4
O1 4
O

(a) When the spring is fully compressed, each cart moves with same velocity $\vec{\mathbf{v}}$. Apply conservation of momentum for the system of two gliders

$$\vec{\mathbf{p}}_i = \vec{\mathbf{p}}_f: \qquad m_1\vec{\mathbf{v}}_1 + m_2\vec{\mathbf{v}}_2 = (m_1 + m_2)\vec{\mathbf{v}} \qquad \boxed{\vec{\mathbf{v}} = \frac{m_1\vec{\mathbf{v}}_1 + m_2\vec{\mathbf{v}}_2}{m_1 + m_2}}$$

(b) Only conservative forces act, therefore $\Delta E = 0$. $\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 = \frac{1}{2}(m_1+m_2)v^2 + \frac{1}{2}kx_m^2$

Substitute for v from (a) and solve for x_m

$$x_m^2 = \frac{(m_1+m_2)m_1v_1^2 + (m_1+m_2)m_2v_2^2 - (m_1v_1)^2 - (m_2v_2)^2 - 2m_1m_2v_1v_2}{k(m_1+m_2)}$$

$$x_m = \sqrt{\frac{m_1m_2\left(v_1^2 + v_2^2 - 2v_1v_2\right)}{k(m_1+m_2)}} = \boxed{(v_1 - v_2)\sqrt{\frac{m_1m_2}{k(m_1+m_2)}}}$$

(c) $m_1\vec{\mathbf{v}}_1 + m_2\vec{\mathbf{v}}_2 = m_1\vec{\mathbf{v}}_{1f} + m_2\vec{\mathbf{v}}_{2f}$

Conservation of momentum: $m_1\left(\vec{\mathbf{v}}_1 - \vec{\mathbf{v}}_{1f}\right) = m_2\left(\vec{\mathbf{v}}_{2f} - \vec{\mathbf{v}}_2\right)$ (1)

Conservation of energy: $\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 = \frac{1}{2}m_1v_{1f}^2 + \frac{1}{2}m_2v_{2f}^2$

which simplifies to: $m_1\left(v_1^2 - v_{1f}^2\right) = m_2\left(v_{2f}^2 - v_2^2\right)$

Factoring gives $m_1\left(\vec{\mathbf{v}}_1 - \vec{\mathbf{v}}_{1f}\right)\cdot\left(\vec{\mathbf{v}}_1 + \vec{\mathbf{v}}_{1f}\right) = m_2\left(\vec{\mathbf{v}}_{2f} - \vec{\mathbf{v}}_2\right)\cdot\left(\vec{\mathbf{v}}_{2f} + \vec{\mathbf{v}}_2\right)$

and with the use of the momentum equation (equation (1)),

this reduces to $\left(\vec{\mathbf{v}}_1 + \vec{\mathbf{v}}_{1f}\right) = \left(\vec{\mathbf{v}}_{2f} + \vec{\mathbf{v}}_2\right)$

or $\vec{\mathbf{v}}_{1f} = \vec{\mathbf{v}}_{2f} + \vec{\mathbf{v}}_2 - \vec{\mathbf{v}}_1$ (2)

Substituting equation (2) into equation (1) and simplifying yields:

$$\boxed{\vec{\mathbf{v}}_{2f} = \left(\frac{2m_1}{m_1+m_2}\right)\vec{\mathbf{v}}_1 + \left(\frac{m_2 - m_1}{m_1+m_2}\right)\vec{\mathbf{v}}_2}$$

Upon substitution of this expression for $\vec{\mathbf{v}}_{2f}$ into equation 2, one finds

$$\boxed{\vec{\mathbf{v}}_{1f} = \left(\frac{m_1 - m_2}{m_1+m_2}\right)\vec{\mathbf{v}}_1 + \left(\frac{2m_2}{m_1+m_2}\right)\vec{\mathbf{v}}_2}$$

Observe that these results are the same as Equations 8.24 and 8.25, which should have been expected since this is a perfectly elastic collision in one dimension.

