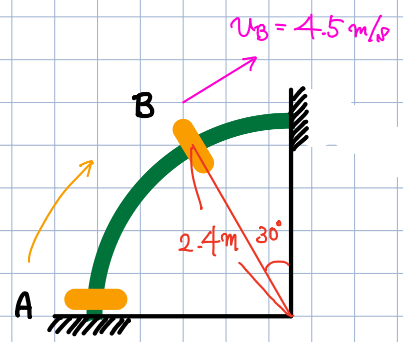
Example : n-t coordinates (3.48)

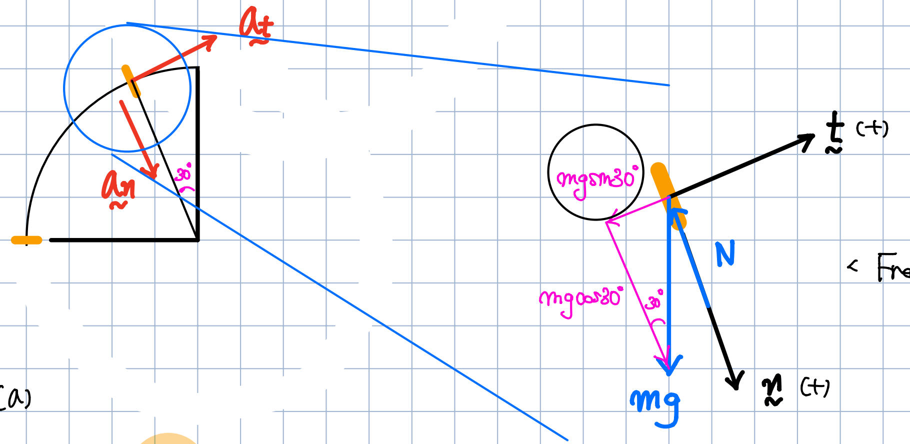


A slider is propelled upward at A along the curved bar

$m = 2\,kg$, $g = 9.81\ m/s^2$

(a) N = the force exerted by the fixed rod on the slider → a_n

(b) the rate at which the speed of the bar is decreasing → a_t



< Free Body Diagram >

(a)

$$\Sigma F_n = m a_n$$

$$\Sigma F_n = (-N) + (mg\cos 30^\circ) = m \cdot v^2/\rho$$

$$N = mg\cos 30^\circ - m v^2/\rho$$

$$= (2kg)\cdot\{(9.81\ m/s^2)\cdot\cos 30^\circ - 4.5^2/2.4\}$$

$$= 0.1164$$

Ans.

(b) $\Sigma F_t = \cancel{m} a_t = -\cancel{m} g\sin 30^\circ$

$$a_t = -(9.81\ m/s^2)\cdot(\sin 30^\circ)$$

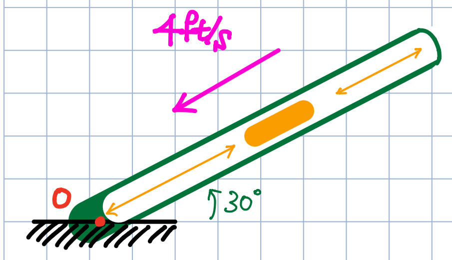
$$= -4.90\ m/s^2$$

Ans.

$$a_n = v^2/\rho = \rho\dot{\beta}^2 = v\dot{\beta} \longrightarrow \Sigma F_n = m a_n$$

$$a_t = \dot{v} = \ddot{s} = dv/dt = d(\rho\dot{\beta})/dt = \rho\ddot{\beta} + \dot{\rho}\dot{\beta} \longrightarrow \Sigma F_t = m a_t$$

Example: Polar Coordinate (3.53)



The hollow tube is pivoted about a horizontal axis through point O.

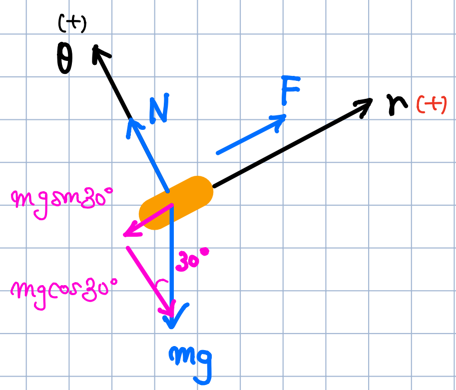
If a 0.2-lb particle is sliding in the tube toward O with a velocity of 4 ft/sec relative to the tube when the position $\theta = 30°$ is passed,

calculate the magnitude N.

