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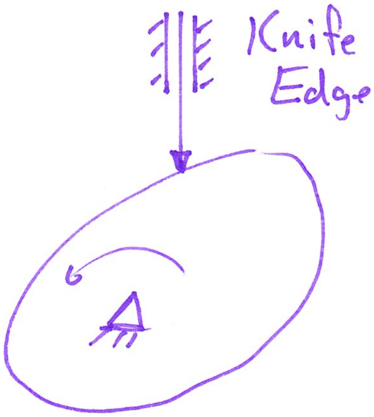
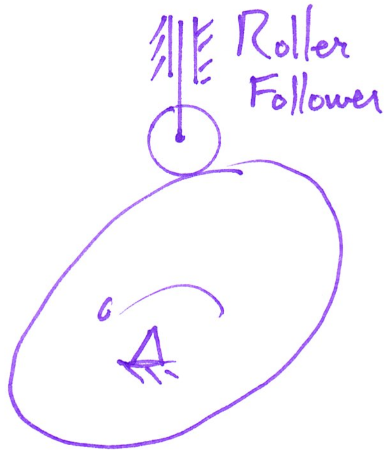
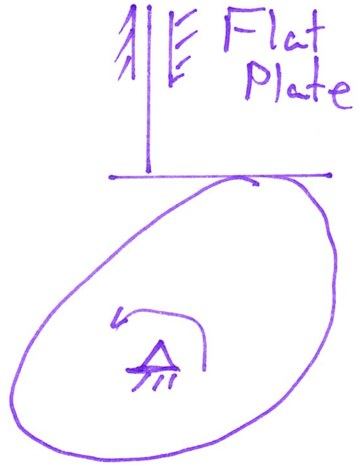
CAMS

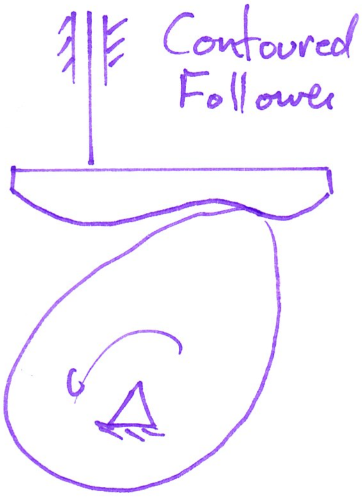
– Transformation of Power from a rotating source to a linear (or arc) motion, called the follower

