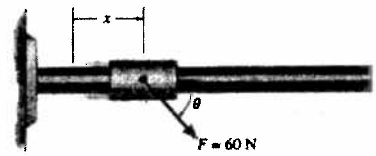
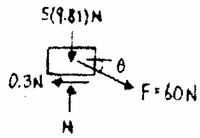
14-25. The collar has a mass of 5 kg and is moving at 8 m/s when $x = 0$ and a force of $F = 60$ N is applied to it. The direction θ of this force varies such that $\theta = 10x$, where x is in meters and θ is clockwise, measured in degrees. Determine the speed of the collar when $x = 3$ m. The coefficient of kinetic friction between the collar and the rod is $\mu_k = 0.3$.



$+\uparrow \Sigma F_y = 0: \quad N - 5(9.81) - 60\sin\theta = 0$

$N = 60\sin\theta + 49.05$



$T_1 + \Sigma U_{1-2} = T_2$

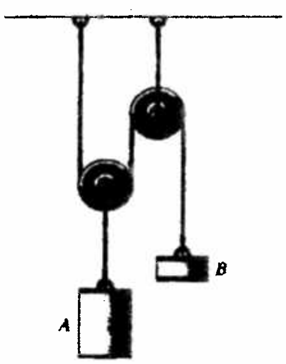
$$\frac{1}{2}(5)(8)^2 + \int_0^3 60\cos\theta\,dx - 0.3\int_0^3 (60\sin\theta + 49.05)\,dx = \frac{1}{2}(5)v^2$$

$$160 + 60\int_0^3 \cos 10x\,dx - 18\int_0^3 \sin 10x\,dx - 14.715\int_0^3 dx = 2.5v^2$$

$$160 + 60\left[\frac{\sin 10x}{10}\right]_0^3 + 18\left[\frac{\cos 10x}{10}\right]_0^3 - 44.145 = 2.5v^2$$

$v = 6.89$ m/s **Ans**

14-26. Cylinder A has a weight of 60 lb and block B has a weight of 10 lb. Determine the distance A must descend from rest before it obtains a speed of 8 ft/s. Also, what is the tension in the cord supporting block A? Neglect the mass of the cord and pulleys.



$2s_A + s_B = l$

$2\Delta s_A = -\Delta s_B$

$2v_A = -v_B$

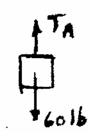
For $v_A = 8$ ft/s, $\quad v_B = -16$ ft/s

For the system:

$T_1 + \Sigma U_{1-2} = T_2$

$$[0+0] + [60(s_A) - 10(2s_A)] = \frac{1}{2}\left(\frac{60}{32.2}\right)(8)^2 + \frac{1}{2}\left(\frac{10}{32.2}\right)(-16)^2$$

$s_A = 2.484 = 2.48$ ft **Ans**



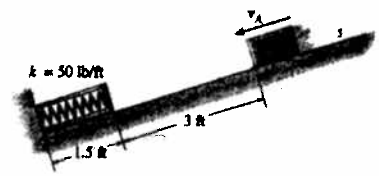
For block A:

$T_1 + \Sigma U_{1-2} = T_2$

$$0 + 60(2.484) - T_A(2.484) = \frac{1}{2}\left(\frac{60}{32.2}\right)(8)^2$$

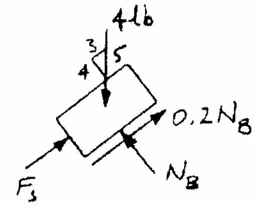
$T_A = 36.0$ lb **Ans**

14-38. The spring has a stiffness $k = 50$ lb/ft and an *unstretched length* of 2 ft. As shown, it is confined by the plate and wall using cables so that its length is 1.5 ft. A 4-lb block is given a speed v_A when it is at A, and it slides down the incline having a coefficient of kinetic friction $\mu_k = 0.2$. If it strikes the plate and pushes it forward 0.25 ft before stopping, determine its speed at A. Neglect the mass of the plate and spring.