02

(a)

$$W = \Delta K + \Delta U$$

$$W = K_f - K_i + U_f - U_i$$

$$0 = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 - mgd\sin\theta - \frac{1}{2}kd^2$$

$$\frac{1}{2}\omega^2\left(I + mR^2\right) = mgd\sin\theta + \frac{1}{2}kd^2$$

$$\boxed{\omega = \sqrt{\frac{2mgd\sin\theta + kd^2}{I + mR^2}}}$$

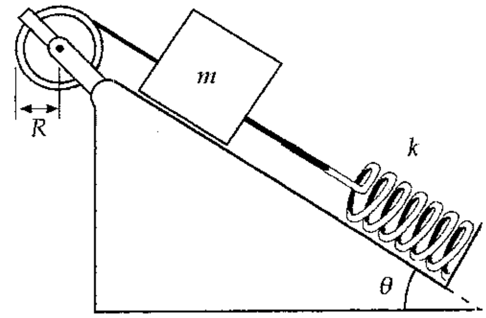


FIG. P10.61

(b)

$$\omega = \sqrt{\frac{2(0.500\text{ kg})(9.80\text{ m/s}^2)(0.200\text{ m})(\sin 37.0°) + 50.0\text{ N/m}(0.200\text{ m})^2}{1.00\text{ kg}\cdot\text{m}^2 + 0.500\text{ kg}(0.300\text{ m})^2}}$$

$$\omega = \sqrt{\frac{1.18 + 2.00}{1.05}} = \sqrt{3.04} = \boxed{1.74\text{ rad/s}}$$

03

$\sum F = ma$

For m_1: $T = m_1 a$

For m_2: $T - m_2 g = 0$

Eliminating T,

$$a = \frac{m_2 g}{m_1}$$

For all 3 blocks:

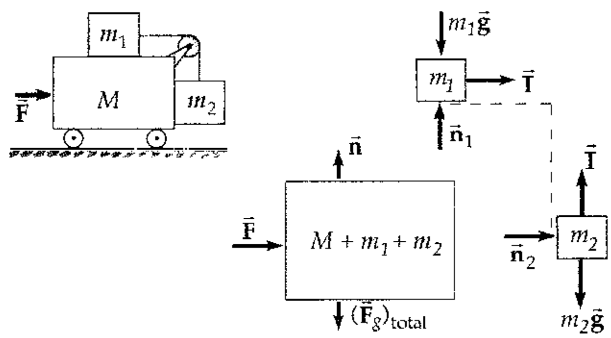


FIG. P4.47

$$F = (M + m_1 + m_2)a = \boxed{(M + m_1 + m_2)\left(\frac{m_2 g}{m_1}\right)}$$

Applying Newton's second law to each object gives:

(1) $T_1 = f_1 + 2m(g\sin\theta + a)$

(2) $T_2 - T_1 = f_2 + m(g\sin\theta + a)$

(3) $T_2 = M(g - a)$

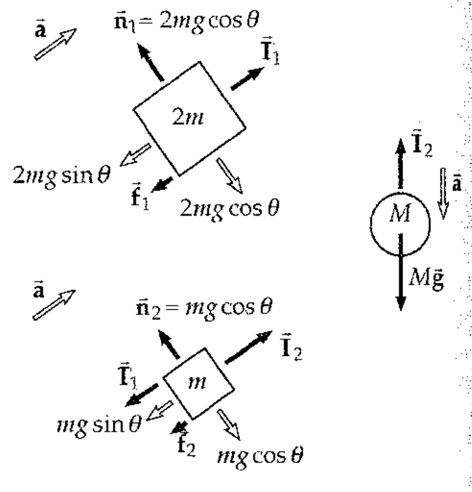


FIG. P5.37

(a), (b) Equilibrium $(a = 0)$

and frictionless incline $(f_1 = f_2 = 0)$

Under these conditions, the equations reduce to

(1′) $\boxed{T_1 = 2mg\sin\theta}$

(2′) $T_2 - T_1 = mg\sin\theta$

(3′) $T_2 = Mg$

Substituting (1′) and (3′) into equation (2′) then gives $\boxed{M = 3m\sin\theta}$

so equation (3′) becomes $\boxed{T_2 = 3mg\sin\theta}$

(c), (d) $M = 6m\sin\theta$ (double the value found above), and $f_1 = f_2 = 0$. With these conditions present, the equations become $T_1 = 2m(g\sin\theta + a)$, $T_2 - T_1 = m(g\sin\theta + a)$ and $T_2 = 6m\sin\theta(g - a)$ Solved simultaneously, these yield

$$\boxed{a = \frac{g\sin\theta}{1 + 2\sin\theta}}, \quad \boxed{T_1 = 4mg\sin\theta\left(\frac{1 + \sin\theta}{1 + 2\sin\theta}\right)} \text{ and } \boxed{T_2 = 6mg\sin\theta\left(\frac{1 + \sin\theta}{1 + 2\sin\theta}\right)}$$

