HW 4 Help

28. ORGANIZE AND PLAN The ball ends up below its starting point, so with our usual definition of a positive
y-direction pointing upwards, the displacement Δy of the ball is negative in this case.
Known: $m = 2.50$ kg; $\Delta y = -58.4$ m.

SOLVE We compute the work done by gravity using Equation 5.5:

$$W_g = -mg\Delta y = -(2.50 \text{ kg})(9.80 \text{ m/s}^2)(-58.4 \text{ m}) = 1.43 \text{ kJ}$$

30. ORGANIZE AND PLAN This is work done by a constant force in one-dimensional motion, so Equation 5.4 will apply.
Known: $F = 125$ N; $\theta = 50°$; $\Delta x = 2.5$ m.

SOLVE We compute the work done on the object by the force F from Equation 5.4:

$$W = (F\cos\theta)\Delta x = (125 \text{ N})(\cos 50°)(2.5 \text{ m}) = 201 \text{ J}$$

REFLECT There must also be at least one other force acting on the object, otherwise the force F would accelerate the object in the $+y$-direction.

37. ORGANIZE AND PLAN The rocket accelerates upward because the engine force is larger than gravity. We expect the work done by the engine force to be larger than the work done by gravity. All work in this problem can be calculated as the product of a force times the displacement.
Known: $m = 1.85$ kg; $F_e = 46.2$ N; $\Delta y = 100$ m.

SOLVE We repeatedly use Equation 5.1 to calculate work done by the different forces.
(a) The work done by the engine force is:

$$W_e = F_e\Delta y = (46.2 \text{ N})(100 \text{ m}) = 4.62 \text{ kJ}$$

(b) The work done by gravitational force $F_g = -mg$ is:

$$W_g = -mg\Delta y = -(1.86 \text{ kg})(9.80 \text{ m/s}^2)(100 \text{ m}) = -1.82 \text{ kJ}$$

(c) The net force is $F_{net} = F_e + F_g = F_e - mg,$ which we can use to calculate the net work with $W_{net} = F_{net}\Delta y.$ Or an easier solution is to simply add up the work by the engine and gravitational forces to obtain the net work:

$$W_{net} = W_e + W_g = (4.62 \text{ kJ}) + (-1.82 \text{ kJ}) = 2.80 \text{ kJ}$$

REFLECT What has the work by the engine force accomplished? It has increased the potential energy of the rocket (by 1.82 kJ) and it has increased the kinetic energy (by 2.80 kJ). Kinetic energy is discussed in Section 5.3 and potential energy in Section 5.4.

44. ORGANIZE AND PLAN Hooke's law (Equation 5.7) says that the spring constant is the ratio of the force applied to the spring and the displacement of the spring's end.

Known: $F = 1.2$ pN; $x = 26$ μm.

SOLVE Calculate the spring constant as the ratio of force and displacement:

$$k = \frac{F}{x} = \frac{(1.2 \text{ pN})}{(26 \text{ μm})} = \frac{(1.2 \times 10^{-12} \text{ N})}{(26 \times 10^{-6} \text{ m})} = 4.6 \times 10^{-8} \text{ N/m}$$

REFLECT Compared to everyday objects, this is an extremely soft spring!

46. ORGANIZE AND PLAN Equation 5.8 gives the work done stretching (or compressing) a spring.

Known: $k = 25.5$ N/m; $x = 0.450$ m.

SOLVE Insert our known values in Equation 5.8:

$$W = \frac{kx^2}{2} = \frac{(25.5 \text{ N/m})(0.450 \text{ m})^2}{2} = 2.58 \text{ J}$$

REFLECT This is a fairly soft spring.

58. ORGANIZE AND PLAN The quantities in this problem are related through Equation 5.10:

$$K = \tfrac{1}{2}mv^2$$

Known: $m = 4.65 \times 10^{-26}$ kg; $K = 6.07 \times 10^{-21}$ J.

SOLVE Rewrite Equation 5.10 to express speed as a function of kinetic energy and mass, and calculate:

$$v = \sqrt{\frac{2K}{m}} = \sqrt{\frac{2(6.07 \times 10^{-21} \text{ J})}{(4.65 \times 10^{-26} \text{ kg})}} = 511 \text{ m/s}$$

REFLECT Compare this to the speed of sound in air, which is about 340 m/s.

62. ORGANIZE AND PLAN The kinetic energy is one half times mass times velocity squared. The velocity is easily calculated from the circumference and period of the Moon's orbit.

