Theory of machinery

Chapter six

Cams

By

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Cams

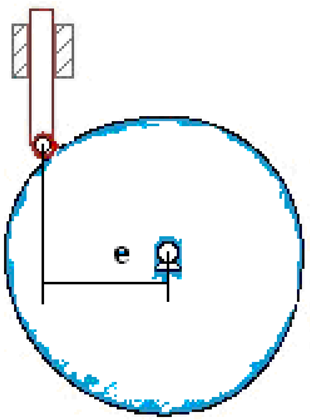
It is required to in many times to accurately relate the input and output motions through a well defined motion program:

$$y_{out} = F(X_{in}) \text{ ----- function of the input}$$

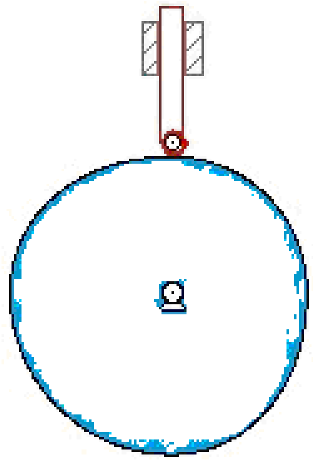
Cam mechanism provide such a facility between input and output motion by understanding that is the relation between input and output is specified by the shape of cam and other known parameters of the cam mechanism geometry

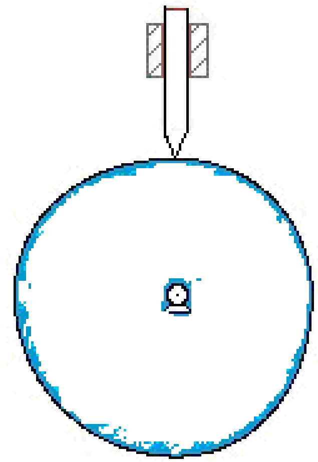
Cams

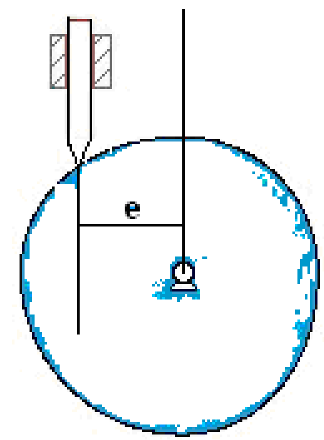
Types of cams



Roller follower with offset(e)


Roller follower without offset

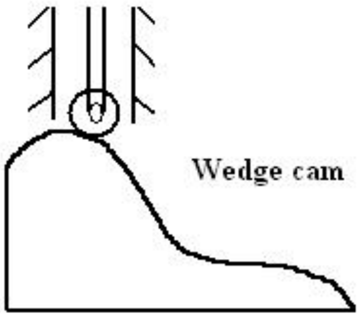

edge follower without offset



edge follower with offset(e)

