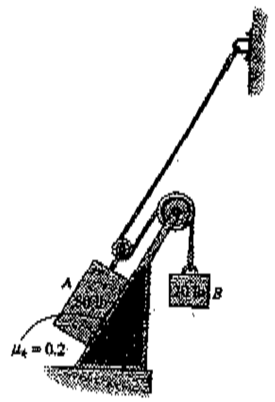
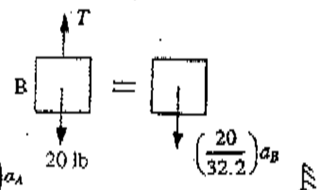
***13-36. Determine the acceleration of block A when the system is released. The coefficient of kinetic friction and the weight of each block are indicated. Neglect the mass of the pulleys and cord.**

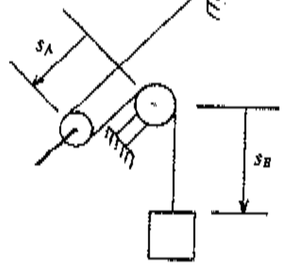


Block A :

$+\nwarrow \Sigma F_y = ma_y;\quad N_A - 80\cos 60° = 0$

$+\swarrow \Sigma F_x = ma_x;\quad 80\sin 60° - 0.2N_A - 2T = \left(\frac{80}{32.2}\right)a_A$





Block B :

$+\downarrow \Sigma F_y = ma_y;\quad -T + 20 = \left(\frac{20}{32.2}\right)a_B$

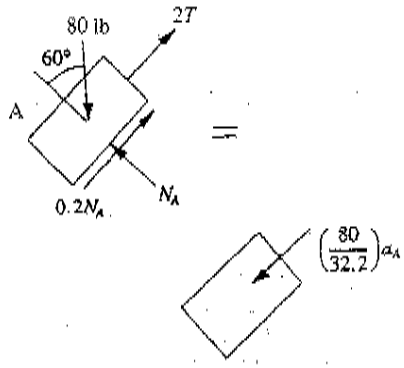
$2s_A + s_B = l$

$2a_A = -a_B$

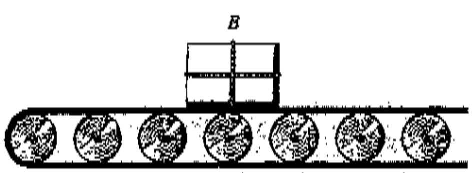
Solving,

$N_A = 40$ lb $\quad T = 25.32$ lb $\quad a_B = -8.57$ ft/s^2

$a_A = 4.28$ ft/s^2 **Ans**



13-37. The conveyor belt is moving at 4 m/s. If the coefficient of static friction between the conveyor and the 10-kg package B is $\mu_s = 0.2$, determine the shortest time the belt can stop so that the package does not slide on the belt.



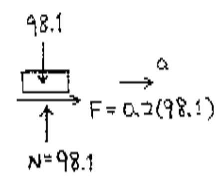
$\xrightarrow{+} \Sigma F_x = m\,a_x;\quad 0.2(98.1) = 10\,a$

$a = 1.962$ m/s^2

$(\xrightarrow{+})\ v = v_0 + a_c t$

$4 = 0 + 1.962\,t$

$t = 2.04$ s **Ans**



13-42. Blocks A and B each have a mass m. Determine the largest horizontal force P which can be applied to B so that A will not move relative to B. All surfaces are smooth.

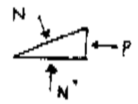
Require

$a_A = a_B = a$

Block A :

$+\uparrow \Sigma F_y = 0; \quad N\cos\theta - mg = 0$

$\overset{+}{\leftarrow} \Sigma F_x = ma_x; \quad N\sin\theta = ma$



$a = g\tan\theta$

Block B :

$\overset{+}{\leftarrow} \Sigma F_x = ma_x; \quad P - N\sin\theta = ma$

$P - mg\tan\theta = mg\tan\theta$

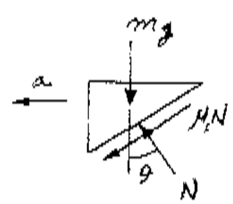
$P = 2mg\tan\theta$ **Ans**

13-43. Blocks A and B each have a mass m. Determine the largest horizontal force P which can be applied to B so that A will not slip up B. The coefficient of static friction between A and B is μ_s. Neglect any friction between B and C.

