JYOTHISHMATHI INSTITUTE OF TECHNOLOGY AND SCIENCE
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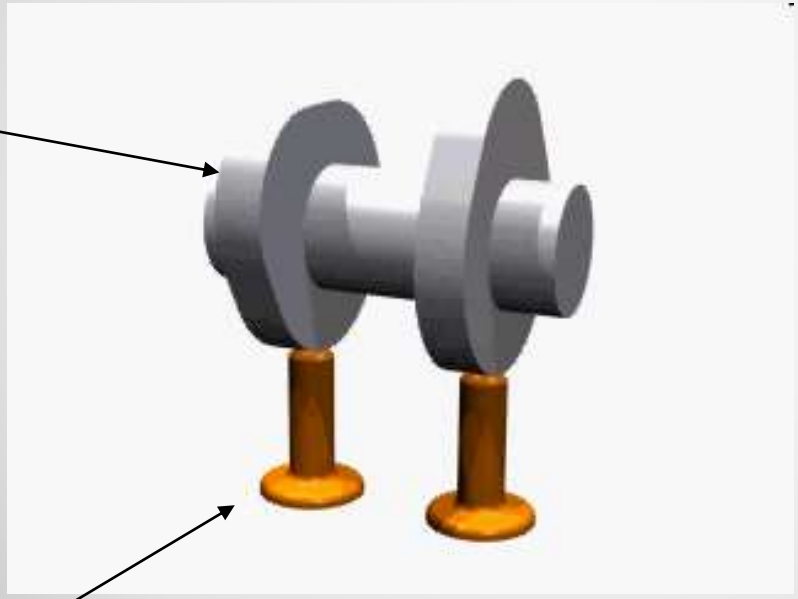
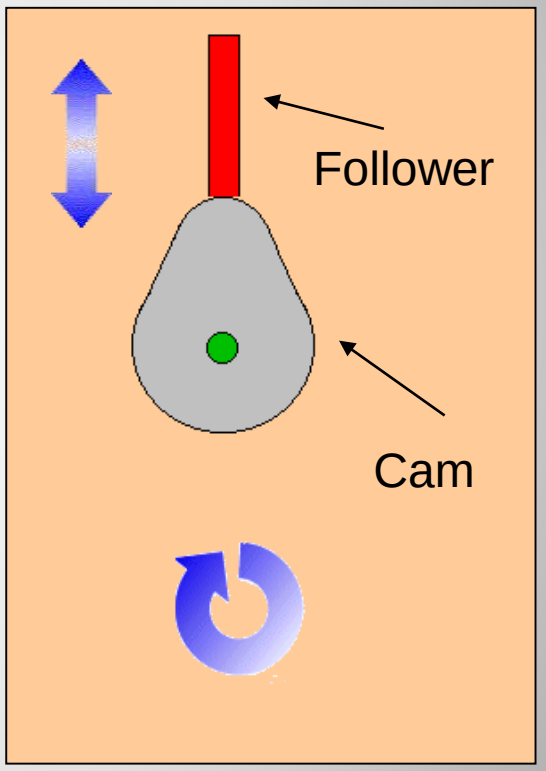
KINEMATICS OF MACHINERY (CAM AND FOLLOWER)

Cam and Follower

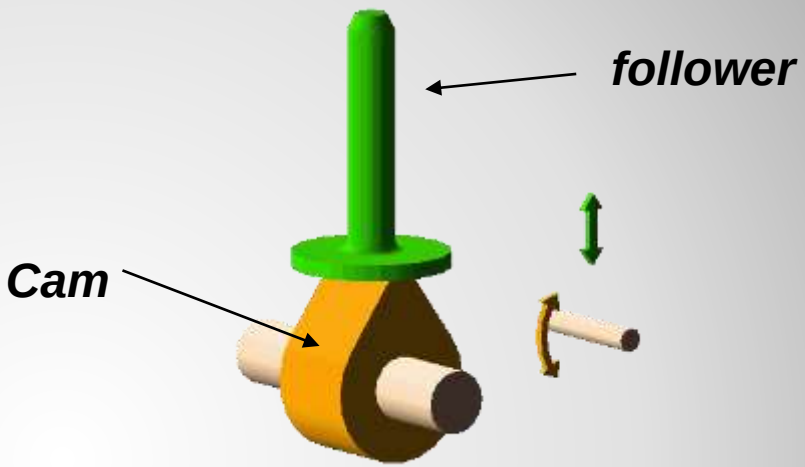
- The ***cam and follower*** is a device which can convert rotary motion (circular motion) into

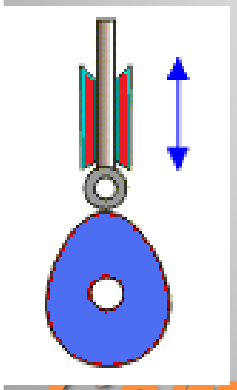
  linear motion (movement in a straight line).

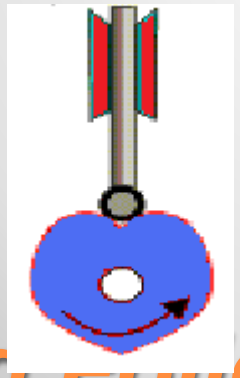


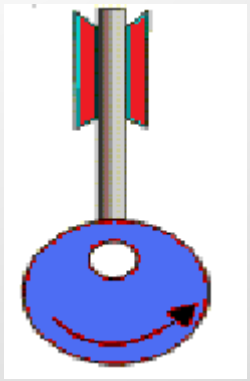


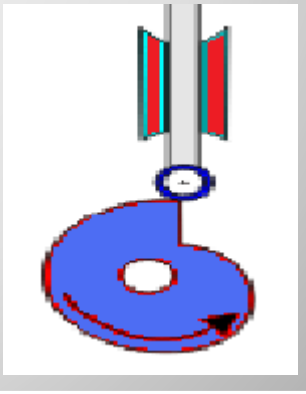
- ***The cam can have various shapes. These are know as cam profiles.***









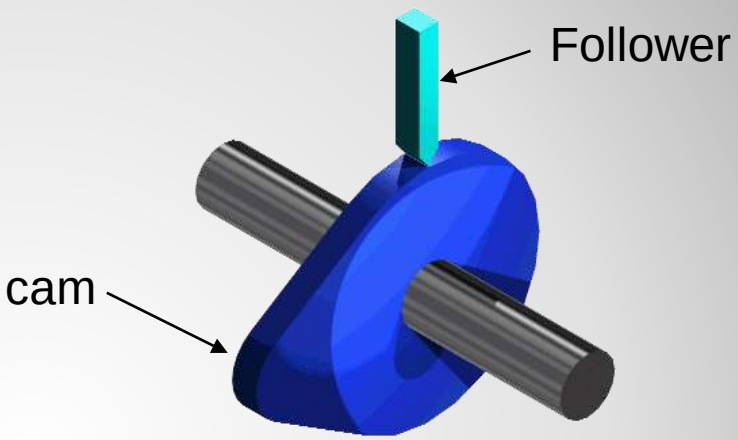


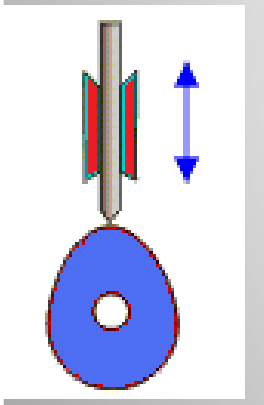
Cam and Follower

Pear ***Heart*** ***Circular*** ***Drop***

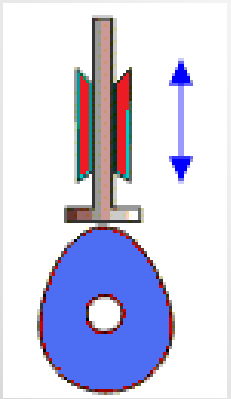
Cam and Follower

- A follower is a component which is designed to move up and down as it follows the edge of the cam.

