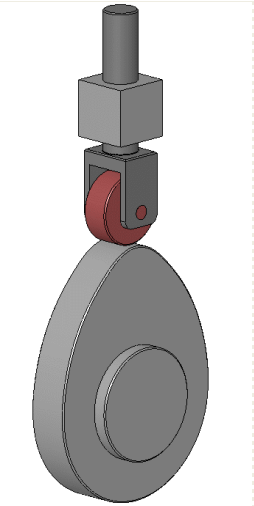
Cam Mechanism

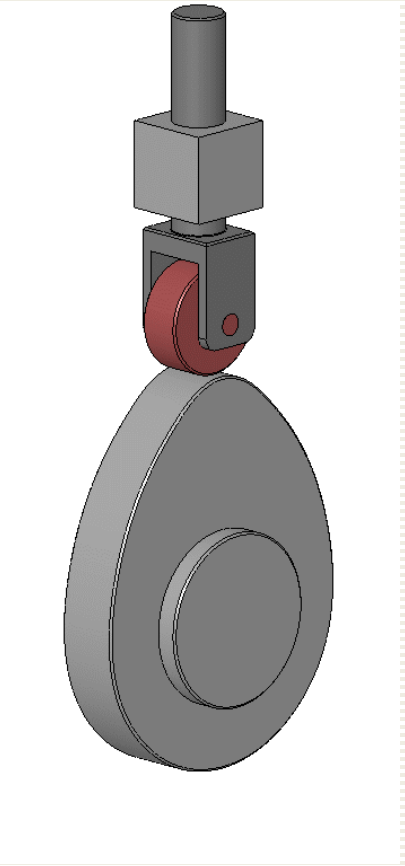


Cam & Follower : A higher pair

A cam is a machine element used to impart desired/specified motion to another element , called follower, by direct contact.

- ✓ **The driving member is called Cam**
- ✓ **The driven member is called Follower**

A ***cam*** may be defined as a machine element having a curved outline or a curved groove, which, by its rotation or reciprocating motion, gives a predetermined specified motion to another element called the ***follower***



The frame which supports the cam & guides the follower

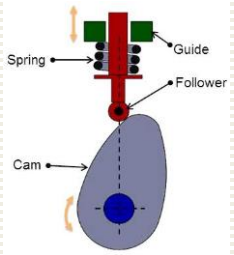
Motion of cam: either rotating or reciprocating

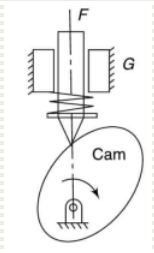
Motion of follower: Reciprocating
Oscillating
Complex coordinated movement

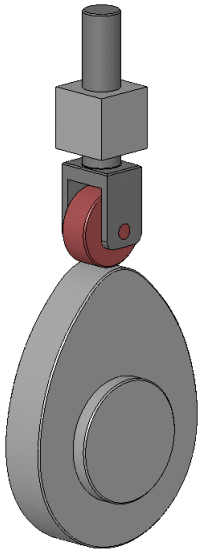
Type of Cams

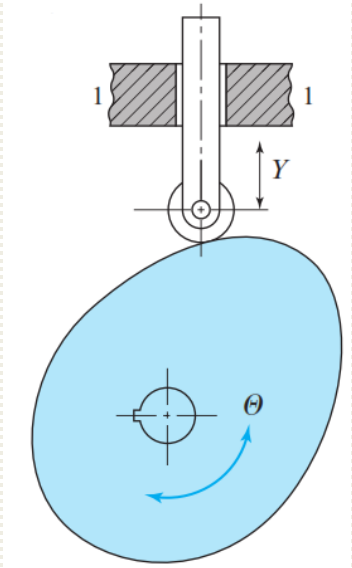
According to shape

- **Plate cam/Radial cam/ Disc cam**

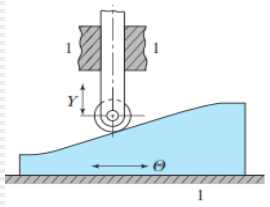


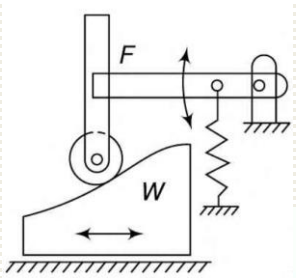




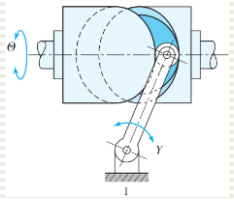


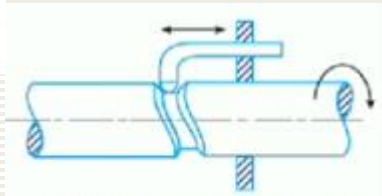
- **Wedge cam/ Flat cam**

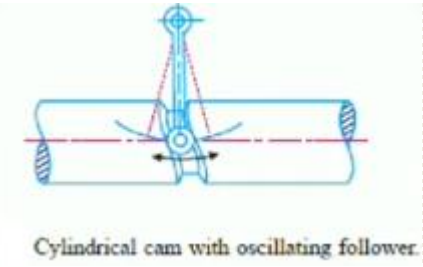




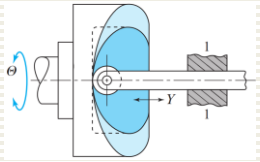
- **Cylindrical cam/ Barrel cam**



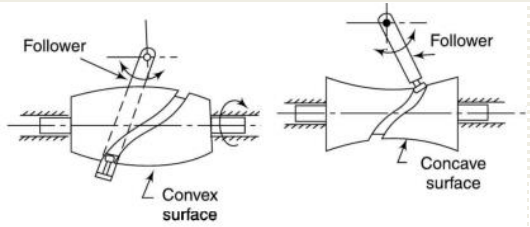

Cylindrical cam with reciprocating follower.


Cylindrical cam with oscillating follower.