Known: $m = 7.36 \times 10^{22}$ kg; $r = 3.84 \times 10^8$ m; $t = 27.3$ days.

SOLVE The velocity of the Moon is its orbit's circumference divided by its period:

$$v = \frac{2\pi r}{t} = \frac{2\pi(3.84 \times 10^8 \text{ m})}{(27.3 \text{ days})} = 1.02 \text{ km/s}$$

The kinetic energy of the Moon is then calculated from Equation 5.10:

$$K = \tfrac{1}{2}mv^2 = \tfrac{1}{2}(7.36 \times 10^{22} \text{ kg})(1.02 \text{ km/s})^2 = 3.85 \times 10^{28} \text{ J}$$

REFLECT How does this compare to the Earth's kinetic energy in its orbit around the Sun?

74. **ORGANIZE AND PLAN** The stored energy equals the work you do on the spring.
Known: $k = 650$ N/m; $W = 450$ J.

SOLVE Rewrite Equation 5.8 to express compression in terms of work done on the spring:

$$W = \tfrac{1}{2}kx^2$$

$$x = \sqrt{\frac{2W}{k}} = \sqrt{\frac{2(450\ \text{J})}{(650\ \text{N/m})}} = 1.18\ \text{m}$$

REFLECT For springs, the stored energy is proportional to the compression squared.

80. **ORGANIZE AND PLAN** If we subtract the potential energy from the total mechanical energy we have the kinetic energy. We can calculate the mass from the kinetic energy and the speed.
Known: $v = 29.2$ m/s; $E = 563$ J; $\text{U} = 175$ J.

SOLVE Calculate the kinetic energy by rewriting Equation 5.18:

$$K = E - U = (563\ \text{J}) - (175\ \text{J}) = 388\ \text{J}$$

Calculate the mass by rewriting Equation 5.10:

$$m = \frac{2K}{v^2} = \frac{2(388\ \text{J})}{(29.2\ \text{m/s})} = 0.91\ \text{kg}$$

REFLECT Potential energy is relative to a certain zero point, i.e., a certain choice of origin of the coordinate system. Since the total mechanical energy is a sum of potential and kinetic energy, the precise value of the total mechanical energy also depend on the choice of origin of origin of the coordinate system.

89. **ORGANIZE AND PLAN** Initially the rubber ball has gravitational potential energy relative to the ground, but no kinetic energy. When the ball is dropped, the potential energy is converted to kinetic energy, keeping the total mechanical energy of the system constant. Just before the ball hits the ground, all of the initial potential energy has been converted to kinetic energy. In the bounce, 25% of the energy is lost (to heat) and the ball rebounds upward with kinetic energy equal to 75% of the initial total mechanical energy. Kinetic energy is converted into gravitational potential energy as the ball travels upward, and when the ball has reached its maximum height, all the kinetic energy the ball had after the bounce has been converted into potential energy.

Known: $h_{\text{before}} = 2.4\text{ m}$; $E_{\text{after}}/E_{\text{before}} = 0.75$.

SOLVE (a) The total mechanical energy before the bounce is the initial gravitational potential energy of the ball:

$$E_{\text{before}} = \Delta U_{\text{before}} = mgh_{\text{before}}$$

When the ball hits the ground, the kinetic energy equals the total mechanical energy. From the kinetic energy we can calculate the speed:

$$v = \sqrt{\frac{2K_{\text{before}}}{m}} = \sqrt{\frac{2E_{\text{before}}}{m}} = \sqrt{\frac{2mgh}{m}} = \sqrt{2gh} = \sqrt{2\left(9.80\text{ m/s}^2\right)\left(2.4\text{ m}\right)} = 6.9\text{ m/s}$$

(b) After the bounce, when the ball reaches its maximum height, the total mechanical energy again equals the gravitational potential energy of the ball:

$$E_{\text{after}} = \Delta U_{\text{after}} = mgh_{\text{after}}$$

Since we know the ratio of the total mechanical energy before and after the bounce, we can calculate the maximum height of the ball after the bounce:

$$h_{\text{after}} = \frac{E_{\text{after}}}{mg} = \frac{0.75E_{\text{before}}}{mg} = 0.75h_{\text{before}} = 0.75\left(2.4\text{ m}\right) = 1.8\text{ m}$$

REFLECT We did not need to know the mass of the ball to calculate either answer.