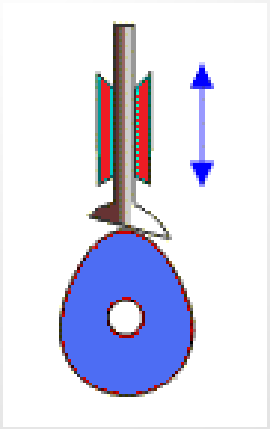




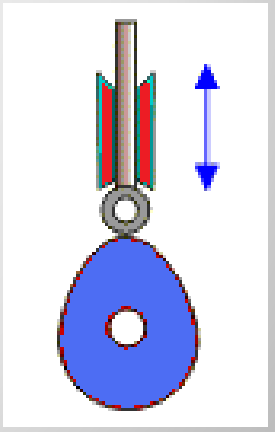
Knife edge Follower



Flat foot follower



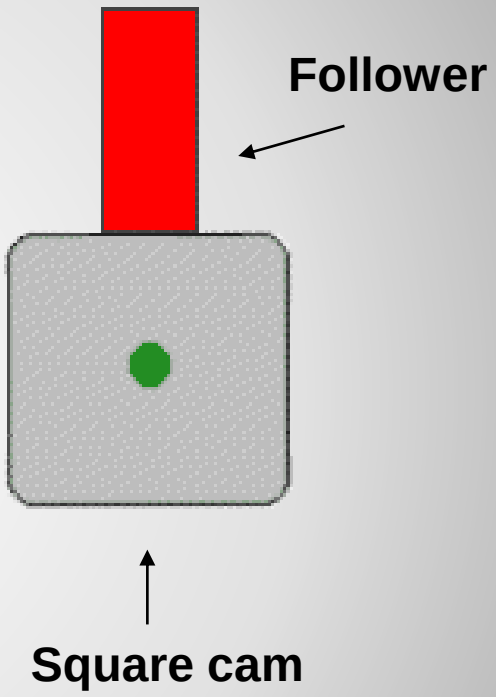
Off set follower

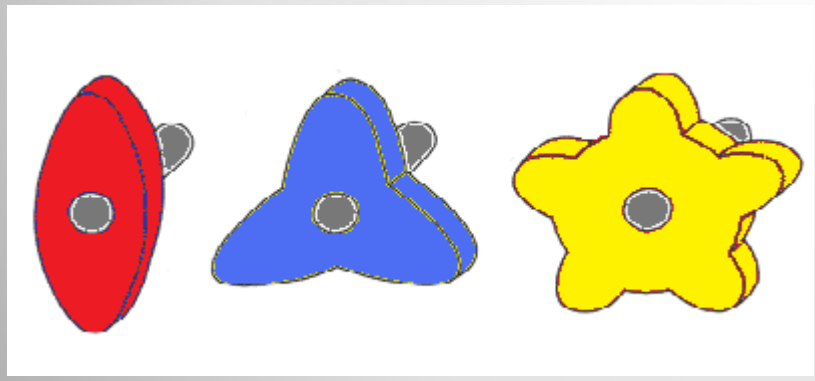


Roller follower

Cam and Follower

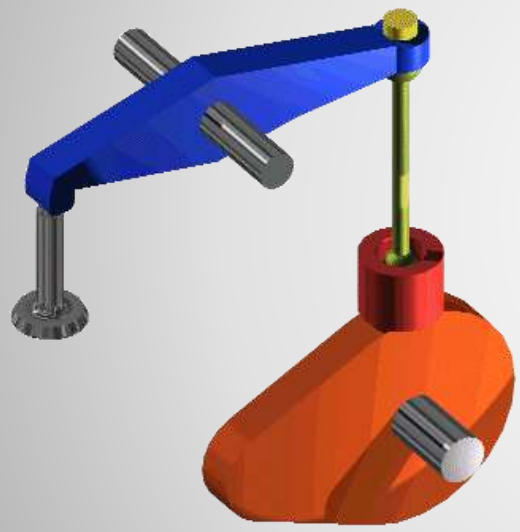
- ***The 'bumps' on a cam are called lobes.***
- ***The square cam illustrated has four lobes, and lifts the follower four times each revolution.***



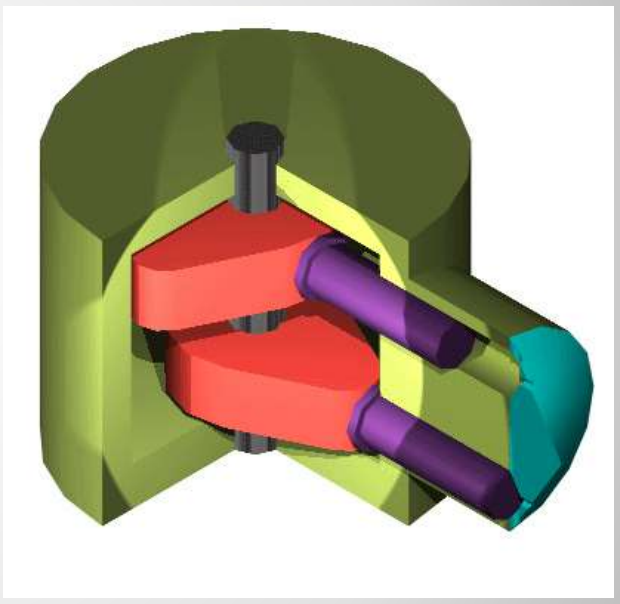


Examples of other rotary cam profiles.

Examples of a Rotary cams in operation.



Control the movement of the engine valves.

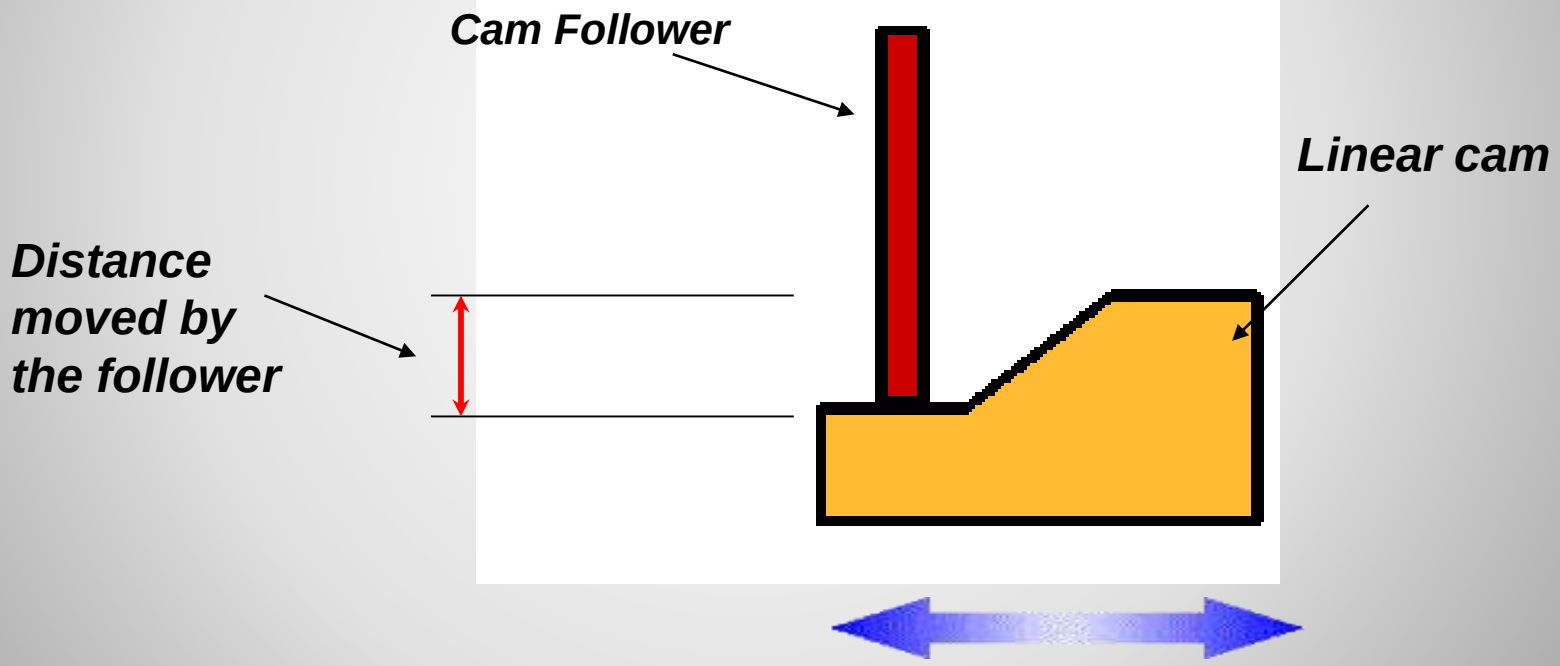


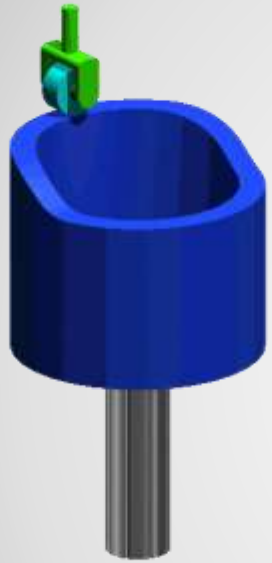
Cams used in a pump.

Cam and Follower

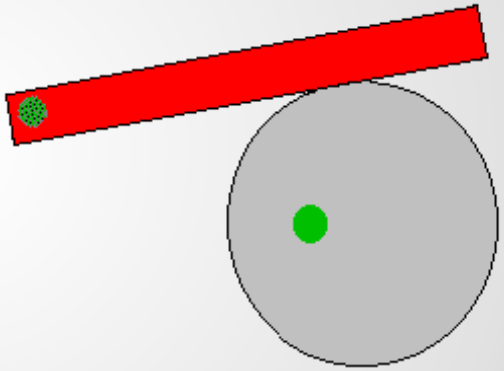
Cam and Follower

- ***The linear cam moves backwards and forwards in a reciprocating motion.***



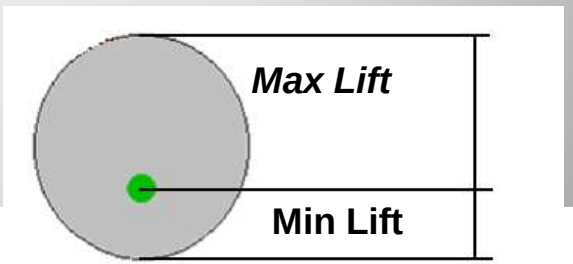


- *Cams can also be cylindrical in shape*
- *Below a cylindrical cam and roller follower*.



