Subject Name & Code:

KINEMATICS AND THEORY OF MACHINES- BE04000171

Assignment – 2

Q-1: A cam is to give the following motion to a knife-edged follower: 1. Outstroke during 60° of cam rotation; 2. Dwell for the next 30° of cam rotation; 3. Return stroke during next 60° of cam rotation, and 4. Dwell for the remaining 210° of cam rotation. The stroke of the follower is 40 mm and the minimum radius of the cam is 50 mm. The follower moves with uniform velocity during both the outstroke and return strokes. Draw the profile of the cam when (a) the axis of the follower passes through the axis of the camshaft, and (b) the axis of the follower is offset by 20 mm from the axis of the camshaft.

Answer:

Given:
Stroke = 40 mm, Min radius = 50 mm
Outstroke: 60°, Dwell: 30°, Return: 60°, Dwell: 210°
Follower motion: Uniform velocity

To Find:
Cam profile for (a) inline, (b) offset 20 mm

Formula – Uniform Velocity

Outstroke: $s = \frac{40}{60} \times \theta$ (θ in degrees)
Return: $s = 40 - \frac{40}{60} \times (\theta - 90)$

Solution – Construction Steps for Profile

(a) Inline (axis through cam centre)

1. Draw base circle radius 50 mm.
2. Divide outstroke (60°) into 6 equal parts (10° each).
   Displacement: 0, 6.67, 13.33, 20, 26.67, 33.33, 40 mm.
3. Dwell 30° → radius = 50+40 = 90 mm constant.

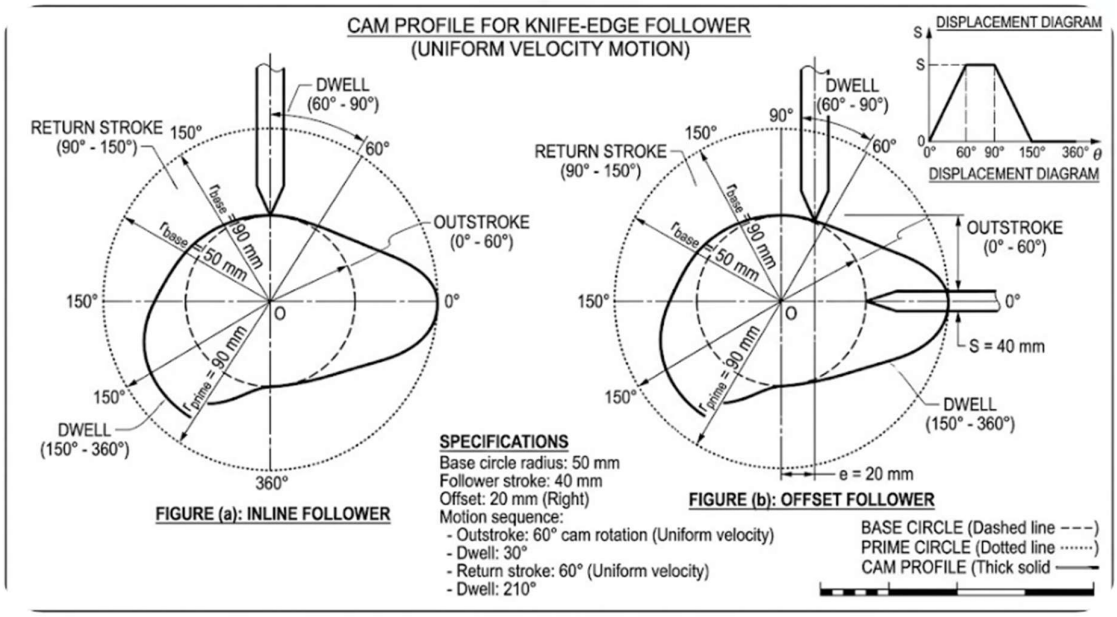
4. Return 60° → divide into 6 parts, displacement decreases uniformly.
5. Dwell 210° → radius = 50 mm.
6. Plot points and draw smooth curve.

(b) Offset 20 mm
Same displacement diagram, but lift points are plotted on lines tangent to offset circle (radius 20 mm) drawn concentric with cam.

Final Answer:

Profile drawn as per construction steps above

Figure Just for Reference:



Q-2: 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 SHM. 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 camshaft, and (b) the line of stroke is offset 20 mm from the axis of the camshaft. 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.

Answer:

Given:
Lift = 40 mm, Base circle radius = 40 mm

Outstroke: 90° (SHM), Dwell: 30°, Return: 60° (SHM), Dwell: 180°
Cam speed N = 240 rpm

To Find:
Max velocity & acceleration during ascent & descent, and cam profile.