$$+\nwarrow \Sigma F_y = 0: \quad N_B - 4\left(\frac{4}{5}\right) = 0$$

$$N_B = 3.20 \text{ lb}$$



$$T_1 + \Sigma U_{1-2} = T_2$$

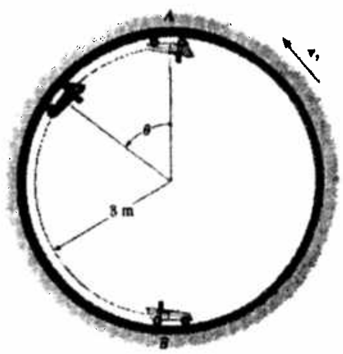
$$\frac{1}{2}\left(\frac{4}{32.2}\right)v_A^2 + (3 + 0.25)\left(\frac{3}{5}\right)(4) - 0.2(3.20)(3 + 0.25) - \left[\frac{1}{2}(50)(0.75)^2 - \frac{1}{2}(50)(0.5)^2\right] = 0$$

$v_A = 5.80$ ft/s **Ans**

$x_1 = s_1 - l_0 = .5$

$x_2 = s_2 - l_0 = .75$

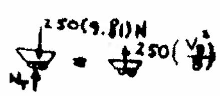
14-39. The "flying car" is a ride at an amusement park which consists of a car having wheels that roll along a track mounted inside a rotating drum. By design the car cannot fall off the track, however motion of the car is developed by applying the car's brake, thereby gripping the car to the track and allowing it to move with a constant speed of the track, $v_t = 3$ m/s. If the rider applies the brake when going from B to A and then releases it at the top of the drum, A, so that the car coasts freely down along the track to B ($\theta = \pi$ rad), determine the speed of the car at B and the normal reaction which the drum exerts on the car at B. Neglect friction during the motion from A to B. The rider and car have a total mass of 250 kg and the center of mass of the car and rider moves along a circular path having a radius of 8 m.



$$T_A + \Sigma U_{A-B} = T_B$$

$$\frac{1}{2}(250)(3)^2 + 250(9.81)(16) = \frac{1}{2}(250)(v_B)^2$$

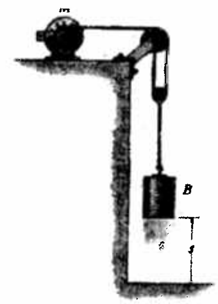
$v_B = 17.97 = 18.0$ m/s **Ans**

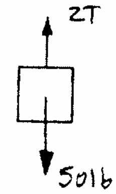


$$+\uparrow \Sigma F_n = ma_n \qquad N_B - 250(9.81) = 250\left(\frac{(17.97)^2}{8}\right)$$

$N_B = 12.5$ kN **Ans**

14-58. The 50-lb load is hoisted by the pulley system and motor M. If the crate starts from rest and by constant acceleration attains a speed of 15 ft/s after rising $s = 6$ ft, determine the power that must be supplied to the motor at this instant. The motor has an efficiency of $\epsilon = 0.76$. Neglect the mass of the pulleys and cable.





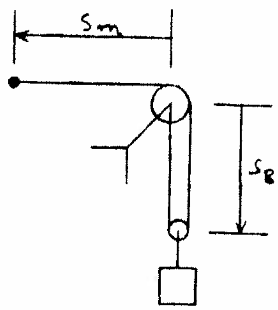
$(+\uparrow)\quad v^2 = v_0^2 + 2a_c(s - s_0)$

$(15)^2 = 0 + 2a_c(6 - 0)$

$a_c = 18.75\ \text{ft/s}^2$

$+\uparrow\Sigma F_y = m a_y; \quad 2T - 50 = \dfrac{50}{32.2}(18.75)$

$T = 39.56$ lb



$2s_B + s_M = l$

$2v_B = -v_M$

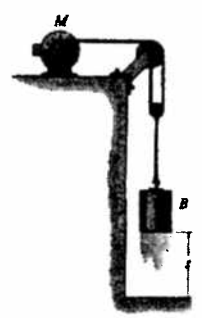
$2(-15) = -v_M$

$v_M = 30$ ft/s

$P_o = 30(39.56) = 1186.7\ \text{ft}\cdot\text{lb/s} = 2.16$ hp

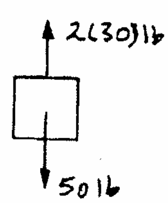
$P_i = \dfrac{2.16}{0.76} = 2.84$ hp **Ans**

14-59. The 50-lb load is hoisted by the pulley system and motor M. If the motor exerts a constant force of 30 lb on the cable, determine the power that must be supplied to the motor if the load has been hoisted $s = 10$ ft starting from rest. The motor has an efficiency of $\epsilon = 0.76$.