- *The cam follower does not have to move up and down - it can be an oscillating lever as shown above.*

Cam rise and Fall



Cam and Follower

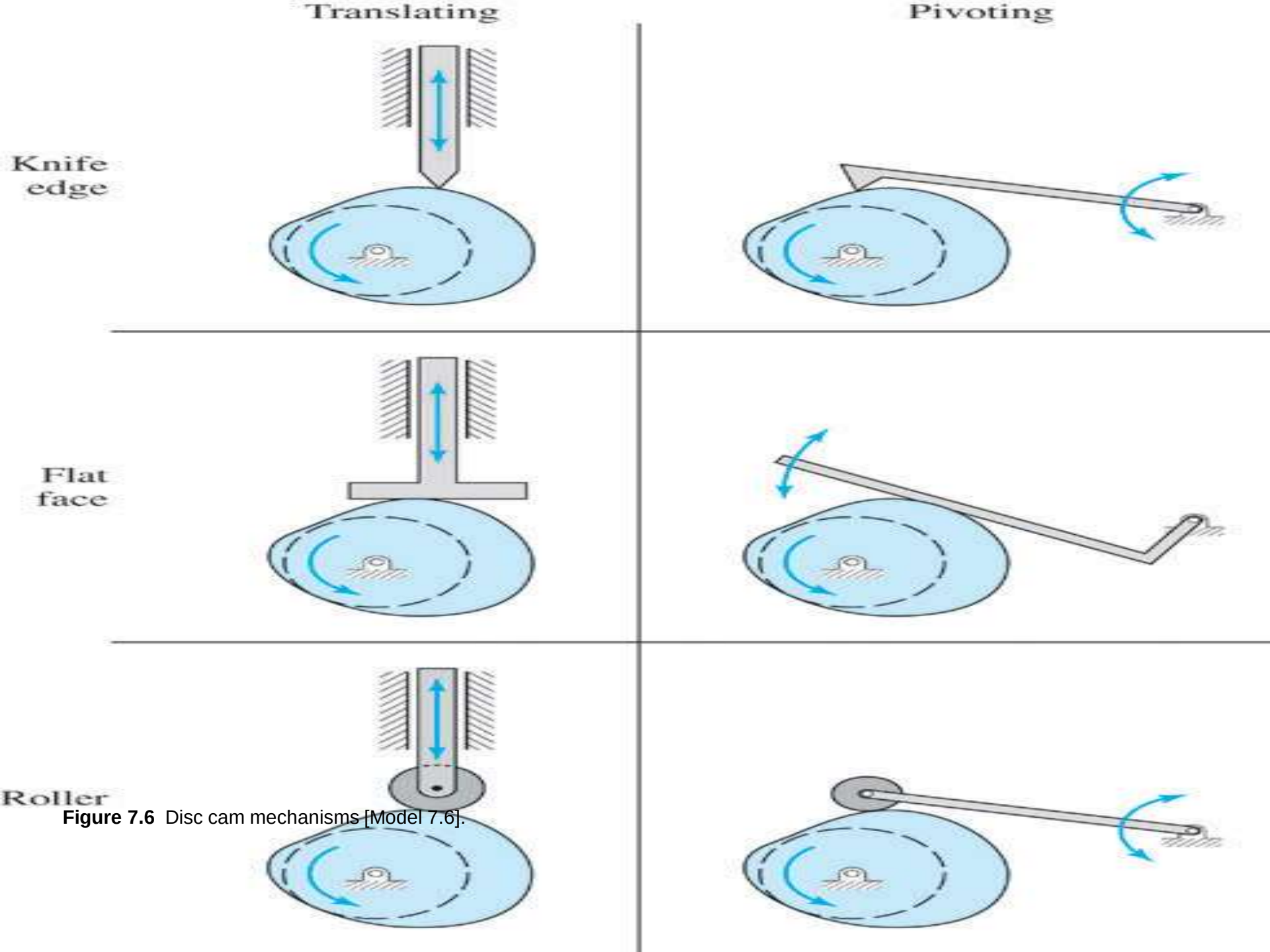


Figure 7.6 Disc cam mechanisms [Model 7.6].

Three types of follower motion

1. Cycloidal : acceleration is zero at the beginning and end of motion
2. Parabolic: constant acceleration
3. Simple harmonic: a sine wave motion

Lift

Displacement: cycloidal, period is four time than acceleration's

Velocity: period is double than acceleration's

Acceleration: sine wave

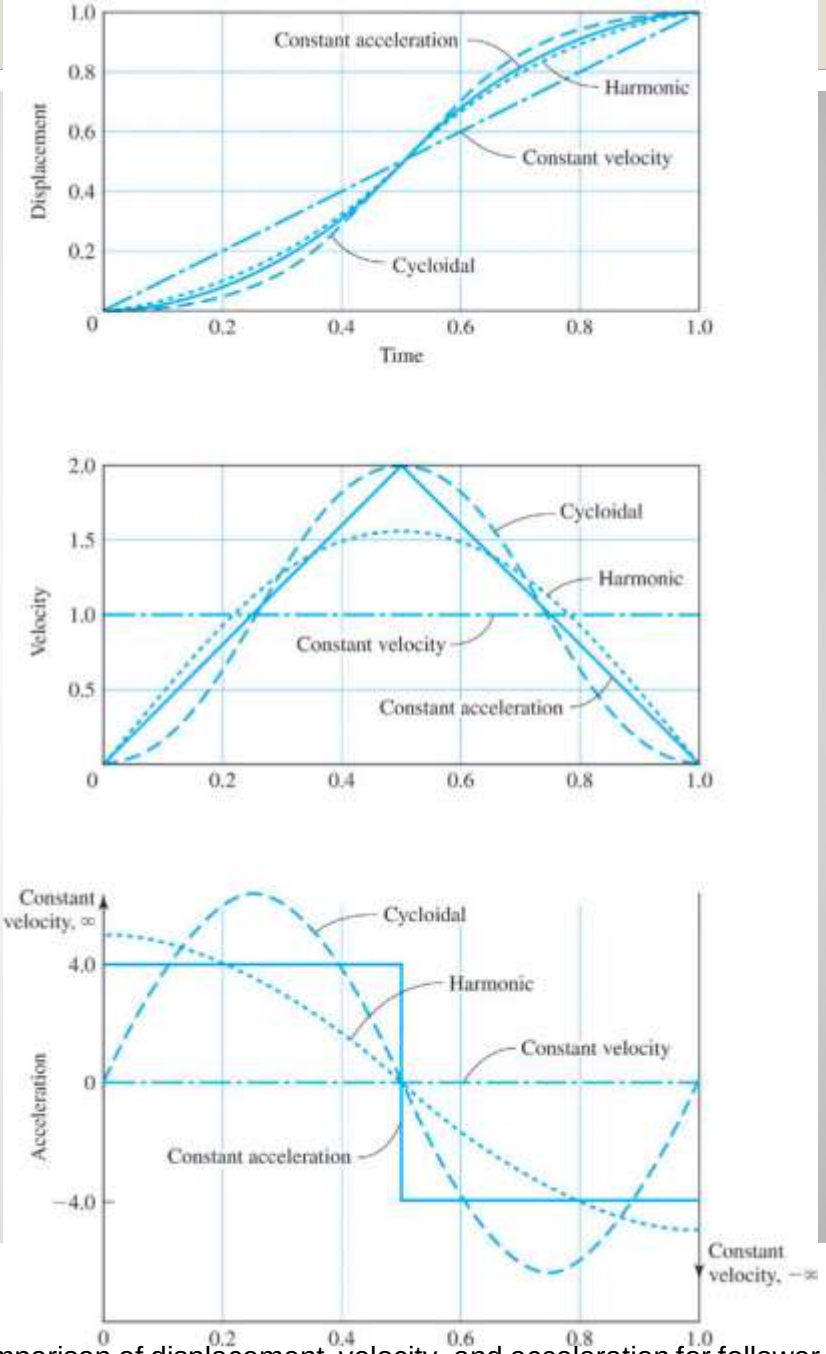
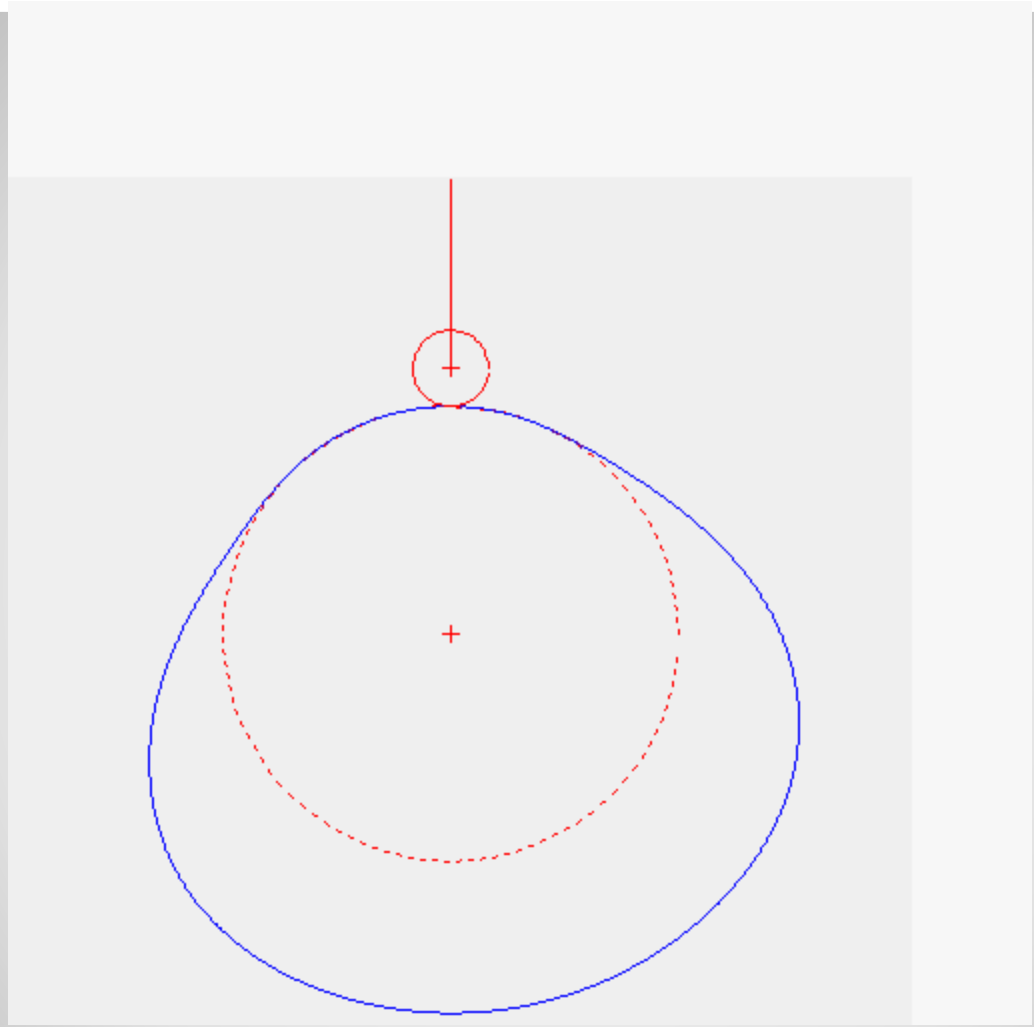
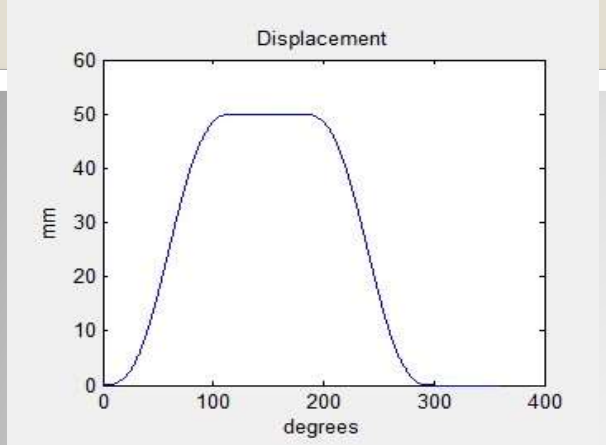
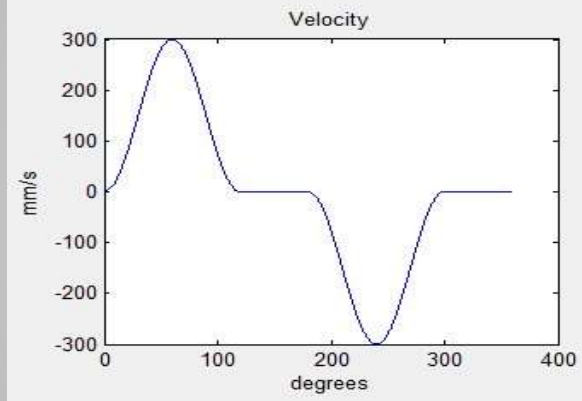


