Kinematics & Dynamics of Linkages

Lecture 17: Cams

Ali H. Ammouri

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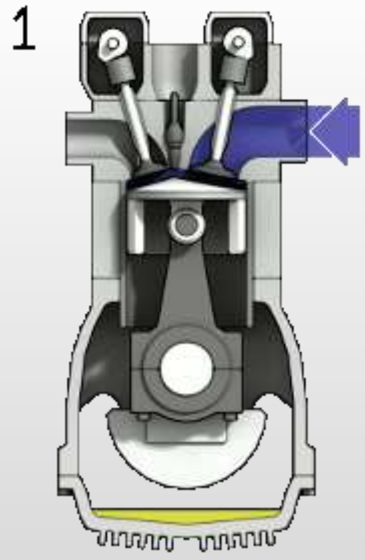
LAU

Introduction and Applications

- Cams can be observed in many designs
- The most common type of cam is the one observed in an internal combustion engine

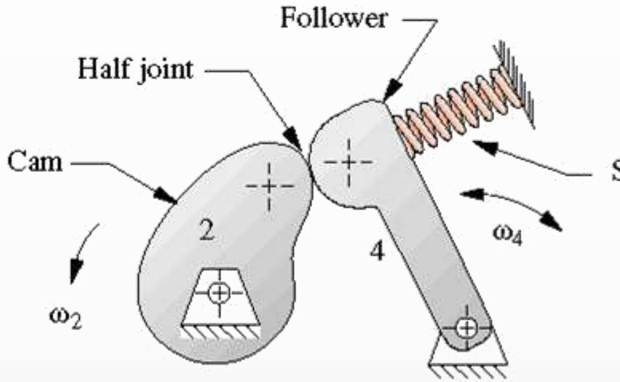


Cam Design

Cams produce a specific output function

- Usually either cyclic or repeating (timed)
- Cam–followers are 4–bars with variable length links

- Cams systems are function generators
    - When a specific output function is desired
    - We create a curved surface on the cam to generate that function in the motion of the follower



Classification of cams

Type of follower motion
- Translating
- Rotating

Type of follower
- Curved or flat
- Rolling or sliding

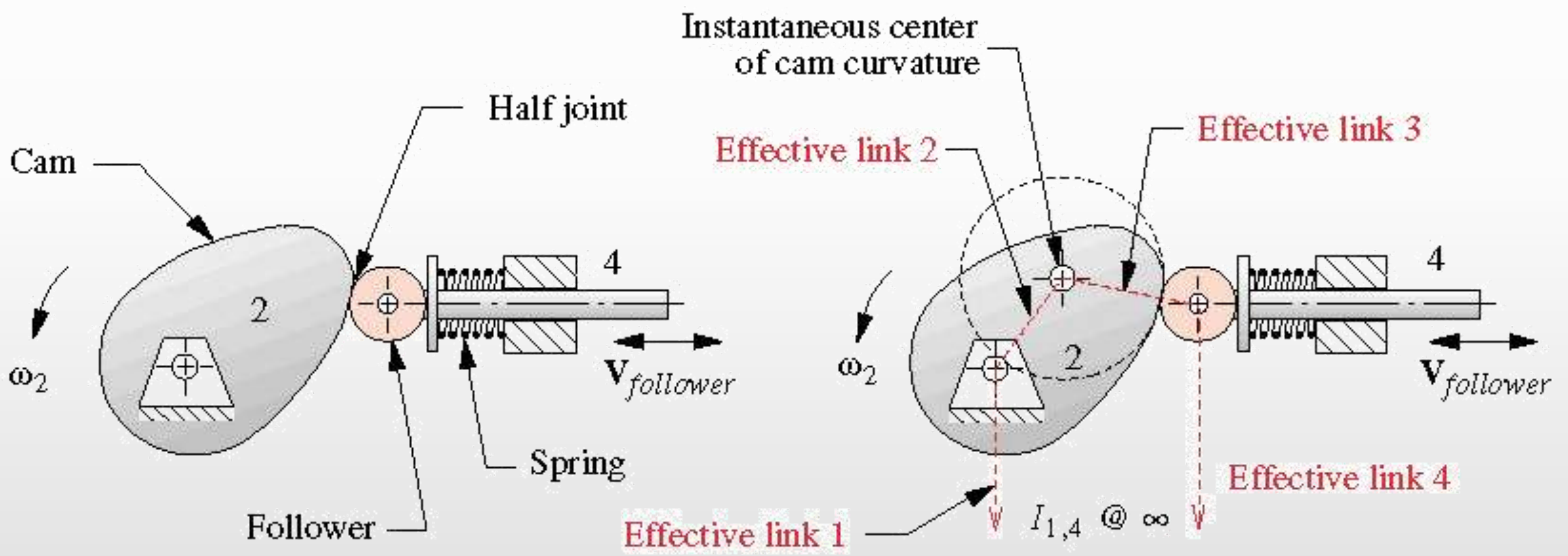
Type of cam
- Radial
- Axial
- Three dimensional

