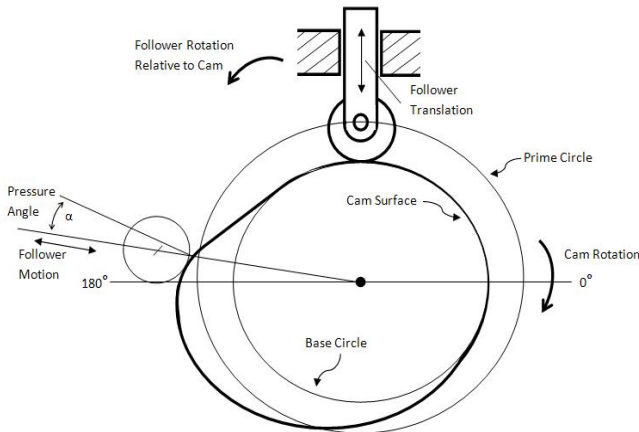## .1.What do u mean by cams and followers?

Cams are mechanical devices which are used to generate curvilinear or irregular motion of mechanical elements. They are used to convert rotary motion into oscillatory motion or oscillatory motion into rotary motion. There are two links namely the cam itself which acts as an input member. The other link that acts as an output member is called the follower. The cam transmits the motion to the follower by direct contact. In a cam-fo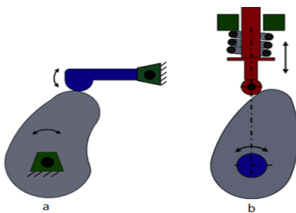llower pair, the cam usually rotates while the follower translates or oscillates. Complicated output motions which are otherwise difficult to achieve can easily be produced with the help of cams. Cams are widely used in internal combustion engines, machine tools, printing control mechanisms, textile weaving industries, automated machines etc.

Q.2.Classify various types of Followers

A follower is classified in two ways:
According to the motion of the follower

1. Reciprocating or Translating follower When the follower reciprocates in guides as the can rotates uniformly, it is known as reciprocating or translating follower.Shown in fig a.


2. Oscillating or Rotating follower When the uniform rotary motion of the cam is converted into predetermined oscillatory motion of the follower, it is called oscillating or rotating follower. shown in figure b.

Classification of follower based on motion
{Image:http://nptel.ac.in/courses/112103174/module4/lec3/2.html}

According to the nature of contact:

- The Knife-Edge follower: When contacting end of the follower has a sharp knife edge, it is called a knife edge follower. This cam follower mechanism is rarely used because of excessive wear due to small area of contact. In this follower a considerable thrust exists between the follower and guide.
- The Flat-Face follower: When contacting end of the follower is perfectly flat faced, it is called a flat faced follower. The thrust at the bearing exerted is less as compared to other followers. The only side thrust is due to friction between the contact surfaces of the follower and the cam. These are commonly used in automobiles.
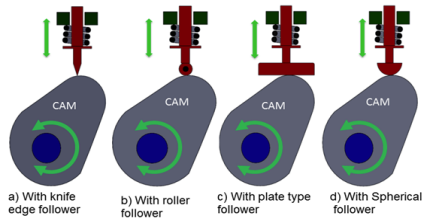
Types of follower based on the surface in contact
{Image source : http://nptel.ac.in/courses/112103174/module4/lec3/2.html }

- The Roller follower :When contacting end of the follower is a roller, it is called a roller follower. Wear rate is greatly reduced because of rolling motion between contacting surfaces. In roller followers also there is side thrust present between follower and the guide. Roller followers are commonly used where more space is available such as large stationary gas or oil engines and aircraft engines.

- The Spherical-Faced follower :When contacting end of the follower is of spherical shape, it is called a spherical faced follower. In flat faced follower high surface stress are produced. To minimize these stresses the follower is machined to spherical shape.

According to the path of motion of the follower:

1. Radial follower When the motion of the follower is along an axis passing through the centre of the cam, it is known as radial follower.

