P6.1 (a) $W = F\Delta r\cos\theta = (16.0\text{ N})(2.20\text{ m})\cos 25.0° = \boxed{31.9\text{ J}}$

(b), (c) The normal force and the weight are both at 90° to the displacement in any time interval. Both do $\boxed{0}$ work.

(d) $\sum W = 31.9\text{ J} + 0 + 0 = \boxed{31.9\text{ J}}$

P6.4 (a) $W = mgh = \left(3.35\times10^{-5}\right)(9.80)(100)\text{ J} = \boxed{3.28\times10^{-2}\text{ J}}$

(b) Since $R = mg$, $W_{\text{air resistance}} = \boxed{-3.28\times10^{-2}\text{ J}}$

P6.7 (a) $W = \vec{\mathbf{F}}\cdot\Delta\vec{\mathbf{r}} = F_x x + F_y y = (6.00)(3.00)\text{ N}\cdot\text{m} + (-2.00)(1.00)\text{ N}\cdot\text{m} = \boxed{16.0\text{ J}}$

(b) $$\theta = \cos^{-1}\left(\frac{\vec{\mathbf{F}}\cdot\Delta\vec{\mathbf{r}}}{F\Delta r}\right) = \cos^{-1}\frac{16}{\sqrt{\left((6.00)^2+(-2.00)^2\right)\left((3.00)^2+(1.00)^2\right)}} = \boxed{36.9°}$$

P6.9 (a) $\vec{\mathbf{A}} = 3.00\hat{\mathbf{i}} - 2.00\hat{\mathbf{j}}$

$\vec{\mathbf{B}} = 4.00\hat{\mathbf{i}} - 4.00\hat{\mathbf{j}}$ $\qquad \theta = \cos^{-1}\dfrac{\vec{\mathbf{A}}\cdot\vec{\mathbf{B}}}{AB} = \cos^{-1}\dfrac{12.0+8.00}{\sqrt{(13.0)(32.0)}} = \boxed{11.3°}$

(b) $\vec{\mathbf{B}} = 3.00\hat{\mathbf{i}} - 4.00\hat{\mathbf{j}} + 2.00\hat{\mathbf{k}}$

$\vec{\mathbf{A}} = -2.00\hat{\mathbf{i}} + 4.00\hat{\mathbf{j}}$ $\qquad \cos\theta = \dfrac{\vec{\mathbf{A}}\cdot\vec{\mathbf{B}}}{AB} = \dfrac{-6.00-16.0}{\sqrt{(20.0)(29.0)}}$ $\qquad \theta = \boxed{156°}$

(c) $\vec{\mathbf{A}} = \hat{\mathbf{i}} - 2.00\hat{\mathbf{j}} + 2.00\hat{\mathbf{k}}$

$\vec{\mathbf{B}} = 3.00\hat{\mathbf{j}} + 4.00\hat{\mathbf{k}}$ $\qquad \theta = \cos^{-1}\left(\dfrac{\vec{\mathbf{A}}\cdot\vec{\mathbf{B}}}{AB}\right) = \cos^{-1}\left(\dfrac{-6.00+8.00}{\sqrt{9.00}\cdot\sqrt{25.0}}\right) = \boxed{82.3°}$

P6.10 $F_x = (8x - 16)\text{ N}$

(a) See figure to the right.

(b) $$W_{\text{net}} = \frac{-(2.00\text{ m})(16.0\text{ N})}{2} + \frac{(1.00\text{ m})(8.00\text{ N})}{2} = \boxed{-12.0\text{ J}}$$

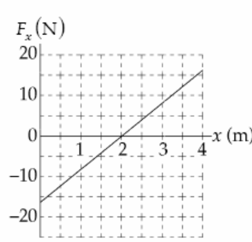

FIG. P6.10

P6.11 $W = \int F_x dx$

and W equals the area under the Force-Displacement curve

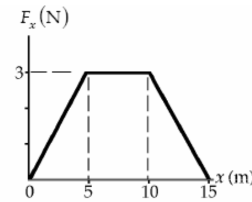

FIG. P6.11

(a) For the region $0 \le x \le 5.00$ m,

$$W = \frac{(3.00 \text{ N})(5.00 \text{ m})}{2} = \boxed{7.50 \text{ J}}$$

(b) For the region $5.00 \le x \le 10.0$,

$$W = (3.00 \text{ N})(5.00 \text{ m}) = \boxed{15.0 \text{ J}}$$

(c) For the region $10.0 \le x \le 15.0$,

$$W = \frac{(3.00 \text{ N})(5.00 \text{ m})}{2} = \boxed{7.50 \text{ J}}$$

(d) For the region $0 \le x \le 15.0$

$$W = (7.50 + 7.50 + 15.0) \text{ J} = \boxed{30.0 \text{ J}}$$

P6.12 Compare an initial picture of the rolling car with a final picture with both springs compressed $K_i + \sum W = K_f$. Work by both springs changes the car's kinetic energy