$+\uparrow\Sigma F_y = m a_y; \quad 2(30) - 50 = \dfrac{50}{32.2}a_B$

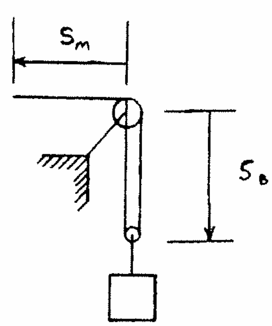
$a_B = 6.44\ \text{ft/s}^2$



$(+\downarrow)\ v^2 = v_0^2 + 2a_c(s - s_0)$

$v_B^2 = 0 + 2(6.44)(10 - 0)$

$v_B = -11.349$ ft/s



$2s_B + s_M = l$

$2v_B = -v_M$

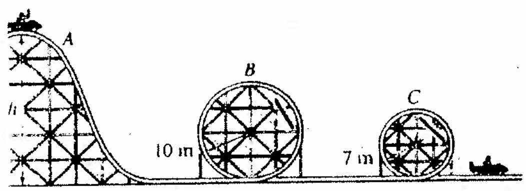
$v_M = -2(-11.349) = 22.698$ ft/s

$P_o = \mathbf{F}\cdot\mathbf{v} = 30(22.698) = 680.94\ \text{ft}\cdot\text{lb/s}$

$P_i = \dfrac{680.94}{0.76} = 895.97\ \text{ft}\cdot\text{lb/s}$

$P_i = 1.63$ hp **Ans**

***14-80.** The roller-coaster car has a mass of 800 kg, including its passenger. If it is released from rest at the top of the hill A, determine the minimum height h of the hill crest so that the car travels around both inside loops without leaving the track. Neglect friction, the mass of the wheels, and the size of the car. What is the normal reaction on the car when the car is at B and when it is at C?

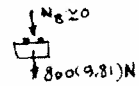


Since friction is neglected, the car will travel around the 7 m - loop provided it first travels around the 10 m - loop.

$$T_A + V_A = T_B + V_B$$

$$0 + 0 = \frac{1}{2}(800)(v_B^2) - 800(9.81)(h - 20)$$

$$+\downarrow \Sigma F_n = m a_n; \qquad 800(9.81) = 800\left(\frac{v_B^2}{10}\right)$$



Thus, $\quad v_B = 9.90$ m/s

$h = 25.0$ m **Ans**

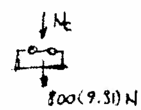
At B: $\quad N_B = 0$ **Ans** (For h to be minimum.)

$$T_A + V_A = T_C + V_C$$

$$0 + 0 = \frac{1}{2}(800)(v_C)^2 - 800(9.81)(25 - 14)$$

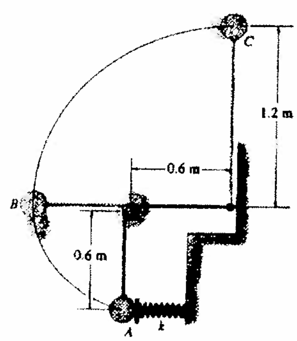
$$v_C = 14.69 \text{ m/s}$$

$$+\downarrow \Sigma F_n = m a_n; \qquad N_C + 800(9.81) = 800\left(\frac{(14.69)^2}{7}\right)$$



$N_C = 16.8$ kN **Ans**

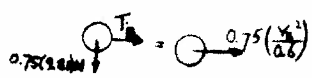
14-81. The 0.75-kg bob of a pendulum is fired from rest at position A by a spring which has a stiffness of $k = 6$ kN/m and is compressed 125 mm. Determine the speed of the bob and the tension in the cord when the bob is at positions B and C. Point B is located on the path where the radius of curvature is still 0.6 m, i.e., just before the cord becomes horizontal.

