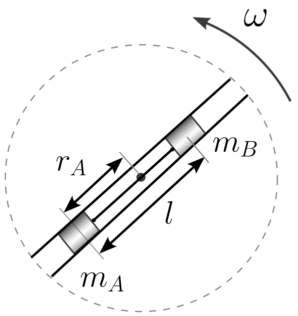
Tutorial 3 **Dynamics in Polar coordinates** 16 August 2024

Problem 1.



Before the catch is released,

(a) $\vec{\boldsymbol{a}}_i = \left(-r_i\omega^2\right)\hat{\boldsymbol{r}}$.

(b) $\overrightarrow{\boldsymbol{F}}_i = -T\hat{\boldsymbol{r}} + N\hat{\boldsymbol{\theta}}$, where T is the tension in the string and N is the normal force on the side of the channel.

At the instant the catch is released, $\ddot{r}$ is non zero for each mass.

(a) $-T = m_i\left(\ddot{r}_i - r_i\omega^2\right)$

(b) Since the tension is the same for both masses,

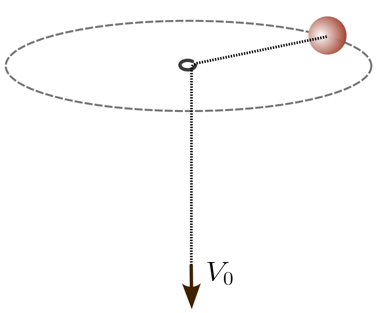
$$\begin{aligned} m_A\left(\ddot{r}_A - r_A\omega^2\right) &= m_B\left(\ddot{r}_B - r_B\omega^2\right) \\ r_A + r_B = l &\implies \ddot{r}_A = -\ddot{r}_B \\ (m_A + m_B)\ddot{r}_A &= m_A r_A\omega^2 - m_B(l - r_A)\omega^2 \\ \ddot{r}_A &= \left(r_A - \frac{l m_B}{m_A + m_B}\right)\omega^2 \end{aligned}$$

Problem 2. (a) $\vec{\boldsymbol{a}} = -v_0\omega^2 t\hat{\boldsymbol{r}} + 2v_0\omega\hat{\boldsymbol{\theta}}$.

(b) At the time when the car starts skidding, the frictional force is $f = \mu M g$ in magnitude. $t_{skid} = \dfrac{\sqrt{\mu^2 g^2 - 4v_0^2\omega^2}}{v_0\omega^2}$.

(c) Angle of frictional force to radial direction is $\tan\theta = \dfrac{a_\theta}{a_r}$ and $\theta = \sin^{-1}\dfrac{2v_0\omega}{\mu M g}$

Practise: (K.K 2.34)



(a) $\dot{\omega} + 2\dfrac{\dot{r}}{r}\omega = 0$.

(b) $\omega(t) = \omega_0\left(\dfrac{r_0}{r_0 - V_0 t}\right)^2$.

(c) $F = m\omega^2\dfrac{r_0^4}{(r_0 - V_0 t)^3}$.