Formula – SHM

$$s = \frac{h}{2}\left[1 - \cos\left(\frac{\pi\theta}{\Theta}\right)\right]$$
$$v_{max} = \frac{\pi h\omega}{2\Theta} \text{ (ω in rad/s)}$$
$$a_{max} = \frac{\pi^2 h\omega^2}{2\Theta^2}$$

where Θ = cam angle for motion (in radians)

Solution

$$\omega = \frac{2\pi \times 240}{60} = 25.133 \text{ rad/s}$$

Ascent (Θ = 90° = π/2 rad):

$$v_{max} = \frac{\pi \times 0.04 \times 25.133}{2 \times (\pi/2)} = \frac{\pi \times 0.04 \times 25.133}{\pi} = 0.04 \times 25.133 = 1.005 \text{ m/s}$$
$$a_{max} = \frac{\pi^2 \times 0.04 \times (25.133)^2}{2 \times (\pi/2)^2} = \frac{\pi^2 \times 0.04 \times 631.66}{2 \times (\pi^2/4)} = \frac{0.04 \times 631.66}{0.5} = 50.53 \text{ m/s}^2$$

Descent (Θ = 60° = π/3 rad):

$$v_{max} = \frac{\pi \times 0.04 \times 25.133}{2 \times (\pi/3)} = \frac{0.04 \times 25.133 \times 3}{2} = 1.508 \text{ m/s}$$
$$a_{max} = \frac{\pi^2 \times 0.04 \times 631.66}{2 \times (\pi/3)^2} = \frac{0.04 \times 631.66}{2 \times (1/9)} = \frac{25.266}{0.222} = 113.8 \text{ m/s}^2$$

Profile construction: Similar to Q1, using SHM displacement. Offset 20 mm case uses offset circle.

Q-3: A cam drives a flat reciprocating follower in the following manner: During the first 120° rotation of the cam, the follower moves outwards through a distance of 20 mm with simple harmonic motion. The follower dwells during next 30° of cam rotation. During the next 120° of cam rotation, the follower moves inwards with

simple harmonic motion. The follower dwells for the next 90° of cam rotation. The minimum radius of the cam is 25 mm. Draw the profile of the cam.

Answer:

Given:
Flat reciprocating follower
Outstroke: 120° (SHM, 20 mm), Dwell: 30°
Return: 120° (SHM), Dwell: 90°
Min radius = 25 mm

To Find:
Cam profile

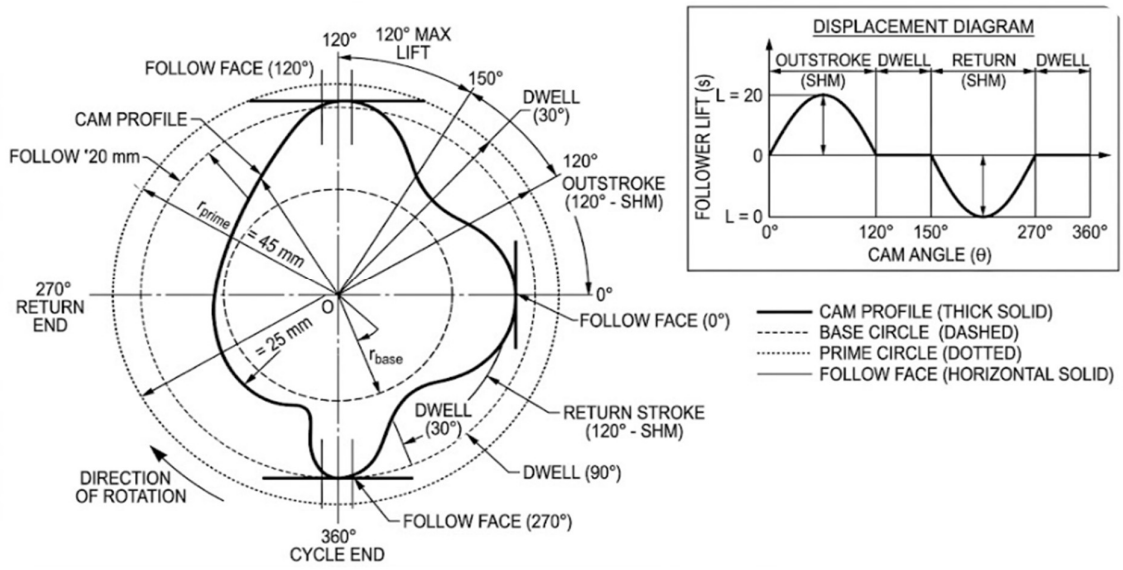
Solution – Construction Steps for Flat Follower

1. Base circle radius = 25 mm.
2. Draw displacement diagram for SHM:
   For 0° to 120°: s = $10[1 - \cos(1.5\theta)]$ (θ in radians? Actually 0 to 120°, use formula)
3. For flat face follower, cam profile is obtained by drawing the follower face (flat line) at each angular position, tangent to the radius (base + displacement).
   The centre of the roller follower method is modified — instead, plot points at distance = base radius + displacement from cam centre, perpendicular to follower axis.
4. Connect points smoothly.