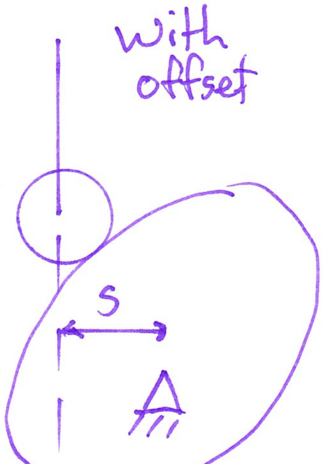
Common types of CAMS

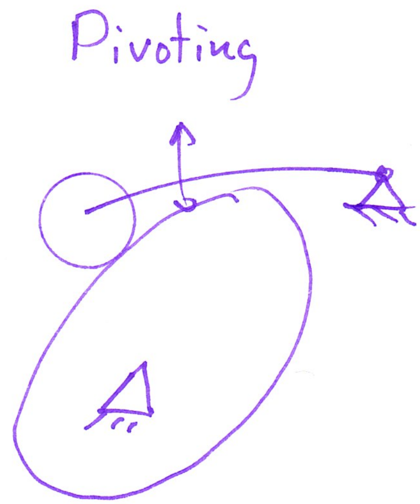


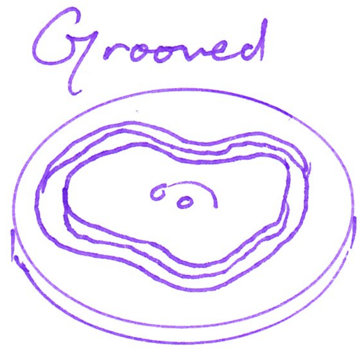


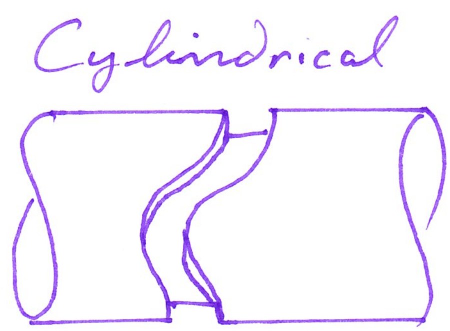












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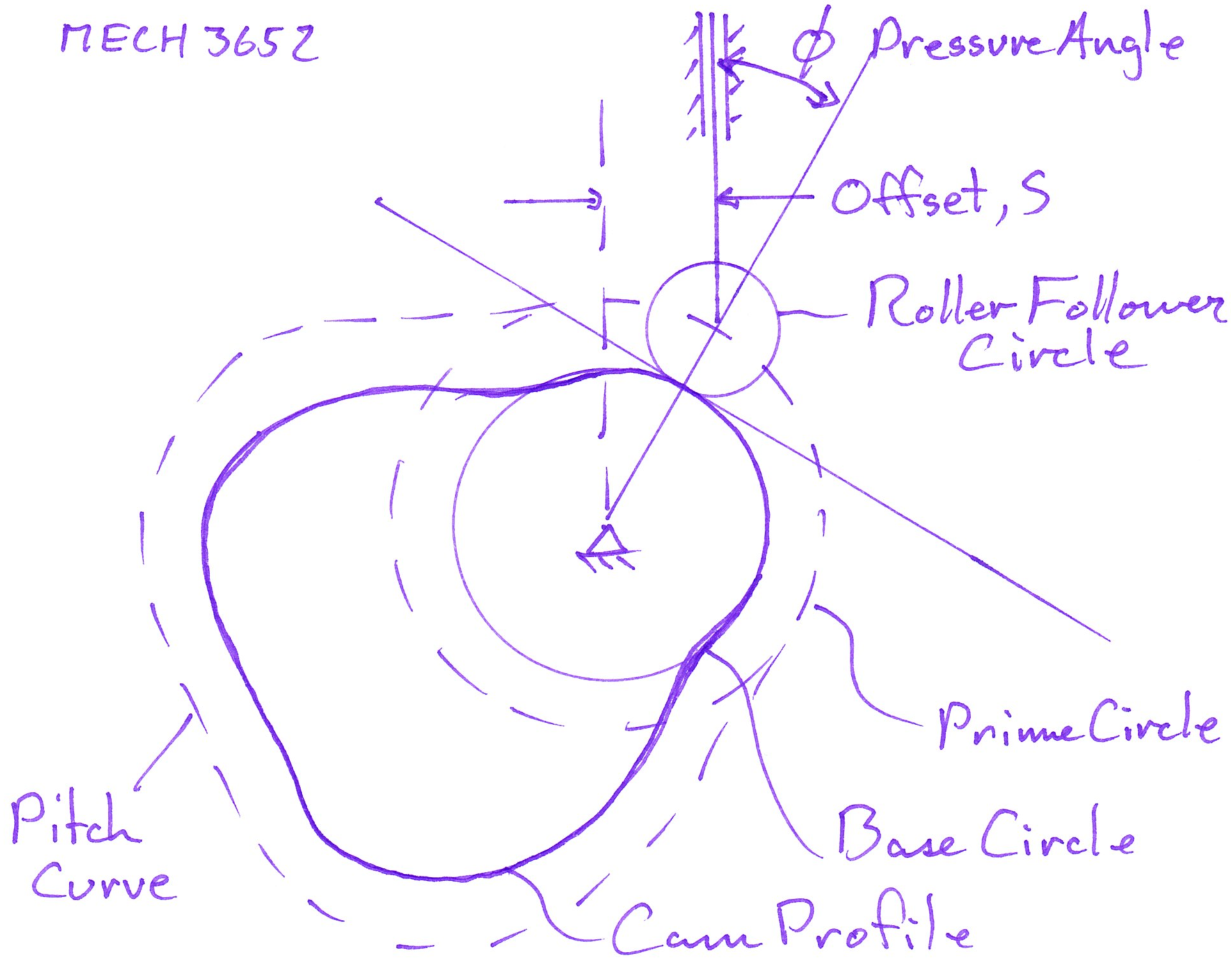


