6.33. **IDENTIFY:** Apply Eq.(6.6) to the box.

**SET UP:** Let point 1 be just before the box reaches the end of the spring and let point 2 be where the spring has maximum compression and the box has momentarily come to rest.

**EXECUTE:**

\[ W_{\text{tot}} = K_2 - K_1 \]

\[ K_1 = \frac{1}{2} m v_i^2, \quad K_2 = 0 \]

Work is done by the spring force. \( W_{\text{tot}} = -\frac{1}{2} k x_2^2 \), where \( x_2 \) is the amount the spring is compressed.

\[-\frac{1}{2} k x_2^2 = -\frac{1}{2} m v_i^2 \quad \text{and} \quad x_2 = v_i \sqrt{\frac{m}{k}} = (3.0 \text{ m/s}) \sqrt{(6.0 \text{ kg})/(7500 \text{ N/m})} = 8.5 \text{ cm} \]

**EVALUATE:** The compression of the spring increases when either \( v_i \) or \( m \) increases and decreases when \( k \) increases (stiffer spring).

6.41. **IDENTIFY and SET UP:** Apply Eq.(6.6) to the glider. Work is done by the spring and by gravity. Take point 1 to be where the glider is released. In part (a) point 2 is where the glider has traveled 1.80 m and \( K_2 = 0 \). There are two points shown in Figure 6.41a. In part (b) point 2 is where the glider has traveled 0.80 m.

**EXECUTE:**

\( W_{\text{tot}} = K_2 - K_1 = 0 \).

Solve for \( x_i \), the amount the spring is initially compressed.

\[ W_{\text{tot}} = W_{\text{spr}} + W_w = 0 \]

\[ W_{\text{spr}} = -W_w \]

(The spring does positive work on the glider since the spring force is directed up the incline, the same as the direction of the displacement.)

The directions of the displacement and of the gravity force are shown in Figure 6.41b.

\[ W_{\text{spr}} = (v \cos \phi) \frac{s}{s} = (mg \cos 130.0^\circ) s \]

\[ W_w = (0.0900 \text{ kg})(9.80 \text{ m/s}^2)(\cos 130.0^\circ)(1.80 \text{ m}) = -1.020 \text{ J} \]

(The component of \( W \) parallel to the incline is directed down the incline, opposite to the displacement, so gravity does negative work.)

\[ W_{\text{spr}} = -W_w = +1.020 \text{ J} \]

\[ W_{\text{spr}} = \frac{1}{2} k x_i^2 \] \( \text{so} \) \( x_i = \sqrt{\frac{2W_{\text{spr}}}{k}} = \sqrt{\frac{2(1.020 \text{ J})}{640 \text{ N/m}}} = 0.0565 \text{ m} \)

(b) The spring was compressed only 0.0565 m so at this point in the motion the glider is no longer in contact with the spring. Points 1 and 2 are shown in Figure 6.41c.

\[ W_{\text{tot}} = K_2 - K_1 \]

\[ K_2 = K_1 + W_{\text{tot}} \]

\[ K_1 = 0 \]
\[ W_{tot} = W_{spr} + W_u \]

From part (a), \( W_{spr} = 1.020 \text{ J} \) and
\[ W_u = (mg \cos 130.0°) \Delta s = (0.0900 \text{ kg})(9.80 \text{ m/s}^2)(\cos 130.0°)(0.80 \text{ m}) = -0.454 \text{ J} \]

Then \( K_2 = W_{spr} + W_u = 1.020 \text{ J} - 0.454 \text{ J} = 0.57 \text{ J} \).

**EVALUATE:** The kinetic energy in part (b) is positive, as it must be. In part (a), \( x_1 = 0 \) since the spring force is no longer applied past this point. In computing the work done by gravity we use the full 0.80 m the glider moves.

### 6.44.

**IDENTIFY:** Energy is power times time.

**Set up:** 1 W = 1 J/s, 1 yr = \( 3.16 \times 10^7 \) s.

**Execute:**
(a) \[
\frac{(1.0 \times 10^{19} \text{ J/yr})}{(3.16 \times 10^7 \text{ s/yr})} = 3.2 \times 10^11 \text{ W.}
\]
(b) \[
\frac{3.2 \times 10^{11} \text{ W}}{3.0 \times 10^7 \text{ folks}} = 1.1 \text{ kW/person.}
\]
(c) \[
A = \frac{3.2 \times 10^{11} \text{ W}}{0.40 \times 10^7 \text{ W/m}^2} = 8.0 \times 10^4 \text{ m}^2 = 800 \text{ km}^2.
\]

**EVALUATE:** The area in part (c) corresponds to a square about 28 km on a side, which is about 18 miles. The space required is not an impediment.