(e) Equilibrium $(a = 0)$ and impending motion up the incline so $M = M_{max}$ while $f_1 = 2\mu_s mg\cos\theta$ and $f_2 = \mu_s mg\cos\theta$, both directed down the incline. Under these conditions, the equations become $T_1 = 2mg(\sin\theta + \mu_s\cos\theta)$, $T_2 - T_1 = mg(\sin\theta + \mu_s\cos\theta)$, and $T_2 = M_{max}g$, which yield $\boxed{M_{max} = 3m(\sin\theta + \mu_s\cos\theta)}$

(f) Equilibrium $(a = 0)$ and impending motion **down** the incline so $M = M_{min}$, while $f_1 = 2\mu_s mg\cos\theta$ and $f_2 = \mu_s mg\cos\theta$, both directed **up** the incline. Under these conditions, the equations are $T_1 = 2mg(\sin\theta - \mu_s\cos\theta)$, $T_2 - T_1 = mg(\sin\theta - \mu_s\cos\theta)$, and $T_2 = M_{min}g$, which yield $\boxed{M_{min} = 3m(\sin\theta - \mu_s\cos\theta)}$. When this expression gives a negative value, it corresponds physically to a mass M hanging from a cord over a pulley at the bottom end of the incline.

(g) $\boxed{T_{2,max} - T_{2,min} = M_{max}g - M_{min}g = 6\mu_s mg\cos\theta}$

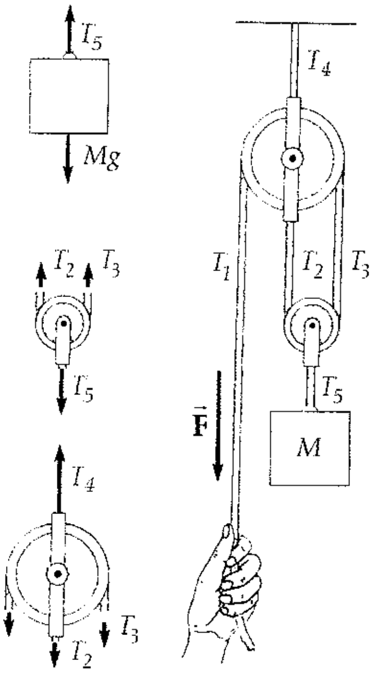
05

(a) First, we note that $F = T_1$. Next, we focus on the mass M and write $T_5 = Mg$. Next, we focus on the bottom pulley and write $T_5 = T_2 + T_3$. Finally, we focus on the top pulley and write $T_4 = T_1 + T_2 + T_3$.

Since the pulleys are not starting to rotate and are frictionless, $T_1 = T_3$, and $T_2 = T_3$. From this information, we have $T_5 = 2T_2$, so $T_2 = \frac{Mg}{2}$.

Then $\boxed{T_1 = T_2 = T_3 = \frac{Mg}{2}}$, and $\boxed{T_4 = \frac{3Mg}{2}}$, and $\boxed{T_5 = Mg}$

(b) Since $F = T_1$, we have $\boxed{F = \frac{Mg}{2}}$.



06

(a) Since only conservative forces act within the system of the rod and the Earth,

$\Delta E = 0$ so $K_f + U_f = K_i + U_i$

$$\frac{1}{2}I\omega^2 + 0 = 0 + Mg\left(\frac{L}{2}\right)$$

where $I = \frac{1}{3}ML^2$

Therefore, $\boxed{\omega = \sqrt{\frac{3g}{L}}}$

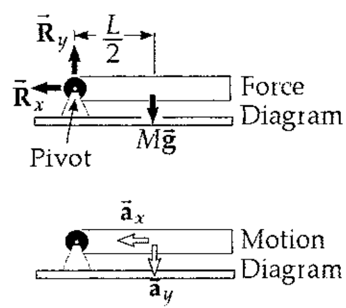


FIG. P10.59

(b) $\sum \tau = I\alpha$, so that in the horizontal orientation,

$$Mg\left(\frac{L}{2}\right) = \frac{ML^2}{3}\alpha$$

$$\boxed{\alpha = \frac{3g}{2L}}$$

(c) $a_x = a_r = -r\omega^2 = -\left(\frac{L}{2}\right)\omega^2 = \boxed{-\frac{3g}{2}}$ $\quad a_y = -a_t = -r\alpha = -\alpha\left(\frac{L}{2}\right) = \boxed{-\frac{3g}{4}}$