The base circle represents the starting (zero) location for the desired follower motion

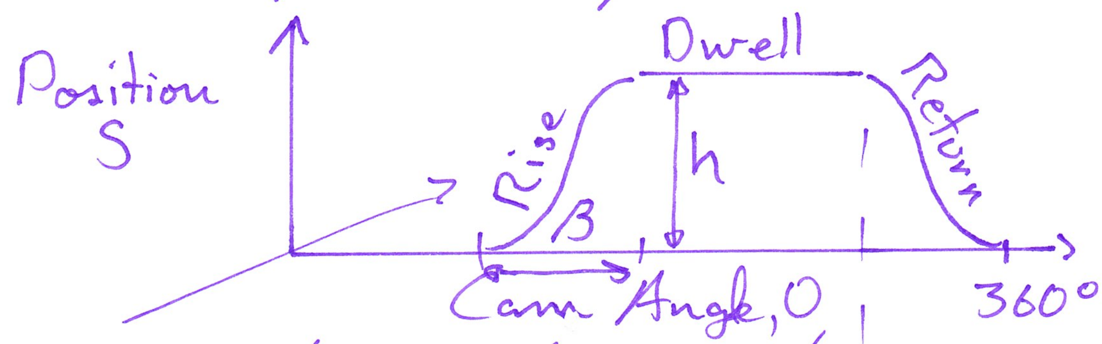
The cam profile is determined in order to achieve the desired follower motion relative to the zero position

Types of Cam Constraints:

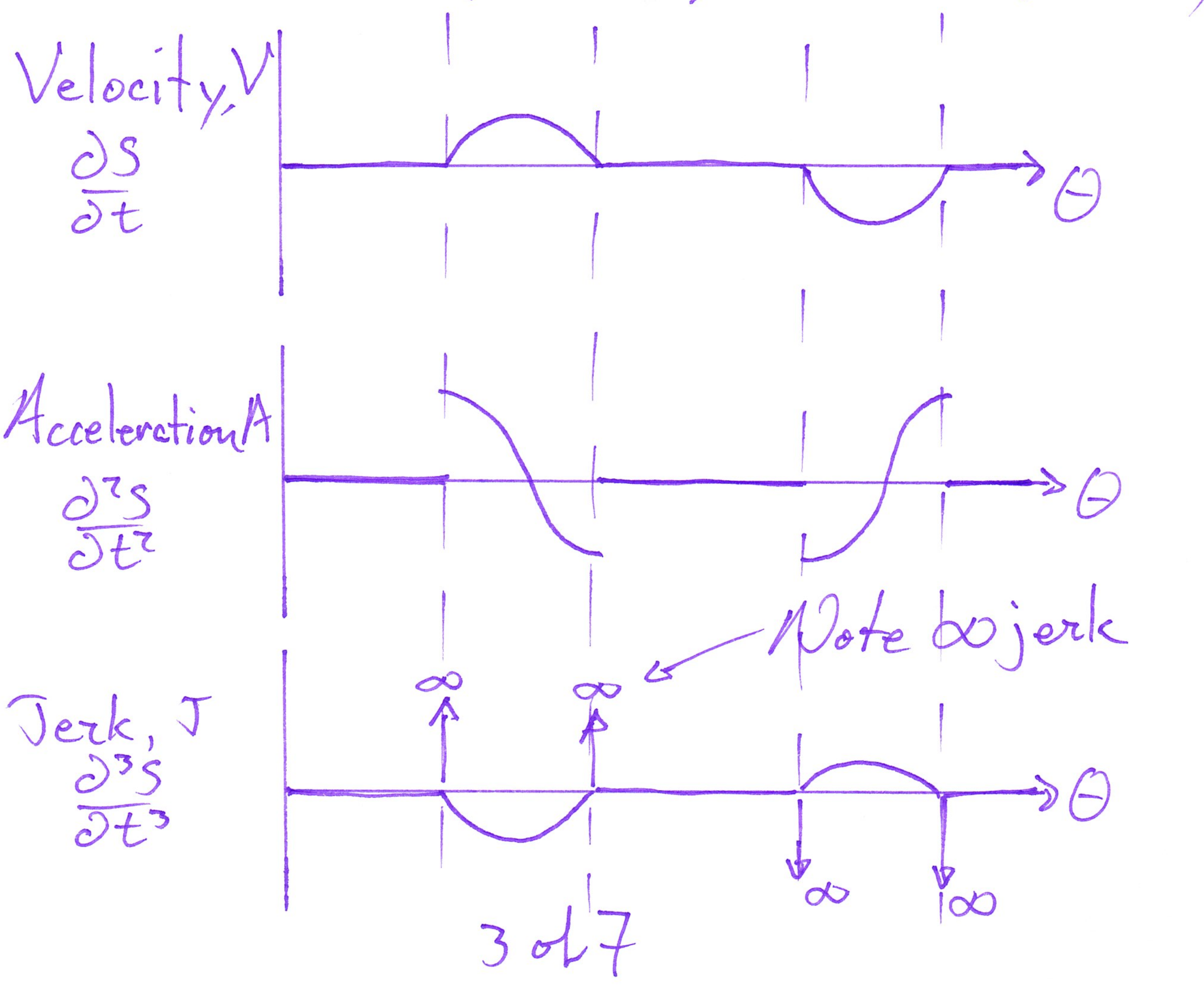
CEP Critical Extreme Position where the start and end positions are specified

CPM Critical Path Motion where the path or derivatives are specified over all or part of the cam.

SVAJ Diagrams are useful for cam designs, they represent the Position, S, Velocity V, Acceleration, A and Jerk, J of the desired follower motion



Assume that in this case, this is a sinusoidal rise (we'll explore other shapes later)



