7.19

$$4.00 \text{ J} = \frac{1}{2}k(0\ 100 \text{ m})^2$$

$\therefore k = 800$ N/m and to stretch the spring to 0 200 m requires

$$\Delta W = \frac{1}{2}(800)(0.200)^2 - 4.00 \text{ J} = \boxed{12.0 \text{ J}}$$

7.20

(a) The radius to the object makes angle θ with the horizontal, so its weight makes angle θ with the negative side of the x-axis, when we take the x–axis in the direction of motion tangent to the cylinder

$$\sum F_x = ma_x$$

$$F - mg\cos\theta = 0$$

$$F = \boxed{mg\cos\theta}$$

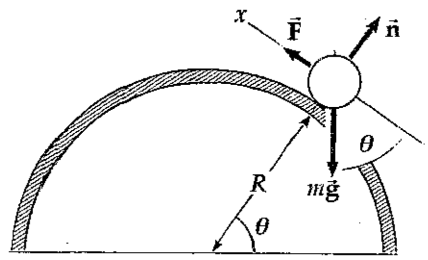


FIG. P6.19

(b) $W = \int_i^f \vec{\mathbf{F}}\, d\vec{\mathbf{r}} = \int_0^{\pi/2} mg \cos\theta\, R\, d\theta = mgR\left[\sin\theta\right]_0^{\pi/2} = mgR$

7.27

Consider the work done on the pile driver from the time it starts from rest until it comes to rest at the end of the fall. Let $d = 5.00$ m represent the distance over which the driver falls freely, and $h = 0\ 12$ m the distance it moves the piling.

$$\sum W = \Delta K: \quad W_{\text{gravity}} + W_{\text{beam}} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

so $\quad (mg)(h+d)\cos 0° + (\bar{F})(d)\cos 180° = 0 - 0.$

Thus, $\quad \bar{F} = \frac{(mg)(h+d)}{d} = \frac{(2\ 100 \text{ kg})(9\ 80 \text{ m/s}^2)(5.12 \text{ m})}{0.120 \text{ m}} = \boxed{8.78\times10^5 \text{ N}}$. The force on the pile driver is $\boxed{\text{upward}}$.

7.35

$v_i = 2.00$ m/s $\qquad \mu_k = 0\ 100$

$K_i - f_k d + W_{\text{other}} = K_f: \qquad \frac{1}{2}mv_i^2 - f_k d = 0$

$\frac{1}{2}mv_i^2 = \mu_k mgd \qquad d = \frac{v_i^2}{2\mu_k g} = \frac{(2.00 \text{ m/s})^2}{2(0.100)(9.80)} = \boxed{2.04 \text{ m}}$

7.49

(a) $x = t + 2.00t^3$

Therefore,

$$v = \frac{dx}{dt} = 1 + 6.00t^2$$

$$K = \frac{1}{2}mv^2 = \frac{1}{2}(4.00)\left(1+6.00t^2\right)^2 = \boxed{\left(2.00 + 24.0t^2 + 72.0t^4\right)\text{ J}}$$

(b) $a = \dfrac{dv}{dt} = \boxed{(12.0t)\text{ m/s}^2}$

$F = ma = 4.00(12.0t) = \boxed{(48.0t)\text{ N}}$

(c) $\mathcal{P} = Fv = (48.0t)\left(1+6.00t^2\right) = \boxed{\left(48.0t + 288t^3\right)\text{ W}}$

(d) $W = \displaystyle\int_0^{2.00} \mathcal{P}dt = \int_0^{2.00}\left(48.0t + 288t^3\right)dt = \boxed{1\,250\text{ J}}$