Final Answer:

Profile drawn with base circle R=25 mm, lift 20 mm, SHM motion

Figure Just for Reference:



Q-4: 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 the next 80°; 3. To return to its starting position during the 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 camshaft, and (ii) when the line of stroke of the follower is off-set by 15 mm. The displacement of the follower is to take place with uniform acceleration and uniform retardation. Determine the maximum velocity and acceleration of the follower when the camshaft rotates at 900 r.p.m. Draw the displacement, velocity and acceleration diagrams for one complete revolution of the cam.

Answer:

Given:
Min radius = 50 mm, Stroke = 40 mm
Outstroke: 100° (uniform accel & retard)
Dwell: 80°, Return: 90° (uniform accel & retard), Dwell: 90°
Cam speed N = 900 rpm

To Find:
Max velocity, max acceleration, displacement/velocity/acceleration diagrams, profile for inline & offset 15 mm.

Formula – Uniform Acceleration/Retardation

For outstroke:
Half stroke in $\Theta/2$:

$$v_{\max} = \frac{2h}{\Theta} \text{ (in rad measure? careful)}$$

Actually:

$$v_{\max} = \frac{2h\omega}{\Theta} (\Theta \text{ in rad})$$
$$a_{\max} = \frac{4h\omega^2}{\Theta^2}$$

Solution

$$\omega = \frac{2\pi \times 900}{60} = 94.248 \text{ rad/s}$$

Ascent (Θ = 100° = 1.745 rad):

$$v_{\max} = \frac{2 \times 0.04 \times 94.248}{1.745} = \frac{7.5398}{1.745} = 4.322 \text{ m/s}$$
$$a_{\max} = \frac{4 \times 0.04 \times (94.248)^2}{(1.745)^2} = \frac{0.16 \times 8882.7}{3.045} = \frac{1421.23}{3.045} = 466.8 \text{ m/s}^2$$

Descent (Θ = 90° = 1.571 rad):

$$v_{\max} = \frac{2 \times 0.04 \times 94.248}{1.571} = \frac{7.5398}{1.571} = 4.80 \text{ m/s}$$
$$a_{\max} = \frac{4 \times 0.04 \times 8882.7}{(1.571)^2} = \frac{1421.23}{2.468} = 575.9 \text{ m/s}^2$$

Displacement diagram: Parabolic segments (symmetric).

Profile: Similar to Q1, using parabolic displacement.

Final Answer:

$$\boxed{v_{\max,asc} = 4.322 \text{ m/s},\ a_{\max,asc} = 466.8 \text{ m/s}^2}$$
$$\boxed{v_{\max,dsc} = 4.80 \text{ m/s},\ a_{\max,dsc} = 575.9 \text{ m/s}^2}$$

Q-5: Construct the profile of a cam to suit the following specifications: Camshaft diameter = 40 mm; Least radius of cam = 25 mm; Diameter of roller = 25 mm; The angle of lift = 120°; Angle of fall = 150°; Lift of the follower = 40 mm; Number of pauses are two of the equal intervals between motions. During the lift, the motion is S.H.M. During the fall the motion is uniform acceleration and deceleration. The speed of the camshaft is uniform. The line of stroke of the follower is offset 12.5 mm from the centre of the cam.

Answer:

Given:
Camshaft dia = 40 mm (irrelevant)
Least radius = 25 mm, Roller dia = 25 mm (radius = 12.5 mm)
Lift = 40 mm, Lift angle = 120° (SHM)
Fall angle = 150° (uniform accel/decel)
Two equal pauses between motions → means:
Lift 120°, Pause ?, Fall 150°, Pause ? — total 360°, so pauses = (360 – 120 – 150)/2 = 45° each.
Offset = 12.5 mm

To Find:
Cam profile (roller follower)

Solution – Construction Steps for Roller Follower

1. Base circle radius = 25 mm.
2. Draw offset circle radius = 12.5 mm.
3. Displacement diagram:
   For lift (120° SHM): use Q2 formula.
   For fall (150° uniform accel/decel): parabolic.
4. For roller follower:
   Draw pitch curve (centre of roller) at distance = base radius + displacement from cam centre, along lines tangent to offset circle.
   Then draw roller circles (radius 12.5 mm) along pitch curve.
   Inner envelope is cam profile.

Final Answer:

Profile constructed using roller follower method with offset 12.5 mm

Figure Just for Reference: