Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
ONLINE
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	ROBOTIC SYSTEMS
COURSE CODE	:	BEJ44203/BEH41703
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS OPEN BOOK EXAMINATION

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1. **Figure Q1** shows a three-link RRP SCARA manipulator with link parameters as tabulated in following **Table Q1**.

(a) Derive the transformation matrix of H_0^3.

(8 marks)

(b) Calculate the Jacobian of the linear velocities of the RRP manipulator.

(14 marks)

(c) Briefly discuss about the problem of singularities.

(3 marks)

Q2. **Figure Q2** shows the 2-axis articulated robot arm. Assign the necessary coordinate systems based on the Denavit-Hartenberg (D-H) representation,

(a) Fill out the parameters table

(3 marks)

(b) Derive the forward kinematic equations for the robot.

(9 marks)

(c) Give the detail explanations the process to assign the coordinate system based on the D-H representation.

(13 marks)

Q3. The Denavit-Hartenberg (D-H) model of representation is a very simple way of modeling robot links and joints that can be used for any robot configuration, regardless of its sequence or complexity. It can also be used to represent transformations in any coordinates such as Cartesian, cylindrical, spherical, Euler, and RPY. Additionally, it can be used for representation of all revolute articulated robots, SCARA robots, or any possible combinations of joints and links. **Figure Q3** shows the 4 degrees-of-freedom (DOF) robot. For the given 4-DOF robot designed for a specific operation:

(a) Assign appropriate frames for the Denavit-Hartenberg representation.

(10 marks)

(b) Fill out the parameters table.

(10 marks)

(c) Write an equation in terms of A matrices that shows how ${}^{U}T_{H}$ can be calculated.

(5 marks)

Q4.

(a) The first joint of a 6-axis robot is required to rotate from initial angle of 30° to a desired final angle of 75 ° in 5 seconds for a car painting operation. Using a third-order polynomial,

I. Calculate the joint angle at 1, 2, 3, and 4 seconds.

(8 Marks)

II. Draw the joint positions, velocities, and accelerations for the entire position.

(2 Marks)

(b) Suppose the 6-axis robot arm is to continue to the next point, where the joint is to reach 105 in another 3 seconds. Draw the position, velocity, and acceleration curves for the motion.

(10 marks)

(c) Explain the different between path planning and trajectory planning.

(5 Marks)

-END OF QUESTIONS-

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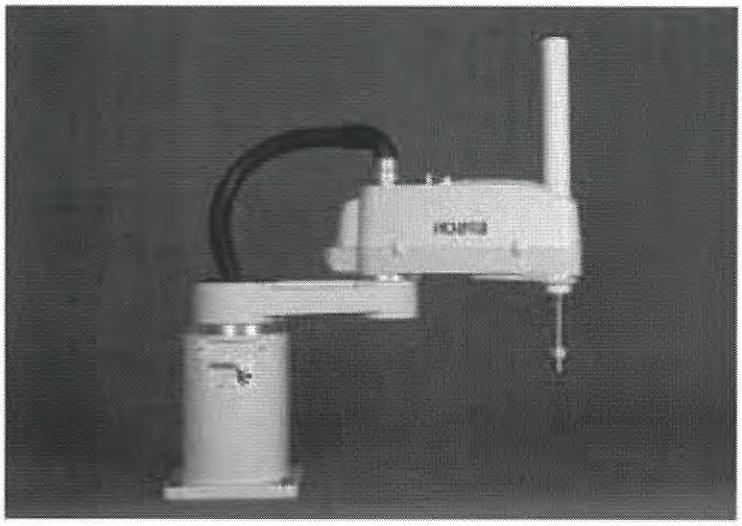

Figure Q1 Three-link RRP SCARA manipulator

Table Q1 Three-link RRP spatial manipulator link parameters

i	θ_{i-1}	a_{i-1}	d_i	α_{i-1}
1	θ_1	a_1	d_1	0
2	θ_2	a_2	0	180°
3	0	0	$L+d_3$	0

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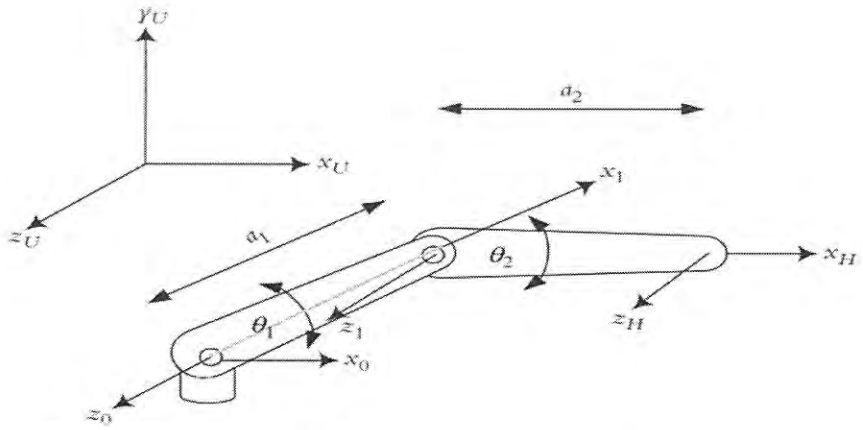

Figure Q2: 2 – axis articulated robot arm.

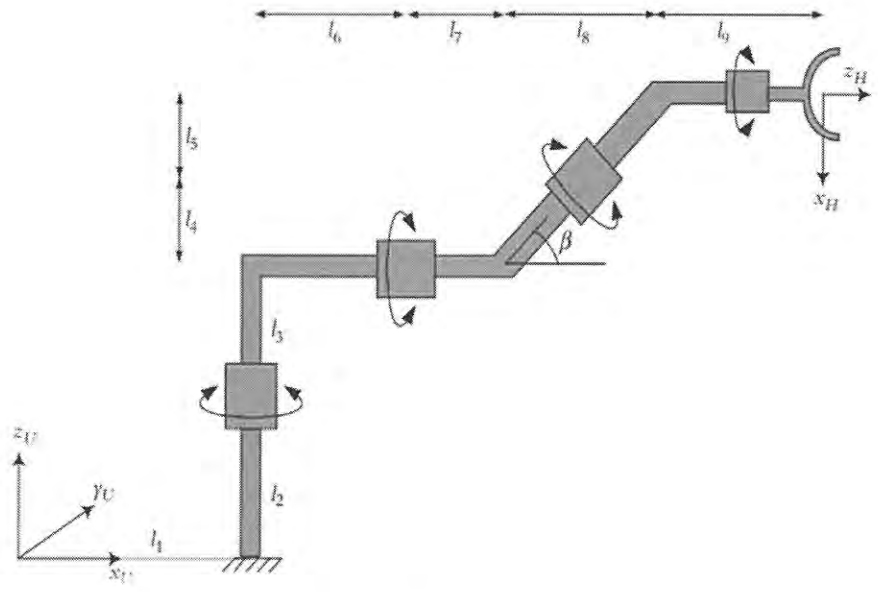

Figure Q3: 4-DOF robot

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Table Q3 Parameter table

#	θ	d	a	α
0–1				
1–2				
2–3				
3–				