Require

$a_A = a_B = a$

Block A :



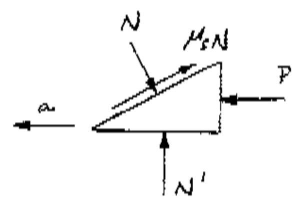
$+\uparrow \Sigma F_y = 0; \quad N\cos\theta - \mu_s N\sin\theta - mg = 0$

$\overset{+}{\leftarrow} \Sigma F_x = ma_x; \quad N\sin\theta + \mu_s N\cos\theta = ma$

$$N = \frac{mg}{\cos\theta - \mu_s\sin\theta}$$

$$a = g\left(\frac{\sin\theta + \mu_s\cos\theta}{\cos\theta - \mu_s\sin\theta}\right)$$

Block B :

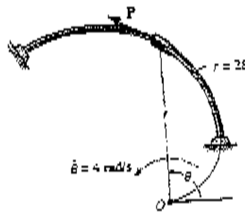


$\overset{+}{\leftarrow} \Sigma F_x = ma_x; \quad P - \mu_s N\cos\theta - N\sin\theta = ma$

$$P - mg\left(\frac{\sin\theta + \mu_s\cos\theta}{\cos\theta - \mu_s\sin\theta}\right) = mg\left(\frac{\sin\theta + \mu_s\cos\theta}{\cos\theta - \mu_s\sin\theta}\right)$$

$$P = 2mg\left(\frac{\sin\theta + \mu_s\cos\theta}{\cos\theta - \mu_s\sin\theta}\right) \quad \textbf{Ans}$$

13–95. Solve Prob. 13–94 if the spiral rod is *vertical*.



$r = 2\theta$

$\tan\psi = \dfrac{r}{dr/d\theta} = \dfrac{2\theta}{2} = \dfrac{\pi}{2} \qquad \psi = 57.52°$

$\dot{\theta} = 4 \qquad \ddot{\theta} = 0$

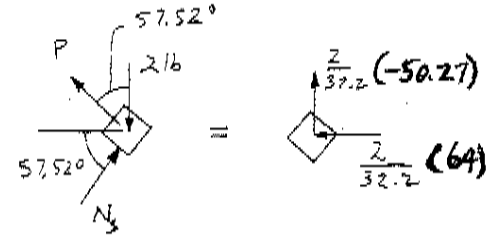
$r = 2\theta = 2\left(\dfrac{\pi}{2}\right) = \pi$

$\dot{r} = 2\dot{\theta} = 2(4) = 8$

$\ddot{r} = 2\ddot{\theta} = 0$

$a_r = \ddot{r} - r\dot{\theta}^2 = 0 - \pi(4)^2 = -50.27$

$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta} = 0 + 2(8)(4) = 64$



$+\uparrow \Sigma F_r = ma_r; \qquad P\cos 57.52° - N_r \sin 57.52° - 2 = \left(\dfrac{2}{32.2}\right)(-50.27)$

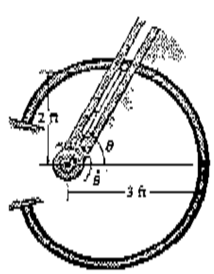
$\overset{+}{\leftarrow} \Sigma F_\theta = ma_\theta; \qquad P\sin 57.52° + N_r \cos 57.52° = \left(\dfrac{2}{32.2}\right)(64)$

Solving :

$P = 2.75$ lb **Ans**

$N_r = 3.08$ lb **Ans**

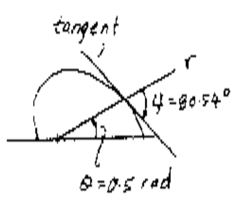
***13-96.** The forked rod is used to move the smooth 2-lb particle around the horizontal path in the shape of a limaçon, $r = (2 + \cos\theta)$ ft. If $\theta = (0.5t^2)$ rad, where t is in seconds, determine the force which the rod exerts on the particle at the instant $t = 1$ s. The fork and path contact the particle on only one side.



