Drawing the Cam-Profile – Part #3

Cam Profile or Shape. Drawing the Cam Profile.

Learning Outcomes – Part #3

- Review of Module #7-Part #2 :
  - Desired motion of a cam-follower system and displacement diagram.
  - Cam-Follower Kinematics Profiles (Tables 9.1 – 9.4)
  - In-line, Knife-edge, and In-line Roller Follower.
- Construct Cam Profile with the Desired Cam-Follower Motion.

Cam-Follower Systems – Construct Cam Profile with Prescribed Cam-Follower Motion

- Once the desired motion of a cam-follower system has been defined through a displacement diagram (Part #2), the actual shape of the cam can be designed.
- The shape of the cam depends on the size of the cam and the geometric features as defined in Module #7, Part #1, in Cam nomenclature. Figure (a) shows the Cam nomenclature:

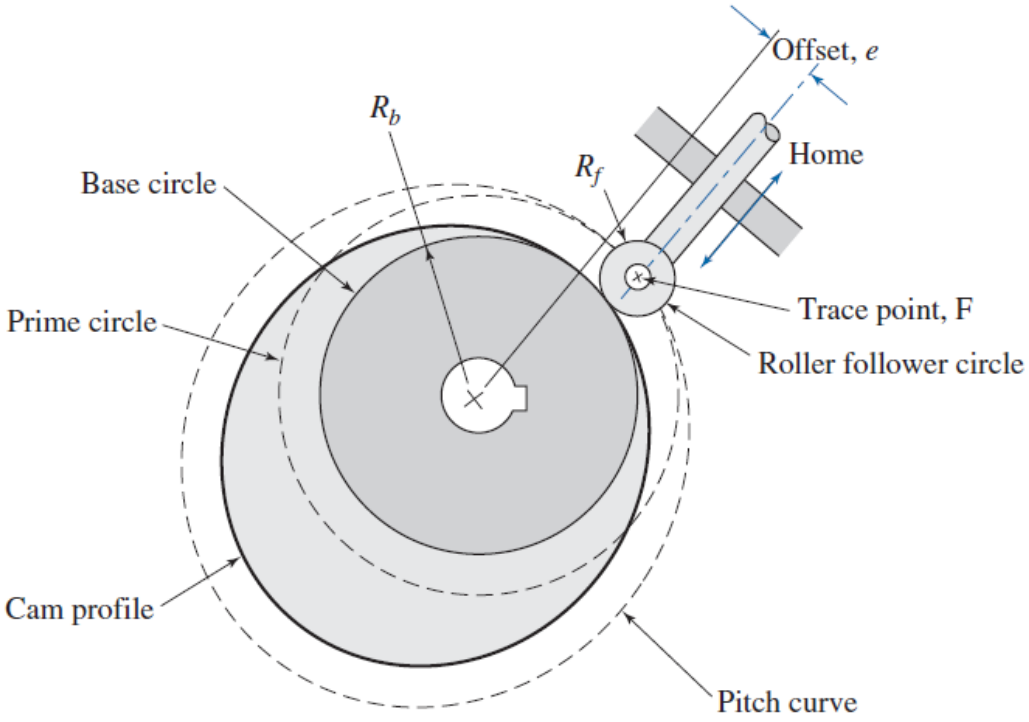

Figure (a)

Source: Myszka, D.H. Machines and Mech. Applied Kinematic Analysis. Prentice Hall. 4th Edition. USA.

Cam-Follower Systems – Construct Cam Profile with Prescribed Cam-Follower Motion

- *Procedure to Draw Displacement Diagram* for Cam-Follower System:

1. Calculate the "Time for a Full Cycle".
2. From Eq. (8-2), calculate the "Required Rotational Speed of the Cam".
3. Determine the Cam Rotation for Each Follower Motion Interval, β_i.
4. Calculate the displacement during Each Follower Motion Interval. The displacement diagram for a rise or fall interval is divided into two halves, one of constant acceleration and the other of constant deceleration.
5. Construct the shapes of each half of the displacement diagram as mirror-image parabolas [as shown in Figure (d)] .
6. Calculate the displacement during each follower motion interval using the cam-follower kinematics profiles as presented in Tables 9.1 – 9.4.

Cam-Follower Systems – Construct Cam Profile with Prescribed Cam-Follower Motion

- Procedure is used to graphically construct a *Cam Profile Design*:

1. Draw the base circle of radius R_B. The size is typically a function of the spatial constraints of the application.
2. Draw the follower in the home position.
3. Draw radial lines from the center of the cam, corresponding t the cam angles identified on the displacement diagram. For construction purposes, the cam will remain stationary, and th follower will be rotated in a direction opposite to the actual cam rotation.
4. Transfer the displacements from the displacement diagram t the radial lines on the cam. Measure these displacements from the base circle.