### 6.50.

**IDENTIFY** and **Set up:** Use Eq. (6.15) to relate the power provided and the amount of work done against gravity in 16.0 s. The work done against gravity depends on the total weight which depends on the number of passengers.

**Execute:**
Find the total mass that can be lifted:
\[
P_{av} = \frac{\Delta W}{\Delta t} = mgh, \quad \text{so} \quad m = \frac{P_{av} t}{gh}
\]
\[
P_{av} = (40 \text{ hp}) \left( \frac{746 \text{ W}}{1 \text{ hp}} \right) = 2.984 \times 10^4 \text{ W}
\]
\[
m = \frac{P_{av} t}{gh} = \frac{(2.984 \times 10^4 \text{ W})(16.0 \text{ s})}{(9.80 \text{ m/s}^2)(20.0 \text{ m})} = 2.436 \times 10^3 \text{ kg}
\]
This is the total mass of elevator plus passengers. The mass of the passengers is \( 2.436 \times 10^3 \text{ kg} - 600 \text{ kg} = 1.836 \times 10^3 \text{ kg} \).

The number of passengers is \( \frac{1.836 \times 10^3 \text{ kg}}{65.0 \text{ kg}} = 28.2 \). 28 passengers can ride.

**EVALUATE:** Typical elevator capacities are about half this, in order to have a margin of safety.

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**Potential Energy and Energy Conservation**

### 7.3.

**Identify:** Use the free-body diagram for the bag and Newton’s first law to find the force the worker applies. Since the bag starts and ends at rest, \( K_1 - K_i = 0 \) and \( W_{tot} = 0 \).

**Set up:** A sketch showing the initial and final positions of the bag is given in Figure 7.3a. \( \sin \phi = \frac{2.0 \text{ m}}{3.5 \text{ m}} \) and \( \phi = 34.85° \). The free-body diagram is given in Figure 7.3b. \( \vec{F} \) is the horizontal force applied by the worker. In the calculation of \( U_{grav} \), take +y upward and \( y = 0 \) at the initial position of the bag.
EXECUTE: (a) $\sum F_y = 0$ gives $T \cos \phi = mg$ and $\sum F_x = 0$ gives $F = T \sin \phi$. Combining these equations to eliminate $T$ gives $F = mg \tan \phi = (120 \text{ kg})(9.80 \text{ m/s}^2) \tan 38.45^\circ = 820 \text{ N}$.

(b) (i) The tension in the rope is radial and the displacement is tangential so there is no component of $T$ in the direction of the displacement during the motion and the tension in the rope does no work. (ii) $W_{\text{tot}} = 0$ so $W_{\text{worker}} = -W_{\text{grav}} = U_{\text{grav},2} - U_{\text{grav},1} = mg(y_2 - y_1) = (120 \text{ kg})(9.80 \text{ m/s}^2)(0.6277 \text{ m}) = 740 \text{ J}$.

EVALUATE: The force applied by the worker varies during the motion of the bag and it would be difficult to calculate $W_{\text{worker}}$ directly.

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7.5. **IDENTIFY** and **SET UP**: Use energy methods.

(a) $K_1 + U_1 + W_{\text{other}} = K_2 + U_2$. Solve for $K_2$ and then use $K_2 = \frac{1}{2}mv_2^2$ to obtain $v_2$.

EXECUTE: $\frac{1}{2}mv_1^2 + mgv_1 = \frac{1}{2}mv_2^2$

$$v_2 = \sqrt{v_1^2 + 2gy_1} = \sqrt{(12.0 \text{ m/s})^2 + 2(9.80 \text{ m/s}^2)(22.0 \text{ m})} = 24.0 \text{ m/s}$$

EVALUATE: The projection angle of $53.1^\circ$ doesn’t enter into the calculation. The kinetic energy depends only on the magnitude of the velocity; it is independent of the direction of the velocity.

(b) Nothing changes in the calculation. The expression derived in part (a) for $v_2$ is independent of the angle, so $v_2 = 24.0 \text{ m/s}$, the same as in part (a).

(c) The ball travels a shorter distance in part (b), so in that case air resistance will have less effect.

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7.12. **IDENTIFY**: Only gravity does work, so apply Eq.(7.5).

**SET UP**: $v_i = 0$, so $\frac{1}{2}mv_2^2 = mg(y_1 - y_2)$.

**EXECUTE**: Tarzan is lower than his original height by a distance $y_1 - y_2 = l(\cos 30^\circ - \cos 45^\circ)$ so his speed is $v = \sqrt{2gl(\cos 30^\circ - \cos 45^\circ)} = 7.9 \text{ m/s}$, a bit quick for conversation.

**EVALUATE**: The result is independent of Tarzan’s mass.