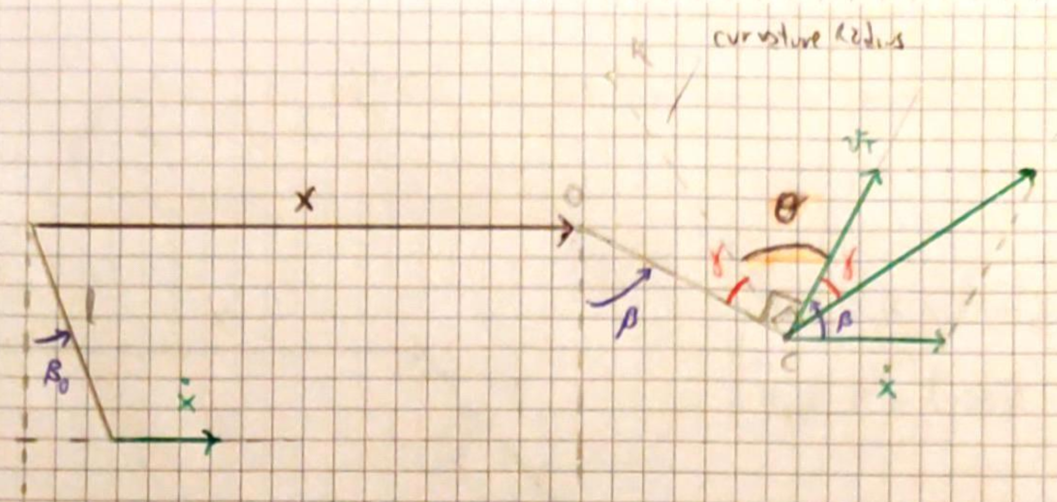
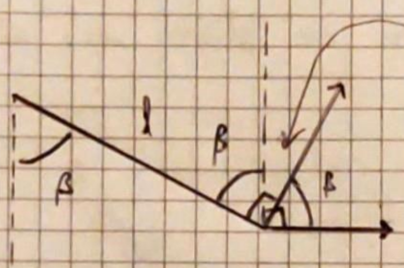



the angle between $v_T$ and $\dot{x}$ is $\beta$ because complementary to the same angle




$\Downarrow$

$$v_a = \sqrt{(v_T \cos\beta + \dot{x})^2 + (v_T \sin\beta)^2} \qquad \text{with} \qquad v_T = l \cdot \dot{\beta}$$

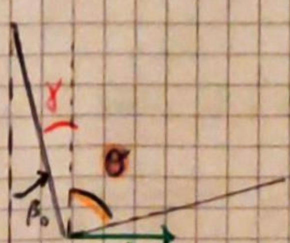
Considering the triangle between $v_T$ and $v_a$ and using the cosine theorem

$$\dot{x}^2 = v_T^2 + v_a^2 - 2\, v_T v_a \cos\gamma$$

$$\gamma = a\cos\left( \frac{v_T^2 + v_a^2 - \dot{x}^2}{2\, v_T v_a} \right)$$

the pressure angle $\theta = \frac{\pi}{2} - \gamma$

Notice that at the start where $v_T = 0$ because $\dot{\beta} = 0$ we would obtain:



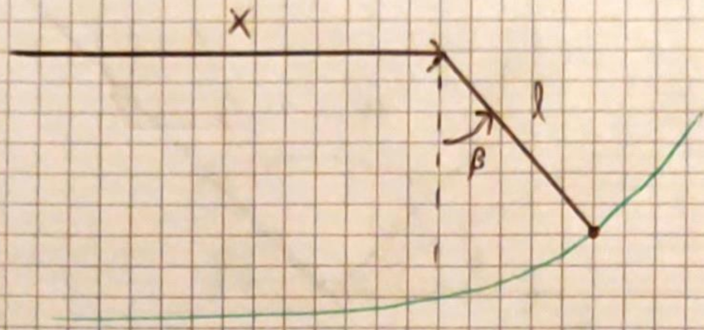

$v_a = \dot{x}$ , $v_T = 0$ $\rightarrow$ $\gamma = a\cos\left(\frac{0}{0}\right)$

we can't define it using $v_T$

but geometrically $\gamma = \beta_0$ in this phase

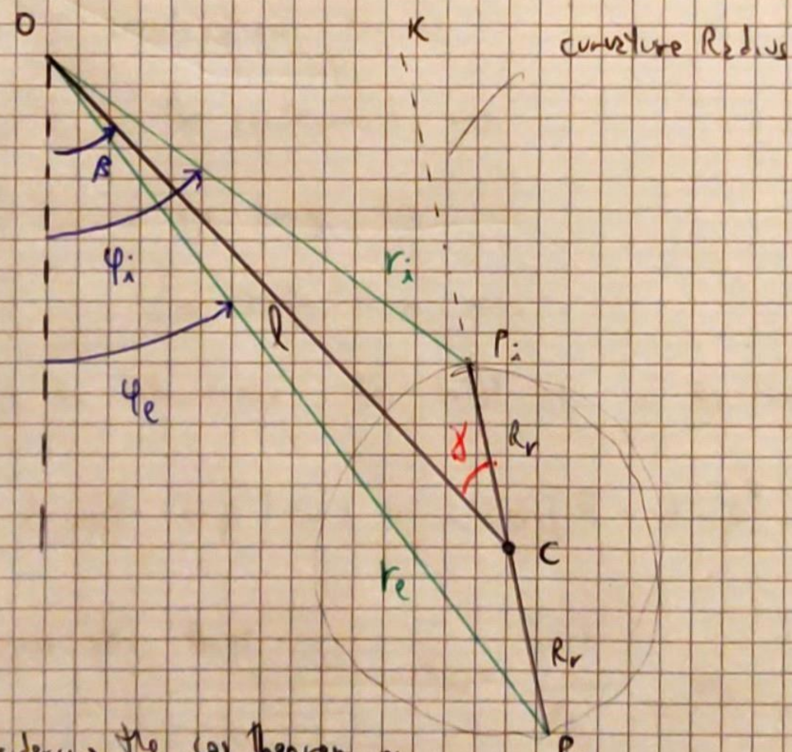
$$\Rightarrow \theta = \frac{\pi}{2} - \beta_0$$