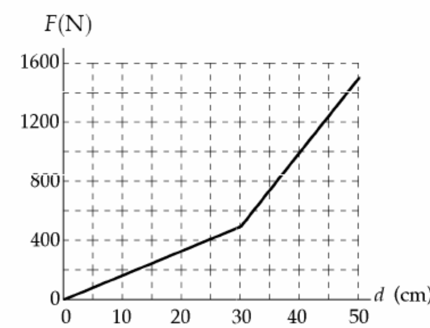

FIG. P6.12

$$K_i + \frac{1}{2}k_1\left(x_{1i}^2 - x_{1f}^2\right) + \frac{1}{2}k_2\left(x_{2i}^2 - x_{2f}^2\right) = K_f$$

$$\frac{1}{2}mv_i^2 + 0 - \frac{1}{2}(1600 \text{ N/m})(0.500 \text{ m})^2$$

$$+0 - \frac{1}{2}(3400 \text{ N/m})(0.200 \text{ m})^2 = 0$$

$$\frac{1}{2}(6\,000 \text{ kg})v_i^2 - 200 \text{ J} - 68.0 \text{ J} = 0$$

$$v_i = \sqrt{\frac{2(268 \text{ J})}{6\,000 \text{ kg}}} = \boxed{0.299 \text{ m/s}}$$

P6.14 $$W = \int_i^f \vec{\mathbf{F}} \cdot d\vec{\mathbf{r}} = \int_0^{5 \text{ m}} \left(4x\hat{\mathbf{i}} + 3y\hat{\mathbf{j}}\right) \text{N} \cdot dx\hat{\mathbf{i}}$$

$$\int_0^{5 \text{ m}} (4 \text{ N/m})x dx + 0 = (4 \text{ N/m})\frac{x^2}{2}\bigg|_0^{5 \text{ m}} = \boxed{50.0 \text{ J}}$$

P6.19 (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.

$$\sum F_x = ma_x$$
$$F - mg\cos\theta = 0$$
$$F = \boxed{mg\cos\theta}$$

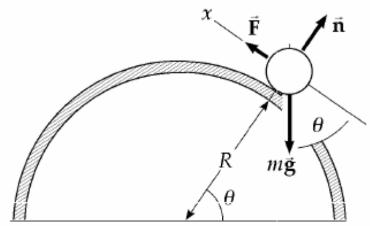

FIG. P6.19

(b) $W = \int_i^f \vec{\mathbf{F}} \cdot d\vec{\mathbf{r}}$

We use radian measure to express the next bit of displacement as $dr = Rd\theta$ in terms of the next bit of angle moved through:

$$W = \int_0^{\pi/2} mg\cos\theta R\,d\theta = mgR\sin\theta\Big|_0^{\pi/2}$$
$$W = mgR(1-0) = \boxed{mgR}$$

P6.21 (a) $K_A = \frac{1}{2}(0.600\text{ kg})(2.00\text{ m/s})^2 = \boxed{1.20\text{ J}}$

(b) $\frac{1}{2}mv_B^2 = K_B$: $\quad v_B = \sqrt{\frac{2K_B}{m}} = \sqrt{\frac{(2)(7.50)}{0.600}} = \boxed{5.00\text{ m/s}}$

(c) $\sum W = \Delta K = K_B - K_A = \frac{1}{2}m\left(v_B^2 - v_A^2\right) = 7.50\text{ J} - 1.20\text{ J} = \boxed{6.30\text{ J}}$

P6.23 $\vec{\mathbf{v}}_i = \left(6.00\hat{\mathbf{i}} - 2.00\hat{\mathbf{j}}\right)\text{ m/s}$

(a) $v_i = \sqrt{v_{ix}^2 + v_{iy}^2} = \sqrt{40.0}\text{ m/s}$

$$K_i = \frac{1}{2}mv_i^2 = \frac{1}{2}(3.00\text{ kg})\left(40.0\text{ m}^2/\text{s}^2\right) = \boxed{60.0\text{ J}}$$

(b) $\vec{\mathbf{v}}_f = 8.00\hat{\mathbf{i}} + 4.00\hat{\mathbf{j}}$

$$v_f^2 = \vec{\mathbf{v}}_f \cdot \vec{\mathbf{v}}_f = 64.0 + 16.0 = 80.0\text{ m}^2/\text{s}^2$$

$$\Delta K = K_f - K_i = \frac{1}{2}m\left(v_f^2 - v_i^2\right) = \frac{3.00}{2}(80.0) - 60.0 = \boxed{60.0\text{ J}}$$

P6.25 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 $\quad (mg)(h+d)\cos 0° + \left(\overline{F}\right)(d)\cos 180° = 0 - 0$.