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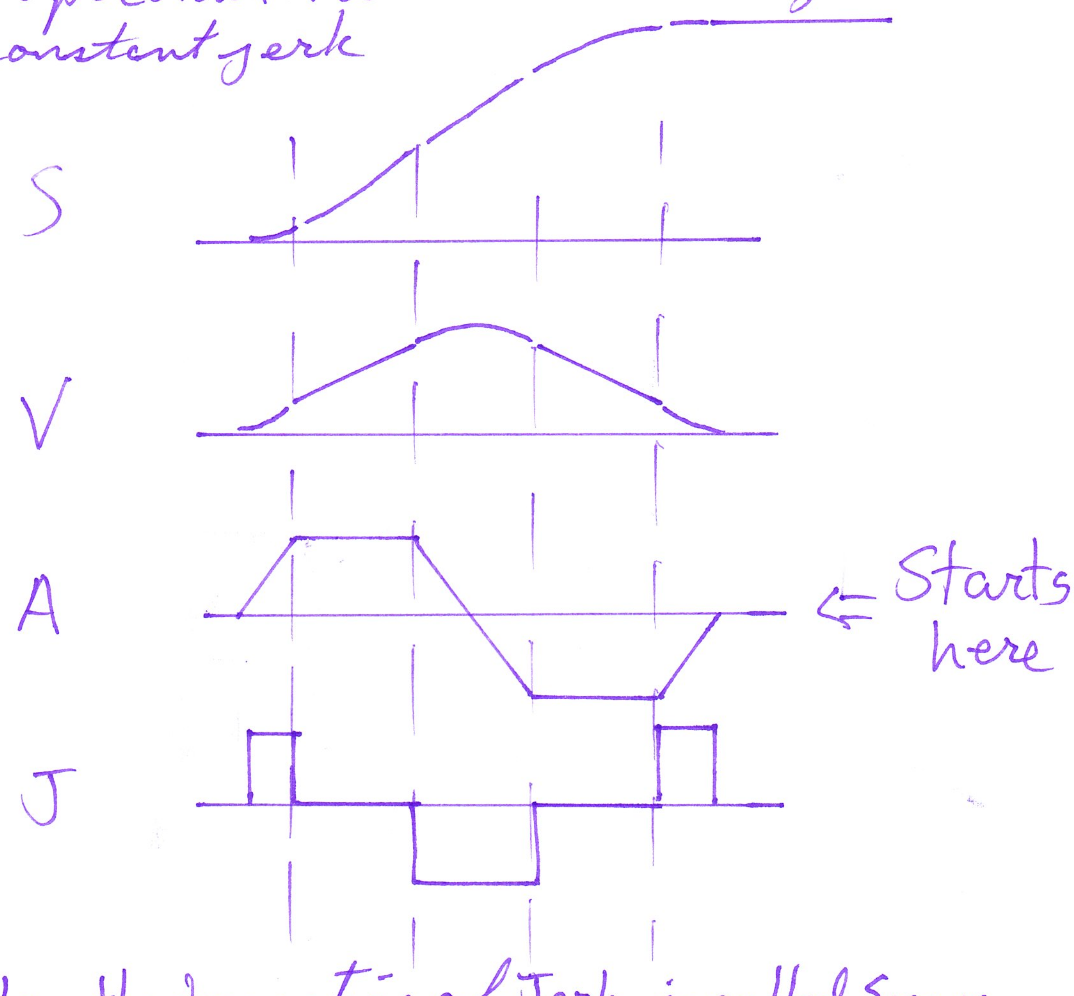
This sinusoidal rise (or return) has the function

$$S = \frac{h}{2}\left(1 - \cos\frac{\pi\theta}{\beta}\right)$$

a cycloidal rise (or return) has a slight modification which keeps the jerk finite

$$S = \frac{h}{\beta}\theta - \frac{h}{2\pi}\sin\left(\frac{2\pi\theta}{\beta}\right)$$

Other common follower motions include Trapezoidal Acceleration which gives a constant jerk



Aside, the derivative of Jerk is called Snap, the derivative of snap is crakle, and the next one is called Pop.

Pressure angle, ϕ is the angle between the direction of the follower motion and the direction of the axis of transmission

Ideally we want ϕ to be as small as possible so that the force exerted by the cam is aligned with the direction of the desired follower motion, $\phi < 30°$.

We can add eccentricity (offset, S) to reduce the pressure angle during the push stroke; however, there is a corresponding increase in ϕ during the return. Note that typically a return spring or gravity supplies the force to the follower during the return, so this is not an issue.

The cam's radius of curvature can also have consequences, as does the radius of the follower. Certain motions/profiles can become ill defined.

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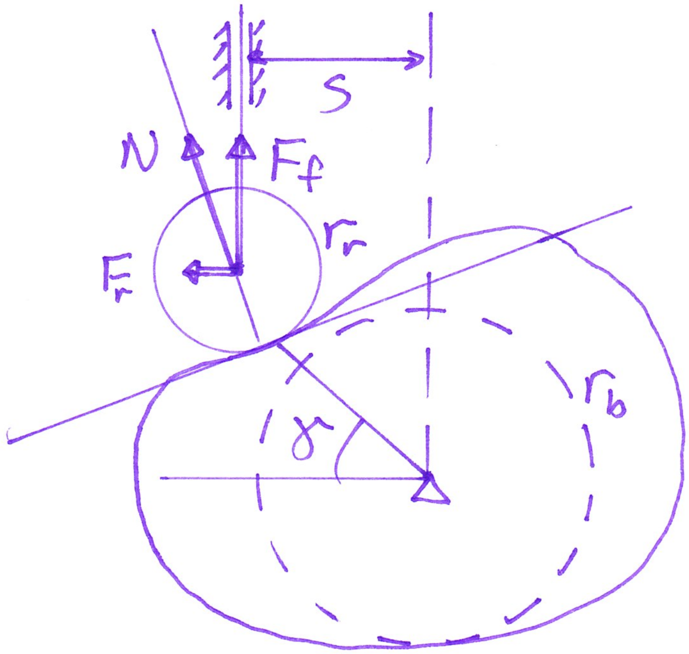
CAM PRESSURES



