Q33. A spring gun is loaded with a rubber dart; the gun is cocked, and then fired at a target on the ceiling. Describe the energy transformations that take place in this process.

Q34. Suppose that a mass is hanging vertically at the end of a spring. The mass is pulled downward and released to set it into oscillation. Is the potential energy of the system increased or decreased when the mass is lowered? Explain.

Q35. A sled is given a push at the top of a hill. Is it possible for the sled to cross a hump in the hill that is higher than its starting point under these circumstances? Explain.

Q36. Can work done by a frictional force ever increase the total mechanical energy of a system? (Hint: Consider the acceleration of an automobile.) Explain.

Q37. Suppose that a pulley system is used to lift a heavy crate, but the pulleys have rusted and there are frictional forces acting on the pulleys. Will the useful work output of this system be greater than, equal to, or less than the work input? Explain.

exercises

E1. A horizontally directed force of 30 N is used to pull a box a distance of 2.5 m across a tabletop. How much work is done by the 30-N force?

E2. A woman does 160 J of work to move a table 4 m across the floor. What is the magnitude of the force that the woman applied to the table if this force is applied in the horizontal direction?

E3. A force of 60 N is used to push a chair across a room does 300 J of work. How far does the chair move in this process?

E4. A rope applies a horizontal force of 190 N to pull a crate a distance of 2 m across the floor. A frictional force of 50 N opposes this motion.
   a. What is the work done by the rope?
   b. What is the work done by the frictional force?
   c. What is the total work done on the crate?

E5. A force of 50 N is used to drag a crate 4 m across a floor. The force is directed at an angle upward from the crate so that the vertical component of the force is 30 N and the horizontal component is 40 N as shown in the diagram.
   a. What is the work done by the horizontal component of the force?
   b. What is the work done by the vertical component of the force?
   c. What is the total work done by the 50-N force?

E6. A net force of 60 N accelerates a 4-kg mass over a distance of 10 m.
   a. What is the work done by this net force?
   b. What is the increase in kinetic energy of the mass?

E7. A 0.4-kg ball has a velocity of 25 m/s.
   a. What is the kinetic energy of the ball?
   b. How much work would be required to stop the ball?

E8. A box with a mass of 5.0 kg is lifted without acceleration) through a height of 2.0 m, in order to place it upon the shelf of a closet.
   a. What is the increase in potential energy of the box?
   b. How much work was required to lift the box to this position?

E9. A spring with a spring constant \( k \) of 30 N/m is stretched a distance of 20 cm (0.20 m) from its original unstretched position. What is the increase in potential energy of the spring?

E10. To stretch a spring a distance of 0.20 m, 40 J of work is done.
   a. What is the increase in potential energy of the spring?
   b. What is the value of the spring constant \( k \) of the spring?

E11. Which requires more work: lifting a 2-kg rock to a height of 4 m without acceleration, or accelerating the same rock horizontally from rest to a speed of 10 m/s?

E12. At the low point in its swing, a pendulum bob with a mass of 0.2 kg has a velocity of 4 m/s.
   a. What is its kinetic energy at the low point?
   b. Ignoring air resistance, how high will the bob swing above the low point before reversing direction?

E13. A 0.30-kg mass attached to a spring is pulled back horizontally across a table so that the potential energy of the system is increased from zero to 120 J. Ignoring friction, what is the kinetic energy of the system after the mass is released and has moved to a point where the potential energy has decreased to 70 J?

E14. A sled and rider with a combined mass of 50 kg are at the top of a hill a height of 14 m above the level ground below. The sled is given a push providing an initial kinetic energy at the top of the hill of 1700 J.
   a. Choosing a reference level at the bottom of the hill, what is the potential energy of the sled and rider at the top of the hill?
   b. After the push, what is the total mechanical energy of the sled and rider at the top of the hill?
   c. If friction can be ignored, what will be the kinetic energy of the sled and rider at the bottom of the hill?

E15. A roller-coaster car has a potential energy of 450 000 J and a kinetic energy of 120 000 J at point A in its travel. At the low point of the ride, the potential energy is zero, and 50 000 J of work has been done against friction since it left