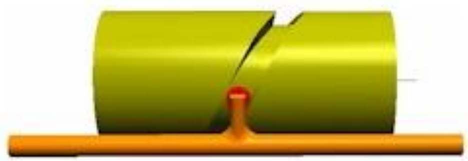
Cams

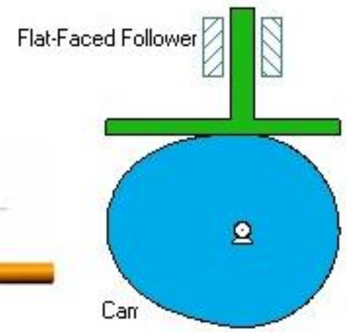
Types of cams



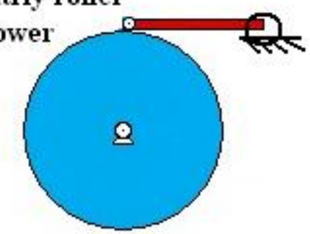
Wedge cam

Cylindrical cam

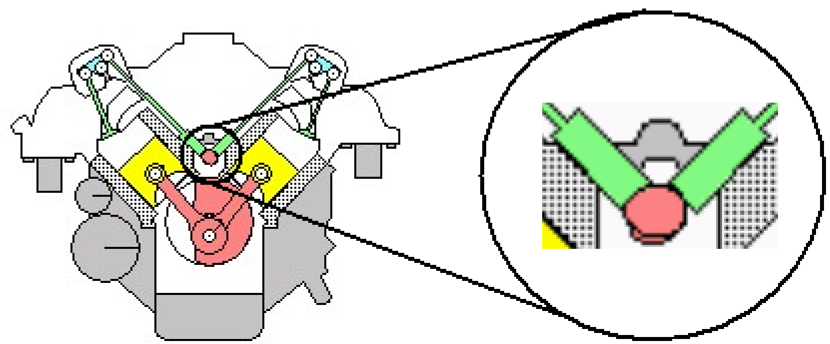




Oscillatriy roller follower



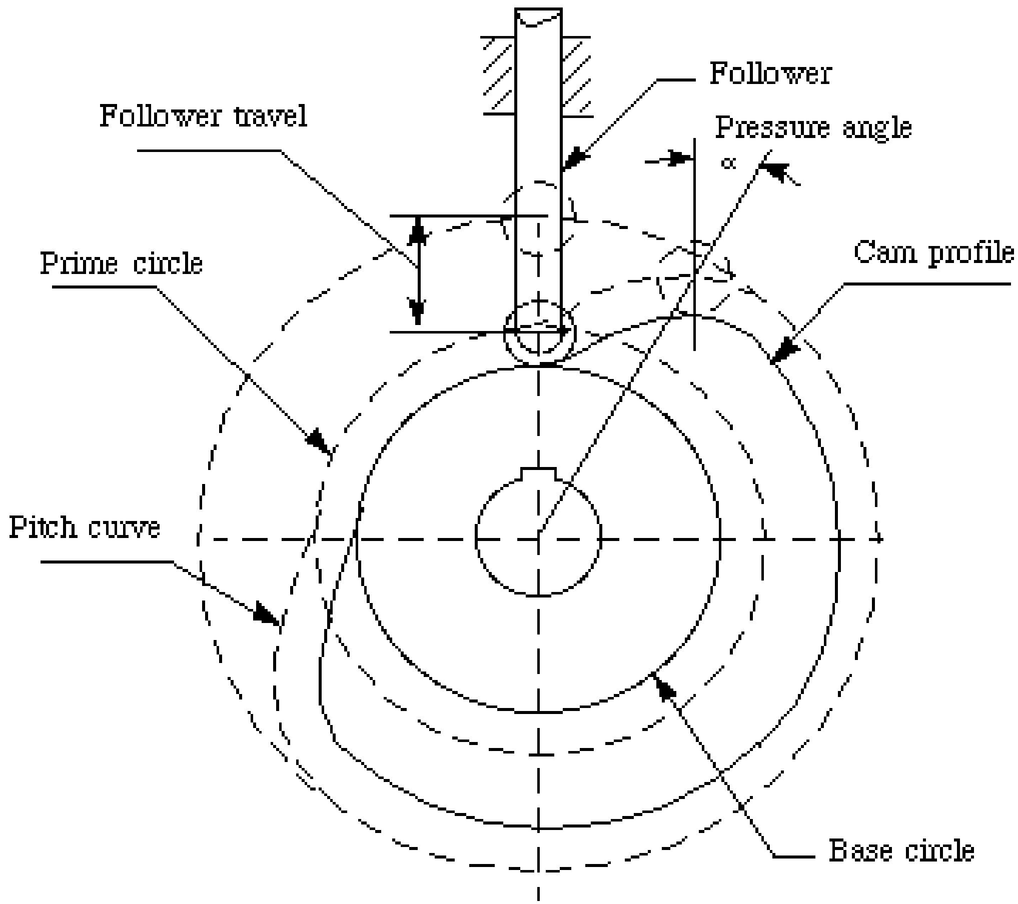
cam is used in filling fluids in bottels you can see that cam control the amount of fluid while it rotate