Type of joint closure
- Force-closed
- Form-closed

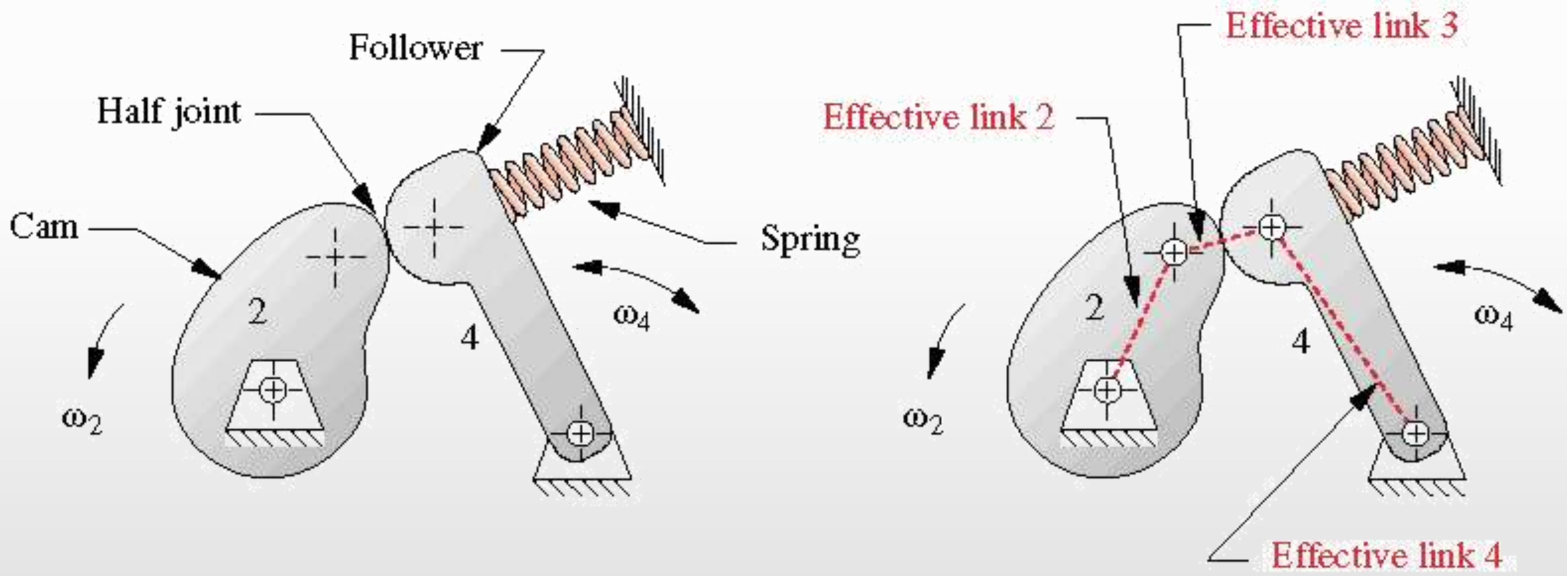
Type of motion constraints
- Critical extreme position
- Critical path motion

Type of motion program
- rise-fall (RF)
- rise-fall-dwell (RFD)
- rise-dwell-fall-dwell (RDFD)

Follower Motion Types: Translating



Follower Motion Types: Rotating



Type of Cam: Radial

- The follower motion is in a radial direction
- Plate cam : radial, open (force-closed) cam