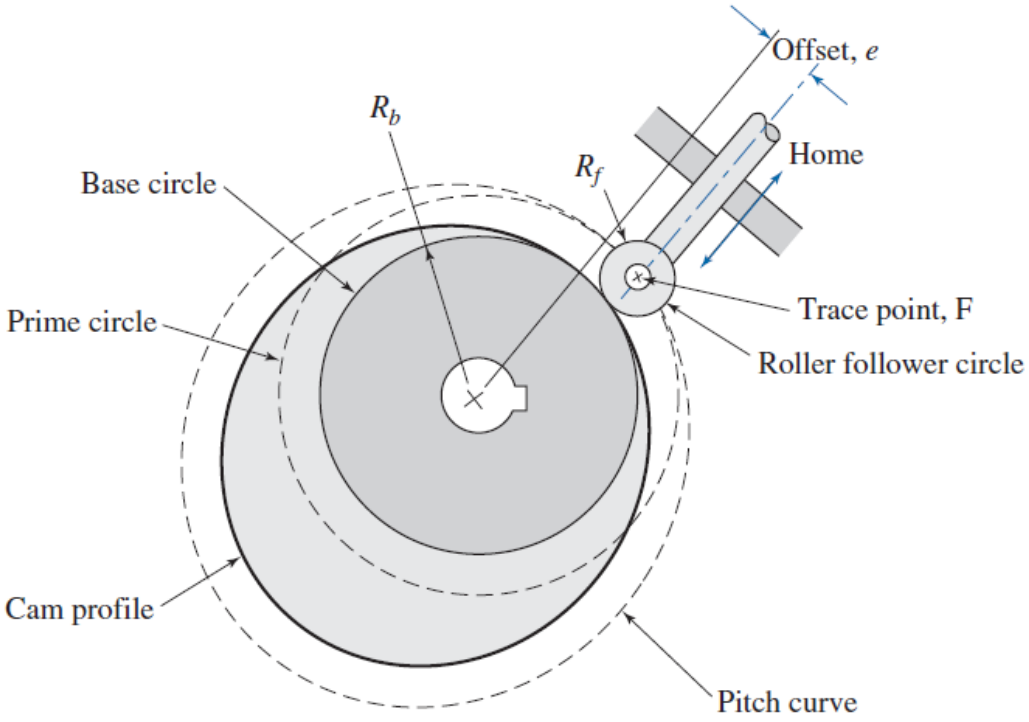

Figure (a)

Source: Myszka, D.H. Machines and Mech. Applied Kinematic Analysis. Prentice Hall. 4th Edition. USA.

Cam-Follower Systems – Construct Cam Profile with Prescribed Cam-Follower Motion

- Procedure is used to graphically construct a *Cam Profile Design* (cont.):

5. Draw a smooth curve through these prescribed displacements.
6. To accurately construct a profile consistent with the displacement diagram, it may be necessary to transfer additional intermediate points from the rise and fall intervals.

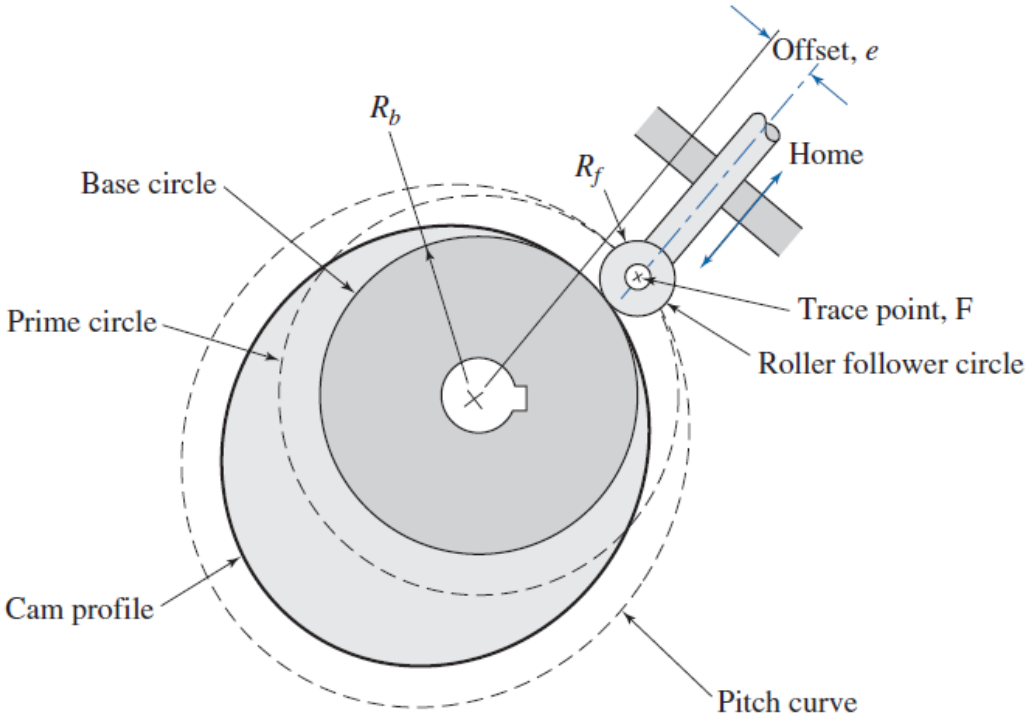

Figure (a)

Source: Myszka, D.H. Machines and Mech. Applied Kinematic Analysis. Prentice Hall. 4th Edition. USA.

Construct Cam Profile with Prescribed Cam-Follower Motion

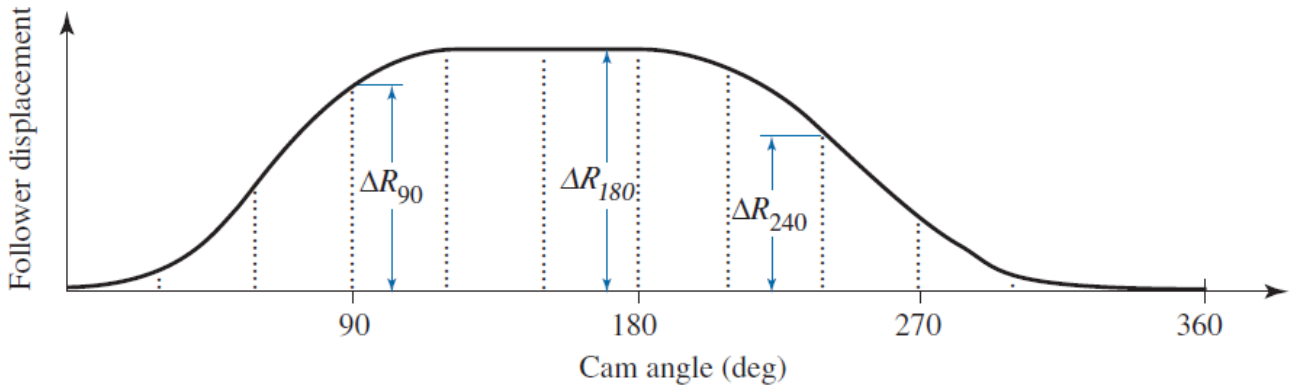

Figure (b) General Follower Displacement Diagram.

In-line Knife-edge Follower:

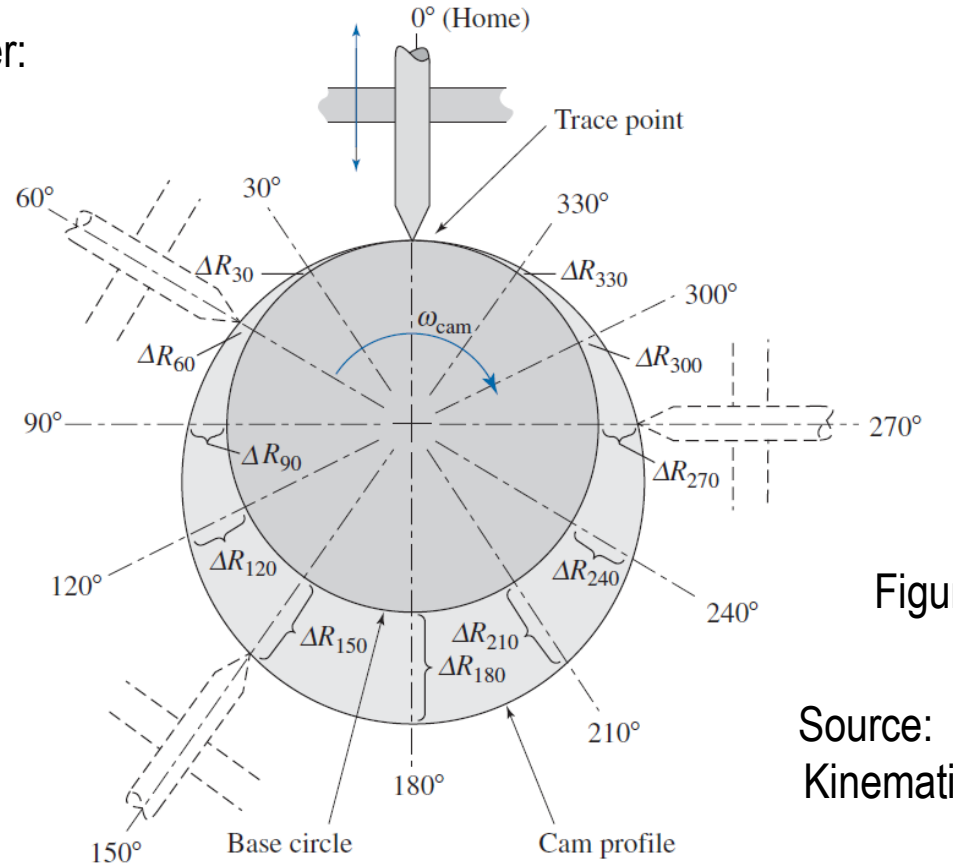

Figure (c) Cam Profile Design—In-line, Knife-edge Follower.

Source: Myszka, D.H. Machines and Mech. Applied Kinematic Analysis. Prentice Hall. 4th Edition. USA.

Construct Cam Profile with Prescribed Cam-Follower Motion

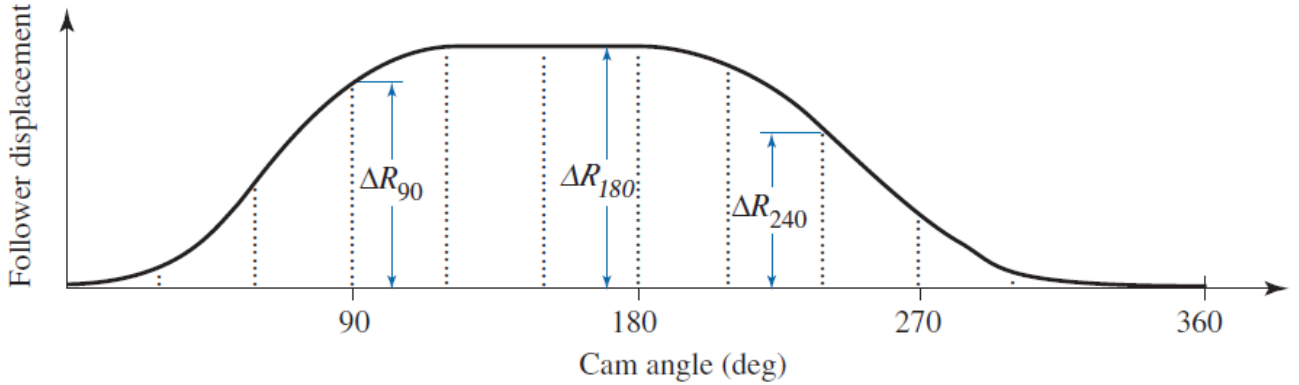

Figure (b) General Follower Displacement Diagram.