cam used to orgnaize the motion of valves in cars engines

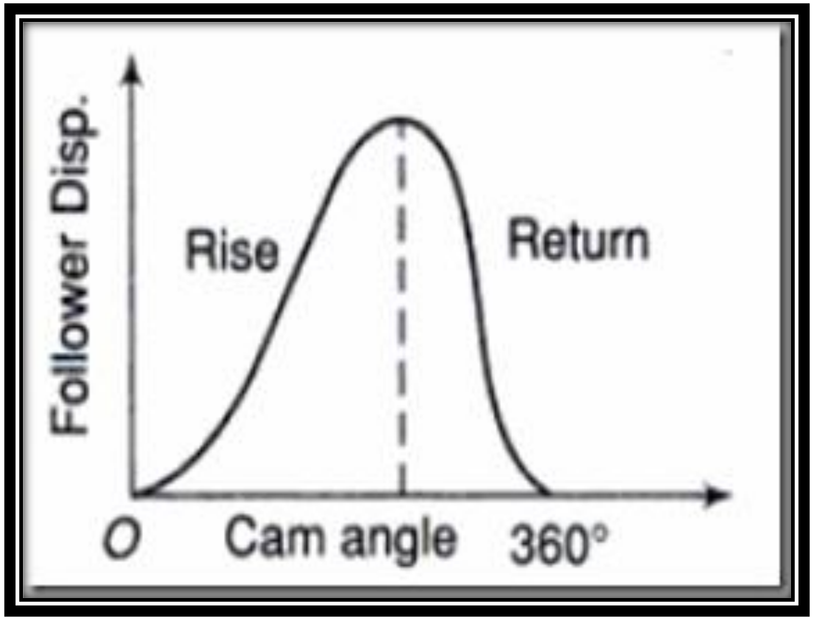
Cams

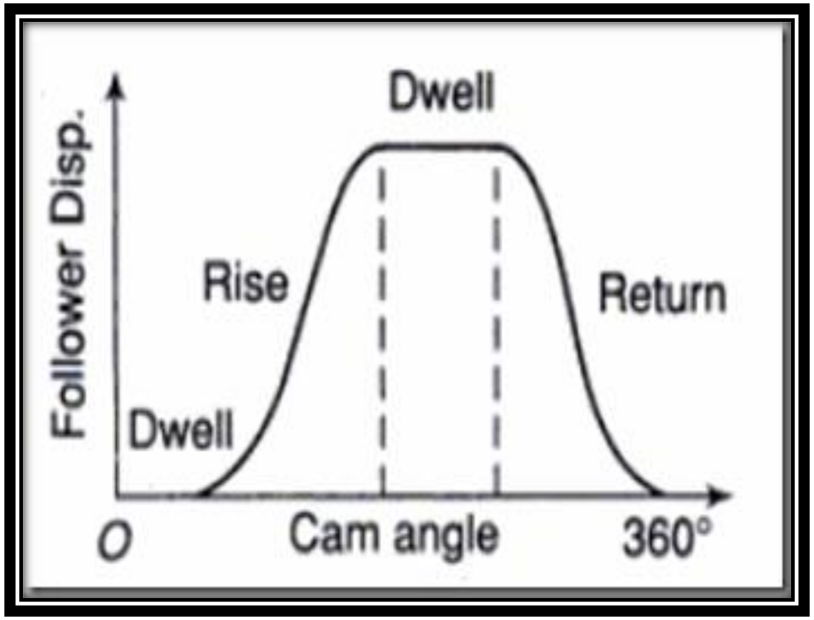
Cam Nomenclature



Cams

Motion segments





Cams

Objectives of Cam

There are two main types of cams according to the task that this cam has to do.

These types are:

1. Give a specific motion to the follower: uniform acceleration and simple harmonic motion (SHM).
2. Cams that have straight lines, circular arcs or other mathematical curves in their profile

For the 1st type, the cam profile is obtained by the geometrical construction

For the 2nd type, the follower displacement is obtained by analytical or graphical methods for any cam angle and the velocity and the acceleration are obtained later by taking the derivatives of the displacement

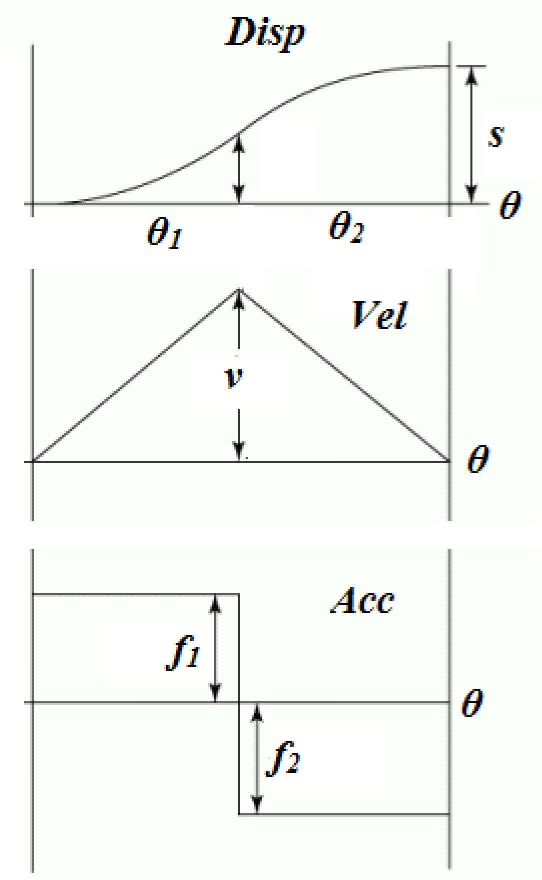
T h e o r y   o f   m a c h i n e r y

Cams

Specified motion of the follower

❖**Uniform acceleration and deceleration (parabolic moition)**

Assume that the follower moves displacement ***s*** in time equal ***t*** while the cam rotates angle ***θ*** and angular velocity ***ω*** the following relations are used to find velocity and acceleration



$$t = \frac{\theta}{\omega} \qquad v_{mean} = \frac{s}{t} = \frac{\omega s}{\theta} \qquad v_{\max} = \frac{2s\omega}{\theta}$$

