CHAPTER 6 Review

REFLECTING ON CHAPTER 6

- Work is the transfer of energy from one system to another, or from one form to another. The equation $W = F_{\parallel}\Delta d$ applies to work done by a constant force that is parallel to the direction of the motion.
- When the force is not constant, the work done can be estimated from the area under the curve of a force-versus-position graph.
- When the force is not parallel to the displacement, only the component of the force that is in the direction of the displacement does work: $W = F\Delta d \cos\theta$, where θ is the angle between the direction of the force and displacement vectors.
- Positive work on a system adds energy to the system.
- Negative work on a system removes energy from the system.
- Kinetic energy is the energy of motion.

$$E_k = \frac{1}{2}mv^2$$

- Gravitational potential energy of a system is its energy stored due to its position above a reference level. $E_g = mg\Delta h$, where Δh is the vertical distance between the system and the reference level.
- For an ideal spring, the restoring force is proportional to the amount of extension or compression of the spring. This is expressed as $F = -kx$, where k is the spring constant.
- The amount of elastic potential energy stored in a spring is equal to the area under the force-extension (or compression) graph for the spring. It can be calculated from $E_e = \frac{1}{2}kx^2$.
- Power, measured in watts, is defined as the amount of work done or energy transferred in a specific amount of time.

$$P = W/\Delta t$$

- Efficiency, provided as a percentage, is a comparison ratio between the useful work output of a system compared to the total work input.

$$\text{Efficiency} = \frac{W_o}{W_i} \times 100\%$$

Knowledge/Understanding

1. How would you describe a physicist's concept of work to a non-physicist?
2. Describe a scenario where there is an applied force and motion and yet no work is done.
3. A bat hitting a baseball is difficult to analyze because the applied force is continuously changing throughout the collision. Describe how such a situation may be investigated without the use of calculus.
4. Describe the two general types of energy into which all forms of energy can be classified.
5. How much more kinetic energy would a baseball have if
   (a) its speed was doubled?
   (b) its mass was doubled?
6. Differentiate between potential energy and gravitational potential energy.

Inquiry

7. Design an experiment to test the following hypothesis: *The work required to pull a smooth wood block a distance of 1.0 m along a smooth 45° slope is three quarters of the work required to lift the block vertically a distance of 1.0 m.*
   (a) List the equipment and materials you will need to test this hypothesis.
   (b) Develop a procedure that lists all the steps you will follow in your investigation.
   (c) What independent variables are you changing? What dependent variables will you be measuring? What variables are you controlling?
   (d) Suggest some sample observations that might confirm the hypothesis.
   (e) Suggest some sample observations that might refute the hypothesis.

(f) Carry out the investigation. Record and analyze your observations, and form a conclusion. Include the percentage deviation of your result from the predicted one.

8. Imagine taking a spring of 10 coils and cutting it in half. Will each smaller spring have a smaller, larger, or the same spring constant as the larger spring? (Hint: Consider the force required to compress the large and small springs by the same amount.)

9. Two young children are racing up a hill. Matt decides to run directly up the hill while Jen decides to zigzag to the top, exactly tripling her total distance as compared to Matt. They both reach the top of the hill at the same time.
   (a) Who did the most work?
   (b) Who was required to exert the most force?
   (c) Who developed the most power?

Communication

10. Draw a force-versus-displacement plot that represents a constant force of 60 N exerted on a Frisbee™ over a distance of 80.0 cm. Show the work done on the Frisbee™ by shading the graph.

11. Make a list of Olympic sports that involve exerting a force over a distance. For example, running involves pushing with a force over a distance. Your foot pushes backwards on the track through a distance as you move forward.

12. Choose *one* of the sports from #11. Analyze the way a force is applied through a distance. Suggest a possible improvement so that less work (either less force or less distance) is needed to produce the same velocity or distance.

Making Connections

13. When stretched or compressed, a spring stores potential energy. Make a list of other common devices that store potential energy when temporarily deformed.

14. Research and write a brief report about how chemists use the concept of ideal springs to model the action of the bonds holding atoms together in molecules.

Problems for Understanding

15. A car travels at a constant velocity of 27.0 m/s for 1.00×10^2 m.
   (a) Name all of the forces that act on the car.
   (b) Which, if any, of these forces are doing work on the car? How much work are these forces doing?

16. In order to start her computer, a student pushes in the button to turn on the monitor. This action requires her to do 0.20 J of work. Find the average force that must be applied if she pushes the button a total distance of 0.450 cm.

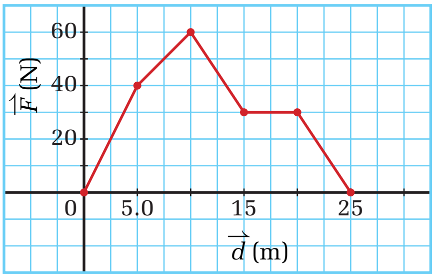
17. A young girl pushes her toy box at a constant velocity with a force of 50.0 N. Calculate the work done by the girl if she moves the box 7.00 m.

18. A horse pulls a wagon that was initially at rest. The horse exerts a horizontal force of 525 N, moving the wagon 18.3 m. The applied force then changes to 345 N and acts for an additional distance of 13.8 m. Calculate the total work done by the horse on the wagon during the trip.