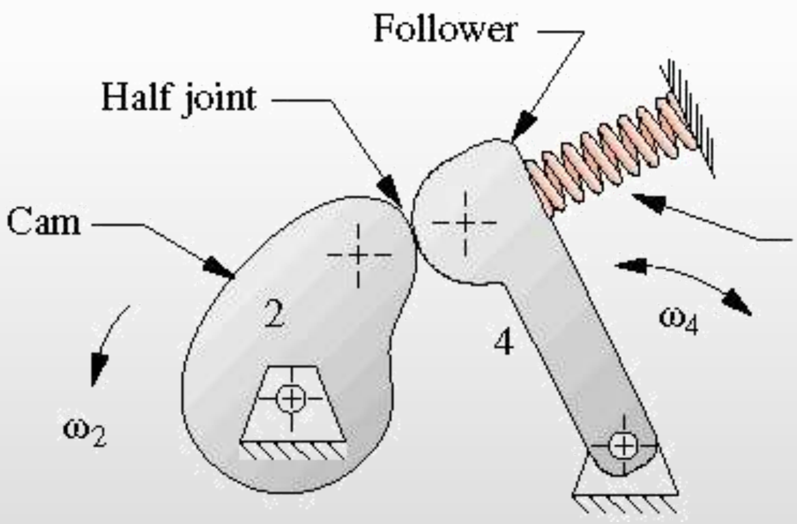
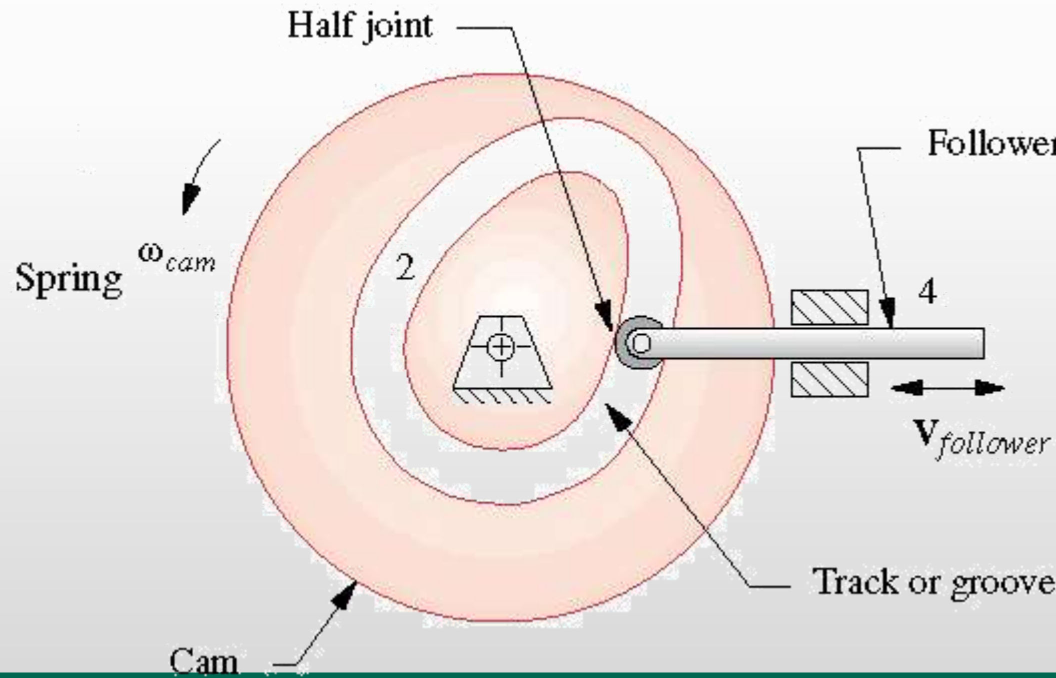
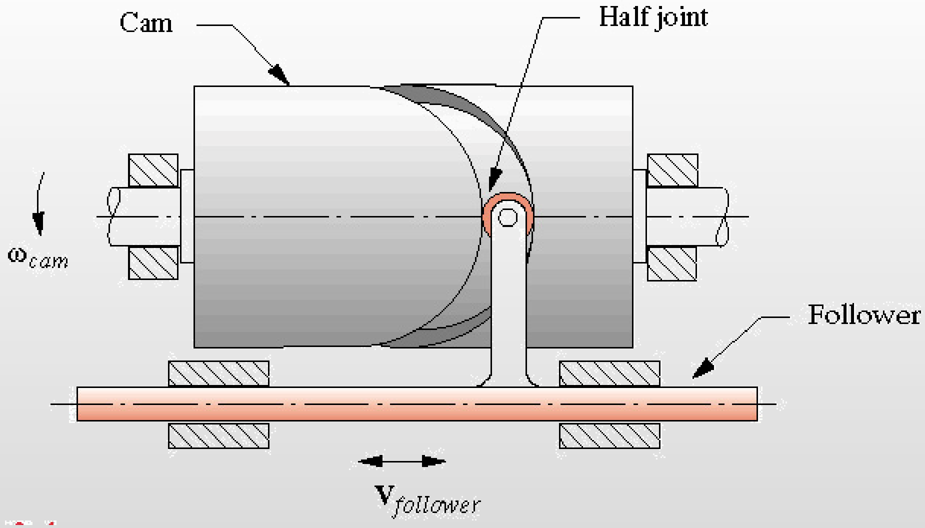


plate cam



Type of Cam: Axial

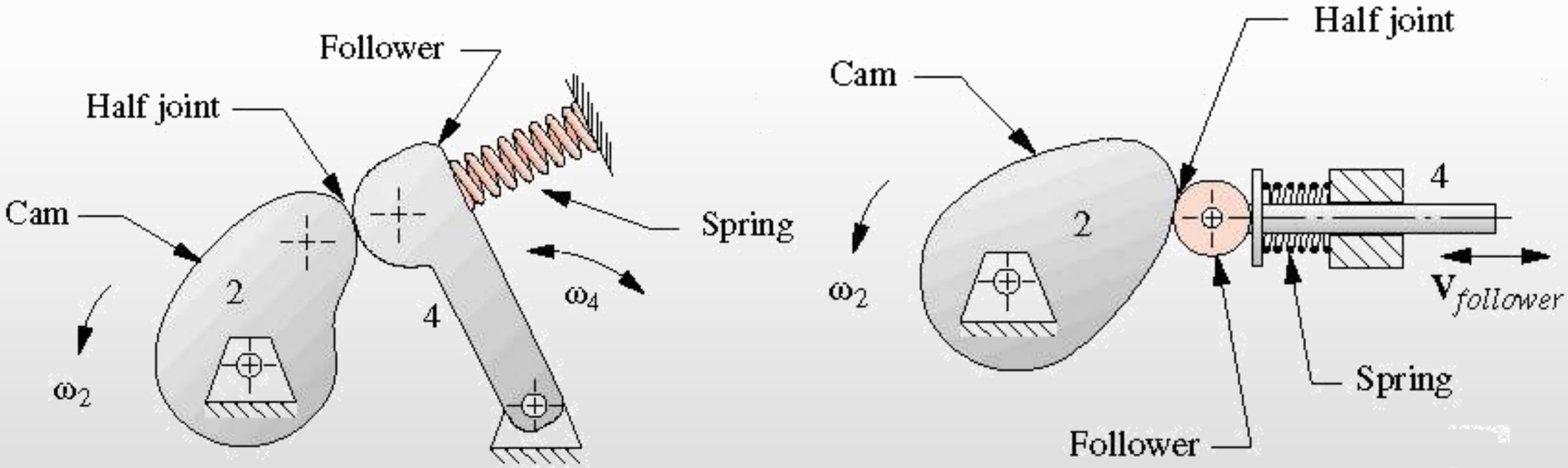
- Follower moves parallel to the axis of cam rotation
- Face cam : axial, force–closed cam
- Cylindrical or barrel : axial, form–closed cam