Assume that the acceleration (f_1) occurs in θ_1 and the deceleration (f_2) in θ_2.

$$f_1 = \frac{v}{t_1} = \frac{2\omega s/\theta}{\theta_1/\omega} = \frac{2\omega^2 s}{\theta\theta_1}$$

$$f_2 = \frac{v}{t_2} = \frac{2\omega s/\theta}{\theta_2/\omega} = \frac{2\omega^2 s}{\theta\theta_2}$$

❖**Parabolic motion** is a one example of constant acceleration motion cam

Cams

Specified motion of the follower

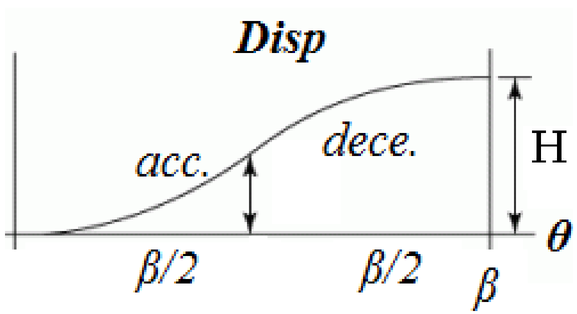
❖ Uniform acceleration and deceleration (parabolic monition)

The following equations represent the follower motion program:

$$S = 2H\left(\frac{\theta}{\beta}\right)^2; \quad 0 < \theta < \beta/2 \qquad S = H\left(1 - 2\left(1 - \frac{\theta}{\beta}\right)^2\right); \quad \beta/2 < \theta < \beta$$

$$\dot{S} = 4H\omega\left(\frac{\theta}{\beta^2}\right); \quad 0 < \theta < \beta/2 \qquad \dot{S} = 4H\frac{\omega}{\beta}\left(1 - \frac{\theta}{\beta}\right); \quad \beta/2 < \theta < \beta$$

$$\ddot{S} = 4H\left(\frac{\omega}{\beta}\right)^2; \quad 0 < \theta < \beta/2 \qquad \ddot{S} = -4H\left(\frac{\omega}{\beta}\right)^2; \quad \beta/2 < \theta < \beta$$