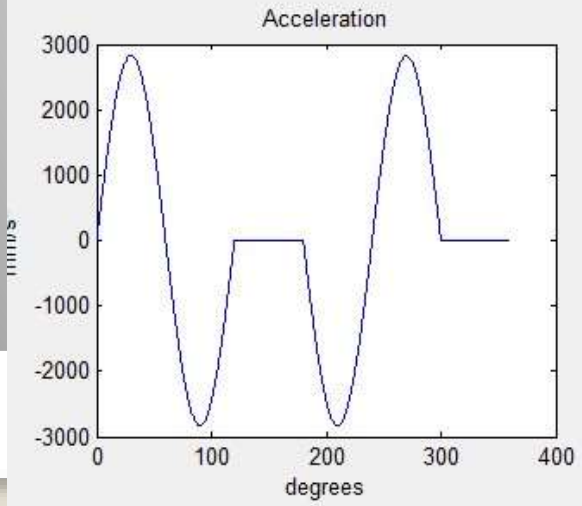
Figure 7.17 Comparison of displacement, velocity, and acceleration for follower motions.



CAM AND FOLLOWER







Function	*Absolute maximum :*	*Maximum at :*
Follower displacement (mm) :	50	120 °
Follower velocity (mm/s):	300	60 °
Follower acceleration (mm/s^2):	2827.43	30 °
Follower jerk (mm/s^3):	53295.9	0 °
Length (mm):	47.7465	60 °

A cam is required such that the follower rises 50 mm in 120° of cam rotation, dwells for 60°, returns in 120°, and dwells for 60°. The cam angular velocity is constant at 60rpm. The requirements are displayed in Fig. P6.17.

(b) Determine the maximum follower velocity (in mm/sec)

Function	*Absolute maximum :*	*Maximum at :*
Follower displacement (mm) :	50	120 °
Follower velocity (mm/s):	300	60 °
Follower acceleration (mm/s^2):	2827.43	30 °
Follower jerk (mm/s^3):	53295.9	0 °
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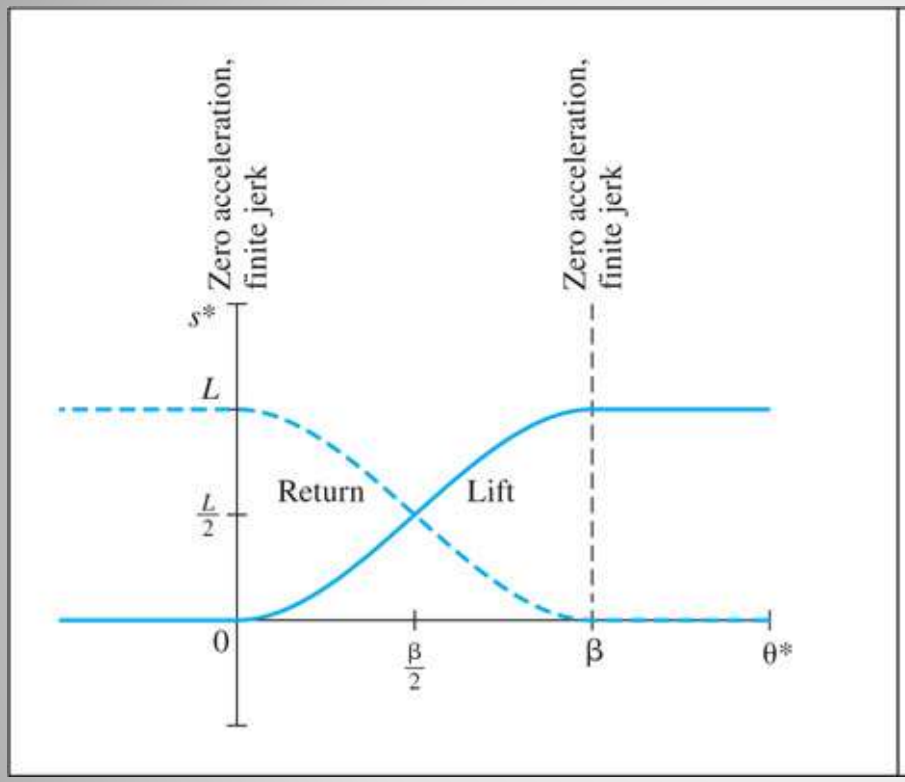


θ* is the angle when the velocity /acceleration is the maximum

Lift

$$s^* = L\left(\frac{\theta^*}{\beta} - \frac{1}{2\pi}\sin\frac{2\pi\theta^*}{\beta}\right) \qquad (0 \le \theta^* \le \beta)$$

Return

$$s^* = L\left(1 - \frac{\theta^*}{\beta} + \frac{1}{2\pi}\sin\frac{2\pi\theta^*}{\beta}\right) \qquad (0 \le \theta^* \le \beta)$$

B is the angle for the lift/return duration
L is the lift distance

Figure 7.16 Cycloidal motion.

- Lift

$$s^* = L\left(\frac{\theta^*}{\beta} - \frac{1}{2\pi}\sin\frac{2\pi\theta^*}{\beta}\right)$$

$$L = 50mm$$

$$\beta = 120^\circ$$

$$\theta^* = 60^\circ$$

$$w = 60rpm = 60 * \frac{360^\circ}{60\,\text{sec}} = \frac{360^\circ}{\text{sec}}$$

$$\left(\theta^*\right)' = w$$

$$V_{\max} = \left(s^*\right)' = L\left(\frac{w}{\beta} - \frac{1}{2\pi} * \frac{2\pi w}{\beta} * \cos\frac{2\pi\theta^*}{\beta}\right) = L * \frac{w}{\beta} * \left(1 - \cos\frac{2\pi\theta^*}{\beta}\right)$$

$$V_{\max} = \left(s^*\right)' = 50mm * \frac{360^\circ}{\text{sec}} * \frac{1}{120^\circ} * \left(1 - \cos\frac{2\pi * 60^\circ}{120^\circ}\right) = 300mm/\text{sec}$$

A cam is required such that the follower rises 50 mm in 120° of cam rotation, dwells for 60°, returns in 120°, and dwells for 60°. The cam angular velocity is constant at 60rpm. The requirements are displayed in Fig. P6.17.

