

**24AG401 THEORY OF MACHINES**

**NOTES UNIT 2**

## Terms Used in Radial Cams

The following terms are important in order to draw the cam profile.

1. Base circle. It is the smallest circle that can be drawn to the cam profile.
2. 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.
3. Pressure angle. It is the angle between the direction of the follower motion and a normal to the pitch curve. This angle is very important in designing a cam profile. If the pressure angle is too large, a reciprocating follower will jam in its bearings.
4. Pitch point. It is a point on the pitch curve having the maximum pressure angle.
5. Pitch circle. It is a circle drawn from the centre of the cam through the pitch points.
6. 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.
7. 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.
8. Lift or stroke. It is the maximum travel of the follower from its lowest position to the topmost position.

### 1.10.3. Displacement, Velocity and Acceleration Diagrams when the Follower Moves with Uniform Velocity

The displacement, velocity and acceleration diagrams when a knife-edged follower moves with uniform velocity are shown in Figures. The abscissa (base) represents the time (i.e. the number of seconds required for the cam to complete one revolution) or it may represent the angular displacement of the cam in degrees. The ordinate represents the displacement, or velocity or acceleration of the follower. Since the follower moves with uniform velocity during its rise and return stroke, therefore the slope of the displacement curves must be constant. In other words, AB1 and C1D must be straight lines. A little consideration will show that the follower remains at rest during part of the cam rotation. The periods during which the follower remains at rest are known as dwell periods, as shown by lines B1C1 and DE. From Figure we see that the acceleration or retardation of the follower at the beginning and at the end of each stroke is infinite. This is due to the fact that the follower is required to start from rest and has to gain a velocity within no time. This is only possible if the acceleration or retardation at the beginning and at the end of each stroke is infinite. These conditions are however, impracticable.

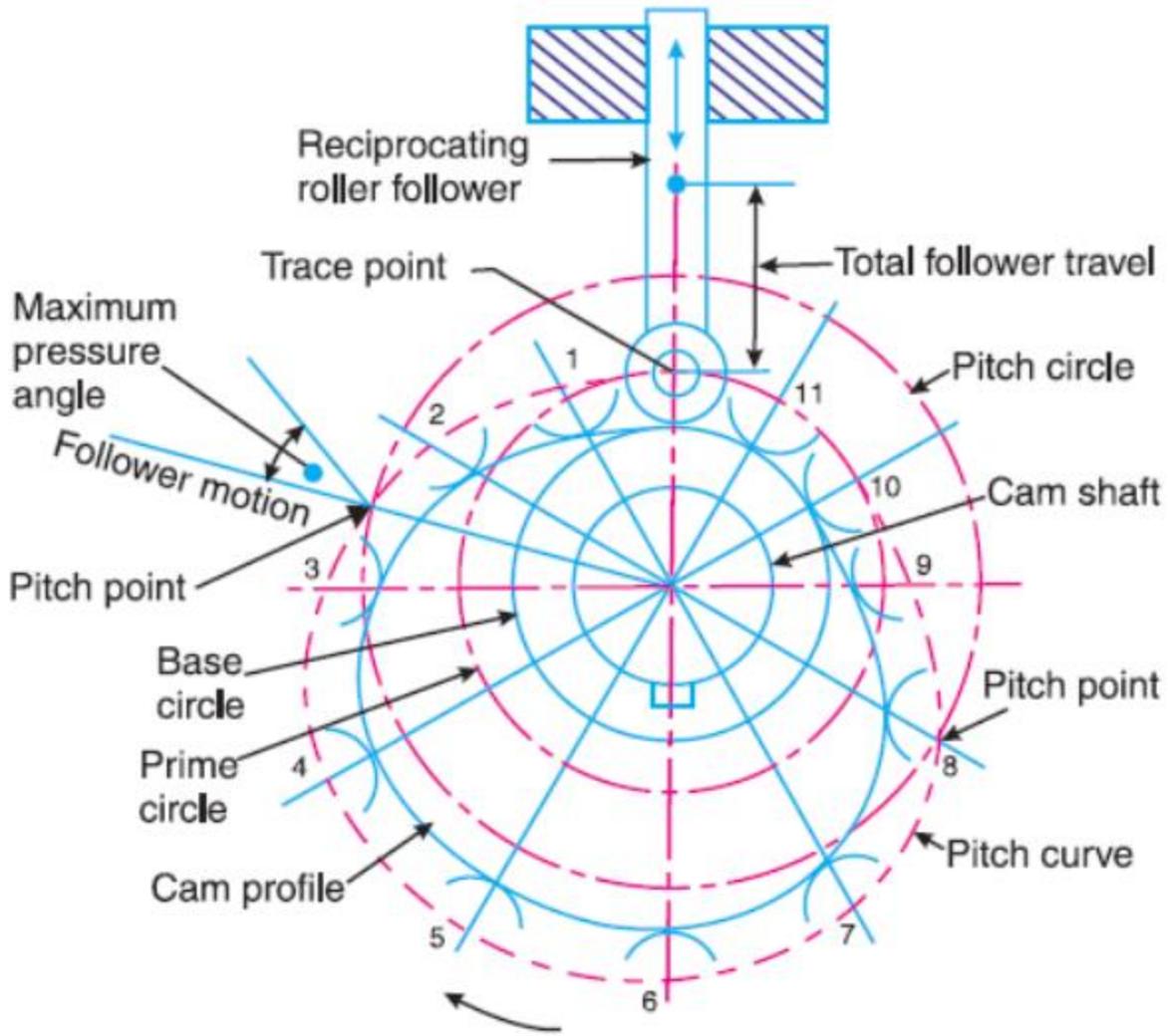
### **Displacement, Velocity and Acceleration Diagrams when the Follower Moves with Simple Harmonic Motion**