Cylindrical or barrel cam

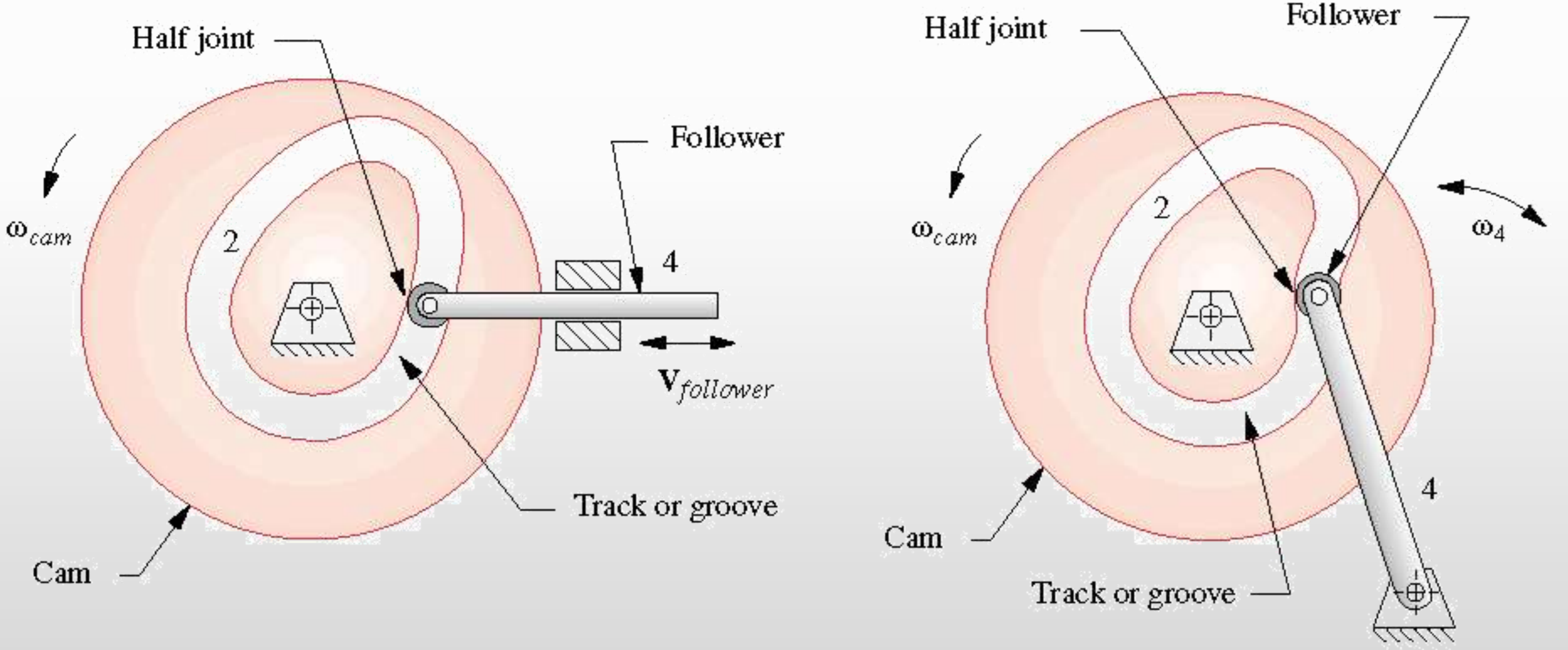
Type of joint closure: Force-Closed

- Requires an external force be applied to the joint in order to
- keep the two links, cam and follower, physically in contact