Cams

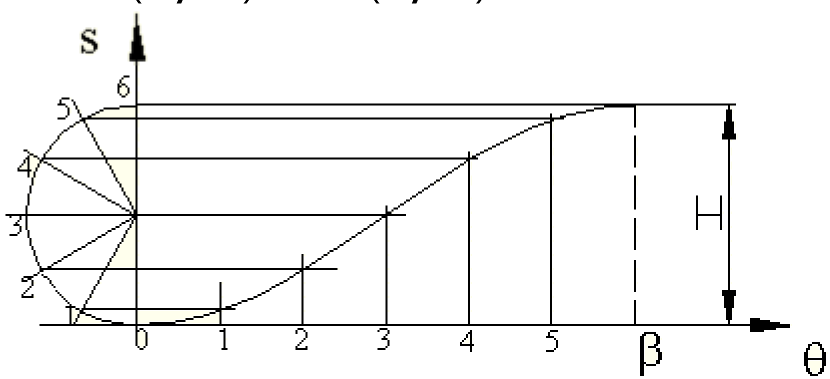
Specified motion of the follower

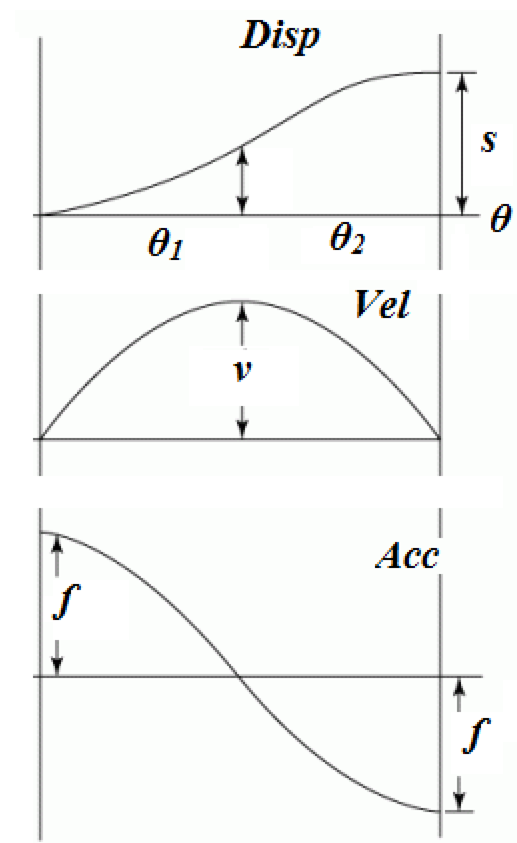
❖Simple harmonic motion

The curve is the projection of a circle about the cam rotation axis cam rotates the following relations are used to find velocity and acceleration

$$s(\theta)=\frac{H}{2}\left(1-\cos\left(\frac{\pi\theta}{\beta}\right)\right) \qquad \dot{s}(\theta)=\frac{H}{2}\left(\frac{\pi\omega}{\beta}\right)\sin\left(\frac{\pi\theta}{\beta}\right)$$

$$\ddot{s}(\theta)=\frac{H}{2}\left(\frac{\pi\omega}{\beta}\right)^{2}\cos\left(\frac{\pi\theta}{\beta}\right)$$



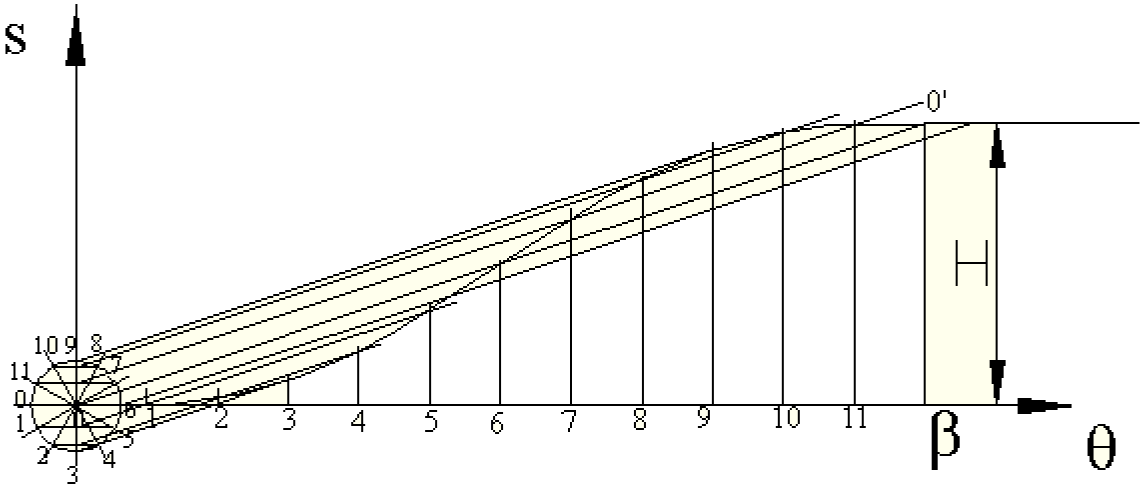


Cams

Specified motion of the follower

❖Cyclodial motion

The circumference of the circle is equal to the total rise; or the diameter is H/p .The circumference is divided into a number of equal parts corresponding to the divisions along the horizontal axis. The points around the circle are first projected to the vertical centerline of the circle and then parallel to OO’ to the corresponding vertical line on the diagram.



