3.4 Problems

1. Verify the statement after Equation (3.18) that the rotation matrix R has the form (3.16) provided assumptions DH1 and DH2 are satisfied.

2. Consider the three-link planar manipulator shown in Figure 3.12. Derive

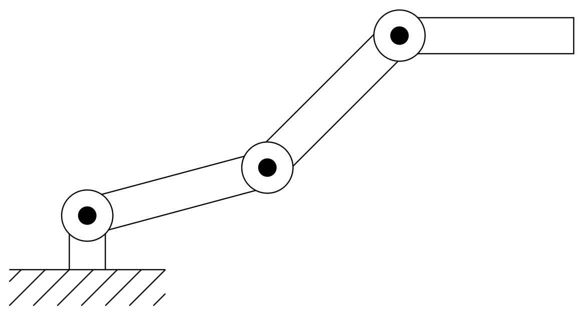

Figure 3.12: Three-link planar arm of Problem 3-2.

the forward kinematic equations using the DH-convention.

3. Consider the two-link cartesian manipulator of Figure 3.13. Derive

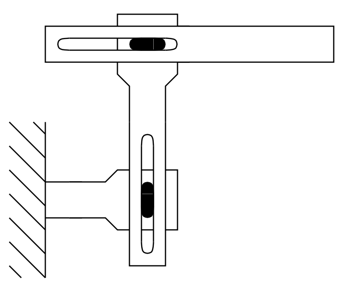

Figure 3.13: Two-link cartesian robot of Problem 3-3.

the forward kinematic equations using the DH-convention.

4. Consider the two-link manipulator of Figure 3.14 which has joint 1 revolute and joint 2 prismatic. Derive the forward kinematic equations using the DH-convention.

5. Consider the three-link planar manipulator of Figure 3.15 Derive the forward kinematic equations using the DH-convention.

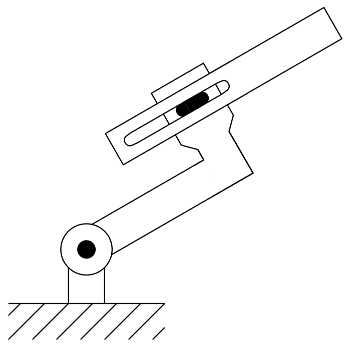

Figure 3.14: Two-link planar arm of Problem 3-4.

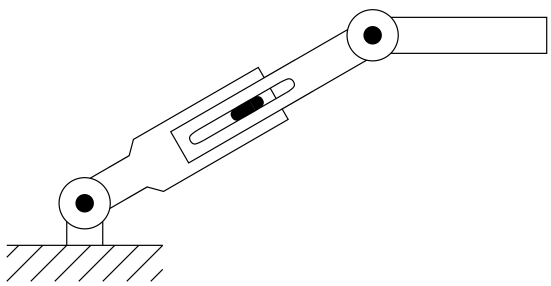

Figure 3.15: Three-link planar arm with prismatic joint of Problem 3-5.

6. Consider the three-link articulated robot of Figure 3.16. Derive the forward kinematic equations using the DH-convention.

7. Consider the three-link cartesian manipulator of Figure 3.17. Derive the forward kinematic equations using the DH-convention.

8. Attach a spherical wrist to the three-link articulated manipulator of Problem 3-6 as shown in Figure 3.18. Derive the forward kinematic equations for this manipulator.

9. Attach a spherical wrist to the three-link cartesian manipulator of Problem 3-7 as shown in Figure 3.19. Derive the forward kinematic equations for this manipulator.

10. Consider the PUMA 260 manipulator shown in Figure 3.20. Derive the complete set of forward kinematic equations, by establishing appropriate D-H coordinate frames, constructing a table of link parameters, forming the A-matrices, etc.

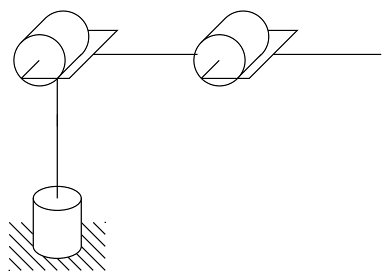

Figure 3.16: Three-link articulated robot.

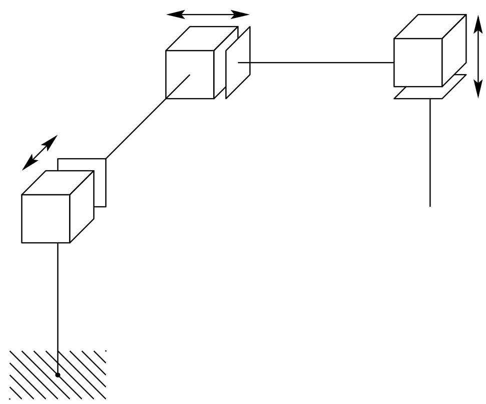

Figure 3.17: Three-link cartesian robot.

11. Repeat Problem 3-9 for the five degree-of-freedom Rhino XR-3 robot shown in Figure 3.21. (Note: you should replace the Rhino wrist with the sperical wrist.)

12. Suppose that a Rhino XR-3 is bolted to a table upon which a coordinate frame $o_s x_s y_s z_s$ is established as shown in Figure 3.22. (The frame $o_s x_s y_x z_s$ is often referred to as the **station frame**.) Given the base frame that you established in Problem 3-11, find the homogeneous transformation T_0^s relating the base frame to the station frame. Find the homogeneous transformation T_5^s relating the end-effector frame to the station frame. What is the position and orientation of the end-effector in the station frame when $\theta_1 = \theta_2 = \cdots = \theta_5 = 0$?

13. Consider the GMF S-400 robot shown in Figure 3.23 Draw the symbolic representation for this manipulator. Establish DH-coordinate frames and write the forward kinematic equations.