In-line Roller Follower:

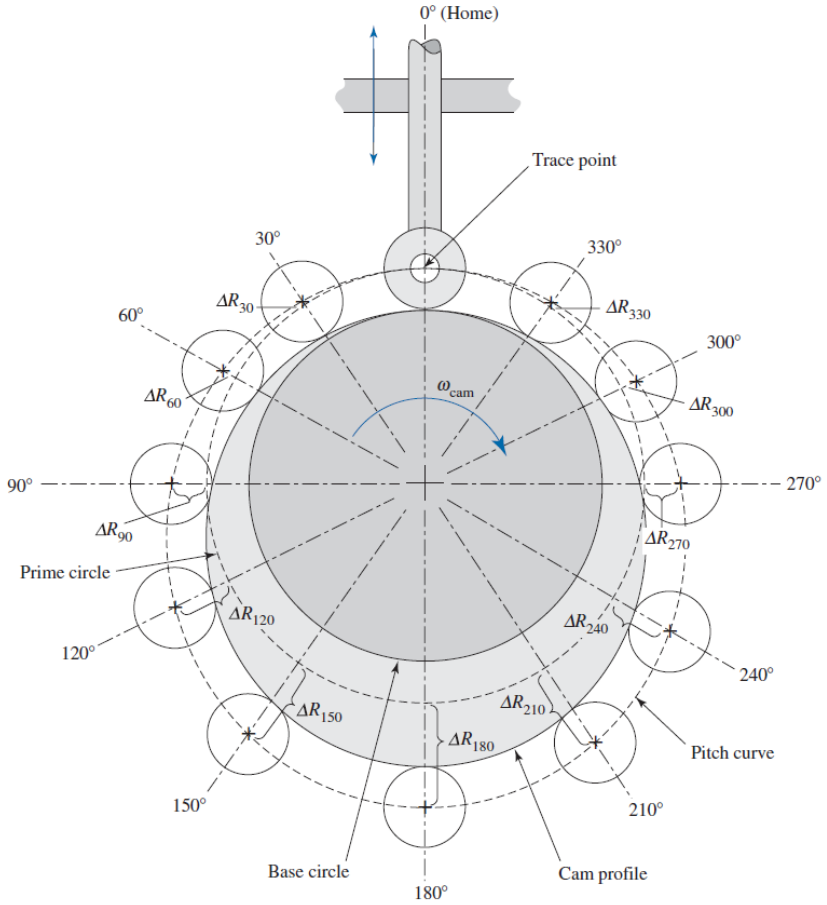

Figure (d) Cam Profile Design—In-line Roller Follower.

Source: Myszka, D.H. Machines and Mech. Applied Kinematic Analysis. Prentice Hall. 4th Edition. USA.

Construct Cam Profile with Prescribed Cam-Follower Motion - Offset Roller Follower

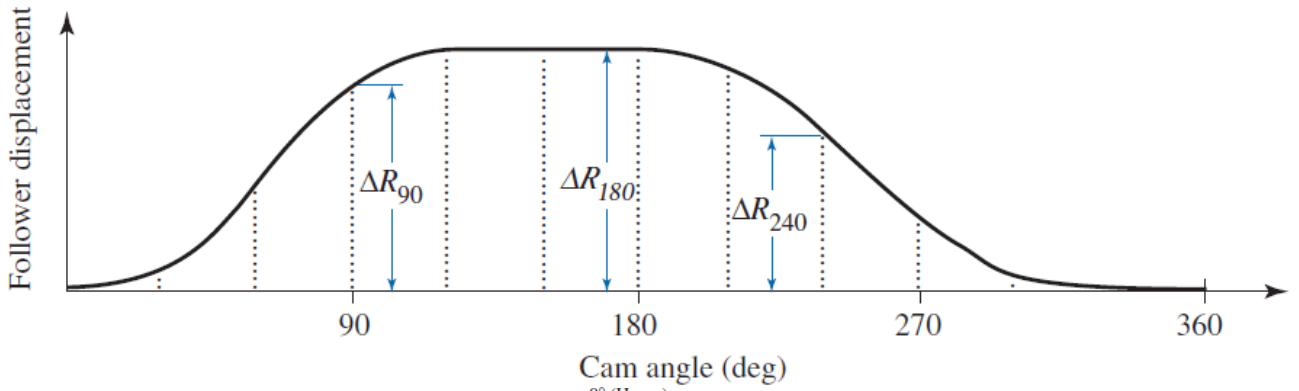

Figure (b) General Follower Displacement Diagram.