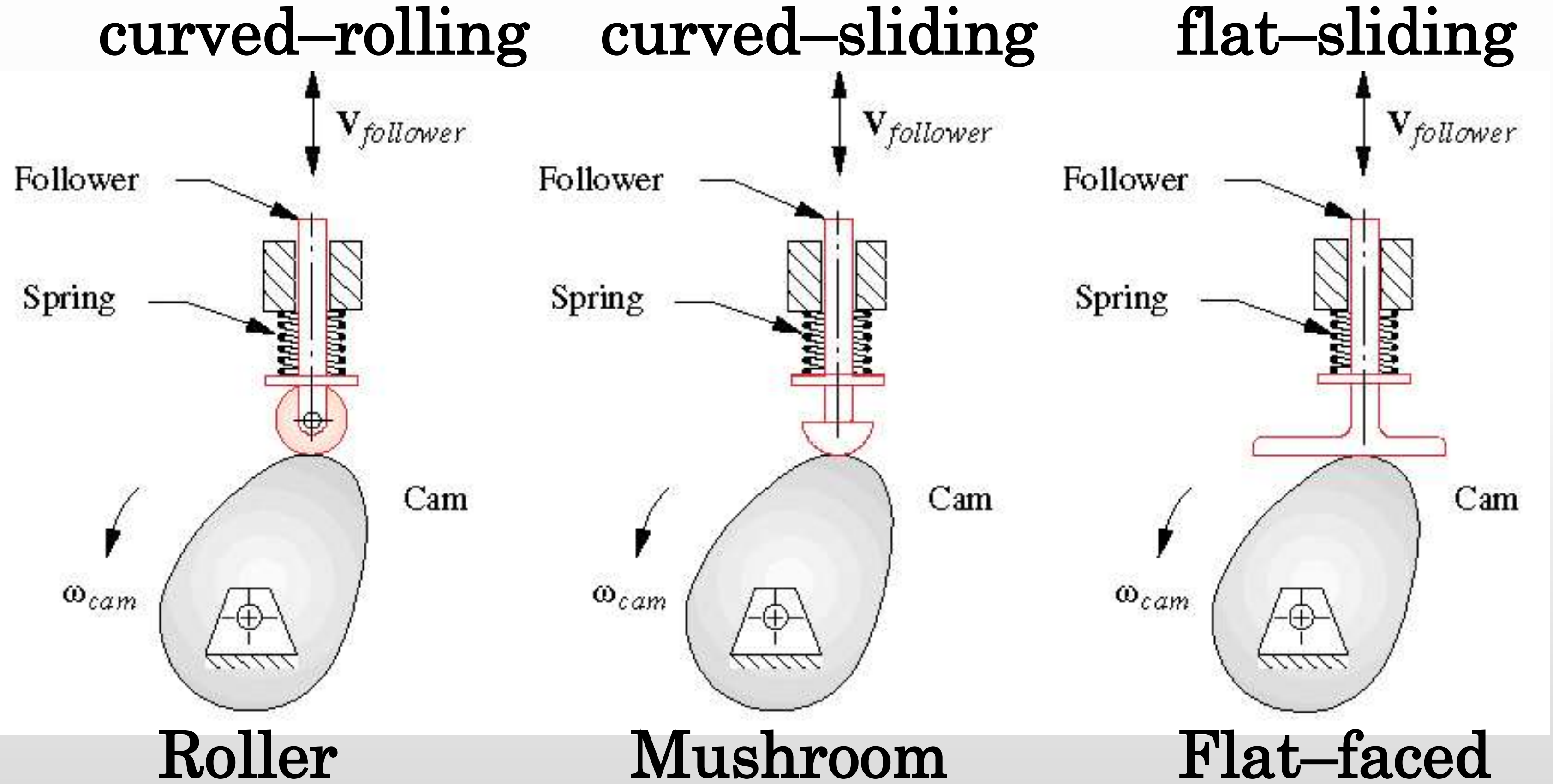


Type of joint closure: Form-Closed

- Closes the joint by geometry



Type of followers



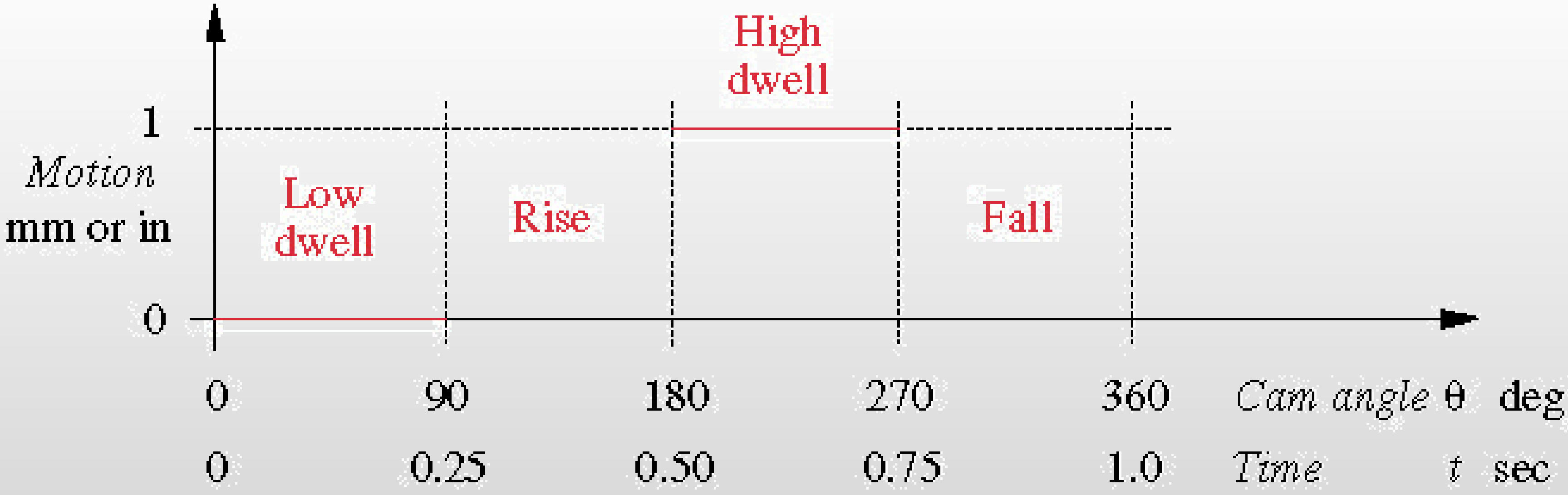
Type of motion constraints

- Critical Extreme Position (CEP) (most of what we will do)
  - Design specifies start & finish positions of the follower
    - Endpoint specifications
  - No constraints on path motion between extreme positions

- Critical Path Motion (CPM)
  - Path motion defined
  - Function generation

Type of motion program
(motion of follower)

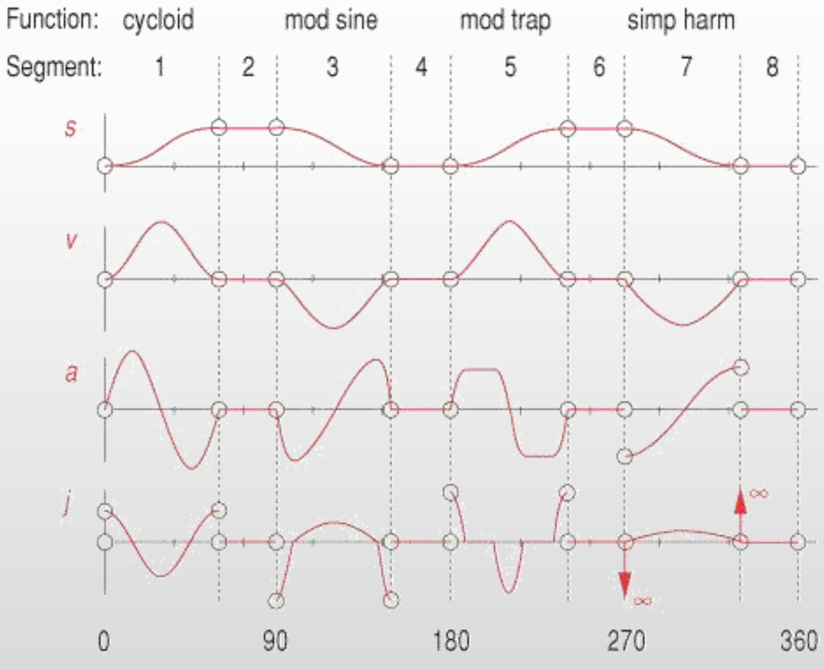
- CEP cases of motion constraint
- Rise–Fall (RF)
- Rise–Fall–Dwell (RFD)
- Rise–Dwell–Fall–Dwell (RDFD) (also called double dwell)
- Dwell = No output motion for a specified period of input motion



SVAJ Diagrams

- S = Displacement of the Follower
- V = Velocity of the Follower
- A = Acceleration of the Follower
- J = Jerk of the Follower

Segment Number	Function Used	Start Angle	End Angle	Delta Angle
1	Cycloid rise	0	60	60
2	Dwell	60	90	30
3	ModSine fall	90	150	60
4	Dwell	150	180	30
5	ModTrap rise	180	240	60
6	Dwell	240	270	30
7	SimpHarm fall	270	330	60
8	Dwell	330	360	30



Define the problem

Cam Design

- Satisfy some specified follower output with a given camshaft angular velocity – ω (normally constant)
- Plot follower displacement as a function of cam angle
- Plot follower velocity – first derivative
- Plot follower acceleration – second derivative
- Plot follower jerk – third derivative