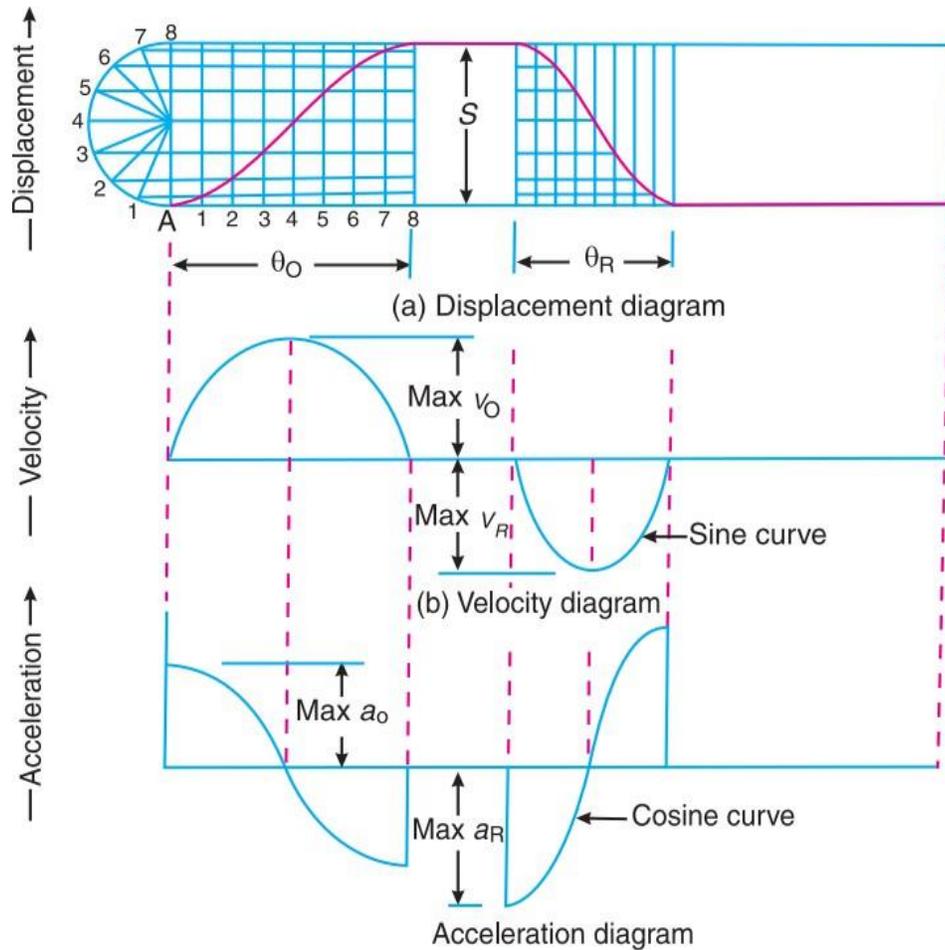
The displacement, velocity and acceleration diagrams when the follower moves with simple harmonic motion are shown in Figure.

The displacement diagram is drawn as follows :

1. Draw a semi-circle on the follower stroke as diameter.
2. Divide the semi-circle into any number of even equal parts (say eight).
3. Divide the angular displacements of the cam during out stroke and return stroke into the same number of equal parts.
4. The displacement diagram is obtained by projecting the points as shown in Figure.

