PROBLEMS

1-1 What are the key features that distinguish robots from other forms of "automation," such as CNC milling machines?

1-2 Briefly define each of the following terms: forward kinematics, inverse kinematics, trajectory planning, workspace, accuracy, repeatability, resolution, joint variable, spherical wrist, end-effector.

1-3 What are the main ways to classify robots?

1-4 Make a list of robotics related magazines and journals carried by the university library.

1-5 From the list of references at the end of this chapter make a list of 20 robot applications. For each application discuss which type of manipulator would be best suited; which least suited. Justify your choices in each case.

1-6 List several applications for non-servo robots; for point-to-point robots, for continuous path robots.

1-7 List five applications that a continuous path robot could do that a point-to-point robot could not do.

1-8 List five applications where computer vision would be useful in robotics.

1-9 List five applications where either tactile sensing or force feedback control would be useful in robotics.

1-10 Find out how many industrial robots are currently in operation in the United States. How many are in operation in Japan? What country ranks third in the number of industrial robots in use?

1-11 Suppose we could close every factory in the United States today and reopen then tomorrow fully automated with robots. What would be some of the economic and social consequences of such a development?

1-12 Suppose a law were passed banning all future use of industrial robots in the United States. What would be some of the economic and social consequences of such an act?

1-13 Discuss possible applications where redundant manipulators would be useful.

1-14 Referring to Figure 1-30 suppose that the tip of a single link travels a distance d between two points. A linear axis would travel the distance d while a rotational link would travel through an arclength $\ell\theta$ as shown. Using the law of cosines show that the distance d is given by

$$d = \ell\sqrt{2(1-\cos(\theta))}$$

which is of course less than $\ell\theta$. With 10-bit accuracy and $\ell = 1$ m, $\theta = 90^o$ what is the resolution of the linear link? of the rotational link?

1-15 A single-link revolute arm is shown in Figure 1-30. If the length of the link is 50 cm and the arm travels 180^o what is the control resolution obtained with an 8-bit encoder?

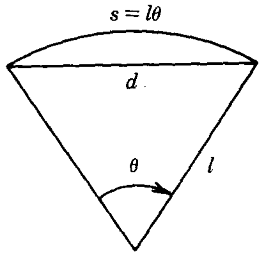

FIGURE 1-30
Diagram for Problem 1-15.

1-16 Repeat Problem 1-15 assuming that the 8-bit encoder is located on the motor shaft that is connected to the link through a 50:1 gear reduction. Assume perfect gears.

1-17 Why is accuracy generally less than repeatability?

1-18 How could manipulator accuracy be improved using direct end-point sensing? What other difficulties might direct end-point sensing introduce into the control problem?

1-19 Derive Equation 1.5.9.

1-20 For the two-link manipulator of Figure 1-25 suppose $a_1 = a_2 = 1$. Find the coordinates of the tool when $\theta_1 = \frac{\pi}{6}$ and $\theta_2 = \frac{\pi}{2}$.

1-21 Find the joint angles θ_1, θ_2 when the tool is located at coordinates $(\frac{1}{2}, \frac{1}{2})$.

1-22 If the joint velocities are constant at $\dot{\theta}_1 = 1$, $\dot{\theta}_2 = 2$, what is the velocity of the tool? What is the instantaneous tool velocity when $\theta_1 = \theta_2 = \frac{\pi}{4}$?

1-23 Write a computer program to plot the joint angles as a function of time given the tool locations and velocities as a function of time in cartesian coordinates.

1-24 Suppose we desire that the tool follow a straight line between the points (0,2) and (2,0) at constant speed s. Plot the time history of joint angles.

1-25 For the two-link planar manipulator of Figure 1-25 is it possible for there to be an infinite number of solutions to the inverse kinematic equations? If so, explain how this can occur.