$r = 2 + \cos\theta \qquad \theta = 0.5t^2$

$\dot{r} = -\sin\theta\dot{\theta} \qquad \dot{\theta} = t$

$\ddot{r} = -\cos\theta\dot{\theta}^2 - \sin\theta\ddot{\theta} \qquad \ddot{\theta} = 1 \text{ rad/s}^2$

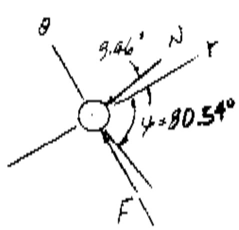


At $t = 1$ s, $\theta = 0.5$ rad, $\dot{\theta} = 1$ rad/s and $\ddot{\theta} = 1$ rad/s^2

$r = 2 + \cos 0.5 = 2.8776$ ft

$\dot{r} = -\sin 0.5(1) = -0.4794$ ft/s

$\ddot{r} = -\cos 0.5(1)^2 - \sin 0.5(1) = -1.357$ ft/s^2



$a_r = \ddot{r} - r\dot{\theta}^2 = -1.357 - 2.8776(1)^2 = -4.2346$ ft/s^2

$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta} = 2.8776(1) + 2(-0.4794)(1) = 1.9187$ ft/s^2

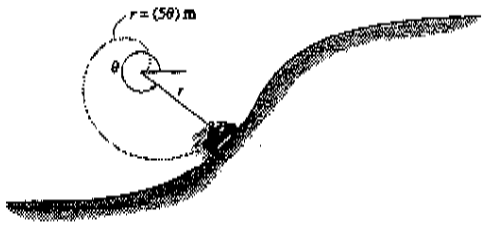
$\tan\psi = \dfrac{r}{dr/d\theta} = \dfrac{2+\cos\theta}{-\sin\theta}\bigg|_{\theta=0.5\text{ rad}} = -6.002 \qquad \psi = -80.54°$

$+\nearrow \Sigma F_r = ma_r; \qquad -N\cos 9.46° = \dfrac{2}{32.2}(-4.2346) \qquad N = 0.2666$ lb

$+\nwarrow \Sigma F_\theta = ma_\theta; \qquad F - 0.2666\sin 9.46° = \dfrac{2}{32.2}(1.9187)$

$F = 0.163$ lb **Ans**

13-99. Determine the normal and frictional driving forces that the partial spiral track exerts on the 200-kg motorcycle at the instant $\theta = \frac{5}{3}\pi$ rad, $\dot{\theta} = 0.4$ rad/s, and $\ddot{\theta} = 0.8$ rad/s². Neglect the size of the motorcycle.



$\theta = \left(\frac{5}{3}\pi\right) = 300°$ $\quad \dot{\theta} = 0.4$ $\quad \ddot{\theta} = 0.8$

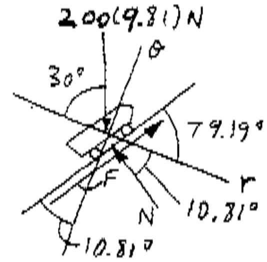
$r = 5\theta = 5\left(\frac{5}{3}\pi\right) = 26.18$

$\dot{r} = 5\dot{\theta} = 5(0.4) = 2$

$\ddot{r} = 5\ddot{\theta} = 5(0.8) = 4$

$a_r = \ddot{r} - r\dot{\theta}^2 = 4 - 26.18(0.4)^2 = -0.1888$

$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta} = 26.18(0.8) + 2(2)(0.4) = 22.54$