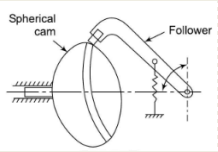
- **Face cam/ End cam**



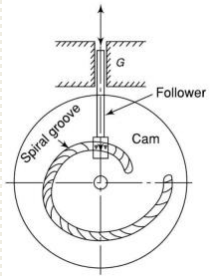
- **Globoidal cam**



- **Spherical cam**



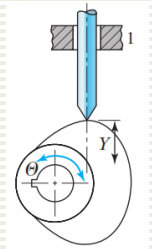
- **Spiral cam**

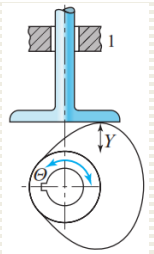


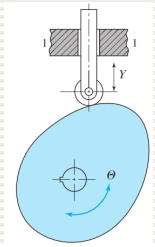
Classification of Followers

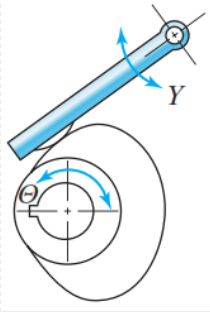
Types of Followers

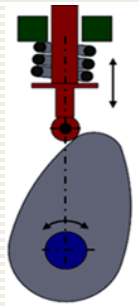
- **According to shape or the nature of surface in contact**
  - Knife-edge follower
  - Flat-face follower
  - Roller follower
  - Spherical-face /curved-shoe follower
- **According to the characteristic of output motion**
  - Reciprocating or translating followers
    - Radial follower
    - Offset follower
  - Oscillating or rotating followers

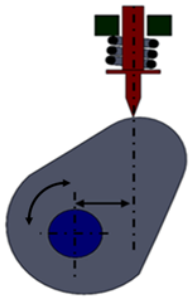






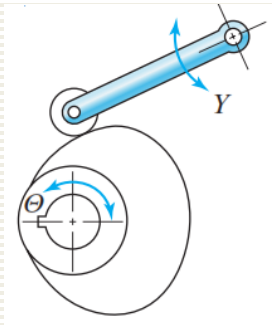






Radial Follower

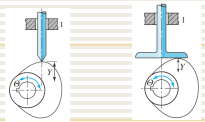
Offset Follower



Radial Cam Nomenclature

Trace point

- is a theoretical point on the follower & its motion describing the movement of the follower.
- For a knife-edge follower, the trace point is at the knife-edge.
- For a roller follower, the trace point is at the roller centre
- For flat-face follower, it is at the point of contact between the follower & the cam surface

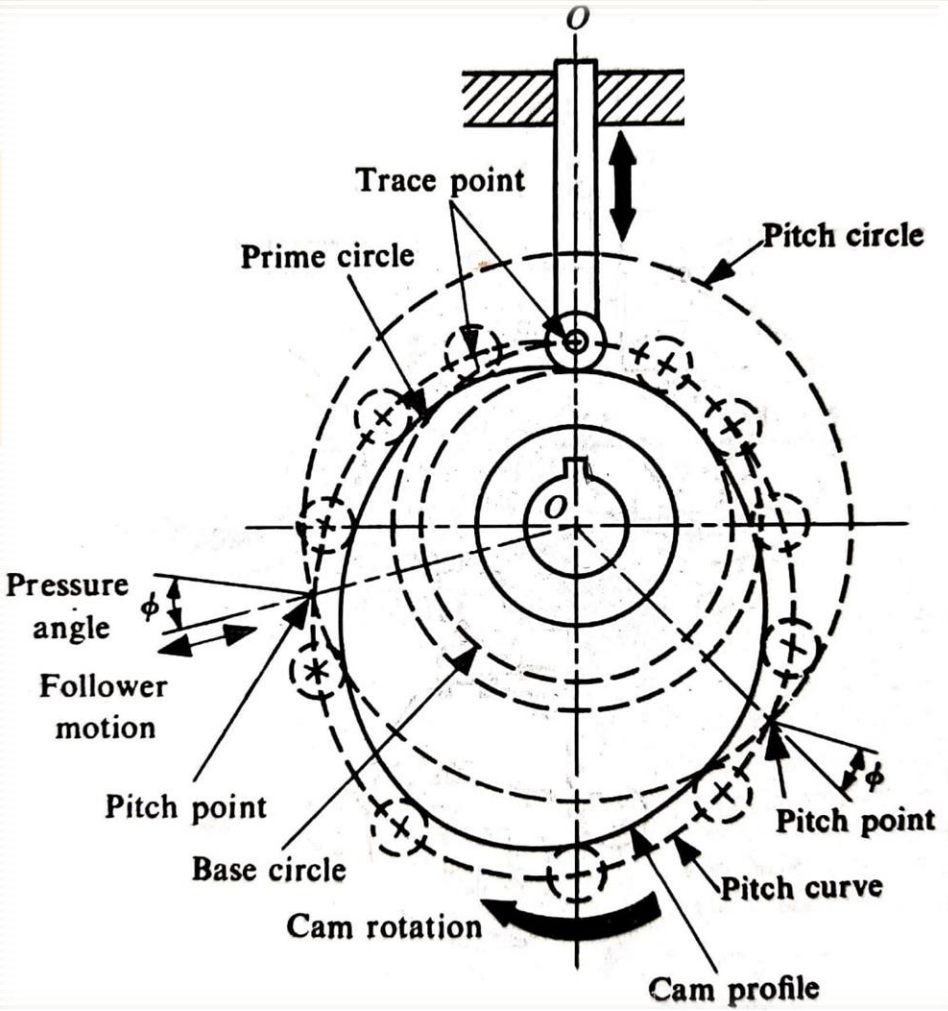


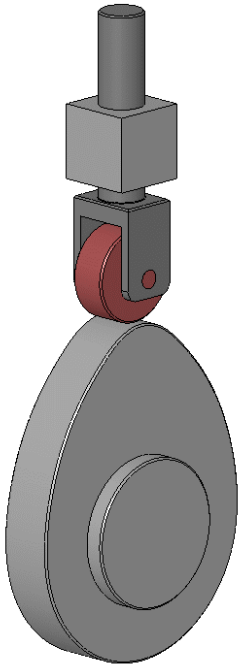
Base circle

- is the smallest circle that can be drawn with center at the cam rotation axis and tangent to the cam profile. The base circle decides the overall size of a cam

Pitch curve

- Is the locus generated by the trace point as the follower moves relative to the cam (after holding the cam fixed).
- For a knife-edge follower, the pitch curve & cam profile are identical.
- For roller follower, they are separated by the radius of the roller.