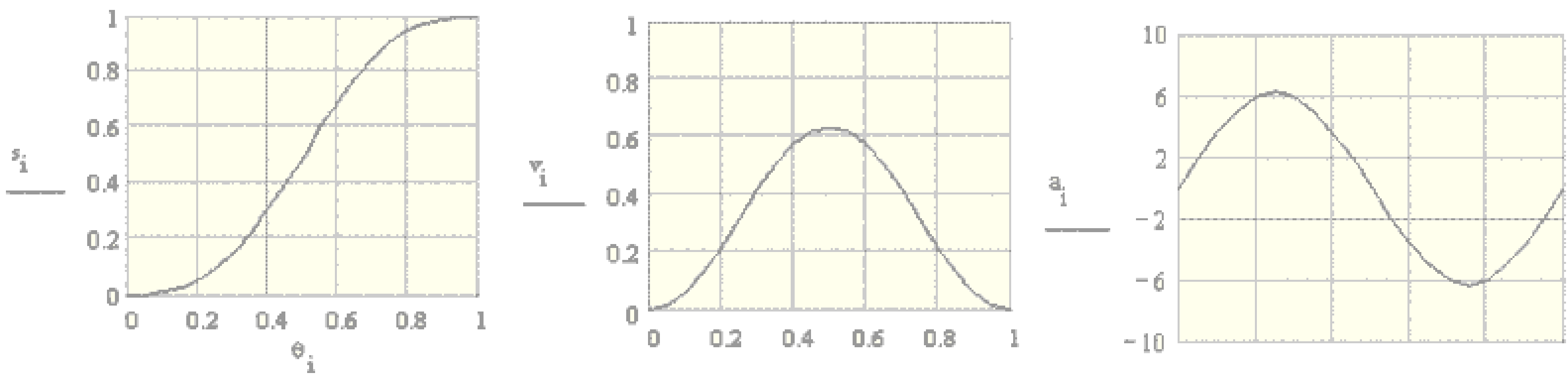
Cams

Specified motion of the follower

❖Cyclodial motion

The relations and graphs for the cam are

$$s(\theta)=\frac{h}{\pi}\left(\frac{\pi\theta}{\beta}-\frac{1}{2}\sin\left(\frac{2\pi\theta}{\beta}\right)\right)\quad \dot{s}(\theta)=\frac{h}{\pi}\left(\frac{\omega}{\beta}\right)\left(1-\cos\left(\frac{2\pi\theta}{\beta}\right)\right)\quad \ddot{s}(\theta)=2h\pi\left(\frac{\omega}{\beta}\right)^2\sin\left(\frac{2\pi\theta}{\beta}\right)$$



Cams

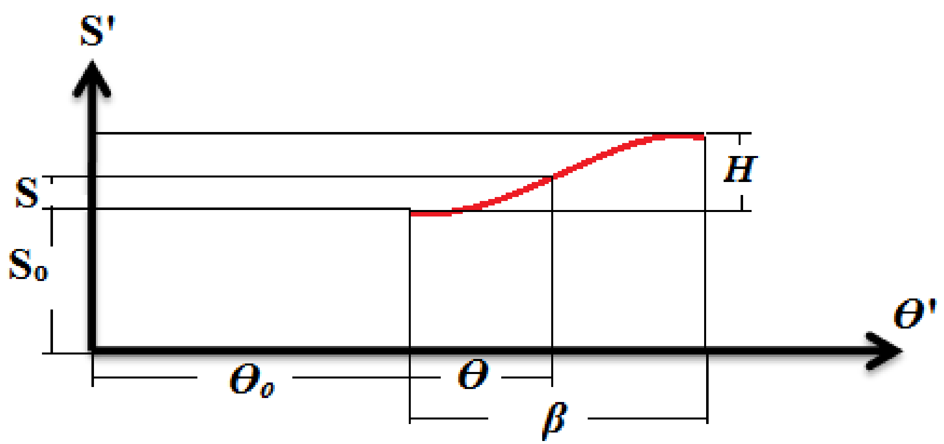
Specified motion of the follower

❖**Application of motion laws**

the three types of specified motions (parabolic, SHM and cycloidial) are designed to find the follower displacement depending on one condition:

The follower displacement equal zero when the cam angle is also zero

however, if the segment doesn't satisfy this condition, a shifting procedure must be applied. To illustrate this procedure, let us assume there is a rise segment starts from S_o and Θ_o as shown in the figure.



Cams

Specified motion of the follower

❖**Application of motion laws**

According to this shifting procedure :

▪ $S` = So \pm S(\theta)$; + if rise and – if return

▪ $\theta` = \theta_o + \theta$

where: $0 < \theta < \beta$ and $\theta = \theta` - \theta_o$.

$r_c = r_b + s$.