(c) Determine the maximum follower acceleration (in mm/ sec2)

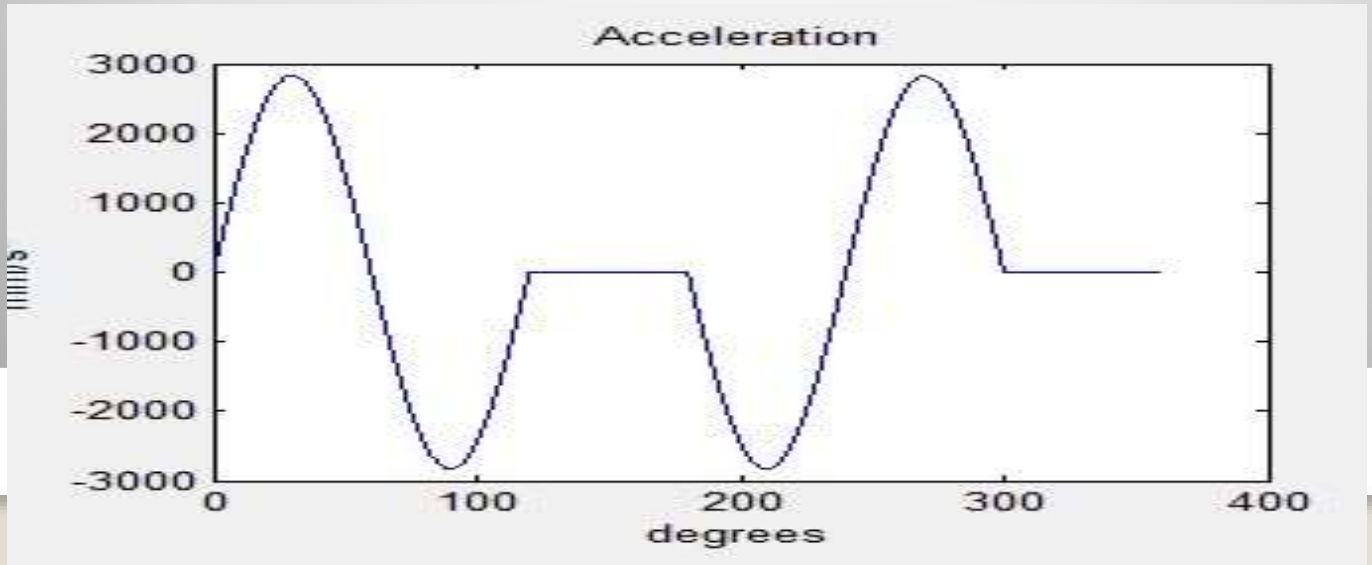
$$V_{\max} = \left(s^*\right)' = L\left(\frac{w}{\beta} - \frac{1}{2\pi} * \frac{2\pi w}{\beta} * \cos\frac{2\pi\theta^*}{\beta}\right) = L * \frac{w}{\beta} * \left(1 - \cos\frac{2\pi\theta^*}{\beta}\right)$$

$$\partial_{\max} = \left(s^*\right)'' = L * \frac{w}{\beta} * \left(-\cos\frac{2\pi\theta^*}{\beta}\right)' = L * \frac{w}{\beta} * \frac{2\pi w}{\beta} * \sin\frac{2\pi\theta^*}{\beta} = L * \left(\frac{w}{\beta}\right)^2 * 2\pi * \sin\frac{2\pi\theta^*}{\beta}$$

$$\theta^* = 30^\circ$$

$$\beta = 120^\circ$$

$$\partial_{\max} = 50mm * \left(\frac{360^\circ}{\sec}\right)^2 * \left(\frac{1}{120^\circ}\right)^2 * \sin\frac{2\pi * 30^\circ}{120^\circ} = 2827mm/s^2$$



A cam is required such that the follower rises 50 mm in 120° of cam rotation, dwells for 60°, returns in 120°, and dwells for 60°. The cam angular velocity is constant at 60rpm. The requirements are displayed in Fig. P6.17.

(d) What is the magnitude of the displacement at 220° of cam rotation?

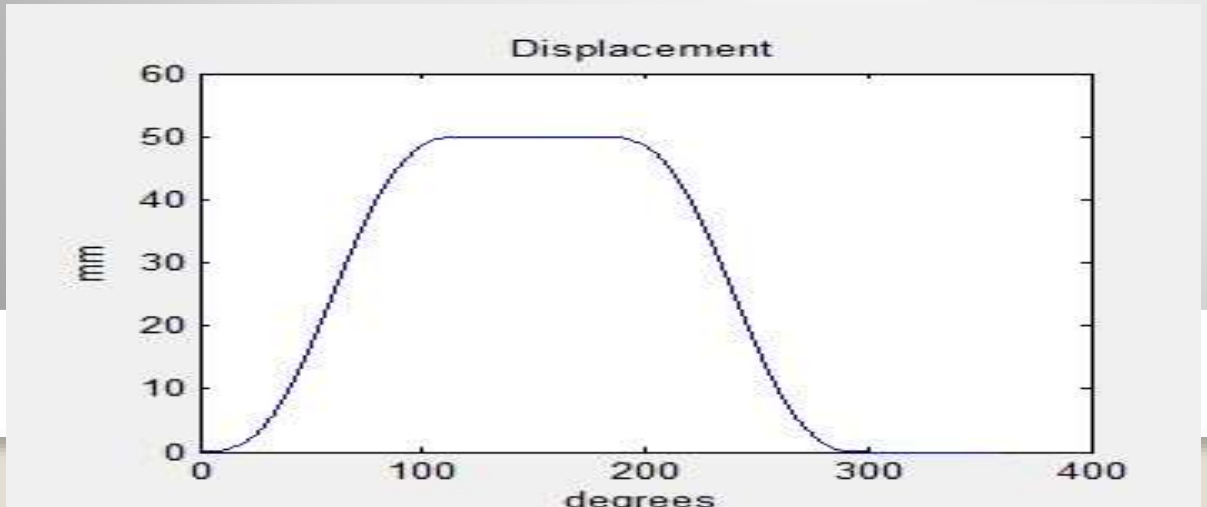
angle (deg)	rise (mm)	velocity (mm/s)	acceleration (mm/s^2)	jerk (mm/s^3)	pressure angle (deg)
0	0	0	0	53295.9	0
10	0.187793	20.0962	1413.72	46155.6	7.23683
20	1.44172	75	2448.63	26647.9	24.2959
30	4.54225	150	2827.43	-1.50975e-011	38.9418
40	9.77506	225	2448.63	-26647.9	45.8399
50	16.8545	279.904	1413.72	-46155.6	46.7856
60	25	300	1.60189e-012	-53295.9	43.6793
70	33.1455	279.904	-1413.72	-46155.6	37.4574
80	40.2249	225	-2448.63	-26647.9	28.7677
90	45.4577	150	-2827.43	-9.79029e-012	18.718
100	48.5583	75	-2448.63	26647.9	9.21729
110	49.8122	20.0962	-1413.72	46155.6	2.44805
120	50	0	0	0	0
130	50	0	0	0	0
140	50	0	0	0	0
150	50	0	0	0	0
160	50	0	0	0	0
170	50	0	0	0	0
180	50	-0	-0	-53295.9	-0
190	49.8122	-20.0962	-1413.72	-46155.6	-2.44805
200	48.5583	-75	-2448.63	-26647.9	-9.21729
210	45.4577	-150	-2827.43	-1.50975e-011	-18.718
220	40.2249	-225	-2448.63	26647.9	-28.7677
230	33.1455	-279.904	-1413.72	46155.6	-37.4574
240	25	-300	-1.60189e-012	53295.9	-43.6793
250	16.8545	-279.904	1413.72	46155.6	-46.7856
260	9.77506	-225	2448.63	26647.9	-45.8399
270	4.54225	-150	2827.43	9.79029e-012	-38.9418
280	1.44172	-75	2448.63	-26647.9	-24.2959
290	0.187793	-20.0962	1413.72	-46155.6	-7.23683
300	7.10543e-015	0	0	0	0
310	7.10543e-015	0	0	0	0
320	7.10543e-015	0	0	0	0
330	7.10543e-015	0	0	0	0
340	7.10543e-015	0	0	0	0
350	7.10543e-015	0	0	0	0
360	7.10543e-015	0	0	0	0

Max. Values Print

$$s^* = L(1 - \frac{\theta^*}{\beta} + \frac{1}{2\pi}\sin\frac{2\pi\theta^*}{\beta}) \qquad \boxed{0 \le \theta^* \le \beta}$$

$$s^*(\theta^* = 220^\circ) = s^*(\theta^* = 40^\circ) = L(1 - \frac{\theta^*}{\beta} + \frac{1}{2\pi}\sin\frac{2\pi\theta^*}{\beta})\Big|_{(\theta^* = 40^\circ)}$$