Offset Roller Follower:

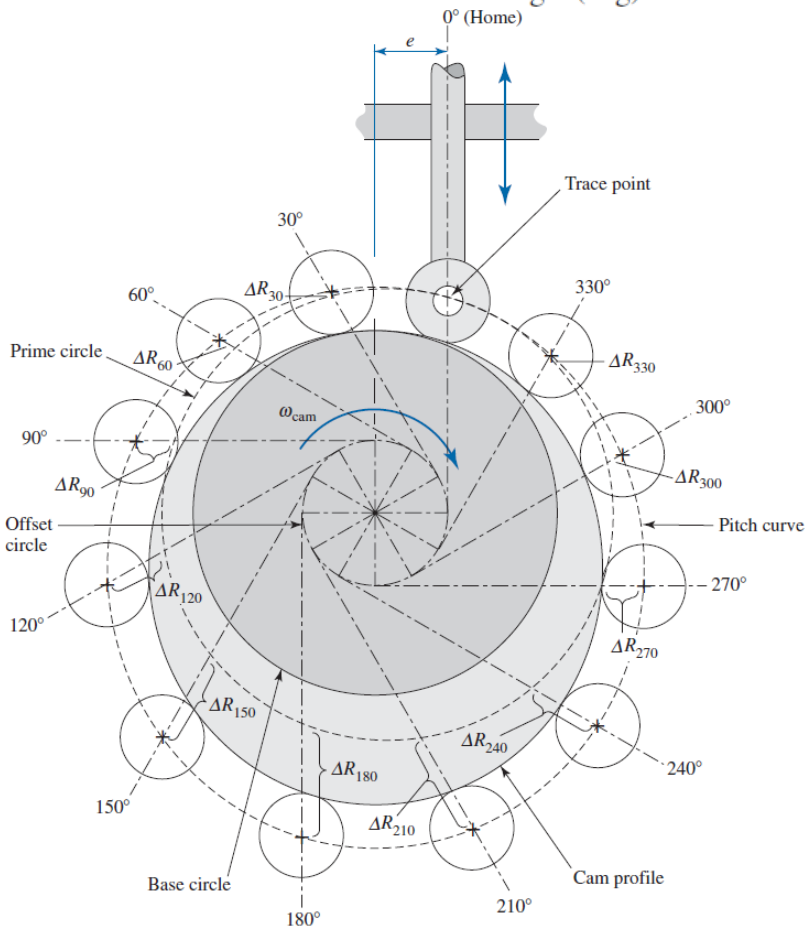

Figure (e) Cam Profile Design - Offset Roller Follower.

Source: Myszka, D.H. Machines and Mech. Applied Kinematic Analysis. Prentice Hall. 4th Edition. USA.

Construct Cam Profile with Prescribed Cam-Follower Motion - Offset Roller Follower

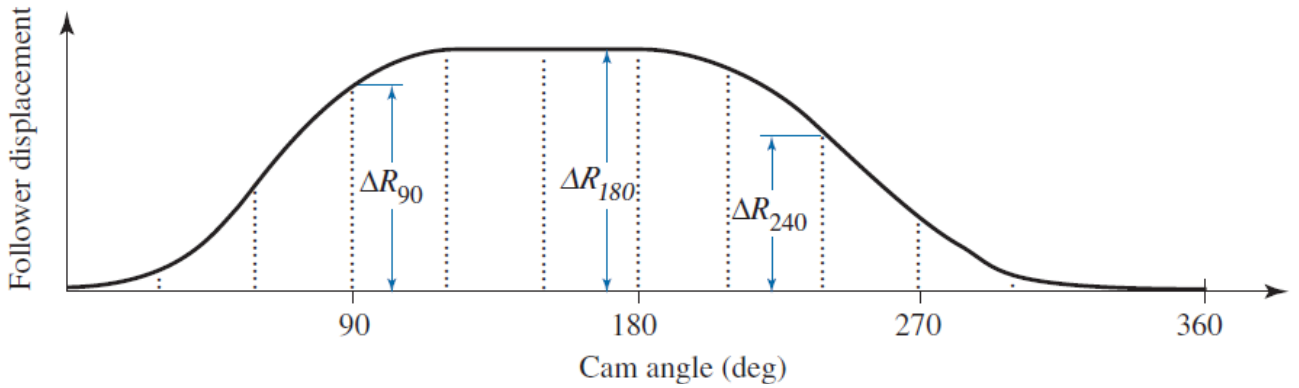

Figure (b) General Follower Displacement Diagram.

Flat-Faced Follower:

