# ME 222: Kinematics of Machines and Mechanisms

## [L32] Cam Design 4



## Effect of Asymmetry

Designing a Polynomial for an Asymmetrical Rise-Fall Single-Dwell Case.

***Problem:*** Redefine the specification from Example 8-8 as:

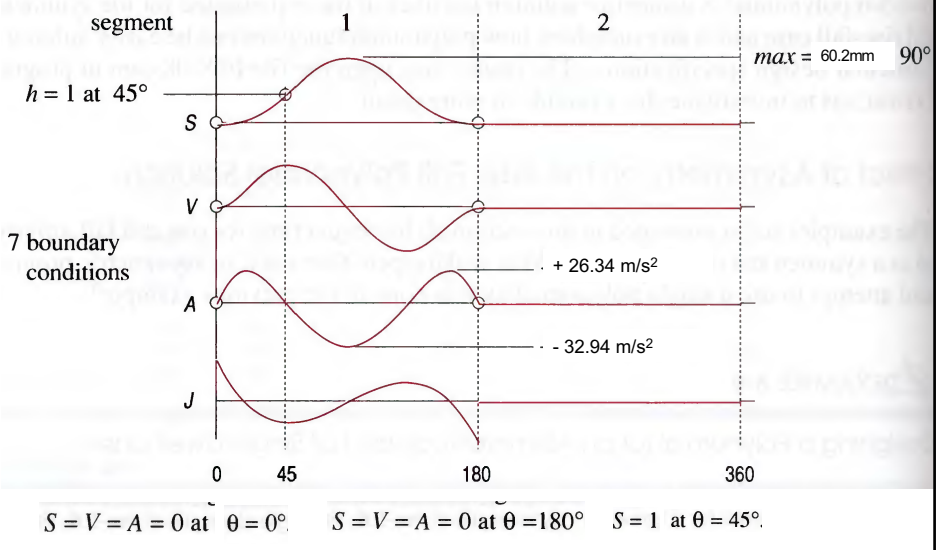
| | |
|---|---|
| **rise-fall** | rise 1 in (25.4 mm) in 45° and fall 1 in (25.4 mm) in 135° for a total of 180° |
| **dwell** | at zero displacement for 180° (low dwell) |
| **cam ω** | 15 rad/sec |

six BCs; $S = V = A = 0$ at each end of the rise-fall segment.

value of displacement at the 25.4 peak of the rise

$$s = h\left[151.704\left(\frac{\theta}{\beta}\right)^3 - 455.111\left(\frac{\theta}{\beta}\right)^4 + 455.111\left(\frac{\theta}{\beta}\right)^5 - 151.704\left(\frac{\theta}{\beta}\right)^6\right]$$

# Solution Acceptable ?




$S = V = A = 0$ at $\theta = 0°$. $S = V = A = 0$ at $\theta = 180°$ $S = 1$ at $\theta = 45°$.

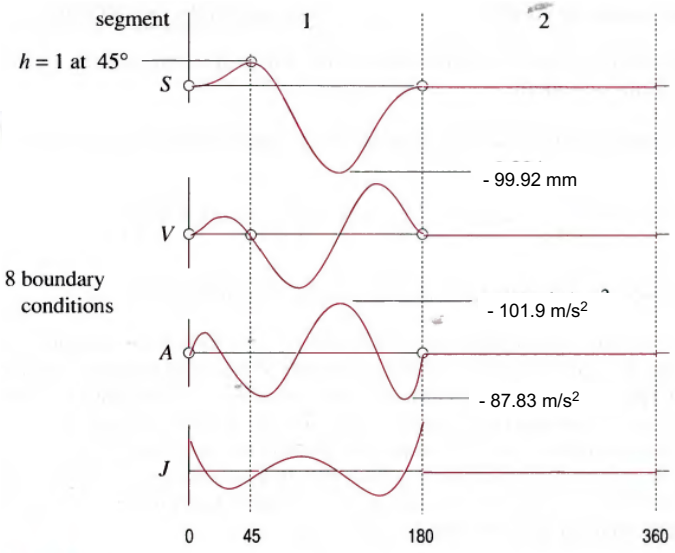


# An alternative: 7th order polynomial

$S = V = A = 0$ at $\theta = 0°$.

$S = V = A = 0$ at $\theta = 180°$

$S = 1, V = 0$ at $\theta = 45°$.



## Designing a Three-Segment Polynomial for an Asymmetrical Rise-Fall Single-Dwell Case Using Minimum Boundary Conditions.