The velocity and acceleration diagrams are shown in Fig. (b) and (c) respectively. Since the follower moves with a simple harmonic motion, therefore velocity diagram consists of a sine curve and the acceleration diagram is a cosine curve. We see from Figure that the velocity of the follower is zero at the beginning and at the end of its stroke and increases gradually to a maximum at mid-stroke. On the other hand, the acceleration of the follower is maximum at the beginning and at the ends of the stroke and diminishes to zero at mid-stroke



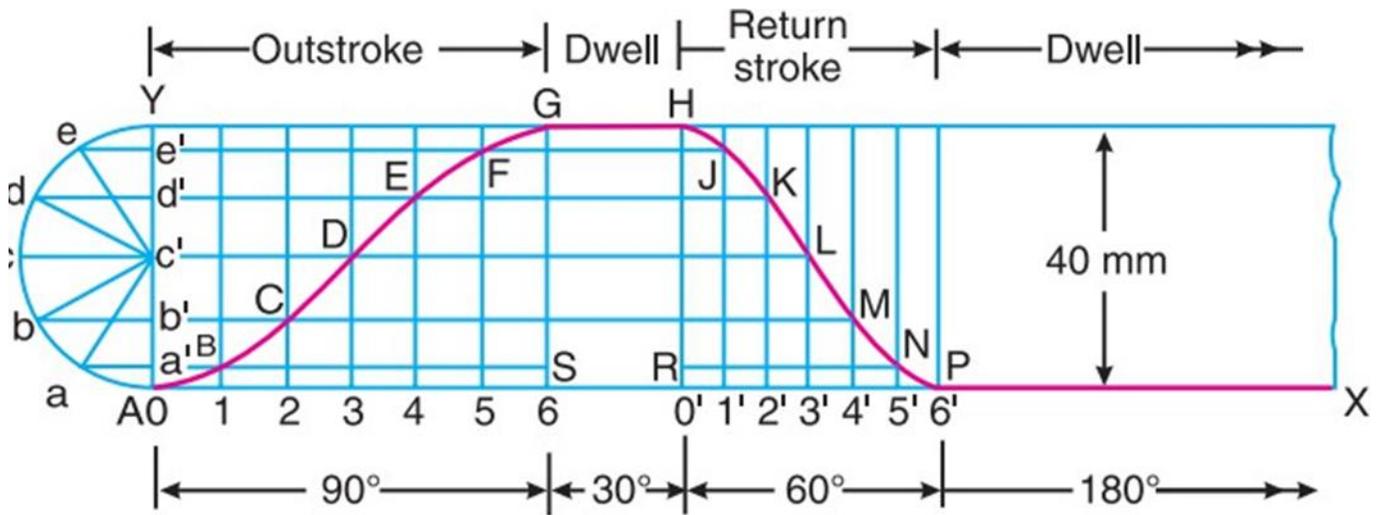


### Problem

A cam is to be designed for a knife edge follower with the following data : 1. Cam lift = 40 mm during  $90^\circ$  of cam rotation with simple harmonic motion. 2. Dwell for the next  $30^\circ$ . 3. During the next  $60^\circ$  of cam rotation, the follower returns to its original position with simple harmonic motion. 4. Dwell during the remaining  $180^\circ$ . 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. Determine the maximum velocity and acceleration of the follower during its ascent and descent, if the cam rotates at 240 r.p.m.

### Given :

$S = 40 \text{ mm} = 0.04 \text{ m}$ ;  $\theta_0 = 90^\circ = \pi/2 \text{ rad} = 1.571 \text{ rad}$ ;  $\theta_R = 60^\circ = \pi/3 \text{ rad} = 1.047 \text{ rad}$ ;  $N = 240 \text{ r.p.m}$



First of all, the displacement diagram, as shown in Figure, is drawn as discussed in the following steps :

1. Draw horizontal line  $AX = 360^\circ$  to some suitable scale. On this line, mark  $AS = 90^\circ$  to represent out stroke ;  $SR = 30^\circ$  to represent dwell ;  $RP = 60^\circ$  to represent return stroke and  $PX = 180^\circ$  to represent dwell.
2. Draw vertical line  $AY = 40 \text{ mm}$  to represent the cam lift or stroke of the follower and complete the rectangle as shown in Figure.
3. Divide the angular displacement during out stroke and return stroke into any equal number of even parts (say six) and draw vertical lines through each point.
4. Since the follower moves with simple harmonic motion, therefore draw a semicircle with  $AY$  as diameter and divide into six equal parts.
5. From points  $a, b, c \dots$  etc. draw horizontal lines intersecting the vertical lines drawn through  $1, 2, 3 \dots$  etc. and  $0', 1', 2' \dots$  etc. at  $B, C, D \dots M, N, P$ .
6. Join the points  $A, B, C \dots$  etc. with a smooth curve as shown in Figure.. This is the required displacement diagram.

