then the velocity is

$$s'(\theta) = \sum_{j=1}^{n-m-1} \frac{c_j - c_{j-1}}{d_j - d_{j-1}} B_{m-1,j}(\theta) \tag{5.53}$$

This is how most computer programs calculate velocity, acceleration, jerk, ping, etc., for a B-spline displacement.

All of these properties of the control polygon suggest a procedure that can be used to help design follower motion. The procedure is to:

5

1 Make a rough sketch of the desired curve.

2 Using the tentative knot sequence, locate the knot averages.

3 Try to draw a control polygon using the knot averages that mimics the curve. If you cannot, then your knot sequence is unsatisfactory and you should change it. If you can, then you will likely find a suitable B-spline displacement for the problem. There is no absolute guarantee though, especially if interior derivatives are involved in the boundary conditions.

Fortunately with software such as program DYNACAM, one can interactively move the knots and the computer will draw not merely the control polygon, but the actual B-spline displacement that results from the knot sequence and the boundary conditions. Some examples will illustrate this.

EXAMPLE 5-5

Designing an 8-Boundary-Condition B-spline Function for an Asymmetrical Rise-Fall Single-Dwell Case.

Problem: Using the CEP specification from Example 4-4:

rise-fall	rise 1 in (25.4 mm) in 45° and fall 1 in (25.4 mm) in 135° in 180°
dwell	at zero displacement for 180° (low dwell)
cam ω	15 rad/sec (143.24 rpm)

Solution:

1 The minimum number of BCs for this problem is eight. The dwell on either side of the combined rise-fall segment has zero values of *S, V, A,* and *J*. The fundamental law of cam design requires that we match these zero values, through the acceleration function, at each end of the rise-fall segment. These then account for six BCs; $S = V = A = 0$ at each end of the rise-fall segment.

2 We also must specify a value of displacement at the 1-in peak of the rise which occurs at $\theta = 45°$ and specify the velocity to be zero at that point. These are the seventh and eighth BCs. See Figure 5-20 for the set of boundary conditions for this problem. Note that these BCs are identical to those used in step 6 of Example 4-4, which failed in its attempt to put an acceptable single polynomial function through these points.

3 If we use a fifth-order spline, then we will need 5 + 8 = 13 knots. Ten of them will be end knots, leaving us to choose 3 interior knots. Figure 5-21 shows a rough sketch of what we anticipate and a control polygon that should more or less obtain it. The "knot symbols"