THE UNIVERSITY OF ADELAIDE
DEPARTMENT OF MECHANICAL ENGINEERING

EXAMINATION FOR THE DEGREE OF B.E.

ROBOTICS M 2551

JUNE 2001

TIME: 3 HOURS + 10 MINUTES

[Students are advised to devote 10 minutes to reading the paper and planning your approach.]
[The use of notes, textbooks and calculating devices other than computers is permitted in the examination room.]

Total 5 pages in this exam paper.

Part 1. Short Questions (Total 40 points)

1. Figure 1 shows a 6DOF spherical robot. Assume Axes 1, 2 and 3 intersect at one point. Affix frames to the links and find the DH parameters (10 points).

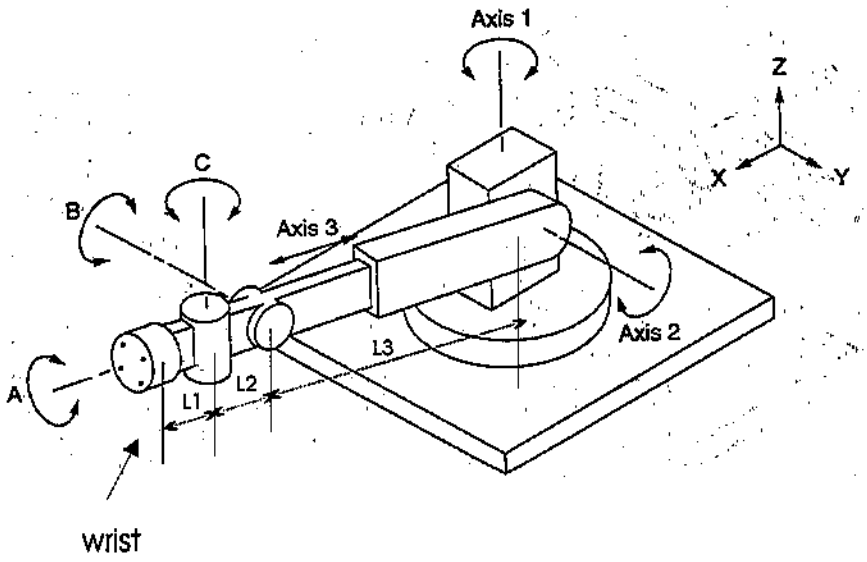

Figure 1. Spherical Robot.

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2. Consider the arrow sign shown in Figure 2. Sketch the arrow position after each intermediate position of the following Roll-Pitch-Yaw operation: roll 90°, pitch -90°, yaw 90° (Hint, this is a "X-Y-Z fixed angles" case).(5 points).