2. Off-set follower When the motion of the follower is along an axis away from the axis of the cam centre, it is called off-set follower.
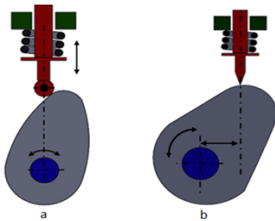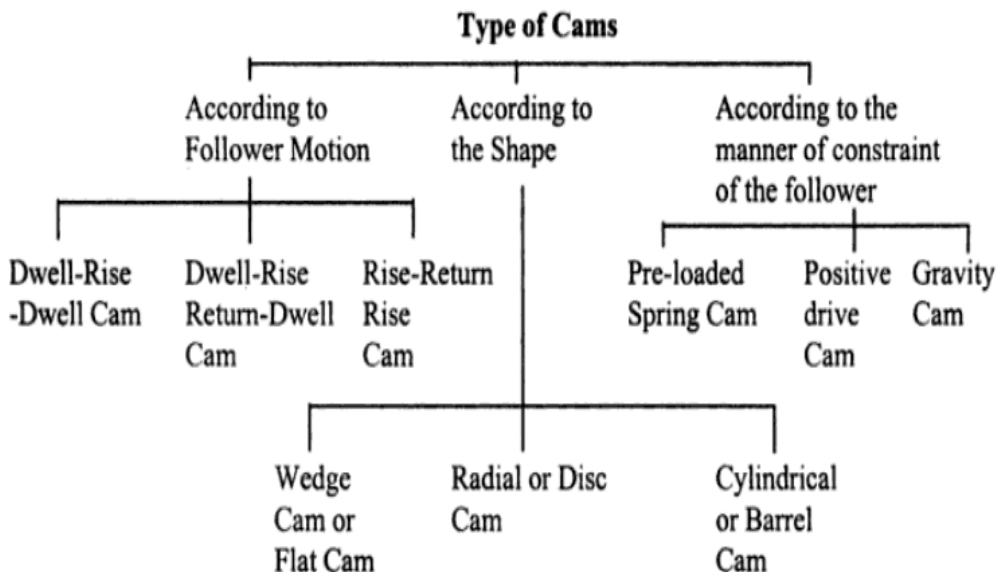

Figure 4.3.7 Classification of follower based on line of motion
{image source : http://nptel.ac.in/courses/112103174/module4/lec3/3.html }

`Q.3.Classify cams.

Type of Cams

According to Follower Motion | According to the Shape | According to the manner of constraint of the follower

Dwell-Rise-Dwell Cam | Dwell-Rise Return-Dwell Cam | Rise-Return Rise Cam | Pre-loaded Spring Cam | Positive drive Cam | Gravity Cam

Wedge Cam or Flat Cam | Radial or Disc Cam | Cylindrical or Barrel Cam

1. Wedge or flat cam :

A wedge cam has a wedge of specified contour and has translational motion. The follower can either translate or oscillate. A spring is used to maintain the contact between the cam and the follower. Figure below shows the typical arrangement of Wedge cam.

Wedge cam
{ Image source : http://nptel.ac.in/courses/112103174/module4/lec3/1.html}
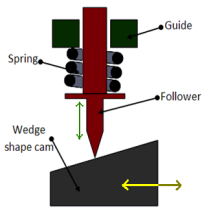
2. Radial or disc (Plate) Cam : In this type of cams, the follower moves in a radial direction from the centre of rotation of the cam (Figure 4.3.3). They are also known as radial or disc cam. The follower reciprocates or oscillates in a plane normal to the cam axis. Plate cams are very popular due to their simplicity and compactness.
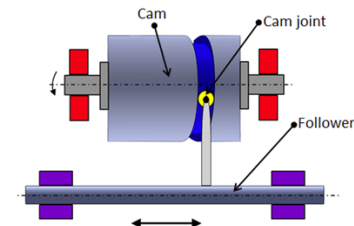
3. Cylindrical cam : Here a cylinder has a circumferential contour cut in the surface and the cam rotates about its axis as shown in figure below. The follower motion is either oscillating or reciprocating type. These cams are also called drum or barrel cams.

