TABLE 8.2. Inverse kinematics solutions of the Fanuc Arc Mate manipulator

Sol'n No.	θ_1	θ_2	θ_3	θ_4	θ_5	θ_6
1 & 2	90°	90°	0°	180°	−180°	0°
3	75.157°	15.325°	150.851°	15.266°	−103.353°	176.393°
4	90°	16.010°	153.403°	−180°	100.588°	0°

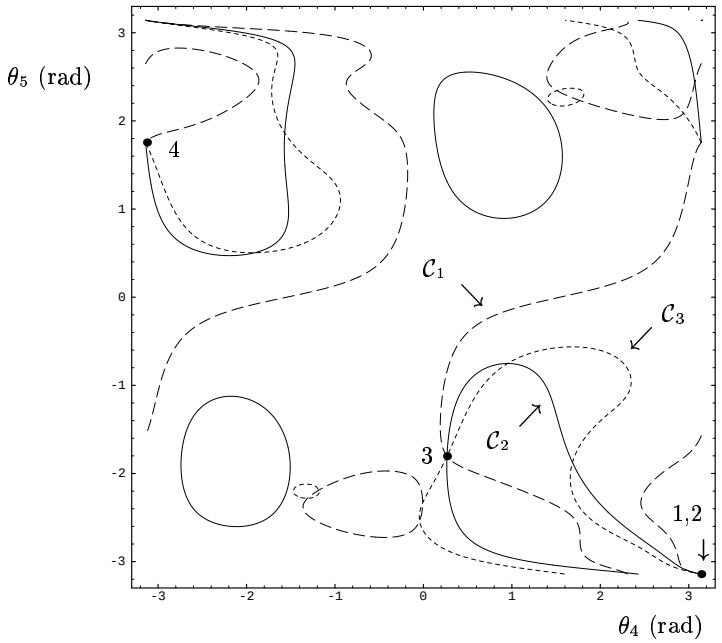

FIGURE 8.3. Contours $\mathcal{C}_1$, $\mathcal{C}_2$, and $\mathcal{C}_3$ for the Fanuc Arc Mate manipulator.

given below:

$$\mathbf{Q} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix} \qquad \mathbf{p} = \begin{bmatrix} 130 \\ 850 \\ 1540 \end{bmatrix}$$

in which $\mathbf{p}$ *is given in mm and the DH parameters of the manipulator are given in Table 4.2.*

Solution: The solutions are obtained from the intersections of the three contours $\mathcal{C}_1$, $\mathcal{C}_2$, and $\mathcal{C}_3$, as shown in Fig. 8.3.

Four intersection points can be detected in this figure, which are numbered 1, 2, 3, and 4. Moreover, at points 1 and 2 the three contours are tangent to each other. Tangency indicates the existence of a multiple root at that point, and hence, a *singularity*, as discussed in Subsection 4.5.2 in connection with decoupled manipulators. The numerical values of the joint angles of the four solutions are given in Table 8.2.

Example 8.2.2 *In this example, we discuss the IKP of DIESTRO, the* isotropic *six-axis orthogonal manipulator shown in Fig. 4.31 (Williams,*