**Problem:** Redefine the specification from Example 8-9 (p. 417) as:

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

5 BCs; $S = V = A = 0$ at the start of the rise

$S = 1$ and $V = 0$ at the end of the rise.

$$s = h\left[4\left(\frac{\theta}{\beta}\right)^3 - 3\left(\frac{\theta}{\beta}\right)^4\right]$$

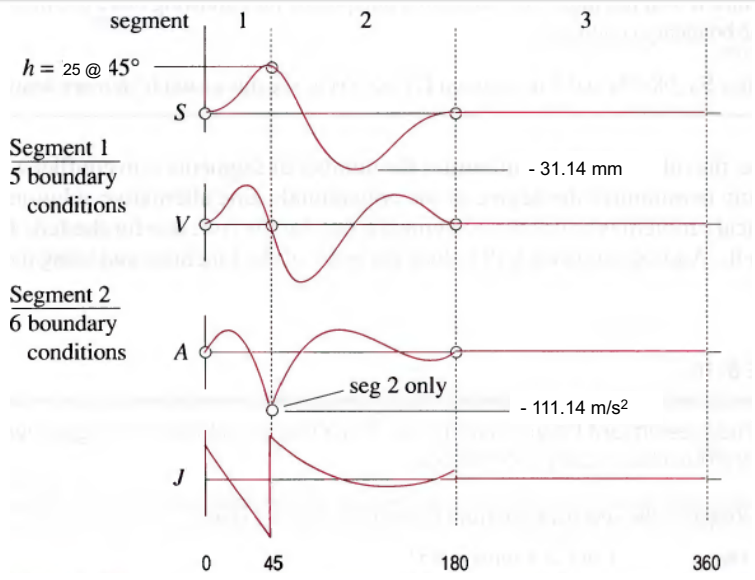
6 BCs for the fall are then: $S = 1, V = 0, A =$ **- 111.14 m/s²**

$S = V = A = 0$ at the end of the fall

$$s = h\left[1 - 54\left(\frac{\theta}{\beta}\right)^2 + 152\left(\frac{\theta}{\beta}\right)^3 - 147\left(\frac{\theta}{\beta}\right)^4 + 48\left(\frac{\theta}{\beta}\right)^5\right]$$



## Is it still Acceptable ?



# A trick

- The trick in this case (and in general) is to first calculate the segment with the smaller acceleration (here the second segment) because of its larger duration angle β. Then use its smaller

$S = 1$ and $V = 0$ at the start of the fall and $S = V = A = 0$ at the end of the fall

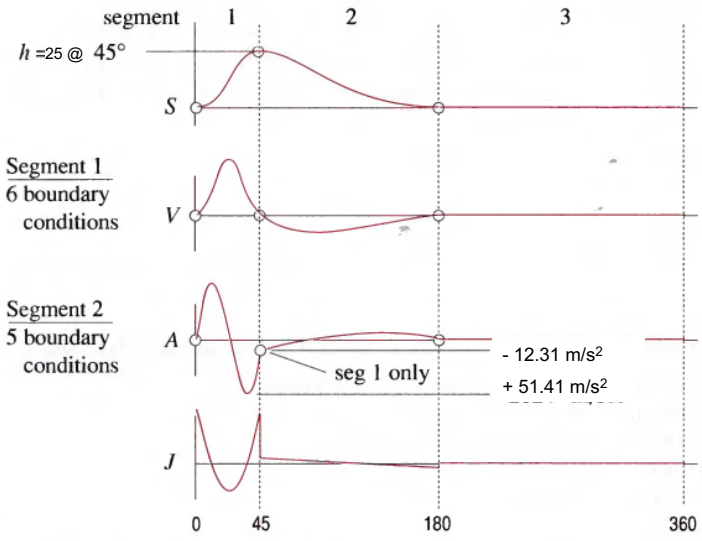
$$s = h\left[1 - 6\left(\frac{\theta}{\beta}\right)^2 + 8\left(\frac{\theta}{\beta}\right)^3 - 3\left(\frac{\theta}{\beta}\right)^4\right]$$

$S = V = A = 0$ at the start of the rise to match the dwells,
and $S = 1, V = 0, A =$ - 12.3 at the end of the rise

$$s = h\left[9.333\left(\frac{\theta}{\beta}\right)^3 - 13.667\left(\frac{\theta}{\beta}\right)^4 + 5.333\left(\frac{\theta}{\beta}\right)^5\right]$$



# Solution



# Critical Path Motion

- Production Machinery
  - Intermittent motion
  - Continuous Motion
- Requirement of **Constant Velocity Motion**