d) $R_x = Ma_x = -\frac{3Mg}{2}$

$R_y = Ma_y + Mg = -\frac{3Mg}{4}$.

4 07

(a) First, draw a free-body diagram, (top figure) of the top block. Since $a_y = 0$, $n_1 = 19.6\ \text{N}$. And $f_k = \mu_k n_1 = 0.300(19.6\ \text{N}) = 5.88\ \text{N}$. $\Sigma F_x = ma_T$

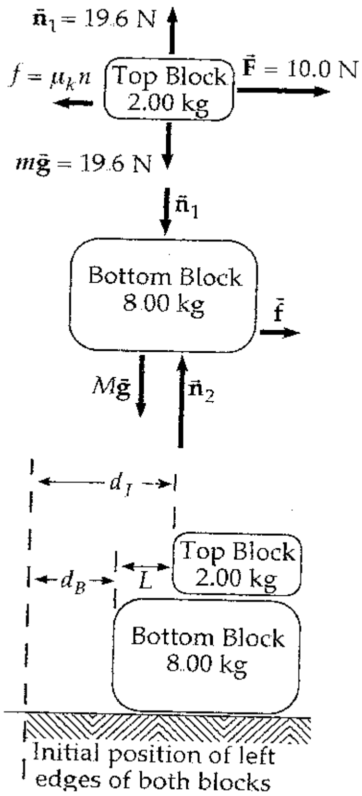
$$10.0\ \text{N} - 5.88\ \text{N} = (2.00\ \text{kg})a_T$$

or $a_T = 2.06\ \text{m/s}^2$ (for top block). Now draw a free-body diagram (middle figure) of the bottom block and observe that $\Sigma F_x = Ma_B$ gives $f = 5.88\ \text{N} = (8.00\ \text{kg})a_B$ or $a_B = 0.735\ \text{m/s}^2$ (for the bottom block). In time t, the distance each block moves (starting from rest) is $d_T = \frac{1}{2}a_T t^2$ and $d_B = \frac{1}{2}a_B t^2$. For the top block to reach the right edge of the bottom block, (see bottom figure) it is necessary that $d_T = d_B + L$ or

$$\frac{1}{2}\left(2.06\ \text{m/s}^2\right)t^2 = \frac{1}{2}\left(0.735\ \text{m/s}^2\right)t^2 + 3.00\ \text{m}$$

which gives: $\boxed{t = 2.13\ \text{s}}$

(b) From above, $d_B = \frac{1}{2}\left(0.735\ \text{m/s}^2\right)(2.13\ \text{s})^2 = \boxed{1.67\ \text{m}}$.



---

4 08

When it is on the verge of slipping, the cylinder is in equilibrium.

$\sum F_x = 0$: $\quad f_1 = n_2 = \mu_s n_1$ and $f_2 = \mu_s n_2$

$\sum F_y = 0$: $\quad P + n_1 + f_2 = F_g$

$\sum \tau = 0$: $\quad P = f_1 + f_2$

As P grows so do f_1 and f_2

Therefore, since $\mu_s = \frac{1}{2}$, $f_1 = \frac{n_1}{2}$ and $f_2 = \frac{n_2}{2} = \frac{n_1}{4}$

then $P + n_1 + \frac{n_1}{4} = F_g$ (1) and $P = \frac{n_1}{2} + \frac{n_1}{4} = \frac{3}{4}n_1$ (2)

So $P + \frac{5}{4}n_1 = F_g$ becomes $P + \frac{5}{4}\left(\frac{4}{3}P\right) = F_g$ or $\frac{8}{3}P = F_g$

Therefore, $P = \boxed{\frac{3}{8}F_g}$.