Where:

r_b = basic circle raduis

r_c = cam profile raduis

Cams

Example

Draw the cam profile needed to achieve:

- Follower is edge
- base radius = 5 cm
- 0→ 90^o : SHM rise to 3cm
- 90^o → 180^o : Dwell
- 180^o → 270^o : SHM return to 0
- 270^o → 360^o : Dwell

Cams

Example

Solution:

- 0→ 90º : SHM rise to 3cm $s(\theta)=\frac{H}{2}\left(1-\cos\left(\frac{\pi\theta}{\beta}\right)\right)=\frac{3}{2}\left[1-\cos(2\theta)\right]$

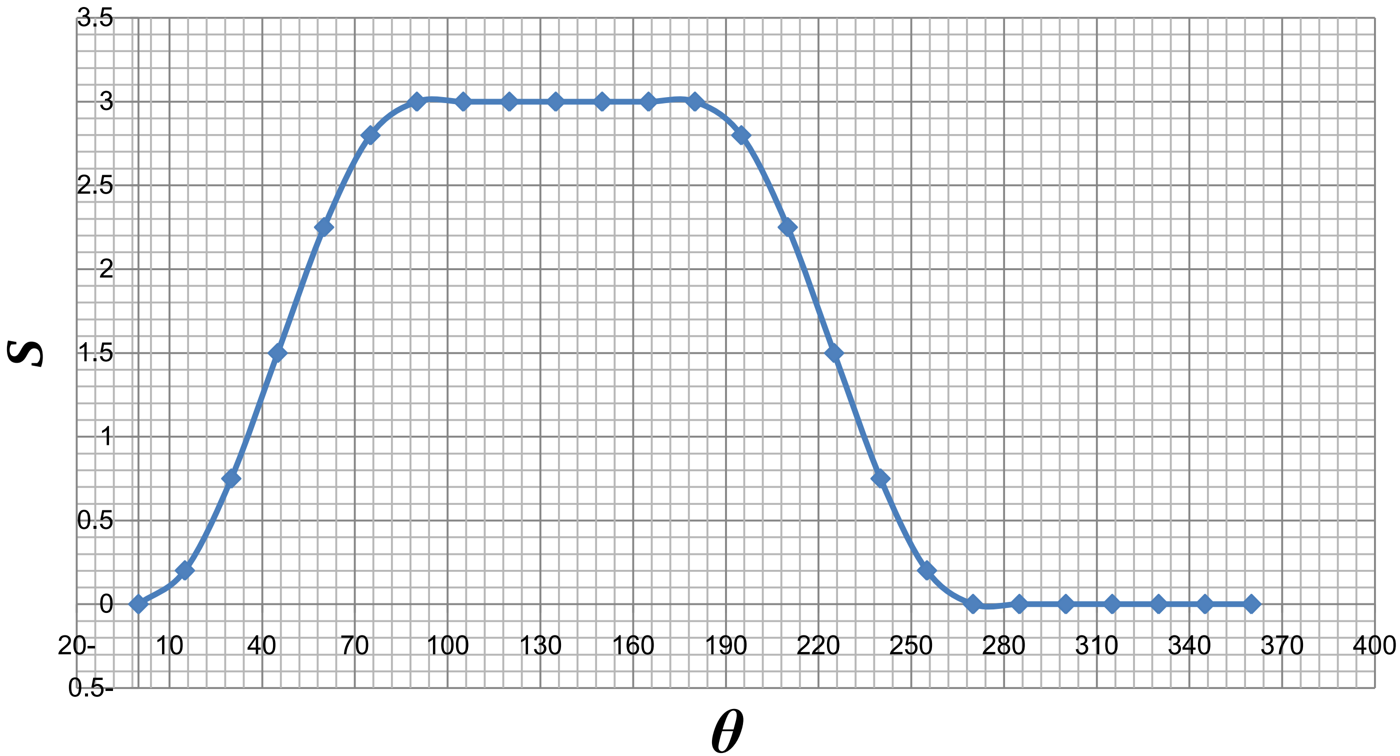
- 90º → 180º : Dwell → S = 3cm

- 180º → 270º : SHM return to 0 $s(\theta)=3-\left\{\frac{3}{2}\left[1-\cos(2\theta)\right]\right\}$