CYLINDRICAL CAM
{source : http://nptel.ac.in/courses/112103174}

Q. 4. Why Roller follower is preferred over knife edge follower.

Knife edge follower has more **rubbing action** on the cam plate due to which there is more wear and tear of cam plate, as well as more power is required for driving the cam due to more frictional force between cam and follower.

Whereas in roller follower there is **rolling action** on the cam plate due to which there is less wear as well as less power required to drive.

Hence Roller follower is preferred over knife edge follower.

Q. 5. Define radial follower and offset follower

Radial follower When the motion of the follower is along an axis passing through the centre of the cam, it is known as radial follower.

Off-set follower When the motion of the follower is along an axis away from the axis of the cam centre, it is called off-set follower.
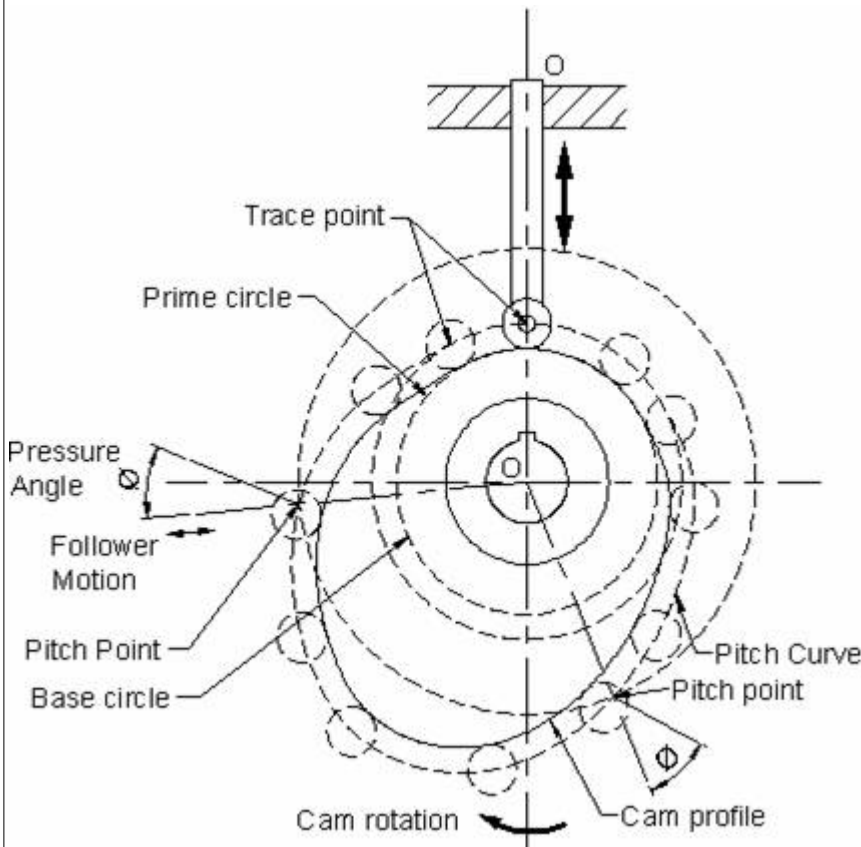
Q. 6. State any two types of motion of the follower.

The follower, during its travel, may have one of the following motions.
1. Uniform velocity,
2. Simple harmonic motion,
3. Uniform acceleration and retardation,
4. Cycloidal motion.