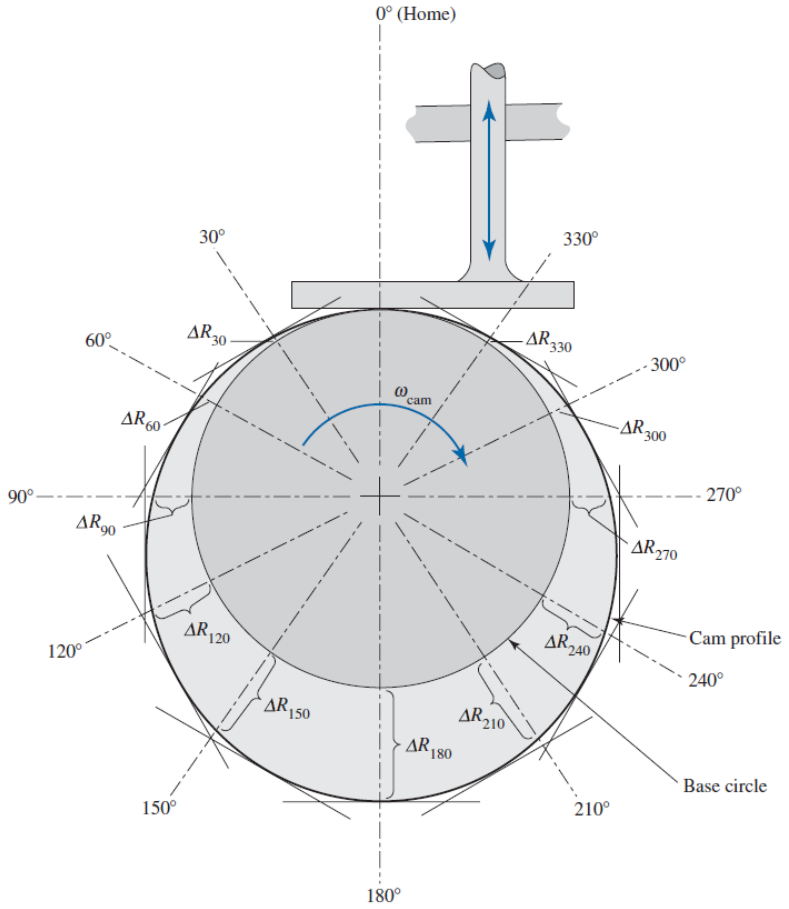

Figure (f) Cam Profile Design - Flat-Faced Follower.

Source: Myszka, D.H. Machines and Mech. Applied Kinematic Analysis. Prentice Hall. 4th Edition. USA.

Cam-Follower Systems – Construct Cam Profile with Prescribed Cam-Follower Motion

- To draw the cam shape, a Cartesian coordinate system is used so that the origin is at the cam center as shown Figure (g):
- In this coordinate system, the positive *y*-axis is along the direction of the follower motion in its home position.
- And the positive x-axis is 90° clockwise from the y-axis, consistent with a right-hand coordinate system.

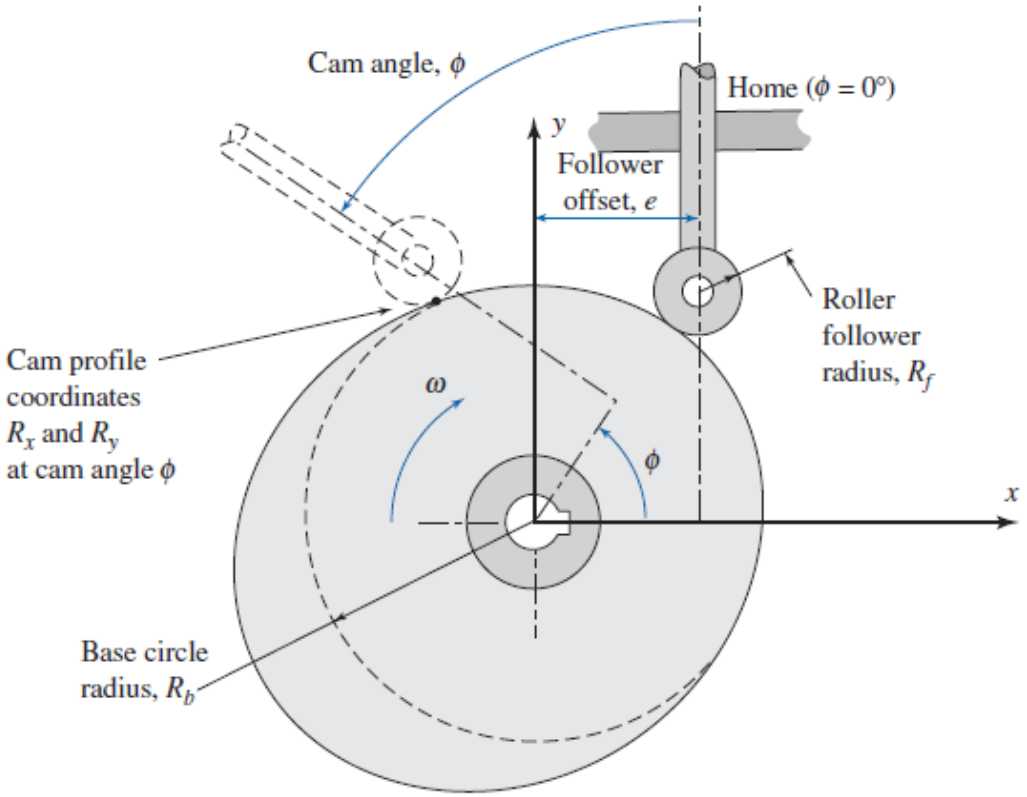

Figure (g)

Source: Myszka, D.H. Machines and Mech. Applied Kinematic Analysis. Prentice Hall. 4th Edition. USA.

Cam-Follower Systems – Knife-Edge Follower

- For Knife-Edge Follower the x and y coordinates of the cam profile are given as:

$$R_x = (R_B + \Delta R)sin(\theta_{cam}) \quad \text{(a)}$$
$$R_y = (R_B + \Delta R)cos(\theta_{cam}) \quad \text{(b)}$$

Where:

R_x:= x – coordinate of the cam profile.

R_y := y – coordinate of cam profile.

R_B: = Base circle radius.

$\theta_{cam} = \phi$:= Cam rotation angle measured against the direction of cam rotation from the home position

ΔR:= Follower displacement at cam angle

Cam Profile Design for a Knife-Edge Follower: An Example

- Example 7-3.
- For the application stated in Example #7-2, analytically determine the cam profile coordinates when a knife-edge follower is incorporated.
- Because of the size constraints of the machine, a cam with a base circle diameter of 200 mm must be used. The cam is to rotate counterclockwise.

