autonomy of robots? [5 marks]

Question 2

a) Explain the significance of the ZYX Euler angle rotation matrix in representing orientation transformations in 3D space. [5 marks]

b) Demonstrate the equivalence of rotation orders ZYX and XYZ by showing how each order produces the same orientation in a given example [5 marks]

c) Construct the homogeneous transformation matrix that represents a sequence of rotations: 30° about the OZ-axis, followed by 60° about the OX-axis, and then 90° about the OY-axis [5 marks]

d) The rotation matrix ${}^{1}R_{2}$, representing the orientation of frame {2} with respect to frame {1}, is given by:

$$ {}^{1}R_{2} = \begin{bmatrix} 0.87 & 0.43 & 0.25 \\ 0.5 & 0.75 & -0.43 \\ 0 & 0.5 & 0.87 \end{bmatrix} $$

Calculate the corresponding ZYX Euler angles that define this orientation. [5 marks]

Question 3

a) What are the essential components of the Denavit-Hartenberg (DH) parameters used in the forward kinematics equations, and how are they utilized to model a robot's kinematic chain? [5 marks]

b) What key mathematical equations are involved in solving forward kinematics, and how do they vary for different robotic arms and manipulators? [5 marks]

c) What are some practical considerations when implementing inverse kinematics algorithms in real-time robotic control systems? [5 marks]

d) How do advancements in robotics, such as parallel mechanisms or redundant manipulators, challenge the traditional methods of forward and inverse kinematics, and how are researchers adapting to these changes? [5 marks]

Question 4

Determine the forward Kinematics model of a 6-DoF articulated arm shown in Figure Q4 and obtain the endpoint transformation matrix. [20 marks]

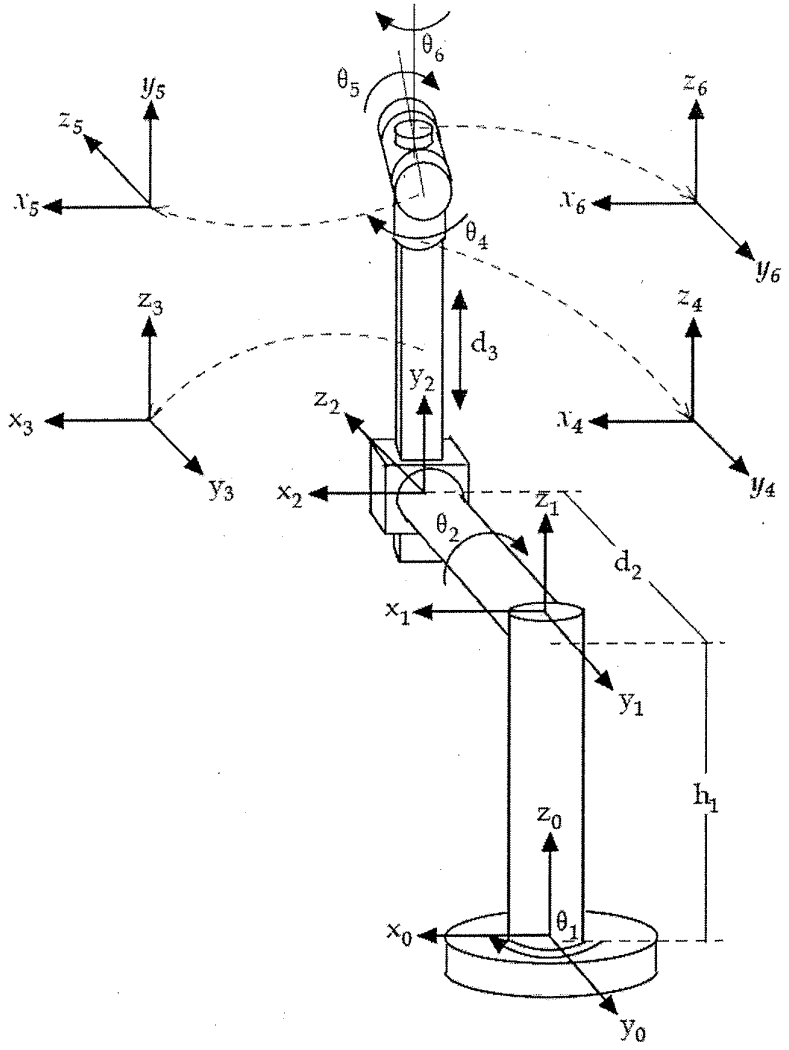

Figure Q4

Question 5

a) Explain the fundamental principles of trajectory generation in robotic systems.

[5 marks]

b) Compare and contrast point-to-point and continuous path trajectory planning.

[5 marks]

c) Describe the role of kinematics in trajectory generation for robotic manipulators.

[5 marks]

d) Explain the differences between time-based, position-based, and dynamic trajectory generation methods. [5 marks]

END