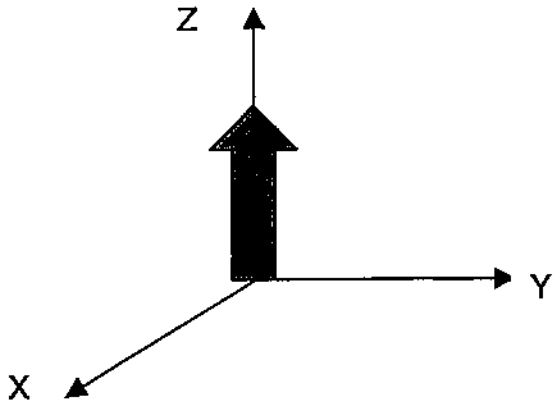

Figure 2. Roll, Pitch and Yaw of the Arrow

3. Exam the following two structures in Figure 3, are they parallel robots? Why? How many DOF each robot has?
(5 points)

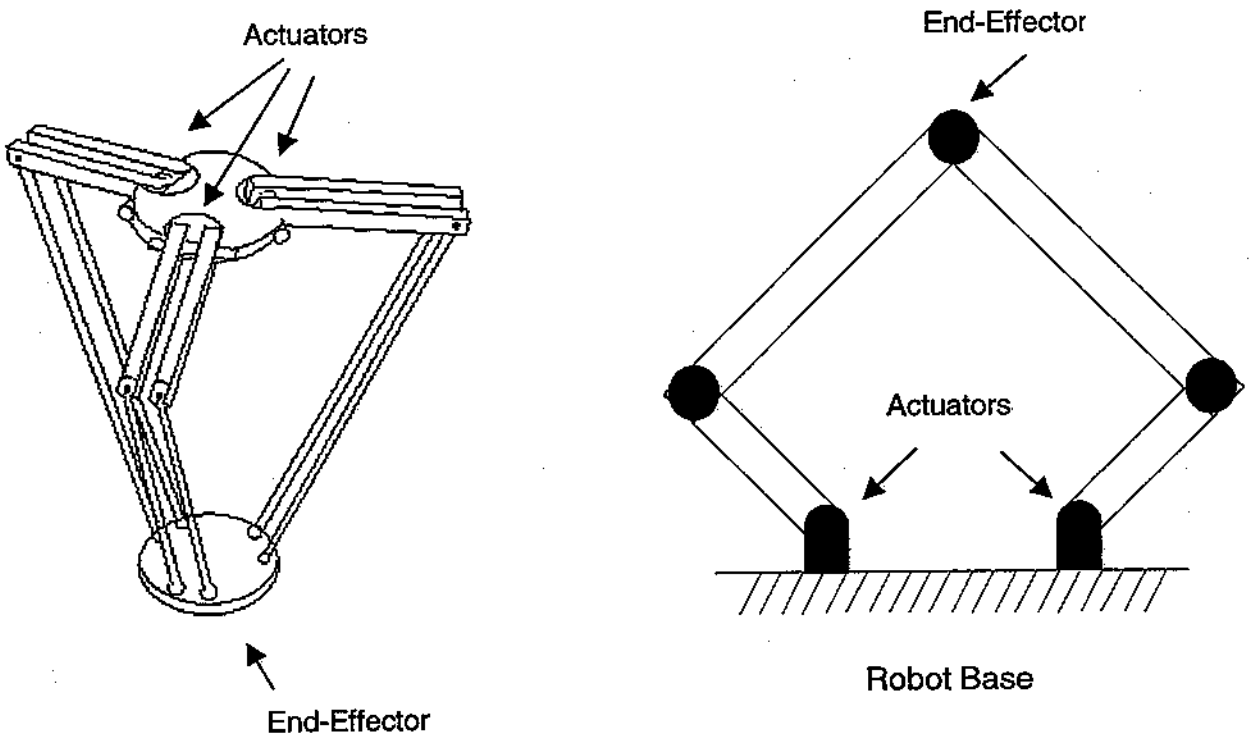

Figure 3. Two Robot Structures

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4. Referring to Figure 4, use three different approaches to give the value of ${}^{A}_{B}T$ (12 points).

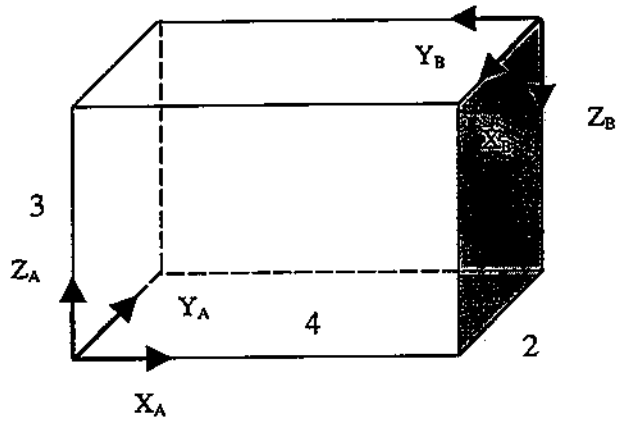
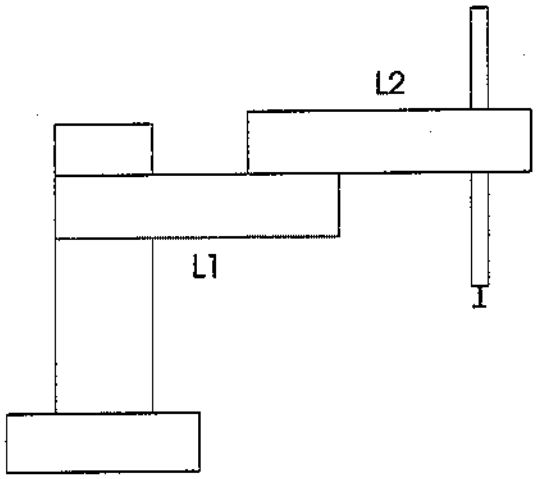


Figure 4. Frame Transformation

5. A SCARA robot is shown in Figure 5, where L1=L2. Find the workspace for the robot and point out the dextrous workspace if there is any, assume both L1 and L2 can rotate for 360^0 (8 pionts).



Figuare 5. A SCARA Robot.