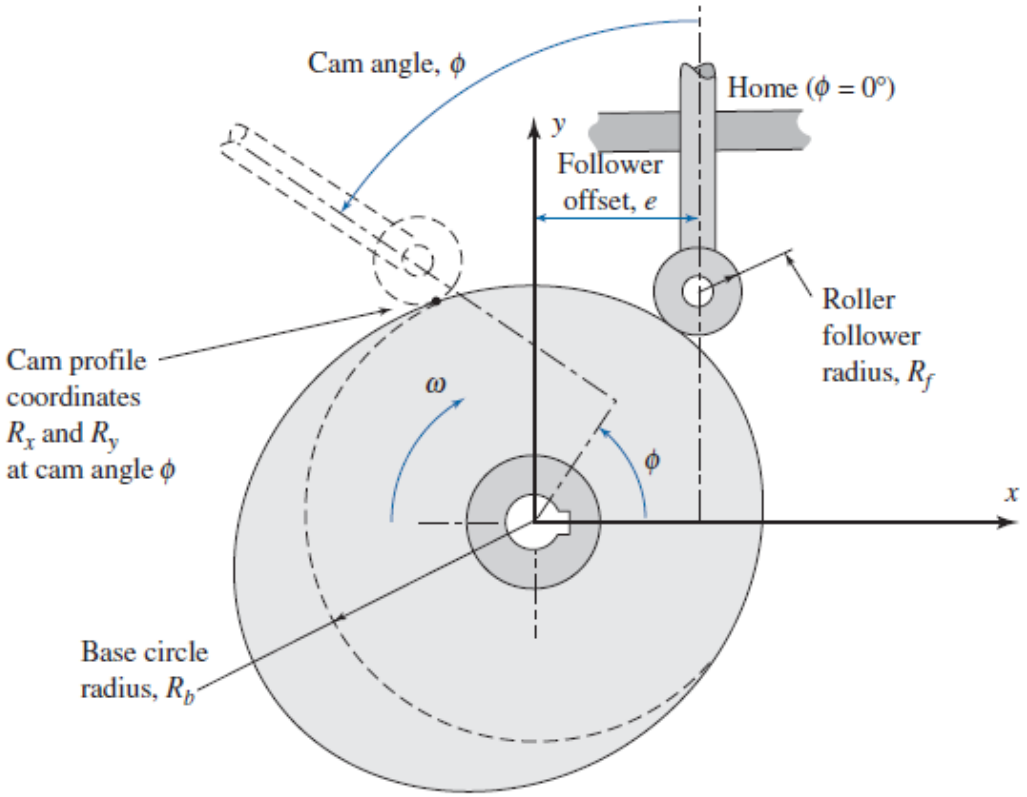

Figure (g)

Source: Myszka, D.H. Machines and Mech. Applied Kinematic Analysis. Prentice Hall. 4th Edition. USA.

Cam Profile Design for a Knife-Edge Follower: An Example

- Solution (cont.).

1. Calculate Coordinates of the Cam Profile: The base circle radius is half of the base circle diameter; therefore:

   $$R_B = 100\ mm$$

   Substitution into Eqs. (a) and (b), we get:

   $$R_x = (R_B + \Delta R)sin(\theta_{cam}) = [(100\ mm) + \Delta R]\ sin(\theta_{cam})$$
   $$R_y = (R_B + \Delta R)cos(\theta_{cam}) = [(100\ mm) + \Delta R]\ cos(\theta_{cam})$$

2. Summarize the Profile Coordinates for Several Cam Angles: Inserting these equations into a MATLAB® script gives the results listed in Figure (h) in the next slide:

Cam Profile Design for a Knife-Edge Follower: An Example

- Solution (cont.).

Time (s)	Cam Angle (degrees)	Follower Displacemet (mm)	Rx (mm)	Ry (mm)
0.00	0.00	0.00	0.00	100.00
0.25	21.18	8.33	39.13	101.02
0.50	42.35	16.67	78.60	86.22
0.75	63.53	25.00	111.90	55.72
1.00	84.71	33.33	132.76	12.30
1.25	105.88	41.67	136.26	-38.77
1.50	127.06	50.00	119.70	-90.40
1.75	148.24	49.38	78.64	-127.00
2.00	169.41	45.46	26.73	-142.98
2.25	190.59	36.88	-25.15	-134.55
2.50	211.76	25.00	-65.80	-106.28
2.75	232.94	13.12	-90.27	-68.17
3.00	254.12	4.54	-100.55	-28.61
3.25	275.29	0.62	-100.19	9.28
3.50	296.47	0.00	-89.52	44.57
3.75	317.65	0.00	-67.37	73.90
4.00	338.82	0.00	-36.12	93.25
4.25	360.00	0.00	0.00	100.00

Figure (h)

Cam Profile Design for a Knife-Edge Follower: An Example

- Solution (cont.).

3. Plot the Profile Coordinates [see Figures (i) and (j)]

Note: A MATLAB script (see Cam_Profile_Design.mlx) can be used to easily create a plot of the profile coordinates. This plot is shown as Figure (j) below.