Q. 7. Define the following terms related to cams

i) Trace point ii) Pitch curve iii) Prime circle iv) Lift of stroke

ANS:**i) Trace point** : It is a reference point on the follower and is used to generate the pitch curve. In case of knife edge follower, the knife edge represents the trace point and the pitch curve corresponds to the cam profile. In a roller follower, the centre of the roller represents the trace point.

ii) Pitch curve : It is the curve generated by the trace point as the follower moves relative to the cam. For a knife edge follower, the pitch curve and the cam profile are same whereas for a roller follower, they are separated by the radius of the roller.

iii) Prime circle It is the smallest circle that can be drawn from the centre of the cam and tangent to the pitch curve. For a knife edge and a flat face follower, the prime circle and the base circle are identical. For a roller follower, the prime circle is larger than the base circle by the radius of the roller

iv) Lift of stroke. It is the maximum travel of the follower from its lowest position to the topmost position

Graphical Problems Solved

A cam, with a minimum radius of 50 mm, rotating clockwise at a uniform speed, is required to give a knife edge follower the motion as described below :

1. To move outwards through 40 mm during 100° rotation of the cam ; 2. To dwell for next 80° ; 3. To return to its starting position during next 90°, and 4. To dwell for the rest period of a revolution i.e. 90°.

Draw the profile of the cam

(i) when the line of stroke of the follower passes through the centre of the cam shaft,

The displacement of the follower is to take place with uniform acceleration and uniform retardation.

(a) Displacement diagram
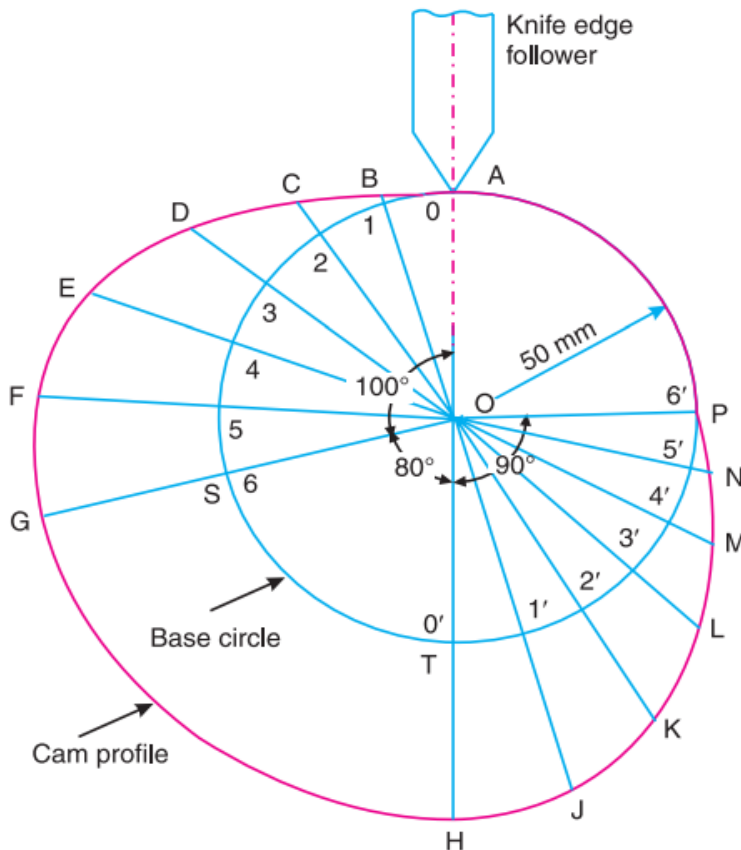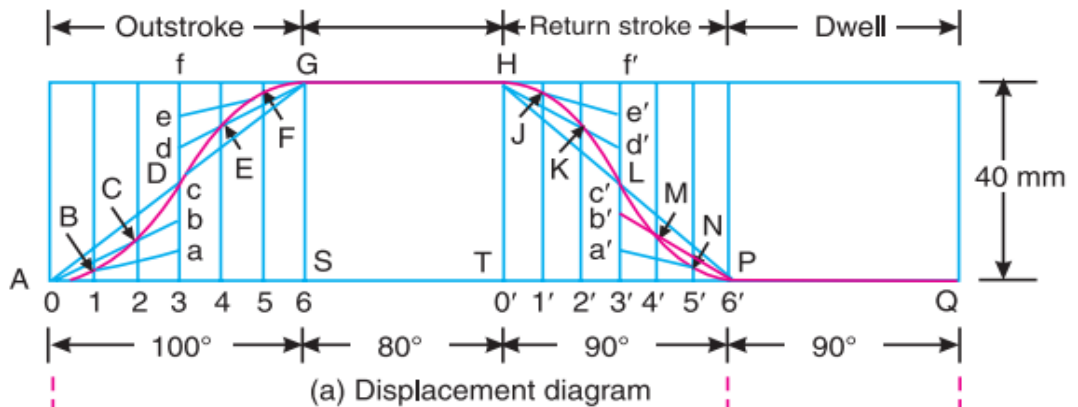
A cam is to be designed for a knife edge follower with the following data :