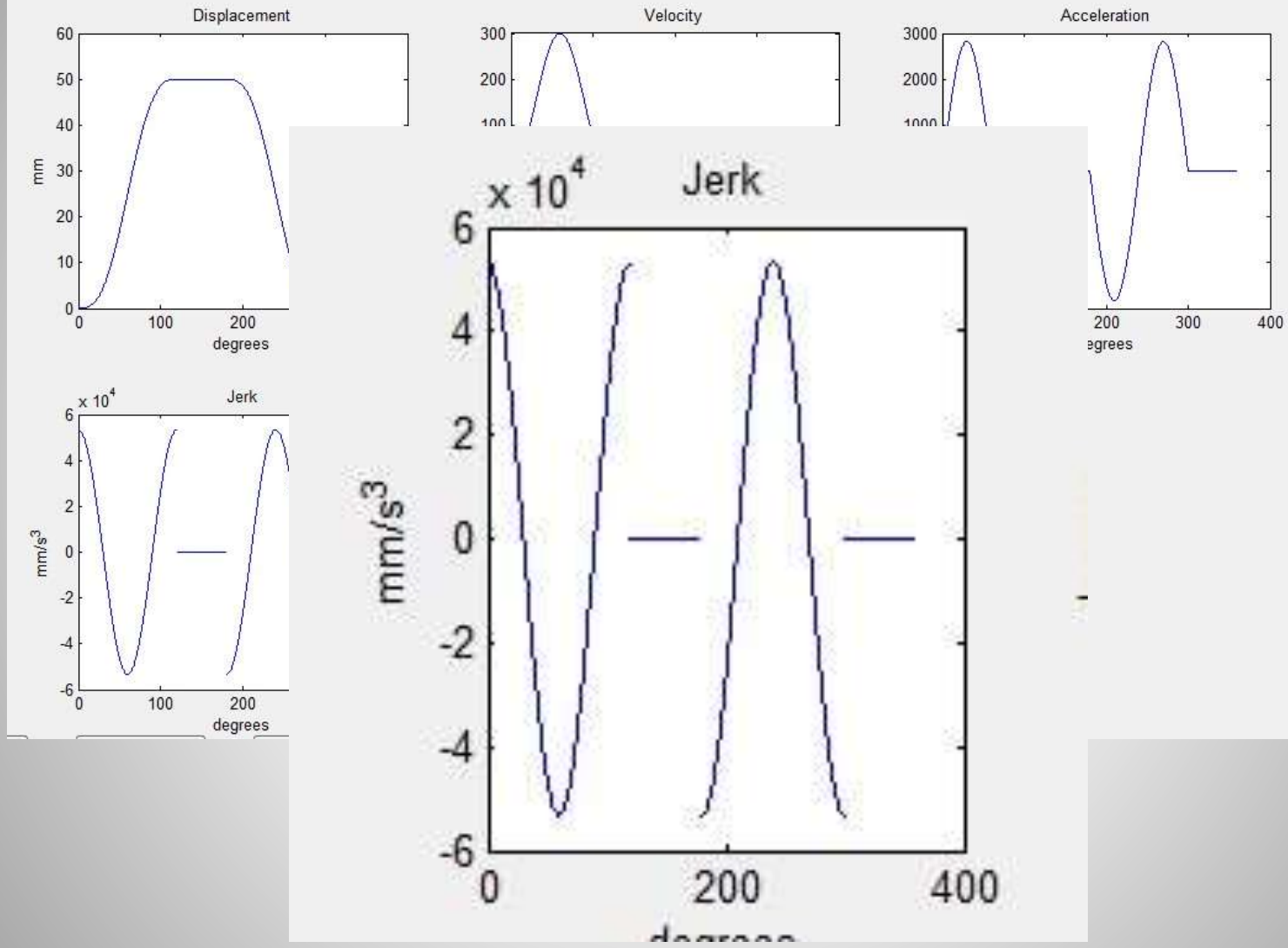
$$= 50mm * (1 - \frac{40^\circ}{120^\circ} + \frac{1}{2\pi}\sin\frac{2\pi * 40^\circ}{120^\circ}) = 40.2mm$$



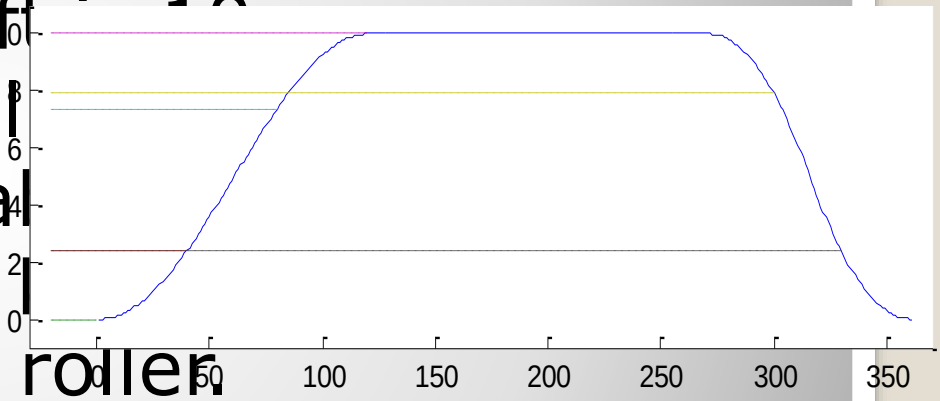
A cam is required such that the follower rises 50 mm in 120° of cam rotation, dwells for 60°, returns in 120°, and dwells for 60°. The cam angular velocity is constant at 60rpm. The requirements are displayed in Fig. P6.17.

(d) Are there infinite spikes in the jerk profile? If so, at what locations?

No


Displacement
mm
degrees
Velocity
Acceleration
degrees
x 10^4
Jerk
mm/s^3
degrees
x 10^4
Jerk
mm/s^3
degrees

- Base circle diameter: 30 mm
- Offset: 0
- Roller diameter: 10 mm
- Angular velocity: 10rad/s
- 0-120 degree SHM lif
- 120-270 degree dwel
- 270-360 degree paral
- Plot cams with three
  knife edge, flat face, roller



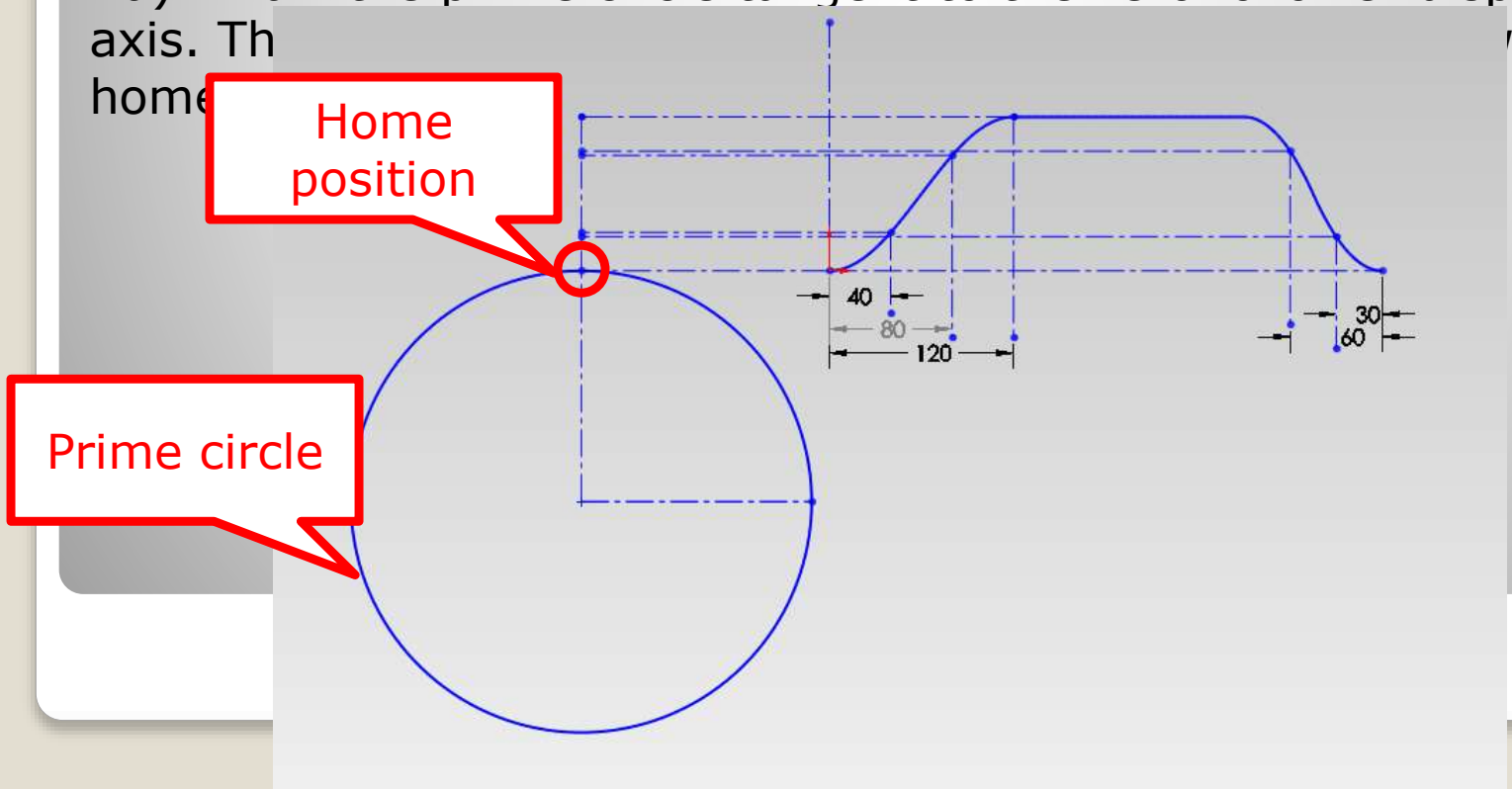
CAM profiles

CAM design steps:

- 1 Specify the displacement diagram, base circle diameter, and follower type.