- 270º → 360º : Dwell → S = 0 mm

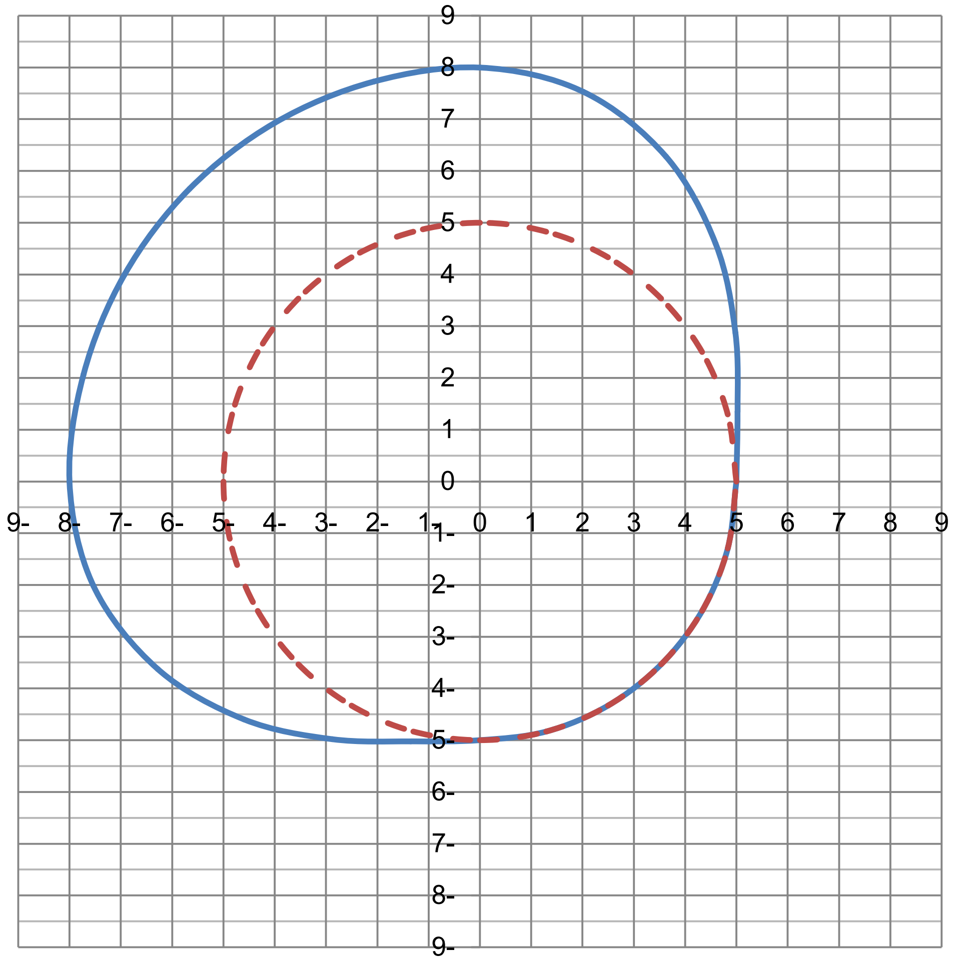
Cams

Example



Cams

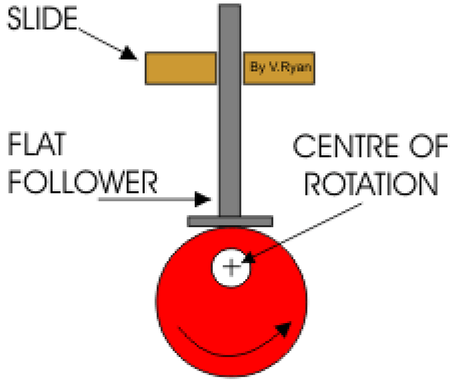
Example

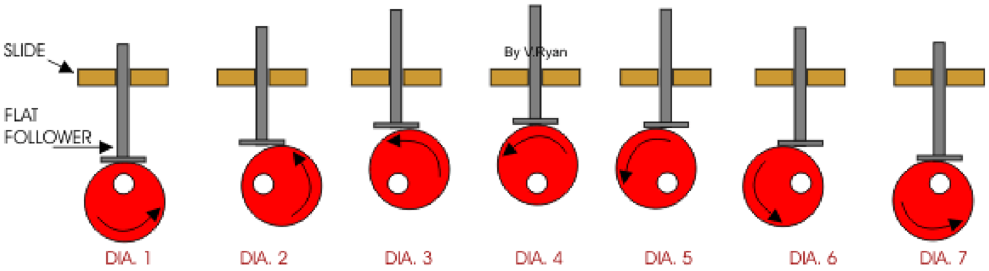


Cams

Eccentric circular cam

- Eccentric cam is a cam has the axis of rotation **not** in the center
- This type of cams depend on the eccentricity to create the follower motion
- When the cam rotate, the distance with respect to the follower (h) changes depending on the value of the eccentricity (e)





Cams

Eccentric circular cam

Eccentric cam is a cam has the axis of rotation **not** in the center

$$h = e\{1 - \cos(\theta)\}$$

$$v = \frac{dh}{dt} = \frac{dh}{d\theta}\frac{d\theta}{dt} = \frac{dh}{d\theta}\omega$$

$$\Rightarrow v = \omega e \sin(\theta)$$

$$a = \frac{dv}{dt} = \frac{dv}{d\theta}\frac{d\theta}{dt}$$

$$\Rightarrow a = \omega^2 e \cos(\theta)$$