Cam Profile Design for a Knife-Edge Follower: An Example

- Solution (cont.). Figure (i) shows the plot of the displacement diagram:

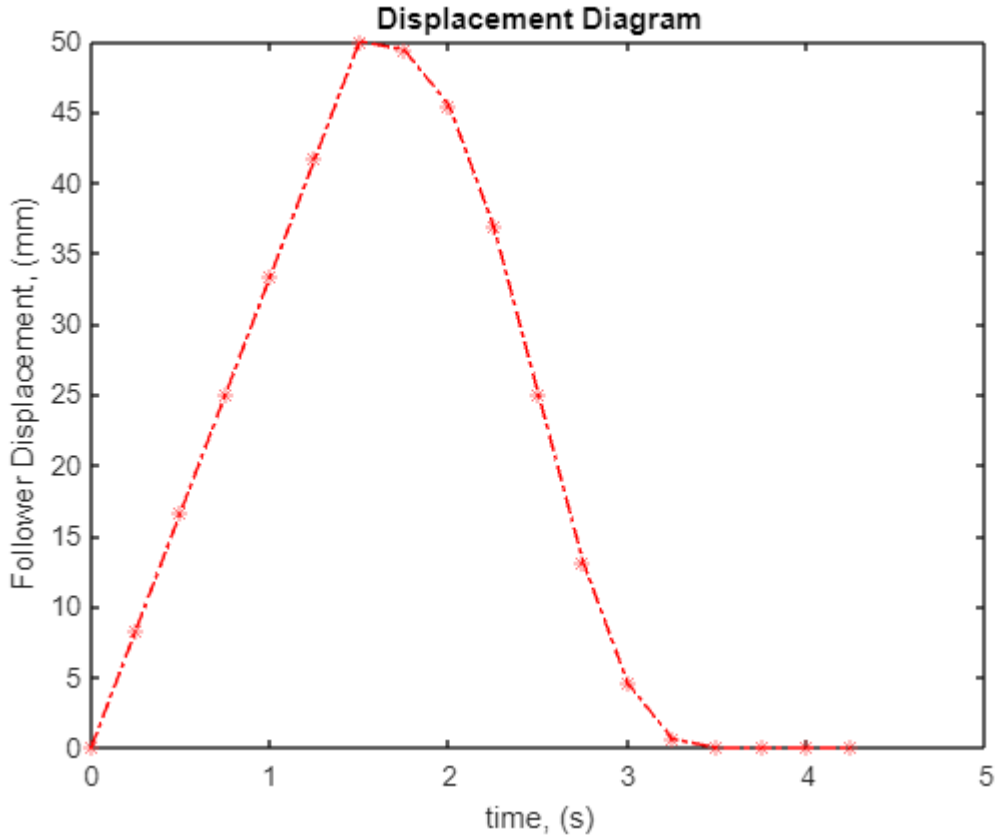

Figure (i) Knife-Edge Follower Displacement Diagram

Cam Profile Design for a Knife-Edge Follower: An Example

- Solution (cont.). And Figure (j) shows the Cam Profile Design:

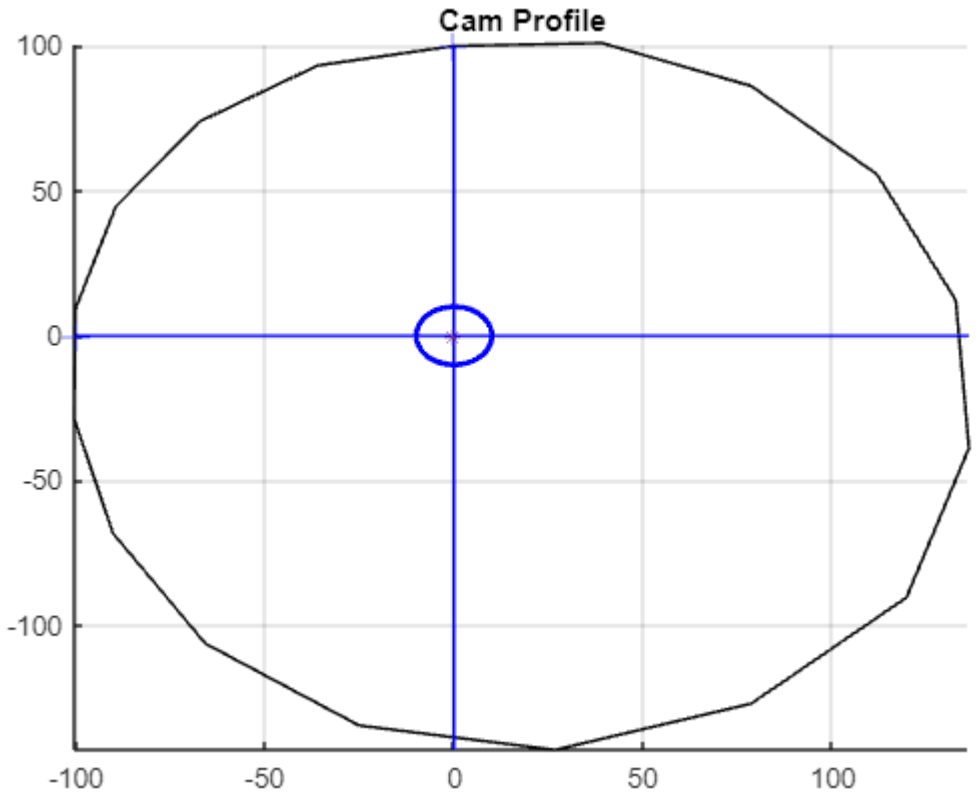

Figure (j) Cam Profile Design for a Knife-Edge Follower.

End of Part #3