- 2. Draw the displacement diagram.

a) Draw the prime circle tangent to the zero follower displacement axis. Th n as the home

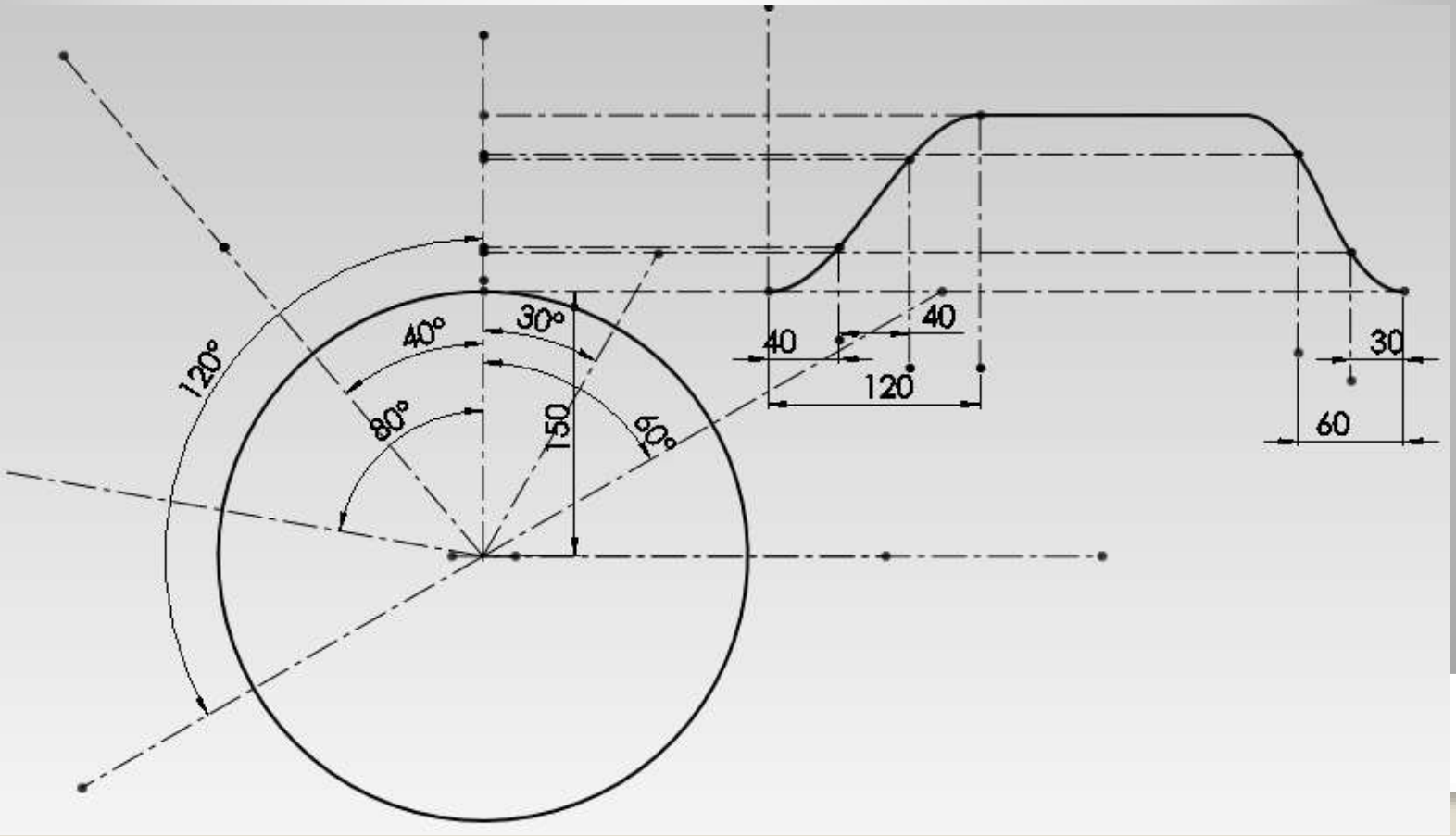


b) Divide the displacement diagram in several intervals.

Six intervals: 0-40; 40-80; 80-120; 120-300; 300-330; 330-360

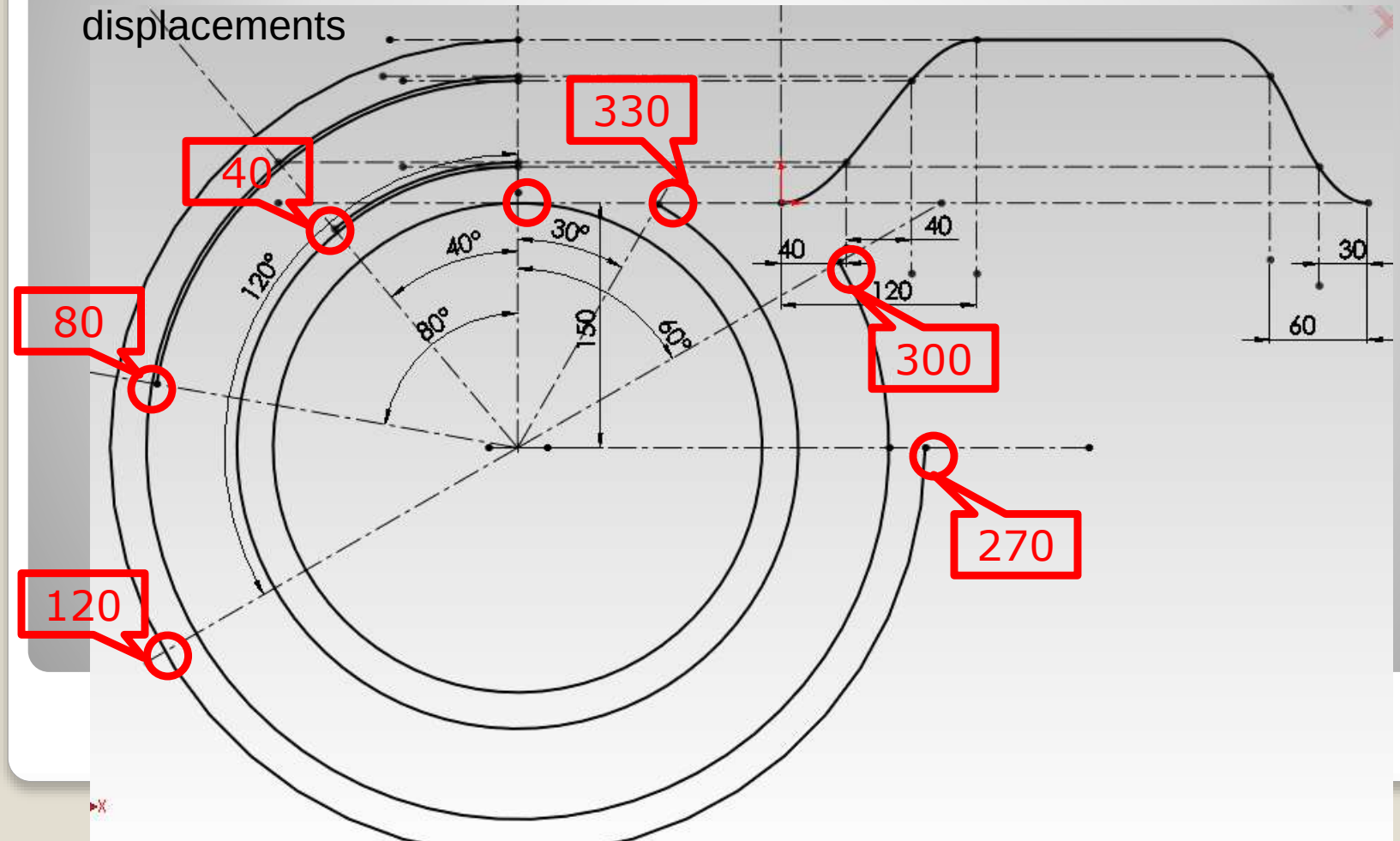
c) Divide the prime circle in the same number of intervals as the displacement diagram.

3. Draw parallel lines from the displacement diagram to the follower home position. Each line represents the rise of the follower at that specific interval.



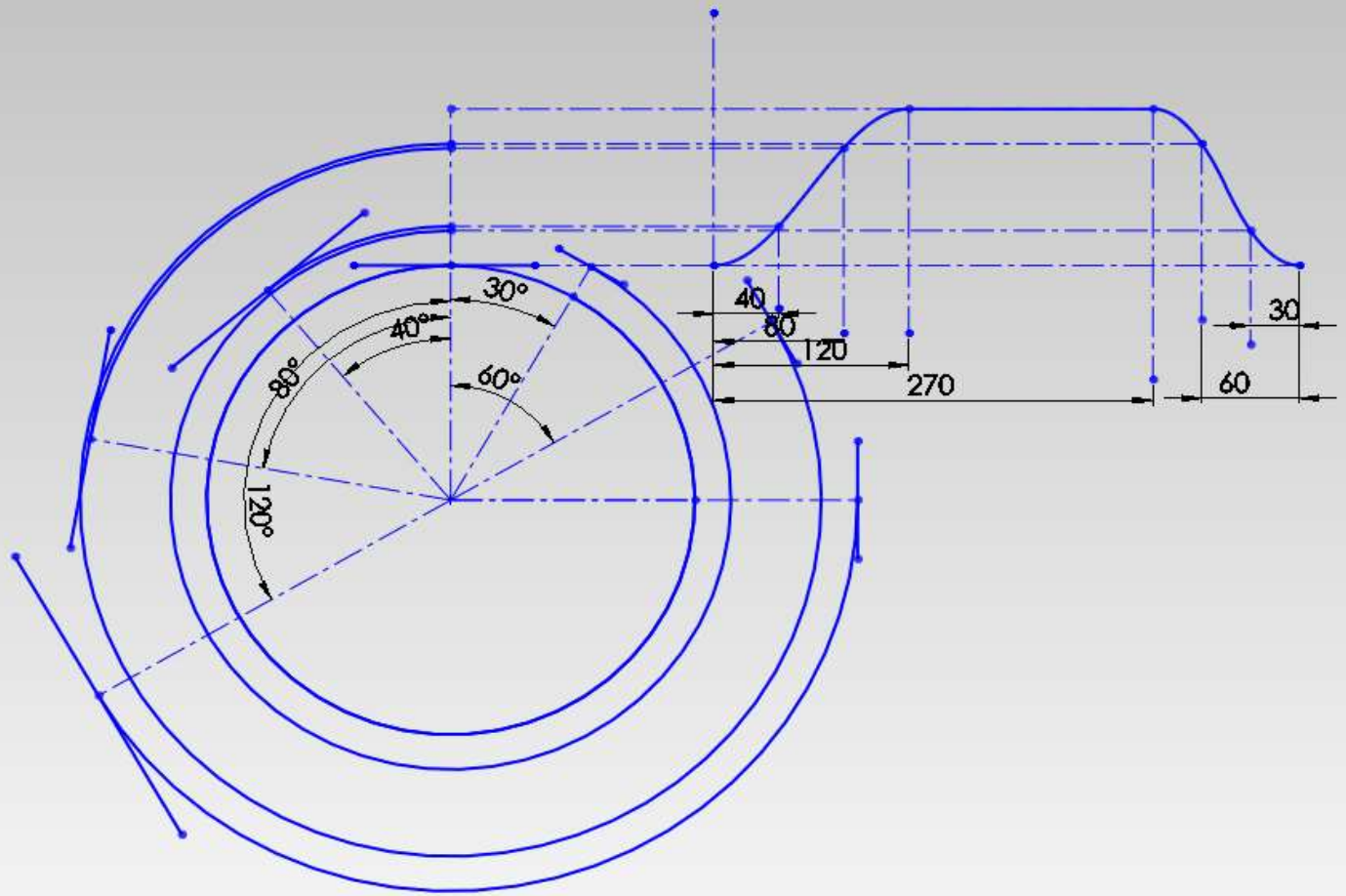
4. Invert the mechanism, fix the cam and move the follower around the cam in the opposite direction to the cam rotation. This is done by drawing circles about the centre of the prime circle, the radius at each circle are the displacements of the follower.