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Part 2. Long Questions (Total 60 points)

6. A 3-DOF RPP robot is shown in Figure 6. Assume the inertia of the base link is J, the masses of links 2 and 3 are concentrated at the ends of the links. Derive the dynamic model of the robot (20 points).

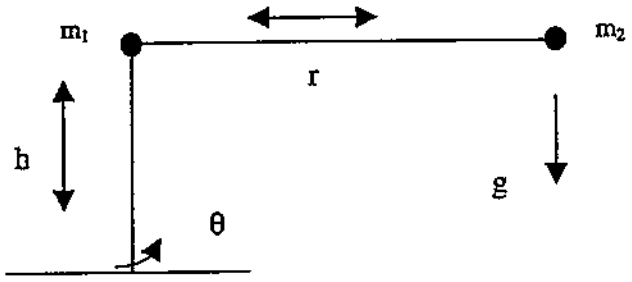

Figure 6. A 3DOF RPP Robot.

7. Refer to the 3-DOF manipulator shown in Figure 7, the position of the fingertip in the Cartesian Space is known, i.e., $[X_d, Y_d, Z_d]^T = [4/5, 3/5, 5/2]^T$, find the joint angles $\theta_1, \theta_2, \theta_3$. The link lengths are given as L1 = 1.7, L2 = 0.8, L3 = 2/3, L4 = 4/3 (20 points).

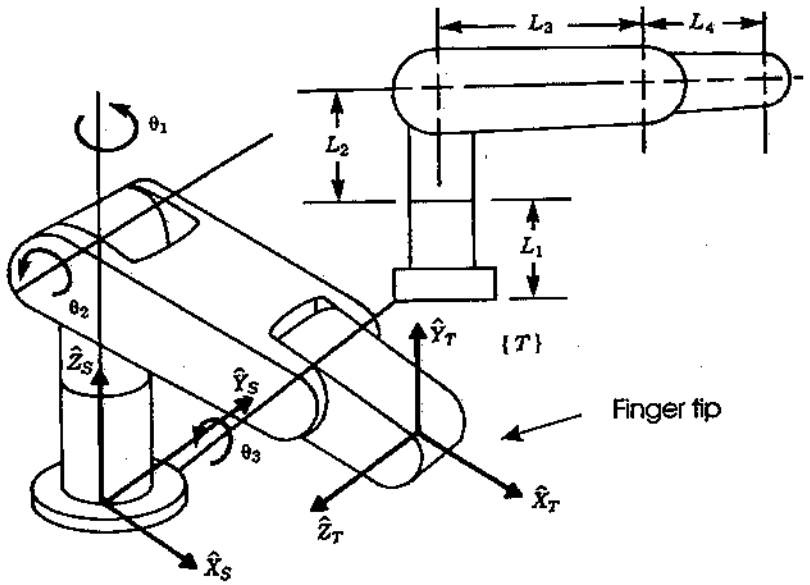

Figure 7. A 3-DOF Robot.

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8. Calculate the linear velocity of the toop fip as the function of the three joint rates for the manipulator shown in Figure 8. Give the answer in the tip-frame (20 points).

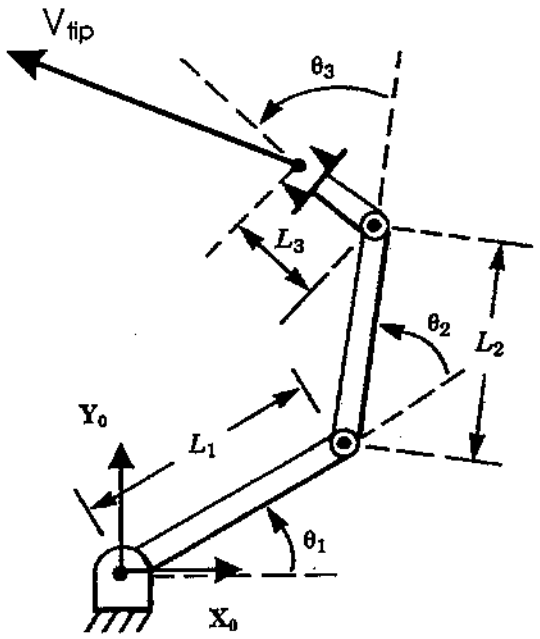

Figure 8. A 3DOF Planar Robot.

Bonus Questions (Total 10 points):

1. Refer to Question 6, design a Model-Based Controller to control the robot. You must give the detailed control algorithms. Comment on the advantages and disadvantages of this controller. (5 points).

2. Refer to Question 8, give the Jacobian in the tip frame. Where are the singularities? (5 points).

End of the Exam Paper