17 When the load of mass $M = 4.00$ kg is hanging on the spring in equilibrium, the upward force exerted by the spring on the load is equal in magnitude to the downward force that the Earth exerts on the load, given by $w = Mg$. Then we can write Hooke's law as $Mg = +kx$. The spring constant, force constant, stiffness constant, or Hooke's-law constant of the spring is given by

$$k = \frac{F}{y} = \frac{Mg}{y} = \frac{(4.00\text{ kg})(9.80\text{ m/s}^2)}{2.50\times10^{-2}\text{ m}} = 1.57\times10^3\text{ N/m}$$

(a) For the 1.50-kg mass,

$$y = \frac{mg}{k} = \frac{(1.50\text{ kg})(9.80\text{ m/s}^2)}{1.57\times10^3\text{ N/m}} = 0.009\ 38\text{ m} = \boxed{0.938\text{ cm}}$$

(b) $\text{Work} = \frac{1}{2}ky^2 = \frac{1}{2}\left(1.57\times10^3\text{ N/m}\right)\left(4.00\times10^{-2}\text{ m}\right)^2 = \boxed{1.25\text{ J}}$

18 In $F = -kx$, F refers to the size of the force that the spring exerts on each end. It pulls down on the doorframe in part (a) in just as real a sense as it pulls on the second person in part (b).

(a) Consider the upward force exerted by the bottom end of the spring, which undergoes a downward displacement that we count as negative:

$$k = -F/x = -(7.50\text{ kg})(9.80\text{ m/s}^2)/(-0.415\text{ m} + 0.350\text{ m})$$
$$= -73.5\text{ N}/(-0.065\text{ m}) = \boxed{1.13\text{ kN/m}}$$

(b) Consider the end of the spring on the right, which exerts a force to the left:

$$x = -F/k = -(-190\text{ N})/(1130\text{ N/m}) = 0.168\text{ m}$$

The length of the spring is then

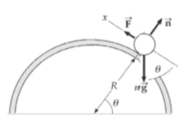
$$0.350\text{ m} + 0.168\text{ m} = \boxed{0.518\text{ m} = 51.8\text{ cm}}$$

.19 (a) Spring constant is given by $F = kx$:

$$k = \frac{F}{x} = \frac{230\text{ N}}{0.400\text{ m}} = \boxed{575\text{ N/m}}$$

(b) $\text{Work} = F_{\text{avg}}x = \left(\frac{230\text{ N} - 0}{2}\right)(0.400\text{ m}) = \boxed{46.0\text{ J}}$

25 (a) The radius to the object makes angle θ with the horizontal. Taking the x axis in the direction of motion tangent to the cylinder, the object's weight makes an angle θ with the $-x$ axis. Then,



ANS. FIG. P7.25

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

(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:

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

28 (a) We find the work done by the gas on the bullet by integrating the function given:

$$W = \int_i^f \vec{\mathbf{F}}\cdot d\vec{\mathbf{r}}$$
$$W = \int_0^{0.600\text{ m}} \left(15\,000\text{ N} + 10\,000x\text{ N/m} - 25\,000x^2\text{ N/m}^2\right)dx\cos0°$$
$$W = 15\,000x + \frac{10\,000x^2}{2} - \frac{25\,000x^3}{3}\Bigg|_0^{0.600\text{ m}}$$
$$W = 9.00\text{ kJ} + 1.80\text{ kJ} - 1.80\text{ kJ} = \boxed{9.00\text{ kJ}}$$

(b) Similarly,

$$W = (15.0\text{ kN})(1.00\text{ m}) + \frac{(10.0\text{ kN/m})(1.00\text{ m})^2}{2} - \frac{\left(25.0\text{ kN/m}^2\right)(1.00\text{ m})^3}{3}$$
$$W = 11.67\text{ kJ} = \boxed{11.7\text{ kJ}}$$

(c) $\frac{11.7\text{ kJ} - 9.00\text{ kJ}}{9.00\text{ kJ}}\times100\% = 29.6\%$

$\boxed{\text{The work is greater by 29.6\%.}}$

.31 $\vec{\mathbf{v}}_i = \left(6.00\hat{\mathbf{i}} - 1.00\hat{\mathbf{j}}\right)\text{ m/s}^2$

(a) $v_i = \sqrt{v_{ix}^2 + v_{iy}^2} = \sqrt{37.0}\text{ m/s}$

$$K_i = \frac{1}{2}mv_i^2 = \frac{1}{2}(3.00\text{ kg})\left(37.0\text{ m}^2/\text{s}^2\right) = \boxed{55.5\text{ J}}$$

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

$$v_f^2 = \vec{\mathbf{v}}_f\cdot\vec{\mathbf{v}}_f = 64.0 + 16.0 = 80.0\text{ m}^2/\text{s}^2$$
$$\Delta K = K_f - K_i = \frac{1}{2}m\left(v_f^2 - v_i^2\right) = \frac{3.00}{2}(80.0) - 55.5 = \boxed{64.5\text{ J}}$$

35 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 $h = 0.12$ 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 $(mg)(h+d)\cos0° + \left(\bar{F}\right)(d)\cos180° = 0 - 0$

Thus,

$$\bar{F} = \frac{(mg)(h+d)}{d} = \frac{(2\,100\text{ kg})\left(9.80\text{ m/s}^2\right)(5.12\text{ m})}{0.120\text{ m}}$$
$$= \boxed{8.78\times10^5\text{ N}}$$

The force on the pile driver is $\boxed{\text{upward.}}$

38 (a) As the bullet moves the hero's hand, work is done on the bullet to decrease its kinetic energy. The average force is opposite to the displacement of the bullet:

$$W_{\text{net}} = F_{\text{avg}}\Delta x\cos\theta = -F_{\text{avg}}\Delta x = \Delta K$$
$$F_{\text{avg}} = \frac{\Delta K}{-\Delta x} = \frac{0 - \frac{1}{2}\left(7.80\times10^{-3}\text{ kg}\right)(575\text{ m/s})^2}{-0.055\ 0\text{ m}}$$

$\boxed{F_{\text{avg}} = 2.34\times10^4\text{ N, opposite to the direction of motion}}$

(b) If the average force is constant, the bullet will have a constant acceleration and its average velocity while stopping is $\bar{v} = (v_f + v_i)/2$. The time required to stop is then

$$\Delta t = \frac{\Delta x}{\bar{v}} = \frac{2(\Delta x)}{v_f + v_i} = \frac{2(5.50\times10^{-2}\text{m})}{0 + 575\text{ m/s}} = \boxed{1.91\times10^{-4}\text{s}}$$