Dwell	for 90°
Speed	180 rpm (3 Hz)
m_{eff}	0.03 bl (11.6 lb)
k_1	50 lb/in at the end effector
k_2	1 000 lb/in for the linkage
Preload	30 lb
ζ_1, ζ_2	0.05, 0.10, respectively

Assumptions: The joint closure spring is at the cam follower, so a SDOF, one-mass model as shown in Figure 10-8b (p. 276) will be used.

Solution:

1 Figure 10-30 shows the difference between displacement, velocity, and acceleration of the follower for a non-polydyne and a polydyne cam with the same motion program, as calculated in program Dynacam. The motion is RDFD, 90-90-90-90 deg, with 1-in rise and fall at 180 rpm. A Peisekah 11th-degree polynomial is used on both rise and fall. The one-mass industrial cam dynamic model of Figure 10-8 is used with a return spring rate of 50 lb/in and a 30-lb preload. The stiffness of the follower train is 1 000 lb/in and the mass of the follower is 0.03 bl. Damping is between 0.05 and 0.1 of critical.

2 Figure 10-30a shows the non-polydyne solution. Note the significant error in the follower's velocity and acceleration functions. The displacement overshoots by 0.034 in and undershoots by 0.036 in.* The peak follower acceleration is 1 446 in/sec^2 in the 2nd cycle.*

3 Figure 10-30b shows the same data for a polydyne cam using the same Peisekah 11th-degree polynomial and equations 10.21. The velocity and acceleration functions now look like the theoretical functions, with the peak acceleration reduced to 1 120 in/sec^2.* This is 1.5% lower than the designed kinematic acceleration of 1 138 in/sec^2, within the numerical error expected from the simulation. The displacement error is reduced to +0.005 / –0.004 in. Some of this error is due to the absence of a damping term in equations 10.21.

4 Figure 10-31 shows the kinetostatic and dynamic follower force functions superposed for each of the cases, non-polydyne and polydyne. In Figure 10-31a, the dynamic force is grossly different than the kinetostatic force and is close to zero at one point, indicating incipient jump. The polydyne cam contour has reduced the dynamic force significantly in Figure 10-31b. It is now close to the kinetostatic ideal and would be exactly equal if the damping were included in the polydyne equations and the dynamic model was exact.

10.9 SPLINEDYNE CAM FUNCTIONS

In Chapters 5 and 6 we showed how spline functions, particularly B-splines, can provide superior solutions to motion control problems than polynomials can in some cases. It would seem logical that splines then might offer some advantages to polydyne-type cam designs as well. The polydyne approach requires a function for the follower motion that has continuity through the 4th derivative of displacement, or ping. This is easy to accomplish with B-splines since they have the ability to control the unwanted excursions that are typical of high-order polynomials. Moreover, manipulation of knot locations can reduce peak velocity and acceleration. Thus, we introduce the concept of a splinedyne cam, a combination of spline functions for the motion and the dynamics of the follower train.

* In these numerical solutions, program DYNACAM calculates two cycles of rotation and then throws away the data from the first cycle and keeps the second cycle data because the Runge-Kutta algorithm is still converging during the first cycle. This accounts for apparent discrepancies in the values quoted in these examples as compared to the numbers shown as max and min in the referenced figures. If you run the example data in DYNACAM and plot the results, you should see comparable numbers to those quoted as the plots show the second cycle data. There still may be small differences in the results of subsequent computations as the numerical methods used are subject to numerical noise.