1. Cam lift = 40 mm during 90° of cam rotation with simple harmonic motion.
2. Dwell for the next 30°.
3. During the next 60° of cam rotation, the follower returns to its original position with simple harmonic motion.
4. Dwell during the remaining 180°.

Draw the profile of the cam when
(a) the line of stroke of the follower passes through the axis of the cam shaft, and
(b) the line of stroke is offset 20 mm from the axis of the cam shaft.

The radius of the base circle of the cam is 40 mm.
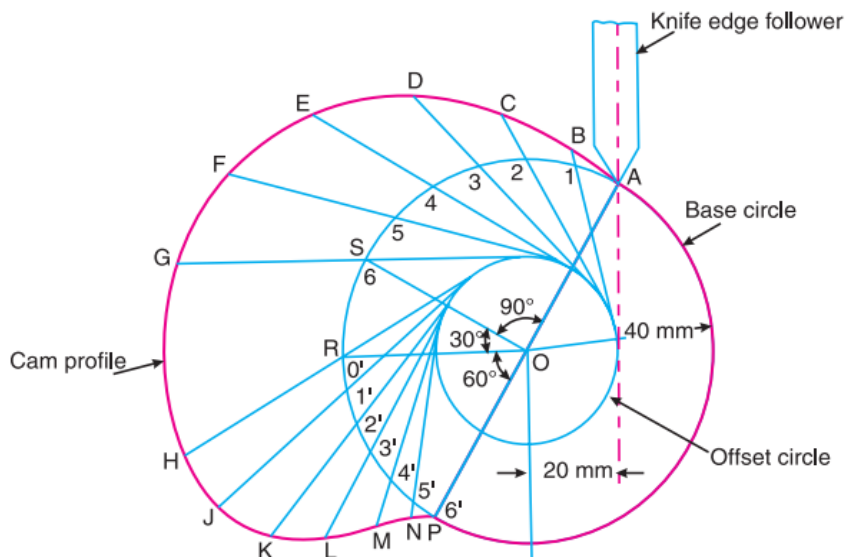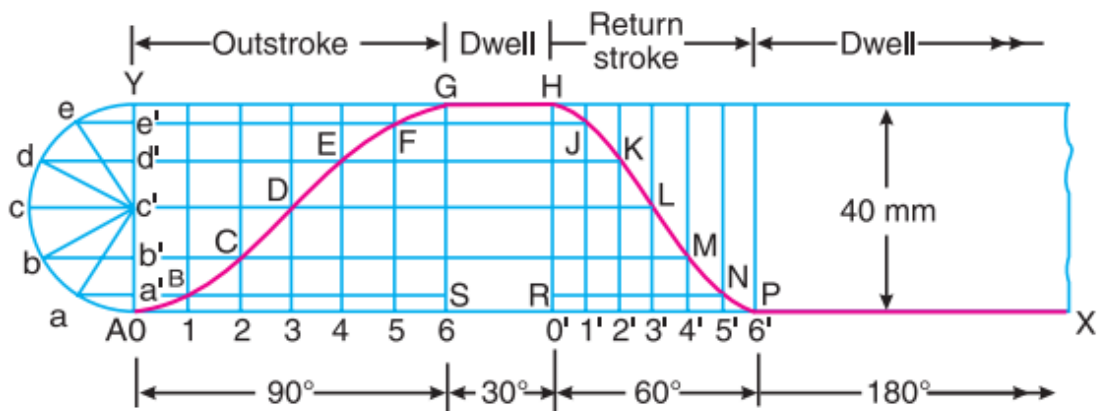
Example 20.7. *Design a cam for operating the exhaust valve of an oil engine. It is required to give equal uniform acceleration and retardation during opening and closing of the valve each of which corresponds to 60° of cam rotation. The valve must remain in the fully open position for 20° of cam rotation.*