$\tan\psi = \frac{r}{dr/d\theta} = \frac{5\left(\frac{5}{3}\pi\right)}{5} = 5.236$ $\quad \psi = 79.19°$

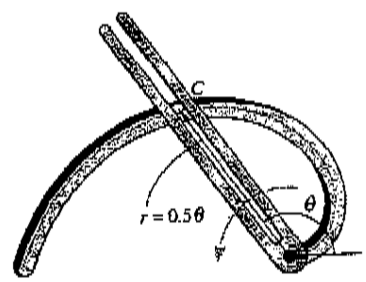
$+\searrow\Sigma F_r = ma_r;$ $\quad F\sin 10.81° - N\cos 10.81° + 200(9.81)\cos 30° = 200(-0.1888)$

$+\nearrow\Sigma F_\theta = ma_\theta;$ $\quad F\cos 10.81° - 200(9.81)\sin 30° + N\sin 10.81° = 200(22.54)$

$F = 5.07$ kN **Ans**

$N = 2.74$ kN **Ans**

***13-100.** Using a forked rod, a smooth cylinder C having a mass of 0.5 kg is forced to move along the *vertical slotted* path $r = (0.5\theta)$ m, where θ is in radians. If the angular position of the arm is $\theta = (0.5t^2)$ rad, where t is in seconds, determine the force of the rod on the cylinder and the normal force of the slot on the cylinder at the instant $t = 2$ s. The cylinder is in contact with only *one edge* of the rod and slot at any instant.



$r = 0.5\theta$ $\quad \dot{r} = 0.5\dot{\theta}$ $\quad \ddot{r} = 0.5\ddot{\theta}$

$\theta = 0.5t^2$ $\quad \dot{\theta} = t$ $\quad \ddot{\theta} = 1$

At $t = 2$ s,

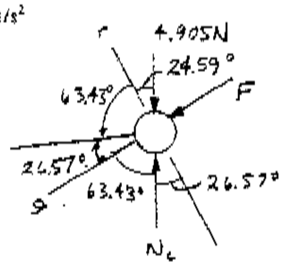
$\theta = 2$ rad $= 114.59°$ $\quad \dot{\theta} = 2$ rad/s $\quad \ddot{\theta} = 1$ rad/s²

$r = 1$ m $\quad \dot{r} = 1$ m/s $\quad \ddot{r} = 0.5$ m/s²

$\tan\psi = \frac{r}{dr/d\theta} = \frac{0.5(2)}{0.5}$ $\quad \psi = 63.43°$

$a_r = \ddot{r} - r\dot{\theta}^2 = 0.5 - 1(2)^2 = -3.5$

$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta} = 1(1) + 2(1)(2) = 5$



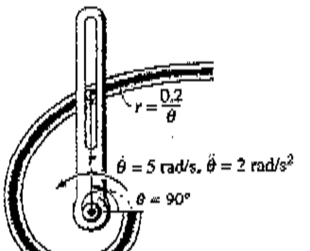
$+\nwarrow\Sigma F_r = ma_r;$ $\quad N_C\cos 26.57° - 4.905\cos 24.59° = 0.5(-3.5)$

$N_C = 3.030 = 3.03$ N **Ans**

$+\nearrow\Sigma F_\theta = ma_\theta;$ $\quad F - 3.030\sin 26.57° + 4.905\sin 24.59° = 0.5(5)$

$F = 1.81$ N **Ans**

•13-108. The arm is rotating at a rate of $\dot{\theta} = 5$ rad/s when $\ddot{\theta} = 2$ rad/s² and $\theta = 90°$. Determine the normal force it must exert on the 0.5-kg particle if the particle is confined to move along the slotted path defined by the *horizontal* hyperbolic spiral $r\theta = 0.2$ m.