7.63

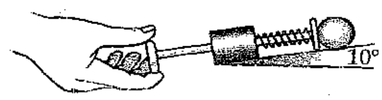


FIG. P6.55

$$K_i + W_s + W_g = K_f$$

$$\frac{1}{2}mv_i^2 + \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2 + mg\Delta x\cos\theta = \frac{1}{2}mv_f^2$$

$$0 + \frac{1}{2}kx_i^2 - 0 + mgx_i\cos 100° = \frac{1}{2}mv_f^2$$

$$\frac{1}{2}(1.20\text{ N/cm})(5.00\text{ cm})(0.050\,0\text{ m}) - (0.100\text{ kg})\left(9.80\text{ m/s}^2\right)(0.050\,0\text{ m})\sin 10.0° = \frac{1}{2}(0.100\text{ kg})v^2$$

$$0.150\text{ J} - 8.51\times10^{-3}\text{ J} = (0.050\,0\text{ kg})v^2$$

$$v = \sqrt{\frac{0.141}{0.050\,0}} = \boxed{1.68\text{ m/s}}$$

8.5

(a) $U_i + K_i = U_f + K_f$: $\quad mgh + 0 = mg(2R) + \dfrac{1}{2}mv^2$

$$g(3.50R) = 2g(R) + \frac{1}{2}v^2$$

$$\boxed{v = \sqrt{3.00gR}}$$

(b) $\sum F = m\dfrac{v^2}{R}$: $\quad n + mg = m\dfrac{v^2}{R}$

$$n = m\left[\frac{v^2}{R} - g\right] = m\left[\frac{3.00gR}{R} - g\right] = 2.00mg$$

$$n = 2.00\left(5.00\times10^{-3}\text{ kg}\right)\left(9.80\text{ m/s}^2\right)$$

$$= \boxed{0.098\,0\text{ N downward}}$$

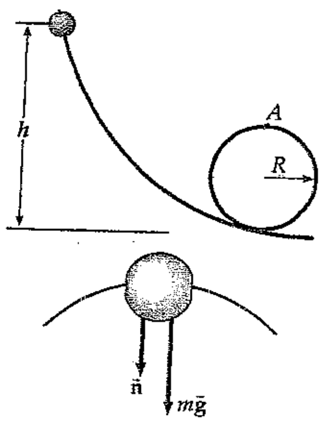


FIG. P7.5

8.13

Using conservation of energy for the system of the Earth and the two objects

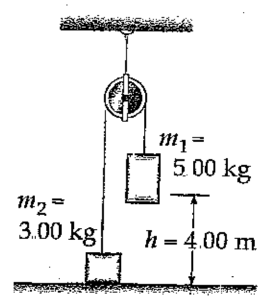


FIG. P7.9

(a) $(5.00\text{ kg})g(4.00\text{ m}) = (3.00\text{ kg})g(4.00\text{ m}) + \frac{1}{2}(5.00+3.00)v^2$

$v = \sqrt{19.6} = \boxed{4.43\text{ m/s}}$

(b) Now we apply conservation of energy for the system of the 3.00 kg object and the Earth during the time interval between the instant when the string goes slack and the instant at which the 3.00 kg object reaches its highest position in its free fall.

$$\frac{1}{2}(3.00)v^2 = mg\,\Delta y = 3.00g\Delta y$$
$$\Delta y = 1.00\text{ m}$$
$$y_{max} = 4.00\text{ m} + \Delta y = \boxed{5.00\text{ m}}$$

8.10

Choose the zero point of gravitational potential energy of the object-spring-Earth system as the configuration in which the object comes to rest. Then because the incline is frictionless, we have $E_B = E_A$: $K_B + U_{gB} + U_{sB} = K_A + U_{gA} + U_{sA}$ or $0 + mg(d+x)\sin\theta + 0 = 0 + 0 + \frac{1}{2}kx^2$. Solving for d gives

$$d = \boxed{\frac{kx^2}{2mg\sin\theta} - x}$$

8.47 (a) When the mass moves distance x, the length of each spring changes from L to $\sqrt{x^2+L^2}$, so each exerts force $k\left(\sqrt{x^2+L^2}-L\right)$ towards its fixed end. The y-components cancel out and the x components add to:

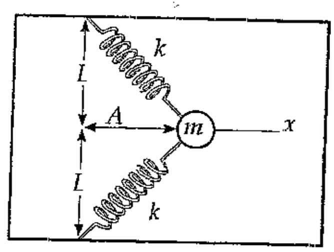


FIG. P7.41(a)