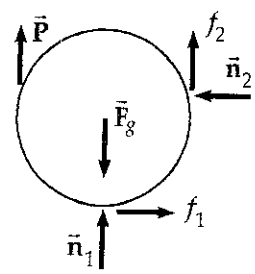


FIG. P10.77

09

(a) The initial momentum of the system is zero, which remains constant throughout the motion. Therefore, when m_1 leaves the wedge, we must have

$$m_2 v_{\text{wedge}} + m_1 v_{\text{block}} = 0$$

or $$(3.00\text{ kg})v_{\text{wedge}} + (0.500\text{ kg})(+4.00\text{ m/s}) = 0$$

so $$v_{\text{wedge}} = \boxed{-0.667\text{ m/s}}$$

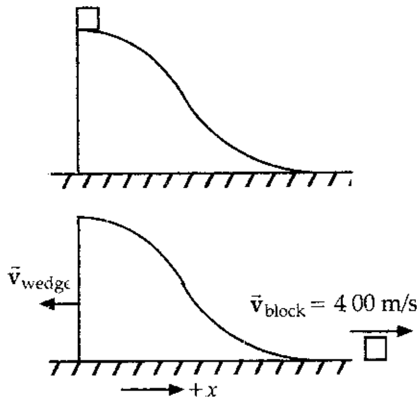


FIG. P8.51

(b) Using conservation of energy for the block-wedge-Earth system as the block slides down the smooth (frictionless) wedge, we have

$$\left[K_{\text{block}} + U_{\text{system}}\right]_i + \left[K_{\text{wedge}}\right]_i = \left[K_{\text{block}} + U_{\text{system}}\right]_f + \left[K_{\text{wedge}}\right]_f$$

or $$\left[0 + m_1 g h\right] + 0 = \left[\frac{1}{2}m_1(4.00)^2 + 0\right] + \frac{1}{2}m_2(-0.667)^2 \text{ which gives } \boxed{h = 0.952\text{ m}}$$

010

(a) Between the second and the third picture, $\Delta E_{\text{mech}} = \Delta K + \Delta U$

$$-\mu m g d = -\frac{1}{2}mv_i^2 + \frac{1}{2}kd^2$$

$$\frac{1}{2}(50.0\text{ N/m})d^2 + 0.250(1.00\text{ kg})\left(9.80\text{ m/s}^2\right)d - \frac{1}{2}(1.00\text{ kg})(3.00\text{ m/s})^2 = 0$$

$$d = \frac{[-2.45 \pm 21.35]\text{ N}}{50.0\text{ N/m}} = \boxed{0.378\text{ m}}$$

(b) Between picture two and picture four, $\Delta E_{\text{mech}} = \Delta K + \Delta U$

$$-f(2d) = \frac{1}{2}mv^2 - \frac{1}{2}mv_i^2$$

$$v = \sqrt{(3.00\text{ m/s})^2 - \frac{2}{(1.00\text{ kg})}(2.45\text{ N})(2)(0.378\text{ m})}$$

$$= \boxed{2.30\text{ m/s}}$$

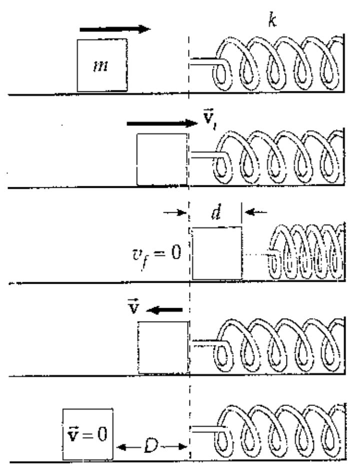


FIG. P7.54

(c) For the motion from picture two to picture five, $\Delta E_{\text{mech}} = \Delta K + \Delta U$

$$-f(D + 2d) = -\frac{1}{2}(1.00\text{ kg})(3.00\text{ m/s})^2$$

$$D = \frac{9.00\text{ J}}{2(0.250)(1.00\text{ kg})\left(9.80\text{ m/s}^2\right)} - 2(0.378\text{ m}) = \boxed{1.08\text{ m}}$$