Pressure Angle

- The angle between the direction of the follower movement & the normal to the pitch curve at any point is referred to as the pressure angle.
- During a complete rotation, the pressure angle varies from its maximum to its minimum value.
- The greater the pressure angle, the higher will be the side thrust & consequently the chances of the translating follower jamming in its guide will increase.
- In case of low-speed cam mechanisms with translating followers, the highest permissible value of the pressure angle is 30°
- For a given motion requirement, the pressure angle can be reduced by increasing the cam size. However, a bigger cam requires more space & is more prone to unbalance at high speeds

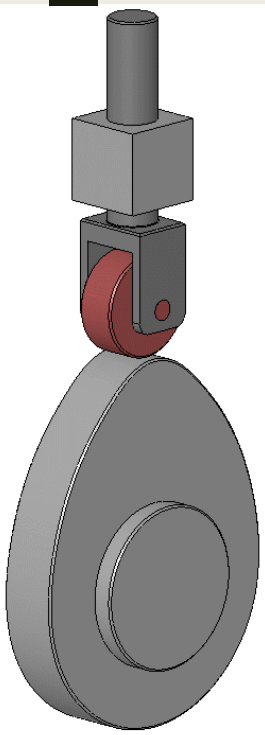
Radial Cam Nomenclature

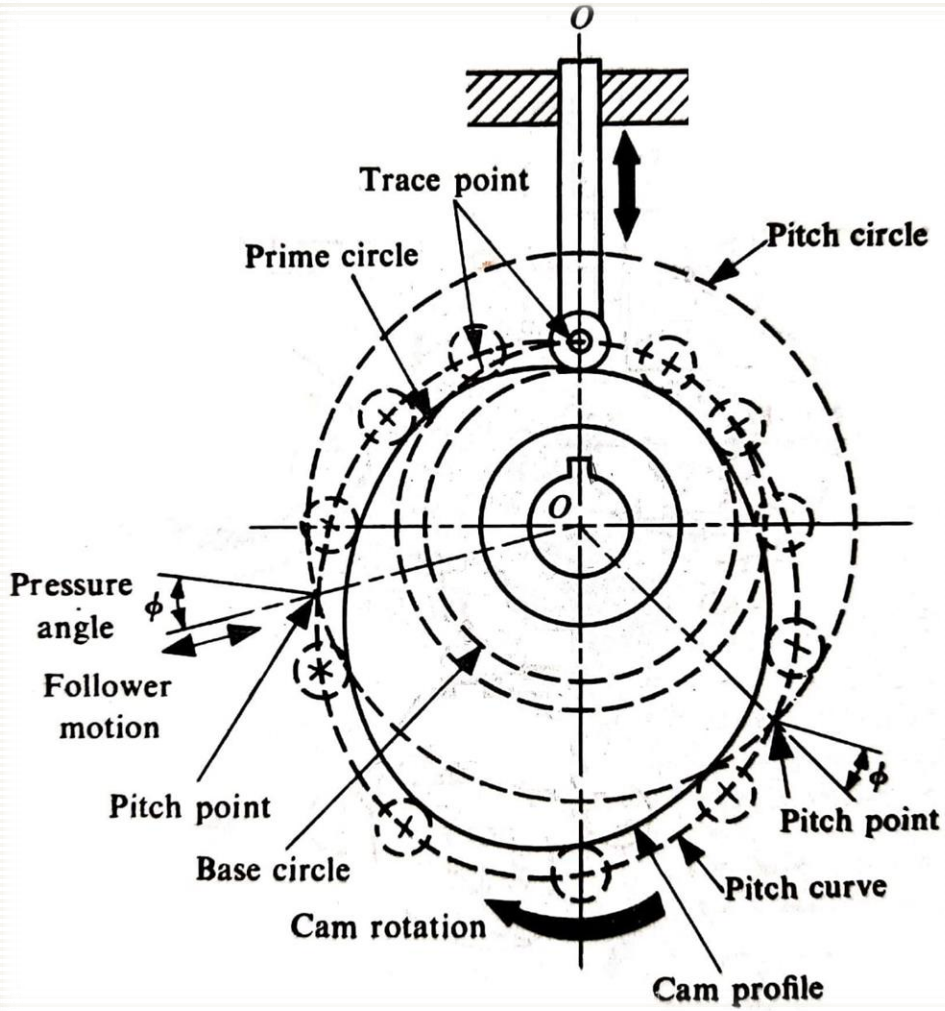
Pitch point & Pitch circle

A pitch point corresponds to the point of maximum pressure angle and a circle drawn with its centre at the cam centre, to pass through the pitch point, is known as the pitch circle.

Prime circle

- is the smallest circle that can be drawn with center at the cam rotation axis and tangent to the pitch curve.





Stroke or Throw

- The greatest distance or angle through which the follower moves or rotates. .
- It is also called as Lift of the Cam

Cam Profile

- The surface in contact with the follower .

Angle of ascent

- Is the angle of rotation of the cam during which the follower rises up.

Angle of Dwell

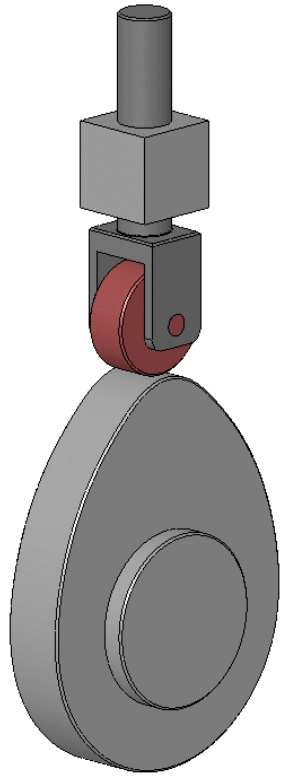
- Is the angle through which the cam turns while the follower remains stationary at the highest or lowest position.