Example

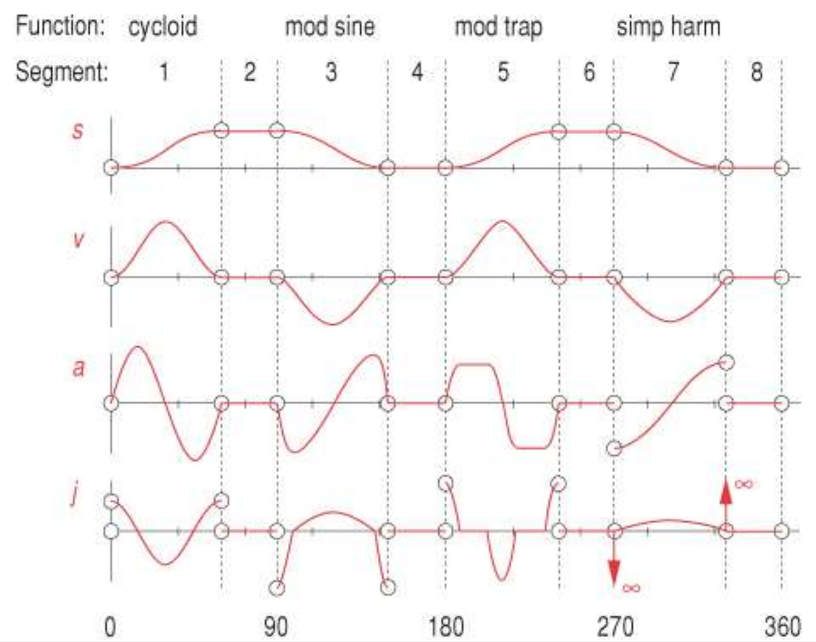
- Cam Design Example – (double dwell cam)
  - Dwell: Zero displacement for 90º (low dwell)
  - Rise: 1" in 90º
  - Dwell: At 1" for 90º (high dwell)
  - Fall: 1" in 90º
  - Cam velocity (ω): 2Π rad/sec = 1 rev/sec
  - Note: Start & stop must be at same position

- Questions
  - Sketch the SVAJ diagrams
  - Draw the cam profile

Fundamental Law of Cam Design

- The cam function must be continuous through the first and second derivatives of displacement across the entire interval The jerk function must be finite across the entire interval

- No discontinuities in displacement, velocity or acceleration functions are allowed (Third order continuity)