The lift of the valve is 37.5 mm and the least radius of the cam is 40 mm. The follower is provided with a roller of radius 20 mm and its line of stroke passes through the axis of the cam.

Draw the profile of the cam when

the line of the stroke is offset 15 mm from the axis of the cam shaft.

Roller follower

Pitch curve

Cam profile
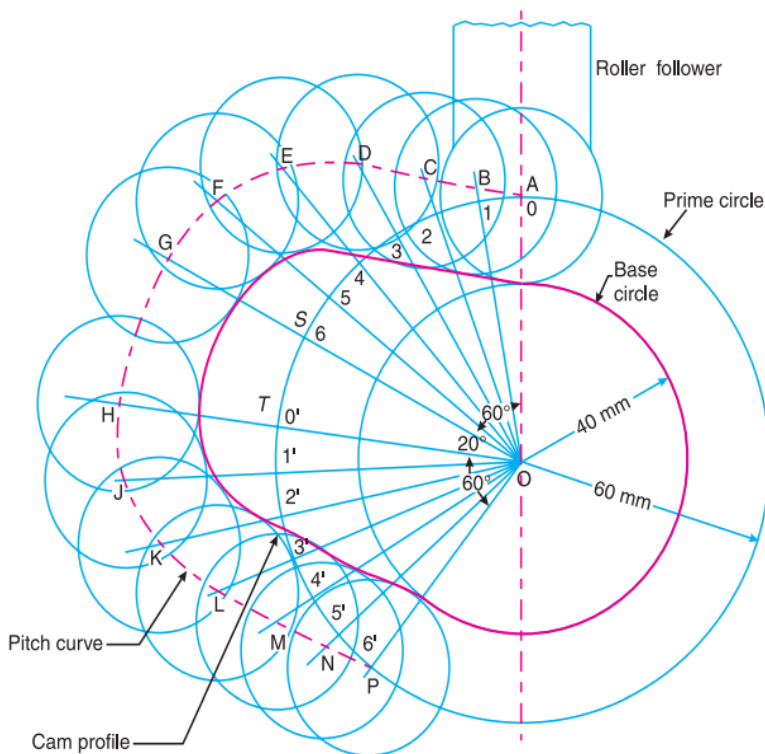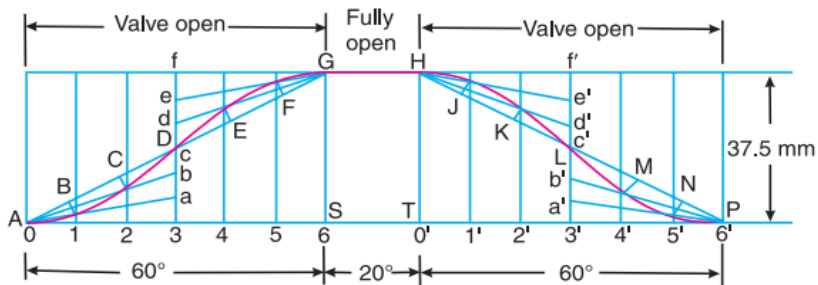
Example 20.3. *A cam, with a minimum radius of 25 mm, rotating clockwise at a uniform speed is to be designed to give a roller follower, at the end of a valve rod, motion described below :*