The upward acceleration of the rod is described by

$$y_f = y_i + v_{yi}t + \frac{1}{2}a_y t^2$$

$$1\times10^{-3}\ \text{m} = 0 + 0 + \frac{1}{2}a_y\left(8\times10^{-3}\ \text{s}\right)^2$$

$$a_y = 31.2\ \text{m/s}^2$$

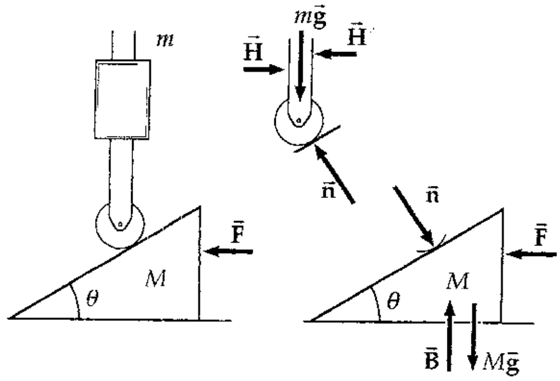


FIG. P4.50

The distance y moved by the rod and the distance x moved by the wedge in the same time are related by $\tan 15° = \frac{y}{x} \Rightarrow x = \frac{y}{\tan 15°}$

Then their speeds and accelerations are related by

$$\frac{dx}{dt} = \frac{1}{\tan 15°}\frac{dy}{dt}$$

and

$$\frac{d^2x}{dt^2} = \frac{1}{\tan 15°}\frac{d^2y}{dt^2} = \left(\frac{1}{\tan 15°}\right)31.2\ \text{m/s}^2 = 117\ \text{m/s}^2$$

The free body diagram for the rod is shown. Here H and H' are forces exerted by the guide.

$$\sum F_y = ma_y: \qquad n\cos 15° - mg = ma_y$$

$$n\cos 15° - 0.250\ \text{kg}\left(9.8\ \text{m/s}^2\right) = 0.250\ \text{kg}\left(31.2\ \text{m/s}^2\right)$$

$$n = \frac{10.3\ \text{N}}{\cos 15°} = 10.6\ \text{N}$$

For the wedge,

$$\sum F_x = Ma_x: \quad -n\sin 15° + F = 0.5\ \text{kg}\left(117\ \text{m/s}^2\right)$$

$$F = (10.6\ \text{N})\sin 15° + 58.3\ \text{N} = \boxed{61.1\ \text{N}}$$

4
O12

Let λ represent the mass of each one meter of the chain and T represent the tension in the chain at the table edge We imagine the edge to act like a frictionless and massless pulley.

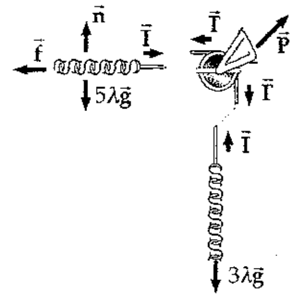


FIG. P7.56

(a) For the five meters on the table with motion impending,

$\sum F_y = 0: \quad +n - 5\lambda g = 0 \qquad n = 5\lambda g$

$f_s \le \mu_s n = 0.6(5\lambda g) = 3\lambda g$

$\sum F_x = 0: \quad +T - f_s = 0 \qquad T = f_s \qquad T \le 3\lambda g$

The maximum value is barely enough to support the hanging segment according to

$\sum F_y = 0: \quad +T - 3\lambda g = 0 \qquad T = 3\lambda g$

so it is at this point that the chain starts to slide.

(b) Let x represent the variable distance the chain has slipped since the start.

Then length $(5 - x)$ remains on the table, with now

$\sum F_y = 0: \quad +n - (5 - x)\lambda g = 0 \qquad n = (5 - x)\lambda g$

$f_k = \mu_k n = 0.4(5 - x)\lambda g = 2\lambda g - 0.4x\lambda g$

Consider energies of the chain-Earth system at the initial moment when the chain starts to slip, and a final moment when $x = 5$, when the last link goes over the brink. Measure heights above the final position of the leading end of the chain. At the moment the final link slips off, the center of the chain is at $y_f = 4$ meters.

