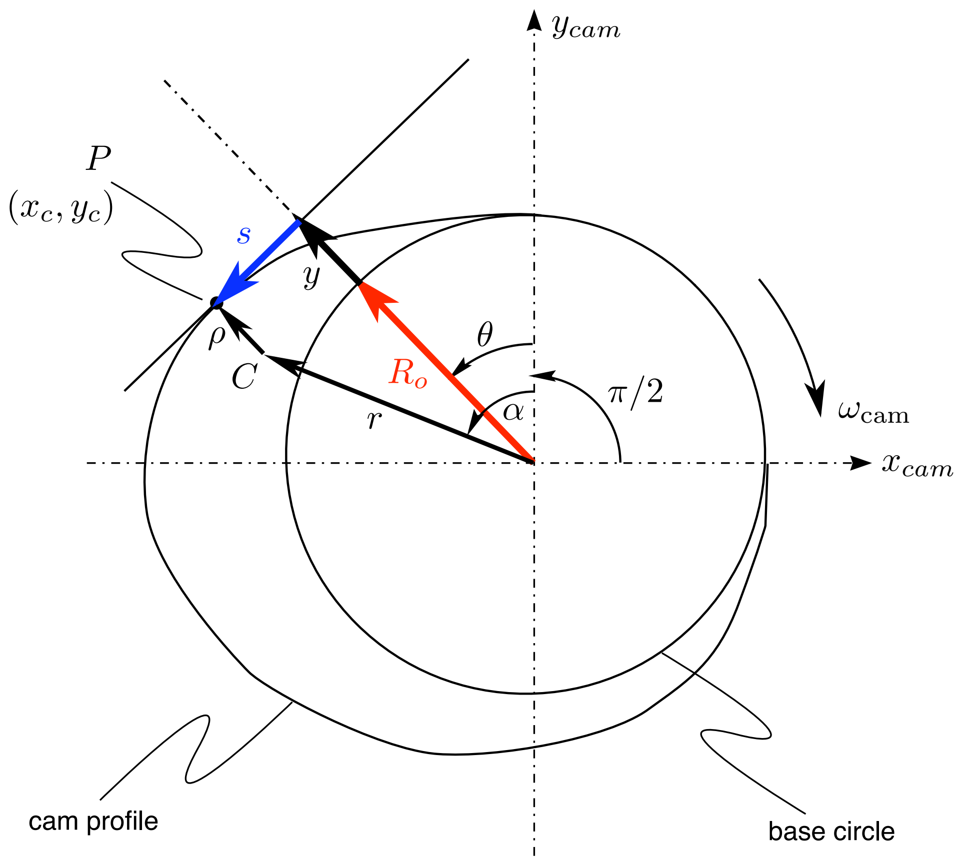
1 Disk Cam Profile and Reciprocating Flat-Face Follower Design using MATLAB

Consider the disk cam with reciprocating flat-face follower shown below (similar to text Figure 5.26). The cam rotates CW, so when the mechanism is inverted the follower rotates CCW. We assume the follower axis is vertical; along the y_{cam} axis. The follower is shown at an angular displacement θ, and corresponding lift y. The radius of the base circle is R_o.



The contact point between cam and follower is at point P, with coordinates (x_c, y_c). If we find the contact point P for all values of θ from $0...2\pi$ that will determine the cam profile.

1.1 Geometry of Cam/Follower Contact.

Point C is the instantaneous *center of curvature* of the cam profile at the contact point, and vector ρ is the *radius of curvature*. Vectors r and angle α are defined to allow the geometric analysis below.

From the figure above, the following two equations must be satisfied:

$$r \sin(\alpha - \theta) = s \tag{1}$$
$$r \cos(\alpha - \theta) + \rho = R_o + y \tag{2}$$

Now differentiate (2) with respect to cam angle θ:

$$\frac{d}{d\theta}\left[\, r\cos(\alpha-\theta) + \rho = R_o + y \,\right] \implies r\sin(\alpha-\theta) + \frac{d\rho}{d\theta} = \frac{dy}{d\theta} \tag{3}$$

However, point C (center of curvature of the cam profile) is an instantaneously stationary point, so

$$\frac{d\rho}{d\theta} = 0 \tag{4}$$

Substituting (4) into (3) yields

$$r\sin(\alpha - \theta) = y', \tag{5}$$

where of course $y' = dy/d\theta$.

Comparing equations (1) and (5) we find that

$$\boxed{s = y'} \tag{6}$$

This is a *very meaningful* result! It tells us that the offset s from the follower axis to the contact point is exactly equal to the first kinematic coefficient of the follower displacement function, which is y'.

1.2 Required Follower Radius.

As a designer, you want the cylindrical cam follower to be as small as possible, but it must be large enough that the contact point doesn't "fall off the end." To find the necessary follower radius, one may simply find the maximum value of y', and this is the required follower radius. Thus we have

$$\boxed{R_{follower} = (y')_{max}} \tag{7}$$

1.3 Cam Profile

We wish to find the coordinates of point P, which are (x_c, y_c). Referring to the figure, we can use vectors R_o, y, and s to find point P. Recalling that $s = y'$, we have

$$x_c = (R_o + y)\cos\left(\theta + \frac{\pi}{2}\right) + y'\cos(\theta + \pi) \tag{8}$$

$$y_c = (R_o + y)\sin\left(\theta + \frac{\pi}{2}\right) + y'\sin(\theta + \pi) \tag{9}$$

Note that there is an angle bias of $\pi/2$ in the trigonometric functions is to rotate the coordinates by 90° in accordance with the follower axis being along the y_{cam} axis.

These equations must be computed for $0 \leq \theta \leq 2\pi$ to obtain the complete profile, with displacement function $y(\theta)$ and first kinematic coefficient $y'(\theta)$ evaluated at each θ.

1.4 MATLAB Function `camprofile`

```
function [xc,yc] = camprofile(Ro,y,yp,theta)
%
% FUNCTION [xc,yc] = prob7cam(Ro,y,yp,theta)
%
% This function finds the cam profile for a disk cam with an reciprocating
% flat-face follower.  It accepts the base circle radius Ro, vectors of y
% and yp (all in displacement units), and cam angle theta (RAD).  These
% vectors should all correspond to a full cycle of cam rotation from 0 to
% 2*PI.  Obviously the smaller the stepsize the more accurate and smoother
% the final plot of cam profile.
%
% Vectors xc and yc containing the coordinates of the cam profile are
% returned.  The cam profile points are generated so the follower axis is
% vertical (i.e. pi/2 has been added to follower angle).

N = length(theta);  % Find number of points in motion

for i = 1:N
    xc(i) = (Ro+y(i))*cos(theta(i)+pi/2)+yp(i)*cos(theta(i)+pi);
    yc(i) = (Ro+y(i))*sin(theta(i)+pi/2)+yp(i)*sin(theta(i)+pi);
end
```