$\theta = \frac{\pi}{2} = 90°$

$\dot{\theta} = 5$ rad/s

$\ddot{\theta} = 2$ rad/s²

$r = 0.2/\theta = 0.12732$ m

$\dot{r} = -0.2\,\theta^{-2}\dot{\theta} = -0.40528$ m/s

$\ddot{r} = -0.2[-2\theta^{-3}(\dot{\theta})^2 + \theta^{-2}\ddot{\theta}] = 2.41801$

$a_r = \ddot{r} - r(\dot{\theta})^2 = 2.41801 - 0.12732(5)^2 = -0.7651$ m/s²

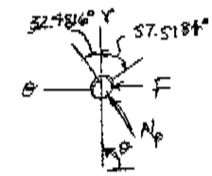
$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta} = 0.12732(2) + 2(-0.40528)(5) = -3.7982$ m/s²

$\tan\psi = \frac{r}{\left(\frac{dr}{d\theta}\right)} = \frac{0.2/\theta}{-0.2\theta^{-2}}$

$\psi = \tan^{-1}\left(-\frac{\pi}{2}\right) = -57.5184°$

$+\uparrow \Sigma F_r = m\,a_r;\quad N_p \cos 32.4816° = 0.5(-0.7651)$

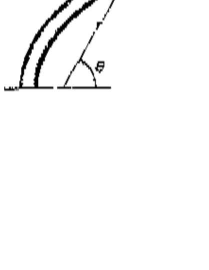
$\overset{+}{\leftarrow} \Sigma F_\theta = m\,a_\theta;\quad F + N_p \sin 32.4816° = 0.5(-3.7982)$



$N_p = -0.453$ N

$F = -1.66$ N **Ans**

13-109. The collar, which has a weight of 3 lb, slides along the smooth rod lying in the *horizontal plane* and having the shape of a parabola $r = 4/(1 - \cos\theta)$, where θ is in radians and r is in feet. If the collar's angular rate is constant and equals $\dot{\theta} = 4$ rad/s, determine the tangential retarding force P needed to cause the motion and the normal force that the collar exerts on the rod at the instant $\theta = 90°$.



$r = \frac{4}{1 - \cos\theta}$

$\dot{r} = \frac{-4\sin\theta\,\dot{\theta}}{(1-\cos\theta)^2}$

$\ddot{r} = \frac{-4\sin\theta\,\ddot{\theta}}{(1-\cos\theta)^2} + \frac{-4\cos\theta\,(\dot{\theta})^2}{(1-\cos\theta)^2} + \frac{8\sin^2\theta\,\dot{\theta}^2}{(1-\cos\theta)^3}$

At $\theta = 90°$, $\dot{\theta} = 4$, $\ddot{\theta} = 0$

$r = 4$

$\dot{r} = -16$

$\ddot{r} = 128$

$a_r = \ddot{r} - r(\dot{\theta})^2 = 128 - 4(4)^2 = 64$

$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta} = 0 + 2(-16)(4) = -128$

$r = \frac{4}{1-\cos\theta}$

$\frac{dr}{d\theta} = \frac{-4\sin\theta}{(1-\cos\theta)^2}$

$\tan\psi = \frac{r}{\left(\frac{dr}{d\theta}\right)} = \left.\frac{\frac{4}{1-\cos\theta}}{\frac{-4\sin\theta}{(1-\cos\theta)^2}}\right|_{\theta = 90°} = \frac{4}{-4} = -1$

$\psi = -45° = 135°$

$+\uparrow \Sigma F_r = m\,a_r;\quad P\sin 45° - N\cos 45° = \frac{3}{32.2}(64)$

$\overset{+}{\leftarrow} \Sigma F_\theta = m a_\theta;\quad -P\cos 45° - N\sin 45° = \frac{3}{32.2}(-128)$

Solving,

$P = 12.6$ lb **Ans**

$N = 4.22$ lb **Ans**