Chapter 8

2. We use Eq. 7-12 for W_g and Eq. 8-9 for U.

(a) The displacement between the initial point and A is horizontal, so ϕ = 90.0° and $W_g = 0$ (since cos 90.0° = 0).

(b) The displacement between the initial point and B has a vertical component of $h/2$ downward (same direction as $\vec{F}_g$), so we obtain

$$W_g = \vec{F}_g \cdot \vec{d} = \frac{1}{2}mgh = \frac{1}{2}(825\text{ kg})(9.80\text{ m/s}^2)(42.0\text{ m}) = 1.70\times10^5\text{ J}.$$

(c) The displacement between the initial point and C has a vertical component of h downward (same direction as $\vec{F}_g$), so we obtain

$$W_g = \vec{F}_g \cdot \vec{d} = mgh = (825\text{ kg})(9.80\text{ m/s}^2)(42.0\text{ m}) = 3.40\times10^5\text{ J}.$$

(d) With the reference position at C, we obtain

$$U_B = \frac{1}{2}mgh = \frac{1}{2}(825\text{ kg})(9.80\text{ m/s}^2)(42.0\text{ m}) = 1.70\times10^5\text{ J}.$$

(e) Similarly, we find

$$U_A = mgh = (825\text{ kg})(9.80\text{ m/s}^2)(42.0\text{ m}) = 3.40\times10^5\text{ J}.$$

(f) All the answers are proportional to the mass of the object. If the mass is doubled, all answers are doubled.

22. From Chapter 4, we know the height h of the skier's jump can be found from $v_y^2 = 0 = v_{0y}^2 - 2gh$ where $v_{0y} = v_0 \sin 28°$ is the upward component of the skier's "launch velocity." To find v_0 we use energy conservation.

(a) The skier starts at rest y = 20 m above the point of "launch" so energy conservation leads to

$$mgy = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2gy} = 20\text{ m/s}$$

which becomes the initial speed v_0 for the launch. Hence, the above equation relating h to v_0 yields

$$h = \frac{(v_0 \sin 28°)^2}{2g} = 4.4 \text{ m} .$$

(b) We see that all reference to mass cancels from the above computations, so a new value for the mass will yield the same result as before.

23. (a) As the string reaches its lowest point, its original potential energy $U = mgL$ (measured relative to the lowest point) is converted into kinetic energy. Thus,

$$mgL = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2gL} .$$

With L = 1.20 m we obtain $v = \sqrt{2gL} = \sqrt{2(9.80 \text{ m/s}^2)(1.20 \text{ m})} = 4.85 \text{ m/s}$.

(b) In this case, the total mechanical energy is shared between kinetic $\frac{1}{2}mv_b^2$ and potential mgy_b. We note that $y_b = 2r$ where $r = L - d = 0.450$ m. Energy conservation leads to

$$mgL = \frac{1}{2}mv_b^2 + mgy_b$$

which yields $v_b = \sqrt{2gL - 2g(2r)} = 2.42 \text{ m/s}$.

27. (a) To find out whether or not the vine breaks, it is sufficient to examine it at the moment Tarzan swings through the lowest point, which is when the vine — if it didn't break — would have the greatest tension. Choosing upward positive, Newton's second law leads to

$$T - mg = m\frac{v^2}{r}$$

where r = 18.0 m and $m = W/g = 688/9.8 = 70.2$ kg. We find the v^2 from energy conservation (where the reference position for the potential energy is at the lowest point).

$$mgh = \frac{1}{2}mv^2 \quad \Rightarrow \quad v^2 = 2gh$$

where h = 3.20 m. Combining these results, we have

$$T = mg + m\frac{2gh}{r} = mg\left(1 + \frac{2h}{r}\right)$$

which yields 933 N. Thus, the vine does not break.

(b) Rounding to an appropriate number of significant figures, we see the maximum tension is roughly 9.3×10^2 N.

49. **THINK** As the bear slides down the tree, its gravitational potential energy is converted into both kinetic energy and thermal energy.

EXPRESS We take the initial gravitational potential energy to be $U_i = mgL$, where L is the length of the tree, and final gravitational potential energy at the bottom to be $U_f = 0$. To solve this problem, we note that the changes in the mechanical and thermal energies must sum to zero.

ANALYZE (a) Substituting the values given, the change in gravitational potential energy is

$$\Delta U = U_f - U_i = -mgL = -(25\,\text{kg})(9.8\,\text{m/s}^2)(12\ \text{m}) = -2.9\times10^3\ \text{J}.$$

(b) The final speed is $v_f = 5.6\,\text{m/s}$. Therefore, the kinetic energy is

$$K_f = \frac{1}{2}mv_f^2 = \frac{1}{2}(25\ \text{kg})(5.6\ \text{m/s})^2 = 3.9\times10^2\ \text{J}.$$

(c) The change in thermal energy is $\Delta E_{\text{th}} = fL$, where f is the magnitude of the average frictional force; therefore, from $\Delta E_{\text{th}} + \Delta K + \Delta U = 0$, we find f to be

$$f = -\frac{\Delta K + \Delta U}{L} = -\frac{3.9\times10^2\ \text{J} - 2.9\times10^3\ \text{J}}{12\ \text{m}} = 2.1\times10^2\ \text{N}.$$

LEARN In this problem, no external work is done to the bear. Therefore,

$$W = \Delta E_{\text{th}} + \Delta E_{\text{mech}} = \Delta E_{\text{th}} + \Delta K + \Delta U = 0,$$

which implies $\Delta K = -\Delta U - \Delta E_{\text{th}} = -\Delta U - fL$. Thus, $\Delta E_{\text{th}} = fL$ can be interpreted as the additional change (decrease) in kinetic energy due to frictional force.

$$\frac{1}{2}ky_i^2 = mgy_{\max} \quad\Rightarrow\quad y_{\max} = \frac{ky_i^2}{2mg} = \frac{(620\ \text{N/m})(0.250\ \text{m})^2}{2(50\ \text{N})} = 0.388\ \text{m}.$$