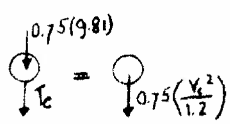


Datum at A:

$$T_A + V_A = T_B + V_B$$

$$0 + \frac{1}{2}(6000)(0.125)^2 = \frac{1}{2}(0.75)(v_B)^2 + 0.75(9.81)(0.6)$$





$v_B = 10.64 = 10.6$ m/s **Ans**

$$\xrightarrow{+} \Sigma F_n = m a_n; \qquad T_B = 0.75\left(\frac{(10.64)^2}{0.6}\right) = 142 \text{ N} \quad \textbf{Ans}$$

$$T_A + V_A = T_C + V_C$$

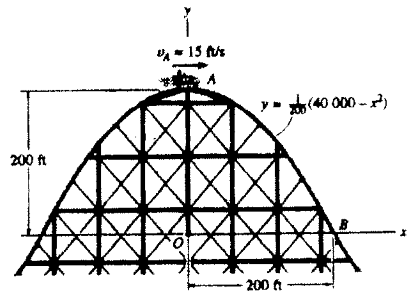
$$0 + \frac{1}{2}(6000)(0.125)^2 = \frac{1}{2}(0.75)(v_C)^2 + 0.75(9.81)(1.8)$$

$v_C = 9.470 = 9.47$ m/s **Ans**

$$+\downarrow \Sigma F_n = m a_n; \qquad T_C + 0.75(9.81) = 0.75\left(\frac{(9.470)^2}{1.2}\right)$$

$T_C = 48.7$ N **Ans**

14-86. The roller-coaster car has a speed of 15 ft/s when it is at the crest of a vertical parabolic track. Determine the car's velocity and the normal force it exerts on the track when it reaches point B. Neglect friction and the mass of the wheels. The total weight of the car and the passengers is 350 lb.



$$y = \frac{1}{200}(40\,000 - x^2)$$

$$\frac{dy}{dx} = -\frac{1}{100}x\bigg|_{x=200} = -2, \qquad \theta = \tan^{-1}(-2) = -63.43^\circ$$

$$\frac{d^2y}{dx^2} = -\frac{1}{100}$$

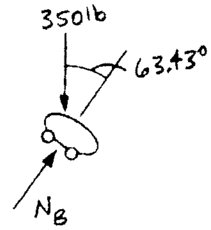
Datum at A :

$$T_A + V_A = T_B + V_B$$

$$\frac{1}{2}\left(\frac{350}{32.2}\right)(15)^2 + 0 = \frac{1}{2}\left(\frac{350}{32.2}\right)(v_B)^2 - 350(200)$$

$v_B = 114.48 = 114$ ft/s **Ans**

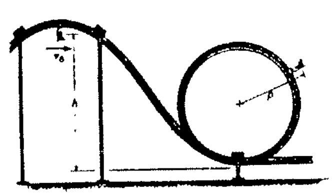
$$\rho = \frac{\left[1+\left(\frac{dy}{dx}\right)^2\right]^{\frac{3}{2}}}{\left|\frac{d^2y}{dx^2}\right|} = \frac{\left[1+(-2)^2\right]^{\frac{3}{2}}}{\left|-\frac{1}{100}\right|} = 1118.0 \text{ ft}$$



$+\swarrow \Sigma F_n = ma_n$: $\quad 350\cos 63.43^\circ - N_B = \left(\frac{350}{32.2}\right)\frac{(114.48)^2}{1118.0}$

$N_B = 29.1$ lb **Ans**

14-87. The Raptor is an outside loop roller coaster in which riders are belted into seats resembling ski-lift chairs. Determine the minimum speed v_0 at which the cars should coast down from the top of the hill, so that passengers can just make the loop without leaving contact with their seats. Neglect friction, the size of the car and passenger, and assume each passenger and car has a mass m.



Datum at ground :

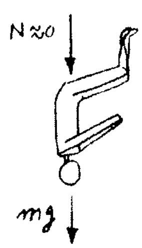
$$T_1 + V_1 = T_2 + V_2$$

$$\frac{1}{2}mv_0^2 + mgh = \frac{1}{2}mv_1^2 + mg2\rho$$

$$v_1 = \sqrt{v_0^2 + 2g(h - 2\rho)}$$

$+\downarrow \Sigma F_n = ma_n$: $\quad mg = m\left(\frac{v_1^2}{\rho}\right)$

$$v_1 = \sqrt{g\rho}$$



Thus,

$$g\rho = v_0^2 + 2gh - 4g\rho$$

$v_0 = \sqrt{g(5\rho - 2h)}$ **Ans**