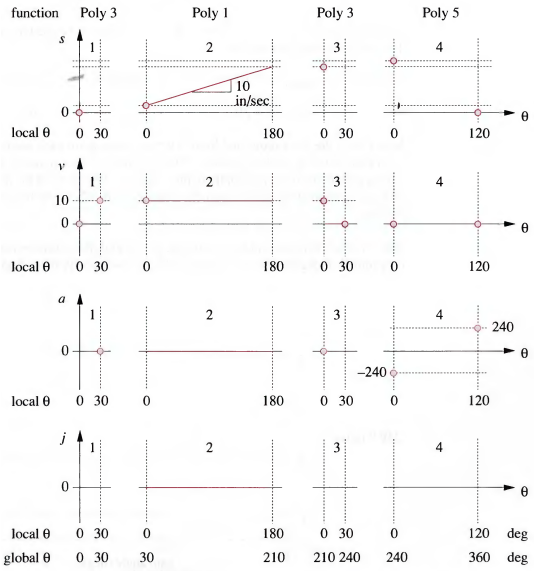


# Polynomials for Critical Path Motion

***Problem:*** Consider the following statement of a critical path motion (CPM) problem:

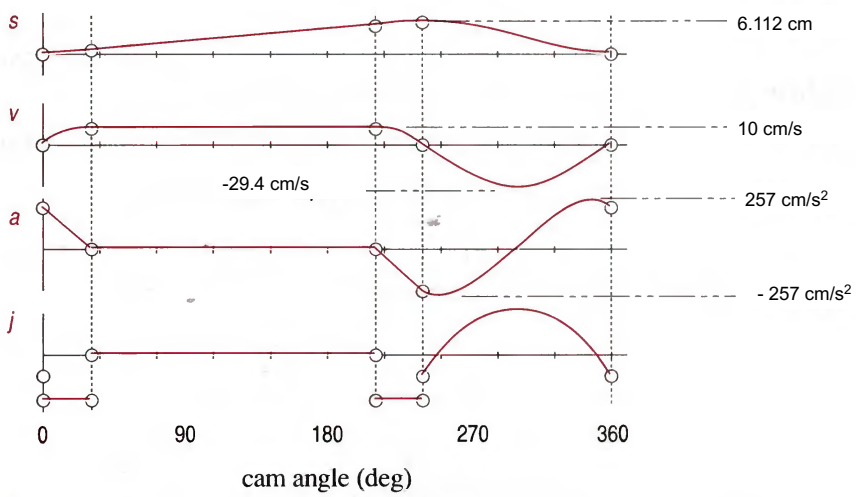
| | |
|---|---|
| **Accelerate** | the follower from zero to 10 cm/s |
| **Maintain** | a constant velocity of 10 cm/s for 0.5 sec |
| **Decelerate** | the follower to zero velocity |
| **Return** | the follower to start position |
| **Cycle time** | exactly 1 sec |

# Boundary conditions






# Polynomials for Critical Path Motion



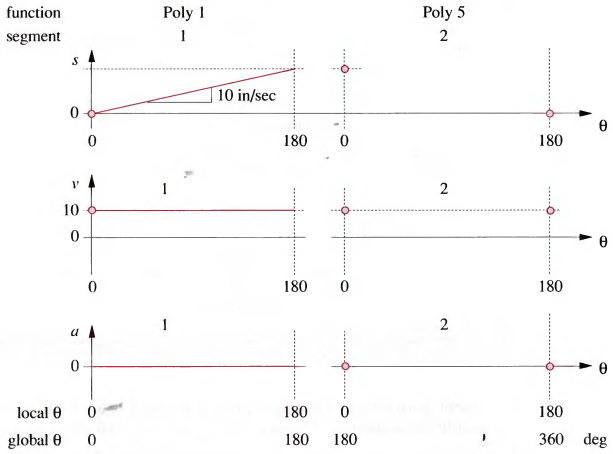
# Polynomials for Critical Path Motion

**Problem:** Redefine the problem statement of Example 8-11 to have only two segments.

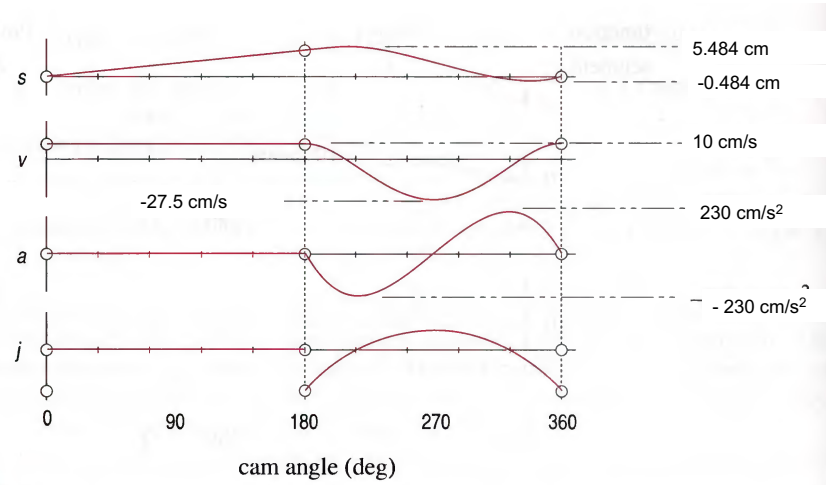
| | |
|---|---|
| **Maintain** | a constant velocity of 10 in/sec for 0.5 sec |
| **Decelerate** | and **accelerate** follower to constant velocity |
| **Cycle time** | exactly 1 sec |



# Boundary conditions



# Polynomials for Critical Path Motion






Thank you

Next Class: Sizing of CAM