Thus, $\quad \overline{F} = \frac{(mg)(h+d)}{d} = \frac{(2\,100\text{ kg})\left(9.80\text{ m/s}^2\right)(5.12\text{ m})}{0.120\text{ m}} = \boxed{8.78\times10^5\text{ N}}$. The force on the pile driver is $\boxed{\text{upward}}$.

P6.27 $\sum W = \Delta K = 0:$

$$\int_0^L mg\sin 35.0°\ dl - \int_0^d kx\,dx = 0$$

$$mg\sin 35.0°(L) = \frac{1}{2}kd^2$$

$$d = \sqrt{\frac{2mg\sin 35.0°(L)}{k}}$$

$$d = \sqrt{\frac{2(12.0\text{ kg})(9.80\text{ m/s}^2)(\sin 35.0°)(3.00\text{ m})}{3.00\times 10^4\text{ N/m}}} = \boxed{0.116\text{ m}}$$

P6.31 (a) $W_g = mg\ell\cos(90.0° + \theta)$

$$W_g = (10.0\text{ kg})(9.80\text{ m/s}^2)(5.00\text{ m})\cos 110° = \boxed{-168\text{ J}}$$

(b) $f_k = \mu_k n = \mu_k mg\cos\theta$

$$\Delta E_{\text{int}} = \ell f_k = \ell\mu_k mg\cos\theta$$

$$\Delta E_{\text{int}} = (5.00\text{ m})(0.400)(10.0)(9.80)\cos 20.0° = \boxed{184\text{ J}}$$

(c) $W_F = F\ell = (100)(5.00) = \boxed{500\text{ J}}$

(d) $\Delta K = \sum W_{\text{other}} - \Delta E_{\text{int}} = W_F + W_g - \Delta E_{\text{int}} = \boxed{148\text{ J}}$

(e) $\Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$$v_f = \sqrt{\frac{2(\Delta K)}{m} + v_i^2} = \sqrt{\frac{2(148)}{10.0} + (1.50)^2} = \boxed{5.65\text{ m/s}}$$

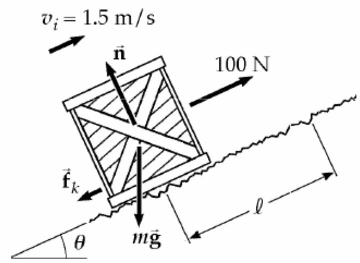

FIG. P6.31

P6.33 $v_i = 2.00 \text{ m/s}$ $\mu_k = 0.100$

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

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

P6.36 (a) $\sum W = \Delta K$, but $\Delta K = 0$ because he moves at constant speed. The skier rises a vertical distance of $(60.0 \text{ m})\sin 30.0° = 30.0 \text{ m}$. Thus,

$$W_{\text{in}} = -W_g = (70.0 \text{ kg})(9.8 \text{ m/s}^2)(30.0 \text{ m}) = \boxed{2.06 \times 10^4 \text{ J}} = \boxed{20.6 \text{ kJ}}.$$

(b) The time to travel 60.0 m at a constant speed of 2.00 m/s is 30.0 s. Thus,

$$\mathcal{P}_{\text{input}} = \frac{W}{\Delta t} = \frac{2.06 \times 10^4 \text{ J}}{30.0 \text{ s}} = \boxed{686 \text{ W}} = 0.919 \text{ hp}.$$

***P6.37** *energy = power × time*

For the 28.0 W bulb:

$$\text{Energy used} = (28.0 \text{ W})(1.00 \times 10^4 \text{ h}) = 280 \text{ kilowatt} \cdot \text{hrs}$$

$$\text{total cost} = \$17.00 + (280 \text{ kWh})(\$0.080/\text{kWh}) = \$39.4$$

For the 100 W bulb:

$$\text{Energy used} = (100 \text{ W})(1.00 \times 10^4 \text{ h}) = 1.00 \times 10^3 \text{ kilowatt} \cdot \text{hrs}$$

$$\text{\# bulb used} = \frac{1.00 \times 10^4 \text{ h}}{750 \text{ h/bulb}} = 13.3$$

$$\text{total cost} = 13.3(\$0.420) + (1.00 \times 10^3 \text{ kWh})(\$0.080/\text{kWh}) = \$85.6$$

Savings with energy-efficient bulb $= \$85.60 - \$39.40 = \boxed{\$46.2}$