1. To raise the valve through 50 mm during 120° rotation of the cam ;

2. To keep the valve fully raised through next 30°;

3. To lower the valve during next 60°; and

4. To keep the valve closed during rest of the revolution i.e. 150° ;

The diameter of the roller is 20 mm and the diameter of the cam shaft is 25 mm.
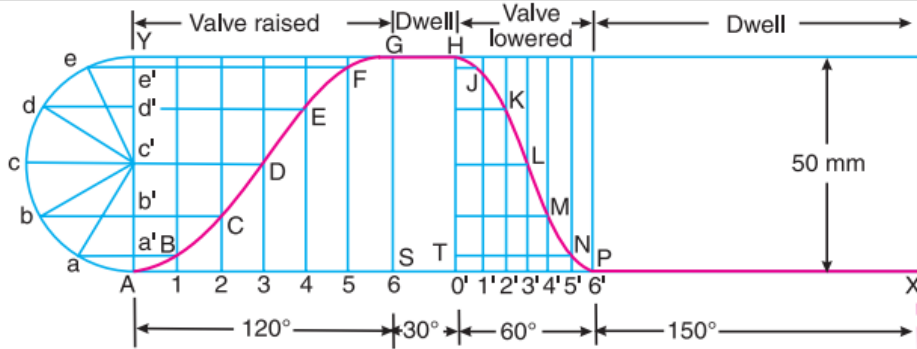
(a) Displacement diagram
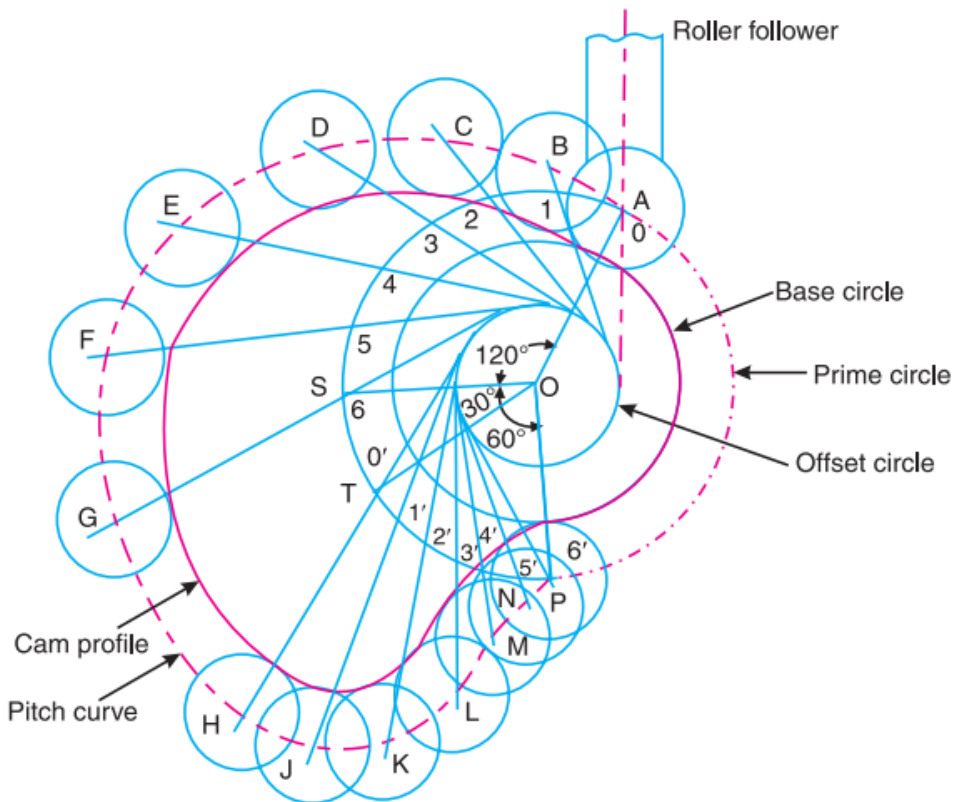
Graphical problems for practice