Angle of descent

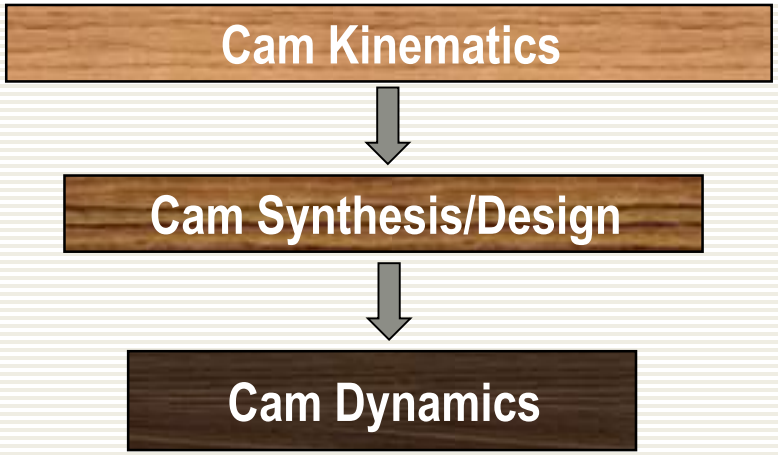
-angle of rotation of cam during which the follower returns to its initial position

Angle of Action

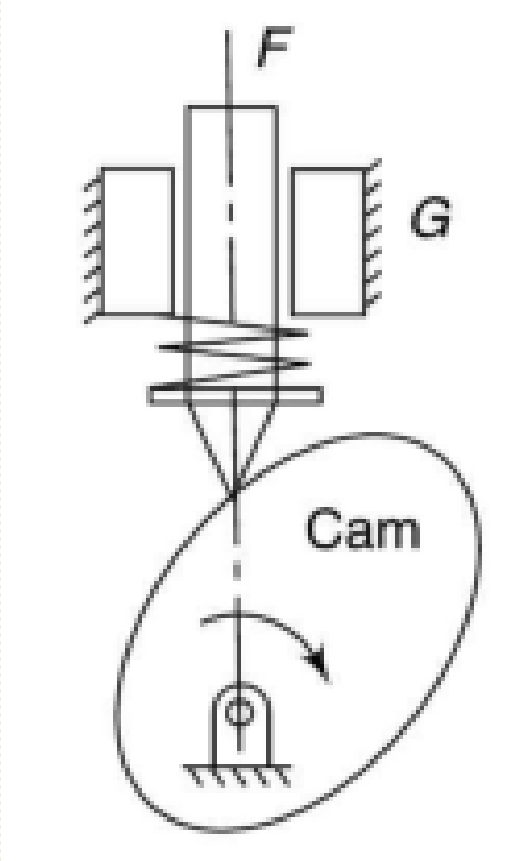
- is the total angle moved by the cam during the time, between the beginning of rise & the end of the return of the follower