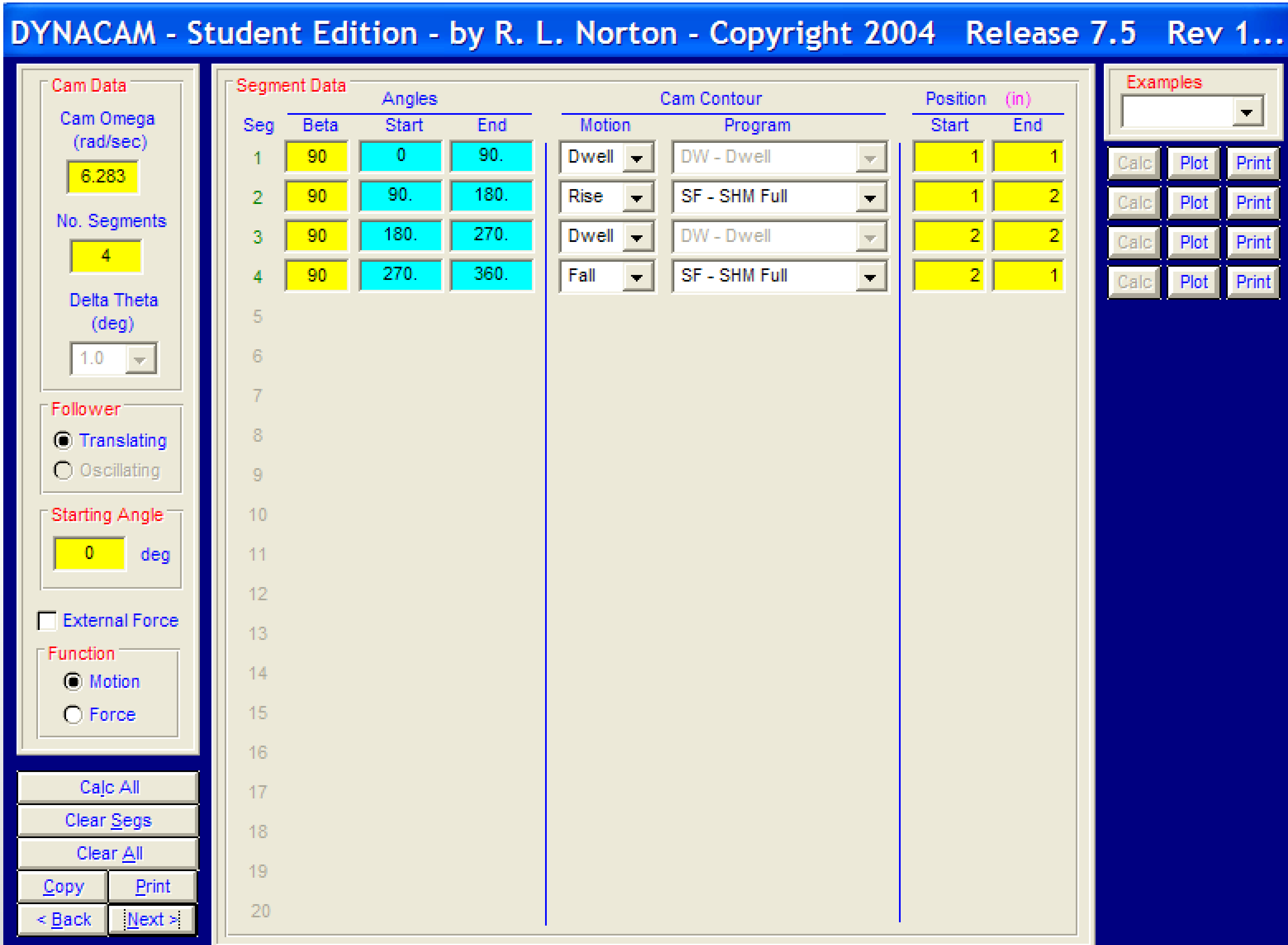


Fundamental Law of Cam Design

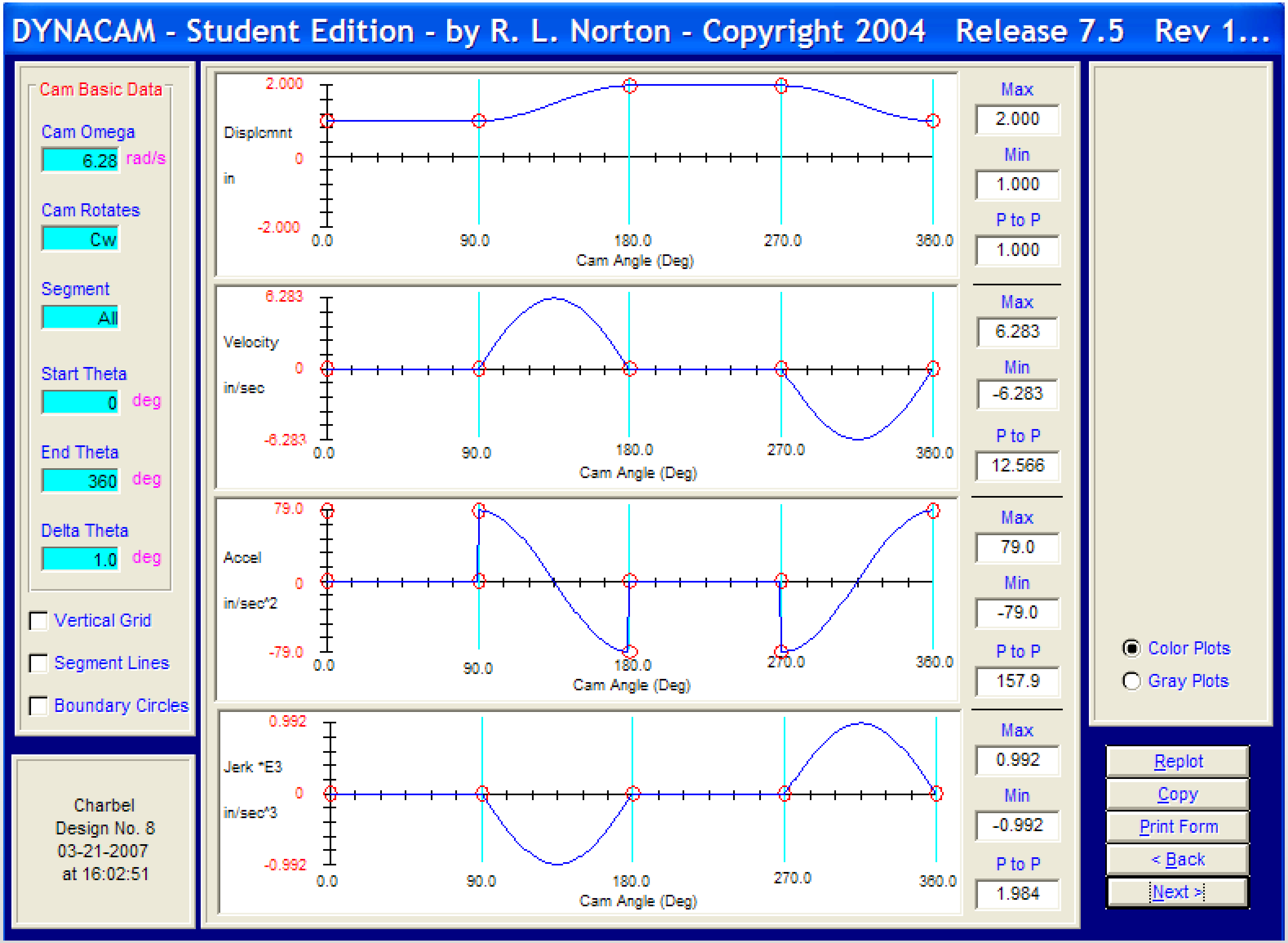
- Polynomials are one of the best choices for cams
  - Each differentiation reduces the function by one degree

- We need to start with a 5th degree polynomial for the
- displacement function of a double dwell cam
  - $S \longrightarrow$ 5th
  - $V \longrightarrow$ 4th
  - $A \longrightarrow$ 3rd (cubic)
  - $J \longrightarrow$ 2nd (parabolic)

Solution : DYNACAM



Solution : DYNACAM



Solution : DYNACAM