Q.1.A cam rotating at a uniform speed is required to give a knife edged follower motions as defined below :1. Follower to move outwards through a distance of 3cm during 90^0 of cam rotation with uniform velocity. 2. Follower to dwell for the next 60^0 of cam rotation .

3. Follower to return to its original position during 90^0 of cam rotation with uniform velocity.

4. Follower to dwell for the remaining period. The minimum radius of the cam is 5 cm . Draw the cam profile for the following cases :When the follower translates along the axis of the cam.

Q.2. Draw the cam profile for a translating knife edged follower moving with uniform acceleration and retardation as given below :

a] The follower moves outwards during 120^0 of cam rotation. b] The follower dwells for 60^0 of cam rotation .c] Follower dwells for remaining period of 90^0 of cam rotation.

The minimum radius of the cam is 3cm and the stroke of the follower is 3cm .

Q.3. Design a cam profile for operating the exhaust valves of an oil engine. The follower is required to execute the simple harmonic motion during the opening and closing of the valve . The valve opens during the cam rotation of 60^0, remains open for 25^0 and then closes during the next 60^0 of cam rotation and remains closed for the remainder of the period. The lift of the valve is 3 cm and the minimum radius of the cam is 4 cm . The follower is provided with 3 cm.

Q.4. Draw the profile of a disc cam to give uniform velocity motion during outstroke of 40 mm to roller follower of diameter 20 mm during the first half of cam rotation. The return of the cam takes place with uniform acceleration and retardation during remaining half of cam rotation . Minimum radius of cam is 30 mm. The axis of follower passes through axis of cam rotating in anticlockwise direction.

Q.5.Draw the cam profile to give the following motions to a roller follower :

i) Lift of follower = 4 cm. ii) Outward stroke during 120^0 of cam rotation with S.H.M.

iii) Dwell period for the next 60^0 degrees of cam rotation.

iv) Return stroke during the next 90^0 with uniform velocity .

v) Minimum radius of cam = 5 cm. vi) Roller diameter = 2 cm.

Q.6.Draw the cam profile for knife edged follower to give the following data :

i) Outward stroke of 90^0 of cam rotation with S.H.M. iii) Dwell period = 30^0. iii) Return stroke = 120^0 of cam rotation with S.H.M. iv) Remaining is dwell period. v) Minimum radius of cam 4 cm. vi) Lift of follower is 4 cm. vii) The line of stroke of the follower is 2 cm offset on lefthand side. Cam rotates in clockwise direction.

Q.7.Draw the cam profile with roller follower to describe

the following motion :i) Follower to move outwards through 2.4 cm during 120^0 of cam rotation.

ii) Follower to dwell for the next 60^0 of cam rotation. iii) Follower to return to its initial position in the next 120^0 of cam rotation. iv) Follower to dwell for the rest of cam rotation.

The minimum radius of cam is 4.5 cm, the line of stroke of the follower is offset by 1.5 cm and the roller radius is 1cm. Displacement of the follower is to take place with uniform acceleration and retardation both for the outward and return strokes.

Q.8.Draw the profile of a cam to raise a valve with S.M.H. through 5 cm is 120^0 of revolution , keep if fully raised through 30^0 and lower it with equal uniform acceleration and retardation through 90^0 of rotation . The valve remains closed during the rest of rotation. The diameter of the roller is 2 cm and minimum radius of the cam is 5 cm . The axis of the valve rod is offset 2cm from the axis of the shaft. Assuming the cam rotating in anticlockwise direction.