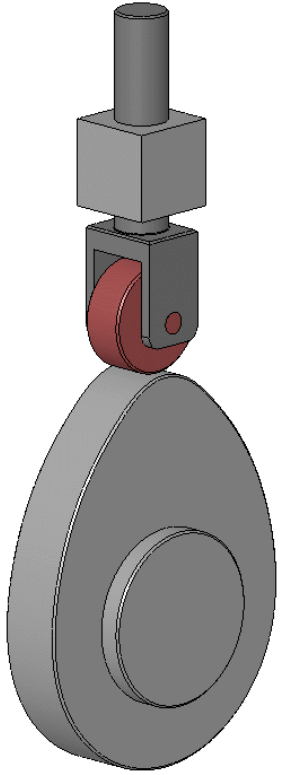
Topics

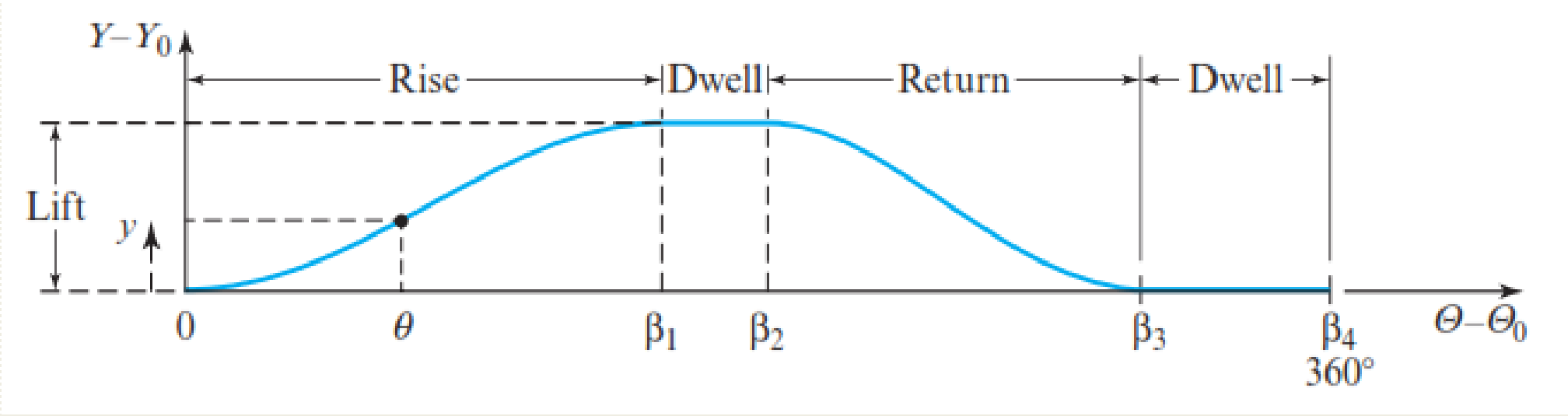


Synthesis of Cam profile



Description of the Follower Movement

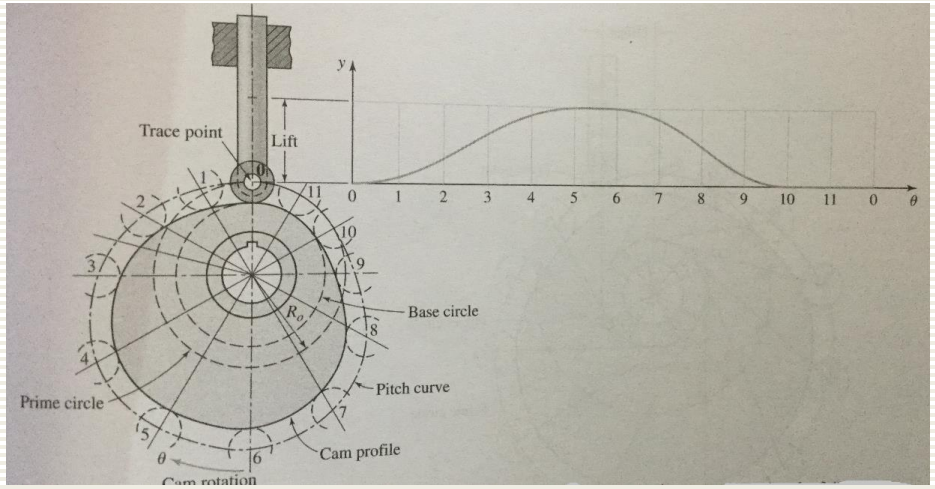




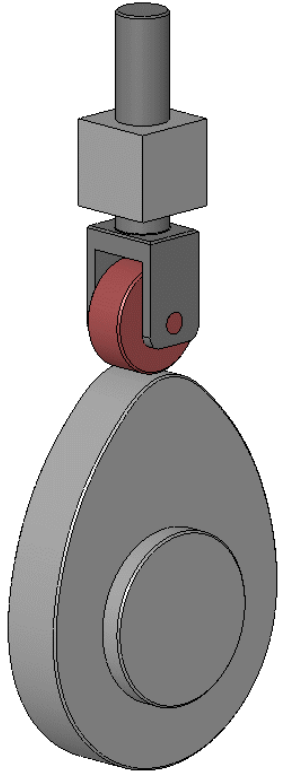
Motion of the Follower

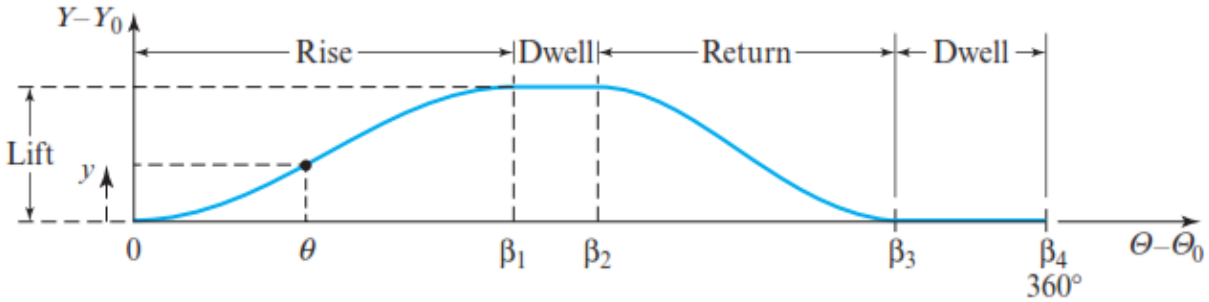
- Uniform motion or Constant velocity & its modification
- Uniform Acceleration & deceleration motion /Parabolic motion
- Simple Harmonic Motion
- Cycloidal motion

Displacement Diagram of Radial Cam



- Usually, cam system is a single DOF device.
- It is driven by a known input motion, usually a shaft that rotates at constant speed & it is intended to produce a certain desired output motion for the follower.





DISPLACEMENT DIAGRAMS

During the rotation of the cam through one cycle of input motion, the follower executes a series of events as demonstrated in graphical form in the Displacement Diagram

Rise: is the portion of the displacement diagram in which the motion of the follower is away from the cam centre. **The maximum rise is called Lift.**

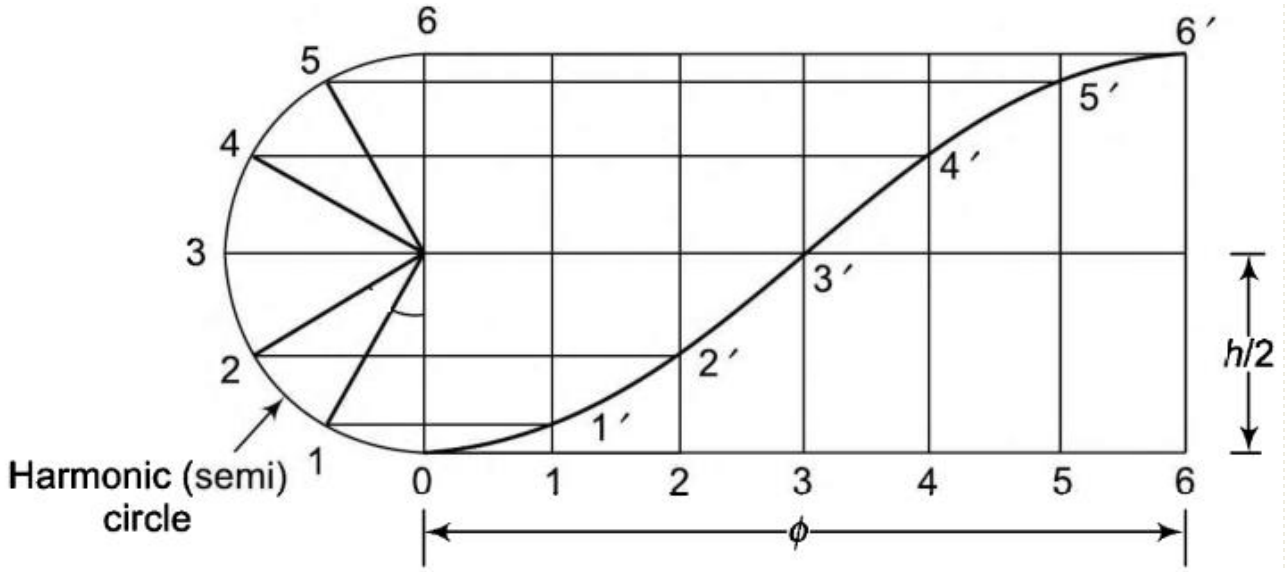
Return: is the portion of the displacement diagram in which the motion of the follower is toward the cam centre