5. Draw the cam profile inside the envelope of the follower displacements

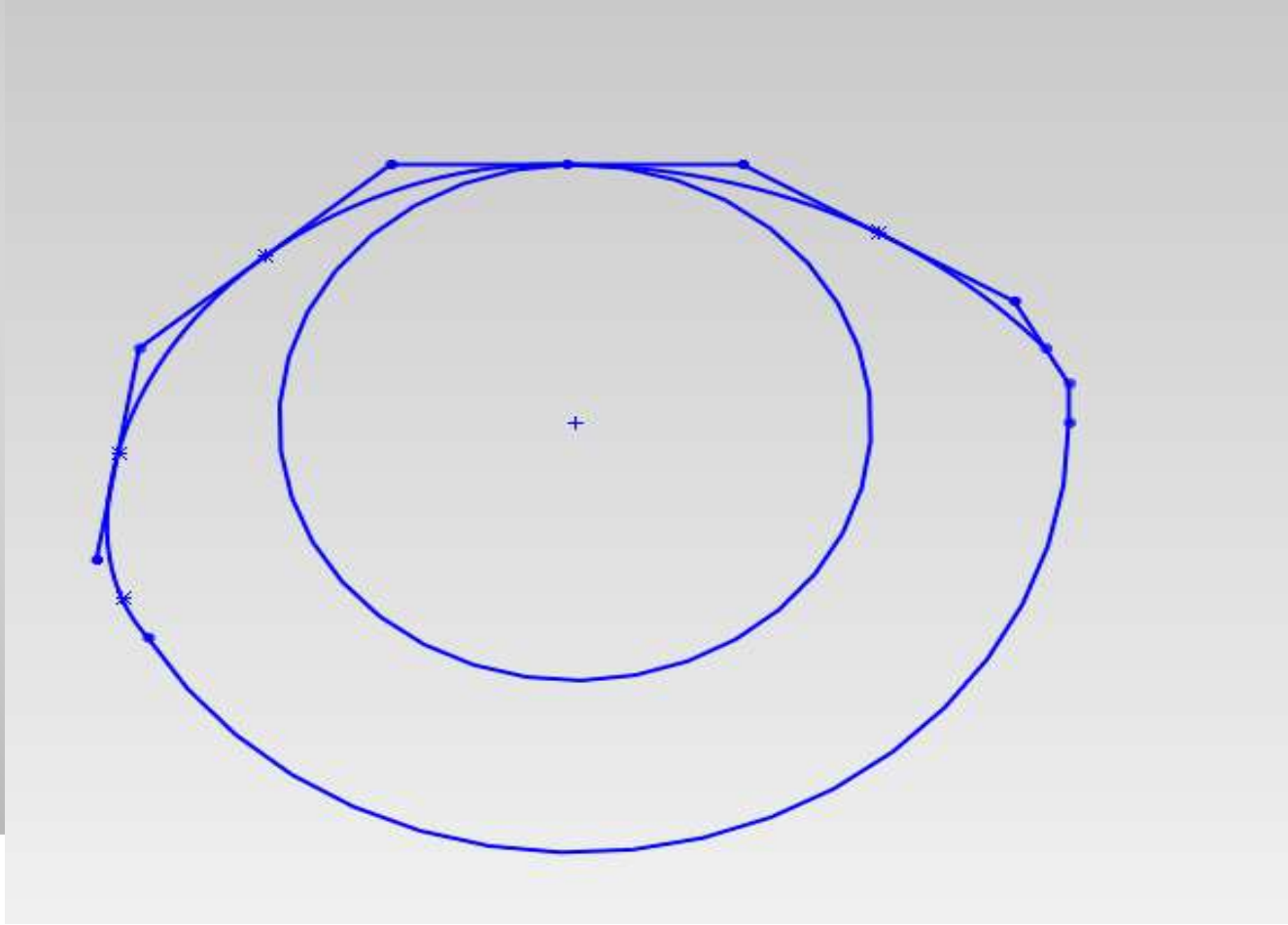


Flat face follower:

Draw lines which are tangent to follower displacement circles

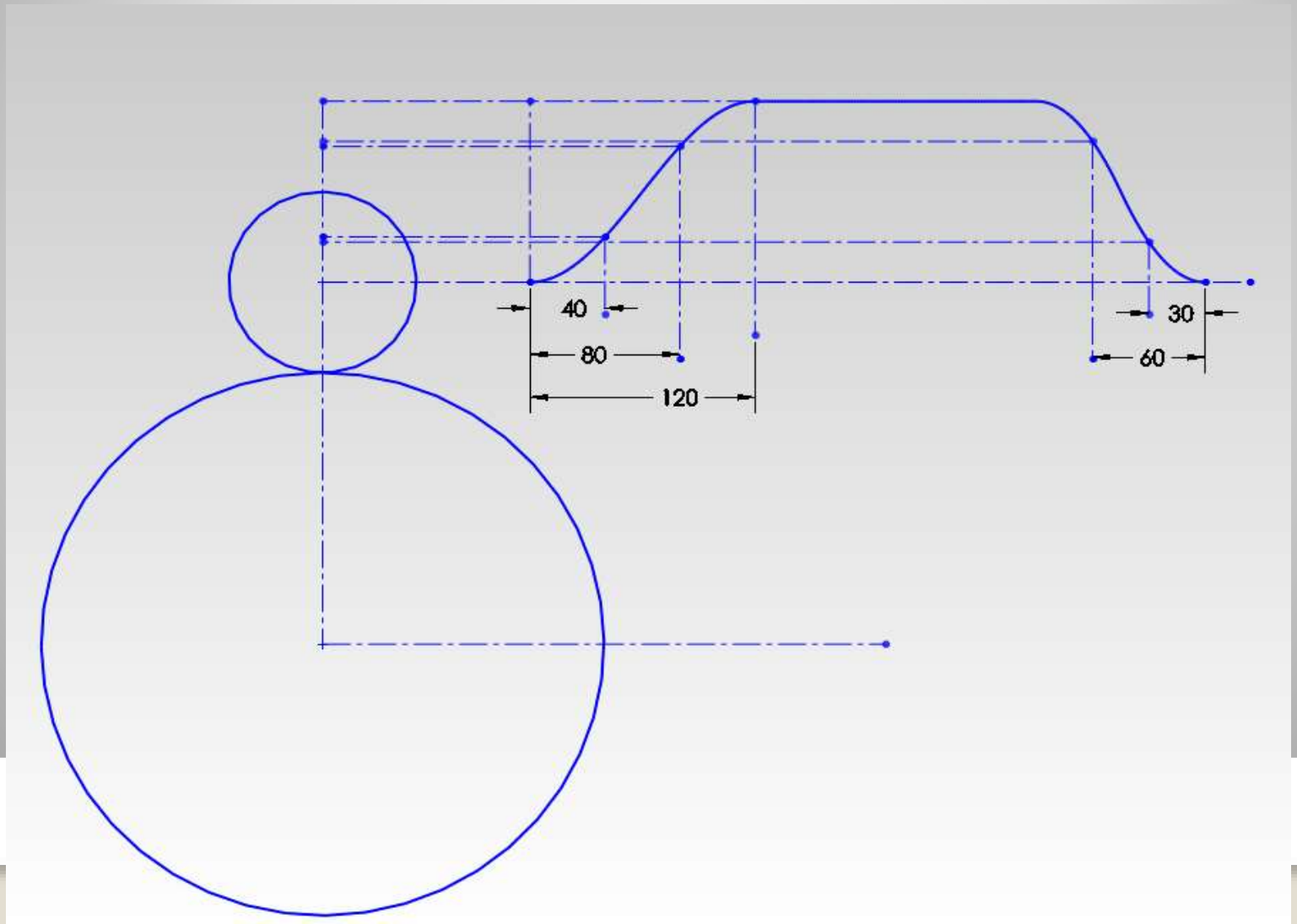


Extend the tangent lines and make them intersect. Connect the midpoints using spline lines to get the cam profile



Roller follower:

Home position is the centre of the roller. The prime circle is tangent to the roller.



Make sure the connect line is tangent with both roller circles.