Originally, 5 meters of chain is at height 8 m and the middle of the dangling segment is at height $8 - \frac{3}{2} = 6\,5$ m

$K_i + U_i + \Delta E_{\text{mech}} = K_f + U_f: \qquad 0 + (m_1 g y_1 + m_2 g y_2)_i - \int_i^f f_k dx = \left(\frac{1}{2}mv^2 + mgy\right)_f$

$$(5\lambda g)8 + (3\lambda g)6\,5 - \int_0^5 (2\lambda g - 0\,4x\lambda g)dx = \frac{1}{2}(8\lambda)v^2 + (8\lambda g)4$$

$$40\,0g + 19.5g - 2.00g\int_0^5 dx + 0.400g\int_0^5 x\,dx = 4.00v^2 + 32\,0g$$

$$27.5g - 2.00gx\Big|_0^5 + 0\,400g\frac{x^2}{2}\Big|_0^5 = 4\,00v^2$$

$$27\,5g - 2.00g(5\,00) + 0.400g(12\,5) = 4\,00v^2$$

$$22.5g = 4.00v^2$$

$$v = \sqrt{\frac{(22\,5 \text{ m})(9.80 \text{ m/s}^2)}{4\,00}} = \boxed{7.42 \text{ m/s}}$$

013

(a) $\Delta K_{rot} + \Delta K_{trans} + \Delta U = 0$

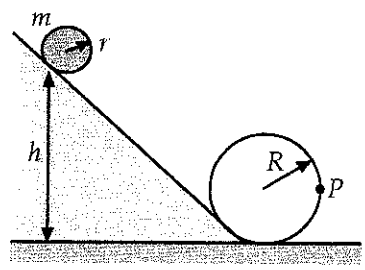


FIG. P10.76

Note that initially the center of mass of the sphere is a distance $h+r$ above the bottom of the loop; and as the mass reaches the top of the loop, this distance above the reference level is $2R-r$. The conservation of energy requirement gives

$$mg(h+r) = mg(2R-r) + \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

For the sphere $I = \frac{2}{5}mr^2$ and $v = r\omega$ so that the expression becomes

$$gh + 2gr = 2gR + \frac{7}{10}v^2 \qquad (1)$$

Note that $h = h_{min}$ when the speed of the sphere at the top of the loop satisfies the condition

$\sum F = mg = \frac{mv^2}{(R-r)}$ or $v^2 = g(R-r)$

Substituting this into Equation (1) gives

$h_{min} = 2(R-r) + 0.700(R-r)$ or $\boxed{h_{min} = 2.70(R-r) \approx 2.70R}$

(b) When the sphere is initially at $h = 3R$ and finally at point P, the conservation of energy equation gives

$mg(3R+r) = mgR + \frac{1}{2}mv^2 + \frac{1}{5}mv^2$, or $v^2 = \frac{10}{7}(2R+r)g$

Turning clockwise as it rolls without slipping past point P, the sphere is slowing down with counterclockwise angular acceleration caused by the torque of an upward force f of static friction. We have $\sum F_y = ma_y$ and $\sum \tau = I\alpha$ becoming $f - mg = -m\alpha r$ and $fr = \left(\frac{2}{5}\right)mr^2\alpha$

Eliminating f by substitution yields $\alpha = \frac{5g}{7r}$ so that $\sum F_y = \boxed{\frac{-5mg}{7}}$

$\sum F_x = -n = -\frac{mv^2}{R-r} = -\frac{\left(\frac{10}{7}\right)(2R+r)}{R-r}mg = \boxed{\frac{-20mg}{7}}$ (since $R >> r$)

Ö14

(a) Locate the origin at the bottom left corner of the cabinet and let $x =$ distance between the *resultant normal force* and the *front of the cabinet* Then we have