Dwell: is the portion of the cycle during which the follower is at rest.

Construction of Displacement Diagram

- **Simple Harmonic Motion**

The follower rises through a distance h while the cam turns through an angle φ.



h = maximum follower displacement

φ = cam rotation angle for the maximum follower displacement

(i) Draw a semicircle with cam rise (or fall) as the diameter. This is, usually known as the harmonic (semi) circle. Divide this semicircle into n equal arcs (n even).

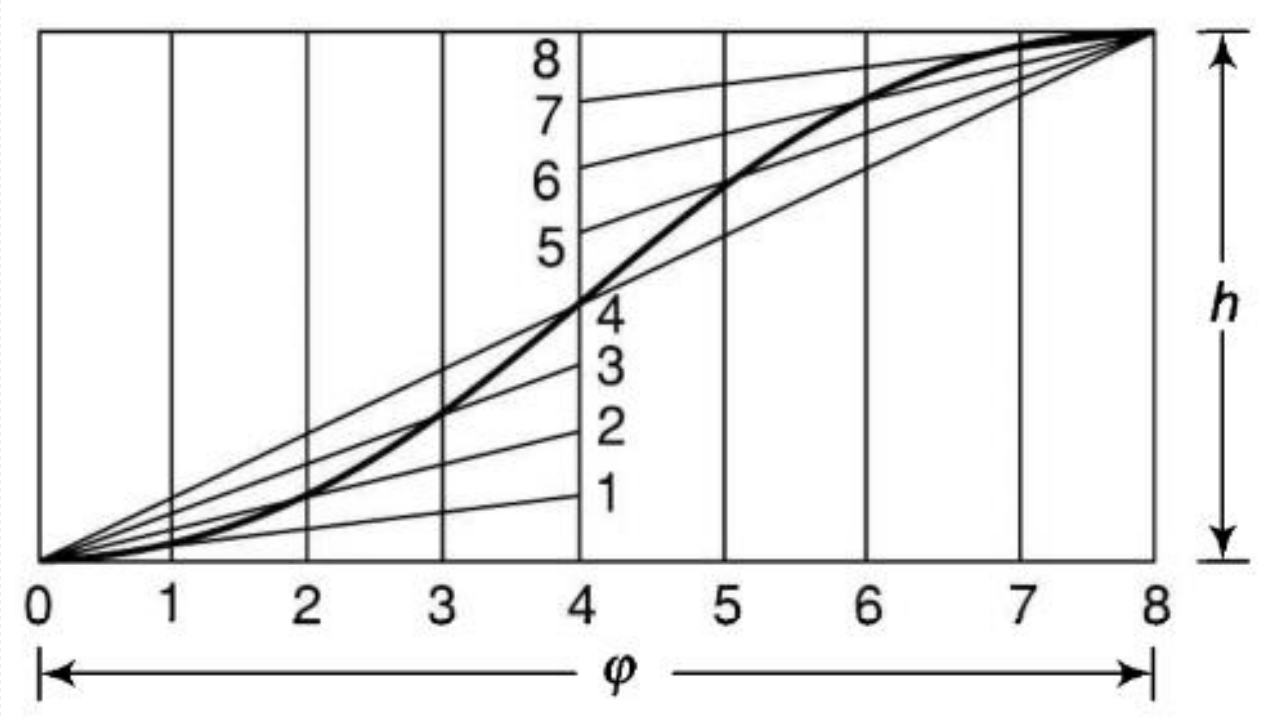
(ii) Divide the cam displacement interval into n equal divisions.

(iii) Project the intercepts of the harmonic semicircle to the corresponding divisions of the cam displacement interval.

(iv) Join the points with a smooth curve to obtain the required harmonic curve.

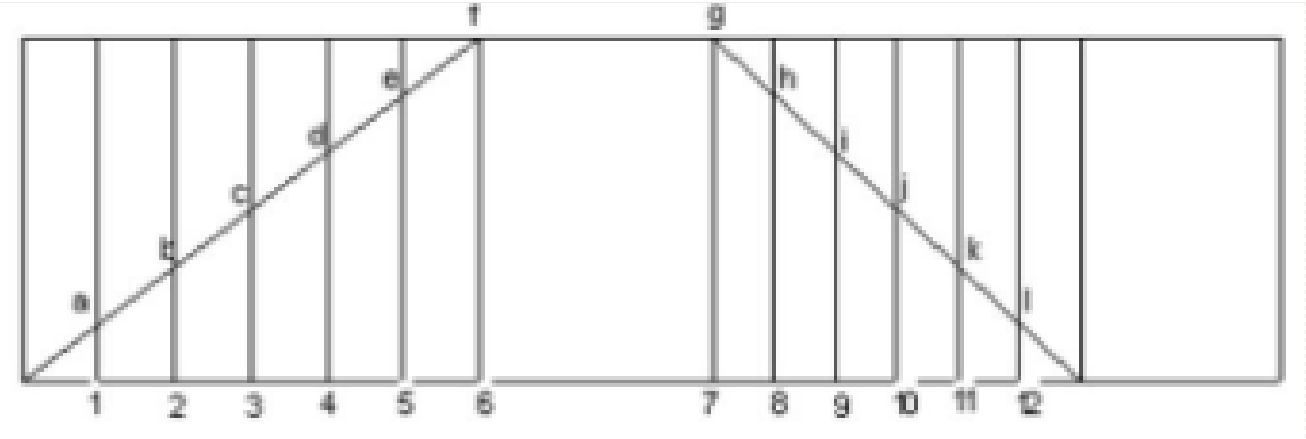
Construction of Displacement Diagram

- **Uniform Acceleration & deceleration motion /Parabolic motion**



Construction of Displacement Diagram

- **Uniform motion or Constant velocity**



Layout of Cam Profile

A cam profile is constructed on the principle of kinematic inversion, i.e., considering the cam to be stationary and the follower to be rotating about it in the opposite direction of the cam rotation.