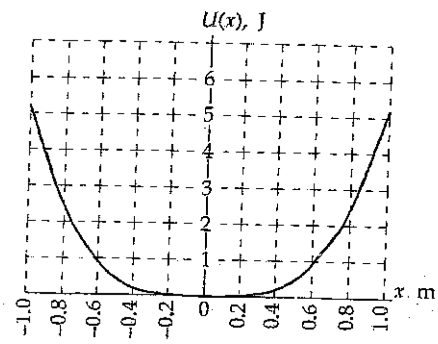
$$F_x = -2k\left(\sqrt{x^2+L^2}-L\right)\left(\frac{x}{\sqrt{x^2+L^2}}\right) = -2kx + \frac{2kLx}{\sqrt{x^2+L^2}}$$

Choose $U=0$ at $x=0$. Then at any point the potential energy of the system is

$$U(x) = -\int_0^x F_x dx = -\int_0^x\left(-2kx + \frac{2kLx}{\sqrt{x^2+L^2}}\right)dx = 2k\int_0^x x\,dx - 2kL\int_0^x \frac{x}{\sqrt{x^2+L^2}}dx$$

$$U(x) = \boxed{kx^2 + 2kL\left(L - \sqrt{x^2+L^2}\right)}$$

(b) $U(x) = 40.0x^2 + 96.0\left(1.20 - \sqrt{x^2+1.44}\right)$



For negative x, $U(x)$ has the same value as for positive x. The only equilibrium point (i.e., where $F_x = 0$) is $\boxed{x=0}$.

(c) $K_i + U_i + \Delta E_{mech} = K_f + U_f$

$0 + 0.400\text{ J} + 0 = \frac{1}{2}(1.18\text{ kg})v_f^2 + 0$

$v_f = \boxed{0.823\text{ m/s}}$

9.3

I have mass 85.0 kg and can jump to raise my center of gravity 25.0 cm. I leave the ground with speed given by

$v_f^2 - v_i^2 = 2a(x_f - x_i)$: $\quad 0 - v_i^2 = 2(-9.80\ \text{m/s}^2)(0.250\ \text{m})$

$$v_i = 2.20\ \text{m/s}$$

Total momentum of the system of the Earth and me is conserved as I push the earth down and myself up:

$$0 = (5.98 \times 10^{24}\ \text{kg})v_e + (85.0\ \text{kg})(2.20\ \text{m/s})$$

$$v_e \sim \boxed{10^{-23}\ \text{m/s}}$$

9.9

$$\Delta\vec{p} = \vec{F}\Delta t$$

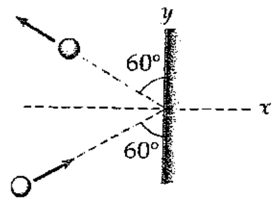
$$\Delta p_y = m(v_{fy} - v_{iy}) = m(v\cos 60.0°) - mv\cos 60.0° = 0$$

$$\Delta p_x = m(-v\sin 60.0° - v\sin 60.0°) = -2mv\sin 60.0°$$

$$= -2(3.00\ \text{kg})(10.0\ \text{m/s})(0.866)$$

$$= -52.0\ \text{kg}\cdot\text{m/s}$$

$$F_{\text{ave}} = \frac{\Delta p_x}{\Delta t} = \frac{-52.0\ \text{kg m/s}}{0.200\ \text{s}} = \boxed{-260\ \text{N}}$$



9.32

We use conservation of momentum for the system of two vehicles for both northward and eastward components.

For the eastward direction:

$$M(13.0\ \text{m/s}) = 2MV_f\cos 55.0°$$

For the northward direction:

$$Mv_{2i} = 2MV_f\sin 55.0°$$

Divide the northward equation by the eastward equation to find:

$$v_{2i} = (13.0\ \text{m/s})\tan 55.0° = 18.6\ \text{m/s} = \boxed{41.5\ \text{mi/h}}$$

Thus, the driver of the north bound car was untruthful.

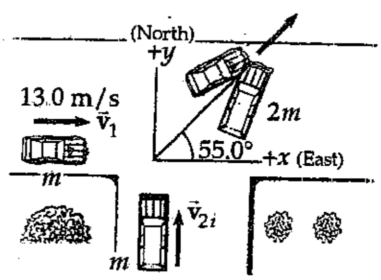


FIG. P8.26