Let $R = R_o + f(\theta)$

Base Location (R_o)

Desired or Prescribed follower motion ($f(\theta)$)

F_f // to follower $= N\cos\phi$

F_p ⊥ to follower $= N\sin\phi$

ϕ is the pressure angle

$$R_o = \sqrt{(r_b + r_r)^2 - S^2}$$

$$\gamma = \pi/2 - \mathrm{Tan}^{-1}\left(\frac{S + r_r\sin\phi}{R - r_r\cos\phi}\right)$$

where

$$\phi = \mathrm{Tan}^{-1}\left(\frac{f'(\theta) - S}{R}\right)$$

and the shape of the cam is

$$r_c = \sqrt{(R - r_r\cos\phi)^2 + (S + r_r\sin\phi)^2}$$

or in terms of x and y

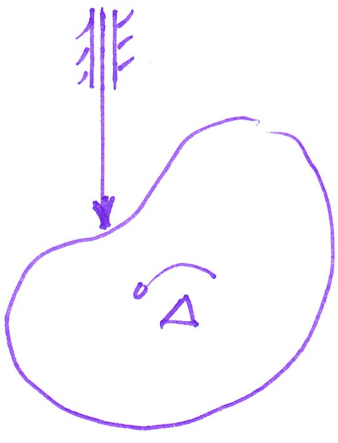
$$x_c = r_c\cos\gamma \quad \text{and} \quad y_c = r_c\sin\gamma$$

Simplified expressions exist for

a Knife edge $r_r \to 0$ and

a Flat plate $r_r \to \infty$

KNIFE EDGE FOLLOWER



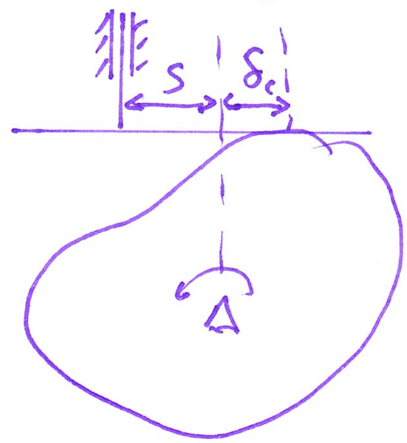
$$R_0 = \sqrt{r_b^2 - S^2}$$

$$r_c = \sqrt{S^2 + R^2}$$

$$\gamma = \frac{\pi}{2} - \tan^{-1}\left(\frac{S}{R}\right)$$

$$\phi = \frac{\pi}{2} - \gamma - \tan^{-1}\left(\frac{R f'(\theta)}{r_c^2}\right)$$

FLAT PLATE FOLLOWER



$$R_0 = r_b$$

$$r_c = \sqrt{R^2 + f'(\theta)^2}$$

$$\gamma = \frac{\pi}{2} - \tan^{-1}\left(\frac{f'(\theta)}{R}\right)$$

Contact Location

$$\delta_c = f'(\theta) - S$$

Standard types of motion

- Dwell or Hold $\quad f(\theta) = \text{Constant}$
- Uniform Rise or Return $\quad f(\theta) = a\theta + b$
- Parabolic (constant accel.) $\quad f(\theta) = a\theta^2 + b\theta + c$
- Harmonic (sinusoidal) $\quad f(\theta) = a\sin\theta + b$
- Cycloidal $\quad f(\theta) = a\sin\theta + b\theta$