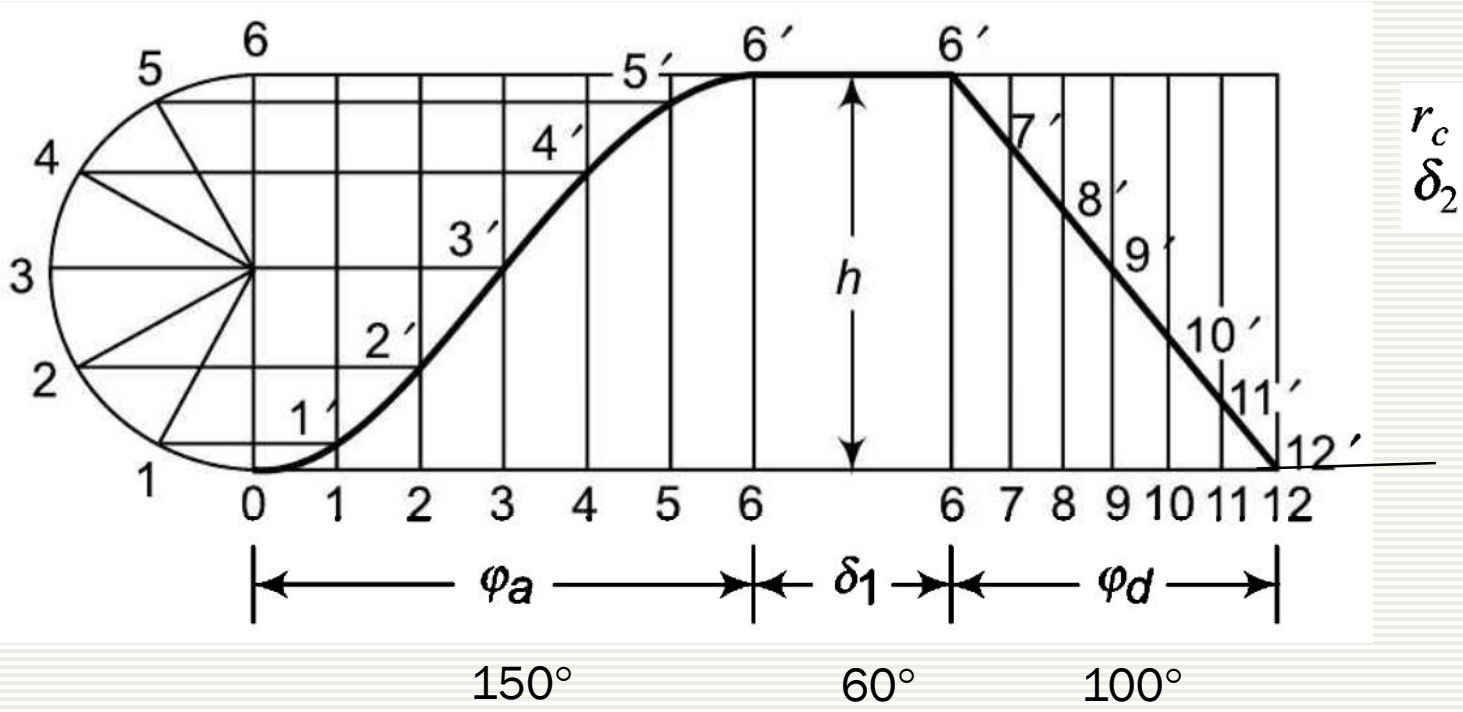
Steps:

1. Draw the displacement diagram of the follower according to the given follower motion by dividing the cam displacement interval into n equal parts
   usual number taken is 6, 8, 10 or 12 depending upon the angular displacement and convenience.
2. Draw the prime circle of the cam with radius
   (a) r_c if it is a knife-edge follower
   (b) $r_c + r_r$ if it is a roller follower
3. Divide the prime circle into segments as follows:
   In case of a radial follower, divide the circle from the vertical position indicating the angles of ascent, dwell period and angle of descent, etc., in the opposite direction of the cam rotation
4. Further, divide each segment of ascent and descent into the same number of angular parts as is done in the displacement diagram.
5. On the radial lines produced, mark distances equal to the lift of the follower beyond the circumference of the prime circle

For a knife-edge follower, draw a smooth curve passing through the marked points which is the required cam profile

A cam operating a knife-edge radial follower having a lift of 30 mm. the cam raises the follower with SHM for 150 deg. of the rotation followed by a period of dwell for 60 deg. The follower descends for the next 100 deg. with uniform velocity, again followed by a dwell period. The cam has a minimum radius of 20 mm & rotates clockwise at a uniform velocity. Draw the profile of the cam.

