***Exercise 7***

(a) Use the equations in (3) and the identity

sin2*(θ*1 + *θ*2*)* + cos2*(θ*1 + *θ*2*)* = 1

to show that

15 sin *θ*1 + 9 cos *θ*1 = 17

(b) Solve the last equation for sin *θ*1 in terms of cos *θ*1 and substitute in the identity

sin2 *θ*1 + cos2 *θ*1 = 1

to obtain

153 cos2 *θ*1 − 153 cos *θ*1 + 32 = 0

(c) Treat this as a quadratic equation in cos *θ*1, and use the quadratic formula to obtain

cos *θ*1 = ±

(d) Use the arccosine (inverse cosine) operation of a calculating utility to solve the equations in

part (c) to obtain

*θ*1 ≈ 0*.*792436 rad ≈ 45*.*4032◦ and *θ*1 ≈ 1*.*26832 rad ≈ 72*.*6693◦

(e) Substitute each of these angles into the first equation in (3), and solve for the corresponding

values of *θ*2.

At first, Robin was surprised that the solutions for *θ*1 and *θ*2 were not unique, but her sketch

in Figure 5*c* quickly made it clear that there will ordinarily be two ways of positioning the links

to put the end effector at a specified point.

**Question 8)**

The equations in (4) will be used in the following way: At a given time *t* , the robot will

report the control angles *θ*1 and *θ*2 of its links to the computer, the computer will use the forward

kinematic equations in (2) to calculate the *x*- and *y*-coordinates of the end effector, and then the

values of *θ*1, *θ*2, *x*, and *y* will be substituted into (4) to produce two equations in the two unknowns

*dθ*1*/dt* and *dθ*2*/dt*. The computer will solve these equations to determine the required rotation

rates for the links.