$mg = 0.2\,lbf$, $g = 32.2\,ft/s^2$, $\dot{\theta} = 3\,rad/s$

(constant counterclockwise angular velocity)

N: the normal force exerted by the wall?



$\dot{r} = -4\,ft/sec$

$$\Sigma F_\theta = m a_\theta = (+N) + (-mg\cos 30°) = m(\cancel{r\ddot{\theta}} + 2\dot{r}\dot{\theta})$$

$\dot{\theta} = constant$

$$= \left(\frac{0.2\,lbf}{32.2\,\cancel{ft/s^2}}\right) \cdot \{(2) \times (-4\,\cancel{ft/s}) \times (3\,rad/\cancel{s})\}$$

$$= -0.149\,lbf$$

$$N = mg\cos 30° - 0.149\,lbf$$

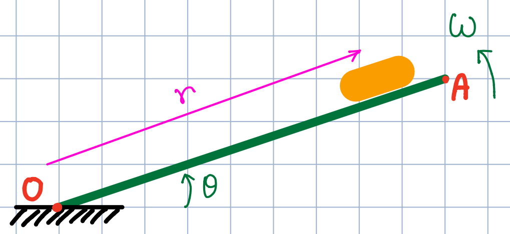
$$= (0.2\,lbf) \cdot \cos 30° - 0.149\,lbf$$

$$= 0.024\,lbf$$

Ans.

$$\boxed{\begin{aligned} a_r &= \ddot{r} - r\dot{\theta}^2 &\longrightarrow\quad & \Sigma F_r = m a_r \\ a_\theta &= r\ddot{\theta} + 2\dot{r}\dot{\theta} &\longrightarrow\quad & \Sigma F_\theta = m a_\theta \\ a &= \sqrt{a_r^2 + a_\theta^2} & & \end{aligned}}$$

Example: Polar Coordinate (3.54)

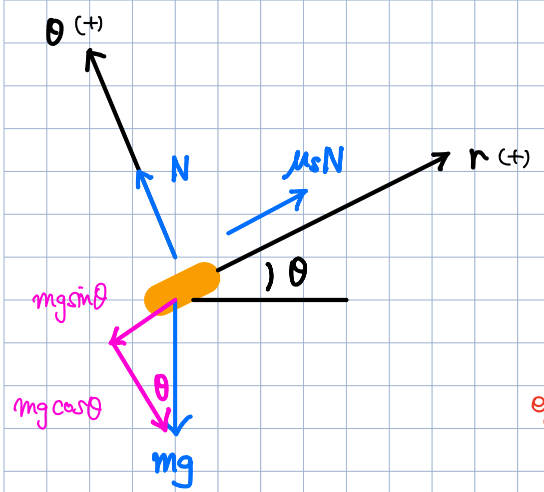


The member OA rotates about a horizontal axis through O with a constant counterclockwise angular velocity.

As it passes the position $\theta = 0°$, a small block is placed at $r = 18$ in.

If the block slips at $\theta = 50°$, determine the coefficient of static friction.

$\omega = 3$ rad/s , $r = 18$ in , $\theta = 50°$, $\mu_s = ?$



$$\Sigma F_\theta = m\cancel{a_\theta} = (+N) + (-mg\cos\theta)$$

a constant ω

$$N = mg\cos\theta$$

$$\Sigma F_r = ma_r = (+\mu_s N) + (-mg\sin\theta)$$

$$m(\cancel{\ddot{r}} - r\dot{\theta}^2) = \mu_s N - mg\sin\theta$$

equilibrium with frictional force

$$\mu_s N = mg\sin\theta - mr\dot{\theta}^2 \leftarrow N = mg\cos\theta$$

$$\mu_s = \frac{mg\sin\theta - mr\dot{\theta}^2}{mg\cos\theta}$$

$$= \tan\theta - \frac{r\omega^2}{g\cos\theta}$$

$$= \tan 50° - \frac{(18\,\cancel{in})\cdot(3\,rad/\cancel{s})^2}{(32.2\,\cancel{ft/s^2})\cdot\cos 50°}\cdot\frac{1\,\cancel{ft}}{12\,\cancel{in}}$$

$$= 0.539$$ Ans.

$$\boxed{\begin{aligned} a_r &= \ddot{r} - r\dot{\theta}^2 &\longrightarrow\quad & \Sigma F_r = ma_r \\ a_\theta &= r\ddot{\theta} + 2\dot{r}\dot{\theta} &\longrightarrow\quad & \Sigma F_\theta = ma_\theta \\ a &= \sqrt{a_r^2 + a_\theta^2} & & \end{aligned}}$$