Construction of Displacement Diagram



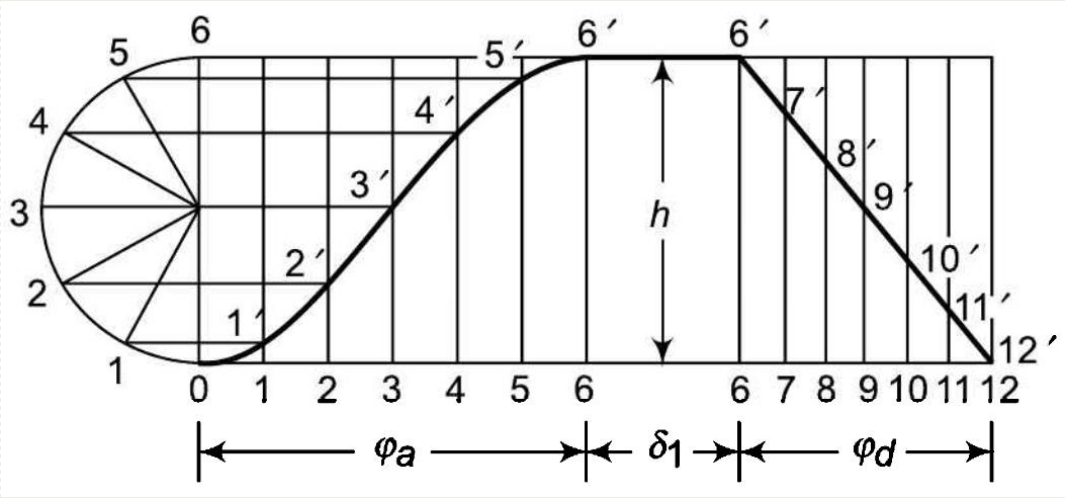
$h = 30$ mm $\quad \varphi_a = 150°$

$N = 120$ rpm $\quad \delta_1 = 60°$

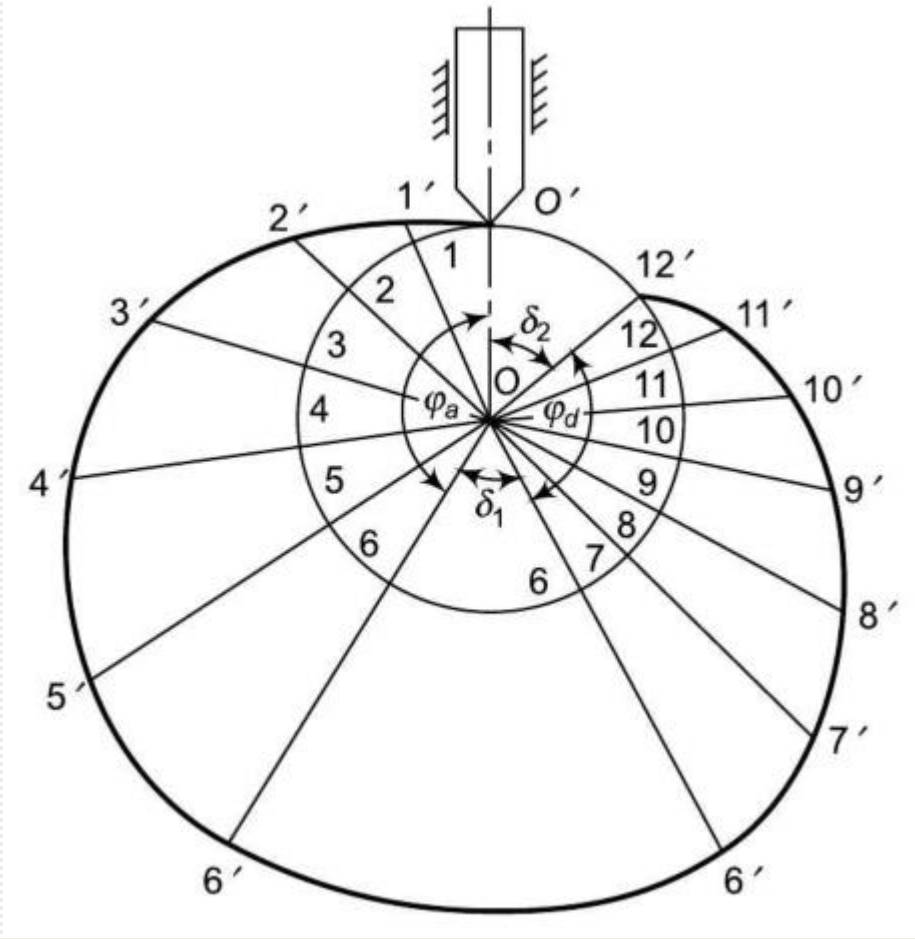
$r_c = 20$ mm $\quad \varphi_d = 100°$

$\delta_2 = (360° - 150° - 100° - 60°) = 50°$

Layout of Cam Profile



150° 60° 100°



(i) Draw a circle with radius r_c.

(ii) If the cam rotates clockwise and the follower remains in vertical direction, the cam profile can be drawn by assuming that the cam is stationary and the follower rotates about the cam in the counter-clockwise direction.
From the vertical position, mark angles φ_a, δ_1, φ_d, and δ_2 in the counter-clockwise direction, representing angles of ascent, rest or dwell, descent and rest respectively.

(iii) Divide the angles φ_a and φ_d into same number of parts as is done in the displacement diagram. In this case, each has been divided into 6 equal parts.

(iv) Draw radial lines O-1, O-2, O-3, etc., O-1 represents that after an interval of $\varphi_d/6$ of the cam rotation in the clockwise direction it will take the vertical position of O-O'.

(v) On the radial lines produced, take distances equal to the lift of the follower beyond the circumference of the circle with radius r_c, i.e., 1-1′, 2-2′, 3-3′, etc.

(vi) Draw a smooth curve passing through O', 1′, 2′,…., 10′, 11′ and 12′. Draw an arc of radius O-6′ for the dwell period δ_1.

A cam is to give the following motion to a radial knife-edged follower: (i) to raise the follower through 30 mm with uniform acceleration and deceleration during 120 deg. rotation of the cam, (ii) dwell for next 30 deg. of the cam rotation, (iii) to lower the follower with simple harmonic motion during the next 90 deg. rotation of the cam, (iv) dwell for the rest of the cam rotation.

The cam has a minimum radius of 30 mm and rotates counter-clockwise at a uniform speed. Draw the profile of the cam.