$$\sum F_x = 200\cos 37.0° - \mu n = 0 \qquad (1)$$

$$\sum F_y = 200\sin 37.0° + n - 400 = 0 \qquad (2)$$

$$\sum \tau = n(0.600 - x) - 400(0.300) + 200\sin 37.0°(0.600)$$

$$-200\cos 37.0°(0.400) = 0 \qquad (3)$$

From (2), $n = 400 - 200\sin 37.0° = 280\text{ N}$

From (3), $x = \dfrac{72.2 - 120 + 280(0.600) - 64.0}{280}$

$x = \boxed{20.1\text{ cm}}$ to the left of the front edge

From (1), $\mu_k = \dfrac{200\cos 37.0°}{280} = \boxed{0.571}$

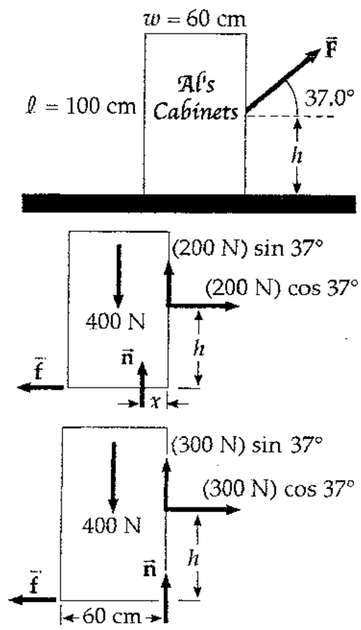


FIG. P10.73

(b) In this case, locate the origin $x = 0$ at the bottom right corner of the cabinet Since the cabinet is about to tip, we can use $\sum \tau = 0$ to find h:

$$\sum \tau = 400(0.300) - (300\cos 37.0°)h = 0 \qquad h = \frac{120}{300\cos 37.0°} = \boxed{0.501\text{ m}}$$

Ö15

(a) Use conservation of the horizontal component of momentum for the system of the shell, the cannon, and the carriage, from just before to just after the cannon firing

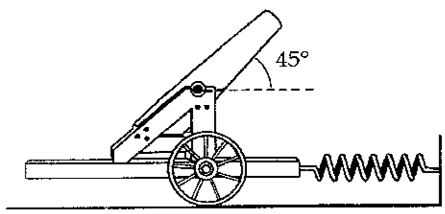


FIG. P8.58

$p_{xf} = p_{xi}$: $\quad m_{\text{shell}} v_{\text{shell}} \cos 45.0° + m_{\text{cannon}} v_{\text{recoil}} = 0$

$(200)(125)\cos 45.0° + (5\,000) v_{\text{recoil}} = 0$

or $\quad v_{\text{recoil}} = \boxed{-3.54\text{ m/s}}$

(b) Use conservation of energy for the system of the cannon, the carriage, and the spring from right after the cannon is fired to the instant when the cannon comes to rest.

$$K_f + U_{gf} + U_{sf} = K_i + U_{gi} + U_{si}: \qquad 0 + 0 + \frac{1}{2}kx_{\max}^2 = \frac{1}{2}mv_{\text{recoil}}^2 + 0 + 0$$

$$x_{\max} = \sqrt{\frac{mv_{\text{recoil}}^2}{k}} = \sqrt{\frac{(5\,000)(-3.54)^2}{2.00\times 10^4}}\text{ m} = \boxed{1.77\text{ m}}$$

c) $|F_{s,max}| = kx_{max} = 3{,}54 \cdot 10^4$ N

d) Nej!

016

(a) $(K+U)_i + \Delta E_{\text{mech}} = (K+U)_f$:

$$0+\frac{1}{2}kx^2 - f\Delta x = \frac{1}{2}mv^2 + 0$$

$$\frac{1}{2}(8.00\text{ N/m})(5.00\times10^{-2}\text{ m})^2 - (3.20\times10^{-2}\text{ N})(0.150\text{ m}) = \frac{1}{2}(5.30\times10^{-3}\text{ kg})v^2$$

$$v = \sqrt{\frac{2(5.20\times10^{-3}\text{ J})}{5.30\times10^{-3}\text{ kg}}} = \boxed{1.40\text{ m/s}}$$

(b) When the spring force just equals the friction force, the ball will stop speeding up. Here $|\vec{\mathbf{F}}_s| = kx$; the spring is compressed by

$$\frac{3.20\times10^{-2}\text{ N}}{8.00\text{ N/m}} = 0.400\text{ cm}$$

and the ball has moved

$$5.00\text{ cm} - 0.400\text{ cm} = \boxed{4.60\text{ cm from the start.}}$$

(c) Between start and maximum speed points,

$$\frac{1}{2}kx_i^2 - f\Delta x = \frac{1}{2}mv^2 + \frac{1}{2}kx_f^2$$

$$\frac{1}{2}8.00(5.00\times10^{-2})^2 - (3.20\times10^{-2})(4.60\times10^{-2}) = \frac{1}{2}(5.30\times10^{-3})v^2 + \frac{1}{2}8.00(4.00\times10^{-3})^2$$

$$v = \boxed{1.79\text{ m/s}}$$