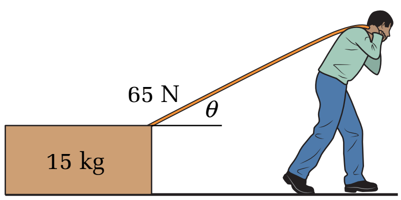
19. A man drags a small boat 6.00 m across the dock with a rope attached to the boat. Find the amount of work done if the man exerts a 112.0 N force on the rope at an angle of 23° with the horizontal.

20. A 65.0 kg rock is moved 12.0 m across a frozen lake. If it is accelerated at a constant rate of 0.561 m/s^2 and the force of friction is ignored, calculate the work done.

21. The following force-versus-position graph shows the horizontal force on a cart as it moves along a frictionless track. If the cart has a mass of 1.25 kg, find the kinetic energy and velocity of the cart at the following positions: 5.0 m, 15.0 m, and 25.0 m.



22. The diagram provided shows a man pulling a box across the floor. Assume that the force of friction can be ignored and that the acceleration of the box is 1.27 m/s^2. Find the angle to the horizontal that the man must pull.



23. A 55 kg running back travelling at 6.3 m/s moves toward a 95 kg linebacker running at 4.2 m/s. Which athlete has more kinetic energy?

24. A 68 kg in-line skater starts from rest and accelerates at 0.21 m/s^2 for 15 s. Find her final velocity and total kinetic energy after the 15 s of travel.

25. A girl climbs a long flight of stairs. She travels a horizontal distance of 30.0 m and a vertical distance of 14.0 m. If her change in gravitational potential energy relative to the ground is 6800 J, find the mass of the girl.

26. A 0.80 kg block of wood has an initial velocity of 0.25 m/s as it begins to slide across a table. The block comes to rest over a distance of 0.72 m.
    - **(a)** What is the average frictional force on the block?
    - **(b)** How much work is done on the block by friction?
    - **(c)** How much work is done on the table by the block?

27. A 1.5 kg book falls 1.12 m from a table to the floor.
    - **(a)** How much work did the gravitational force do on it?
    - **(b)** How much gravitational potential energy did it lose?

28. A 175 kg cart is pushed along level ground for 18 m, with a force of 425 N, and then released.
    - **(a)** How much work did the applied force do on the cart?
    - **(b)** If a frictional force of 53 N was acting on the cart while it was being pushed, how much work did the frictional force do on the cart?
    - **(c)** Determine how fast the cart was travelling when it was released.
    - **(d)** Determine how far the cart will travel after it is released.

29. A man is pushing a 75 kg crate at constant velocity a distance of 12 m across a warehouse. He is pushing with a force of 225 N at an angle of 15° down from the horizontal. The coefficient of friction between the crate and the floor is 0.24. How much work does the man do on the crate?

30. If 25 N are required to compress a spring 5.5 cm, what is the spring constant of the spring?

31. **(a)** What is the change in elastic potential energy of a spring that has a spring constant of 120 N/m if it is compressed by 8.0 cm?
    - **(b)** What force is required to compress the spring by 8.0 cm?

32. A dart gun has a spring with a constant of 74 N/m. An 18 g dart is loaded into the gun, compressing the spring from a resting length of 10.0 cm to a compressed length of 3.5 cm. If the spring transfers 75% of its energy to the dart after the gun is fired, how fast is the dart travelling when it leaves the gun?

33. A spring with a constant of 555 N/m is attached horizontally to a wall at floor level. A 1.50 kg wooden block is pushed against it, compressing the spring by 12 cm, and then released. How fast will the block be travelling at the instant it leaves the spring? (Assume that friction can be ignored and that the mass of the spring is so small that its kinetic energy can be ignored.)

34. A 35 kg child is jumping on a pogo stick. If the spring has a spring constant of 4945 N/m and it is compressed 25 cm, how high will the child bounce? (Assume that the mass of the pogo stick is negligible.)

35. A spring with a spring constant of 450 N/m hangs vertically. You attach a 2.2 kg block to it and allow the mass to fall. What is the maximum distance the block will fall before it begins moving upward?

36. Calculate the power developed by a runner able to do 7.0×10^2 J of work in 2.0 s.

37. Calculate the amount of energy required to operate each of the following devices for 30 min.
   (a) 150 W light bulb
   (b) 900 W hair dryer
   (c) 2000 W portable heater
   (d) 2.5×10^6 W electric motor

38. A 12 kg sled is pulled by a 15 N force at an angle of 35° to the horizontal along a frictionless surface.
   (a) Sketch the situation.
   (b) Calculate the acceleration of the sled.
   (c) Calculate the distance travelled by the sled in 3.0 s if it started from rest.
   (d) Calculate the work done on the sled in 3.0 s.
   (e) Calculate the power generated in pulling the sled.

39. A farmer is contemplating using a small water fall on his property for hydroelectric power generation. He collects data, and finds that 3000 kg of water fall 15.0 m every minute. Assuming the highest possible efficiency that he is able to achieve in transforming the water's gravitational potential energy to electric energy is 74%, what continuous power in Watts could he generate?