the pitch profile is obtained as the sum of the translation $x$ and the rotation $\beta$




$$\begin{cases} X_{pitch} = x + l \sin\beta \\ Y_{pitch} = -l\cos\beta \end{cases}$$

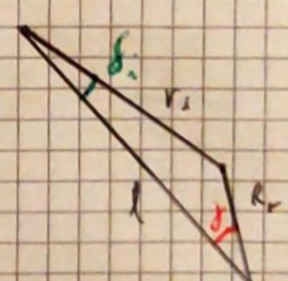
For the cam profile we need to consider also the Roller Radius $R_r$




Again considering the cos theorem on the triangle $O\hat{C}P_i$:

$$r_i = \sqrt{l^2 + R_r^2 - 2 l R_r \cos\gamma}$$

$$\varphi_i = \beta + \delta_i = \beta + \operatorname{asin}\left(\frac{R_r \sin\gamma}{r_i}\right)$$




$$r_i \sin\delta_i = R_r \sin\gamma$$

$$\delta_i = \operatorname{asin}\left(\frac{R_r \sin\gamma}{r_i}\right)$$

the same for $P_e\hat{C}O$

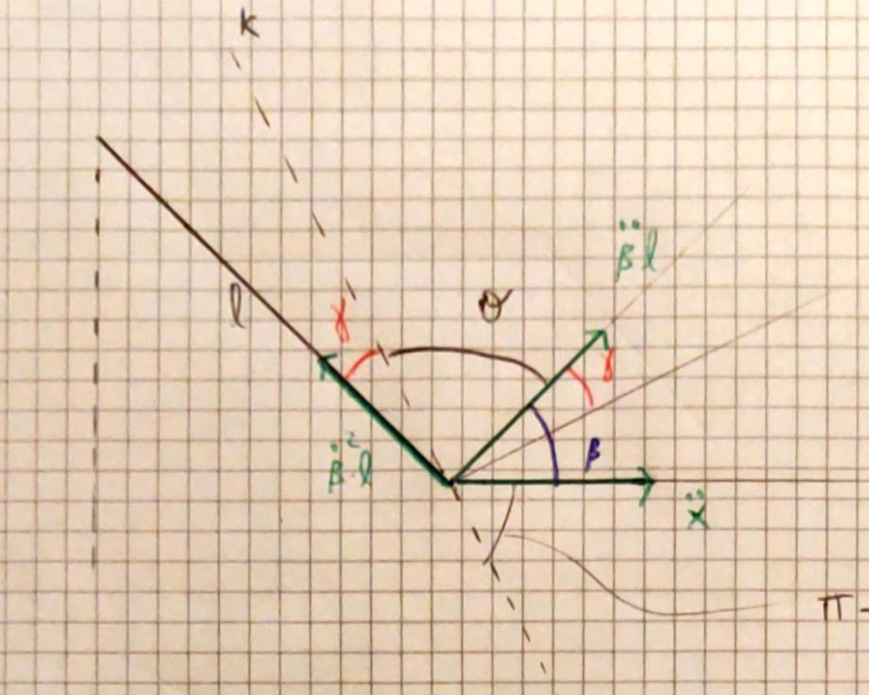
$$r_e = \sqrt{l^2 + R_r^2 + 2 l R_r \cos\gamma}$$

$$\varphi_e = \beta - \delta_e = \beta - \operatorname{asin}\left(\frac{R_r \sin\gamma}{r_e}\right)$$

$$\Rightarrow \begin{cases} x_i = x + r_i \sin\varphi_i \\ y_i = -r_i\cos\varphi_i \end{cases}$$

$$\begin{cases} x_e = x + r_e \sin\varphi_e \\ y_e = -r_e\cos\varphi_e \end{cases}$$

For the curvature Radius we focus on the accelerations




$$\pi - \vartheta - \beta = \frac{\pi}{2} + \gamma - \beta$$

we have 3 acceleration terms:

- $\dot{\beta}^2 l$ the centripetal acc.
- $\ddot{\beta} l$ the tang. acc.
- $\ddot{x}$ the translation acc.

we want to determine the total acc. in the curvature radius direction

$$a_N = \dot{\beta}^2 l \cos\gamma + \ddot{\beta} l \sin\gamma - \ddot{x} \cos\left(\pi - \vartheta - \beta\right)$$

we know also that: $$a_N = \frac{v_a^2}{\rho_0} \Rightarrow \rho_0 = \frac{v_a^2}{a_N}$$