EXERCISES

Conceptual Questions

1. After pushing against a brick wall for a long time, you are feeling extremely tired, but you have not done any work on the wall. Explain.
2. Using the law of conservation of energy, explain what is going on in the motion of a simple pendulum.
3. You now can appreciate that the energy required to make your morning coffee has taken part in many transformations along its "lifetime." Create a list of at least three energy transformations that the energy has undergone, in the appropriate order.
4. Give three examples in which a force is exerted but no work is done.
5. A tennis ball and a squash ball are dropped from the same height, but the tennis ball returns to a higher height than the squash ball after the first bounce. What is happening with the kinetic energy in each case to explain the difference? Which ball has the most efficient bounce?
6. By what factor does the kinetic energy of an object change if its speed is doubled?
7. Describe the energy changes that take place when a small spring-driven toy vehicle is wound up and then released.
8. A billiard player transfers energy to the cue ball to set it in motion. In terms of energy, describe what happens when the ball bounces straight back off the side cushion.
9. A baseball and a car can have the same kinetic energy. If this is true, what must be different about them? In this situation, how would the motion of each object compare?
10. Although energy is conserved in the sense that none of it really disappears, why should we be concerned about conserving energy in our daily lives?
11. Many Canadians "count calories" or joules of energy that they consume while on a diet. The human body is only about 25% efficient in converting stored energy from body fat to actual mechanical energy, such as the gravitational potential energy ($mg\Delta h$) required to lift weights during a workout. Where does the other 75% of the stored energy go?

Problems

7.2 Work, the Transfer of Energy

12. A toddler pushes a chair at a constant speed with a force of 25.0 N for a distance of 2.5 m. How much work is the child doing on the chair?
13. A businesswoman is applying a force of 12.0 N [upwards] to carry her briefcase for a horizontal distance of 200.0 m. How much work is she doing on the briefcase?
14. Some physicists with nothing better to do measured the force that teachers were applying to a rope during a staff-student tug of war. The force that was applied by the teachers was 6000 N. How much work did they do on the other team during the two minutes in which they did not move at all?
15. 4050 J of work was done on a pile of snow to move it 3.4 m. What force must have been applied by the snow plow to do this work?
16. How far is an arrow drawn horizontally in a bow if 1020 J of work was done on it by an average applied force of 2525 N?

17. The toddler in Problem 12 still applies the same 25.0 N force to the chair over a distance of 2.5 m, but this time the chair is being pushed across a smooth floor against a force of friction (resistance of 10.0 N). How much work is being done now?

18. A father is pulling his two girls in their toboggan with a force of 500 N for a distance of 22 m. Calculate the work that would be done by the father in each of the following cases.
    a) The snow provides no friction.
    b) One of the children drags her hands in the snow, producing a frictional force of 500 N.
    c) What visible difference would you see in the motion between a) and b)?

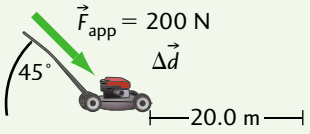
19. How much work is done on a 750 kg load of bricks by a bricklayer if he carried the bricks upward to a height of 8.2 m to repair a chimney?

20. If the bricklayer in Problem 19 decided to use a motor-driven rope lift that can do 2000 J of work, what mass of bricks could be lifted to the 8.2 m height?

21. A woman pushes a shopping cart with a force of 75 N at a constant speed of 0.75 m/s for an hour around a grocery store. How much work does she do on the cart?

22. The school caretaker is applying a 200 N force 45° to the horizontal to push a lawn mower a horizontal distance of 20.0 m, as shown in Fig. 7.24. How much work does he do on the lawn mower, assuming no friction?

Fig. 7.24



7.3 Power, the Rate of Energy Transfer

23. If a hair dryer does 3000 J of work to heat the air every two seconds, what is its power?

24. How much electrical energy is used by a 100 W light bulb if it was accidentally left on for 8.0 h?

25. A snow blower does 1.8×10^6 J of work in 0.600 h. What is its power?

26. How long would it take a 1.00 kW electric motor on a conveyor belt to do 750 J of work?

27. A 613.0 kg mass is placed on a forklift that can generate 950 W of power. What is the constant speed of the forklift while lifting this load?

28. Water is pumped up to a water tower, which is 92.0 m high. The flow rate up to the top of the tower is 75 L/s and each litre of water has a mass of 1.00 kg. What power is required to keep up this flow rate to the tower?

7.4 Kinetic Energy

29. What is the kinetic energy of a 60.0 g tennis ball that is travelling at
    a) 10.0 m/s? b) 25.0 m/s?

30. What is the mass of an object that is travelling at 10.0 m/s with a kinetic energy of 370 J?

31. A 37.0 g arrow is shot from a crossbow at 234.0 km/h. What is the arrow's kinetic energy?

32. A 2000 kg truck is travelling at 80 km/h. What is the kinetic energy of the truck?

33. What speed would the truck in Problem 32 have if its kinetic energy was cut in half by applying the brakes?

34. How much work is done by an Olympic triathlete who accelerates herself on her bicycle (a combined mass of 105 kg) from 5.0 m/s to 10.0 m/s?

35. At what speed must a 250.0 kg motorcycle be travelling to have a kinetic energy of
a) 2.8×10^4 J? b) 1.12×10^5 J?

7.5 Gravitational Potential Energy

36. How much gravitational potential energy would a 275.0 g book have if it was placed on a shelf
a) 2.60 m high? b) 1.80 m high?
c) 0.30 m high?

37. A man decides to climb an office tower using the stairs. If the floors are 3.8 m apart, how much gravitational potential energy would the man have relative to the ground floor if he made it to the
a) fifth floor? b) tenth floor?
c) the first basement level?

38. What percentage of its gravitational potential energy does a squash ball lose if it falls from 3.0 m and returns to a height of 0.76 m after bouncing once?

39. A cliff at the Elora Gorge is 19.6 m above the surface of the Grand River, which is 5.34 m deep. What is a 70.0 kg cliff diver's gravitational potential energy from the top of the cliff with respect to the water's surface and with respect to the bottom of the river?

40. A 1.00 kg book falls 0.75 m from a desk to the floor. How much potential energy did the book lose?

7.7 Conservation of Mechanical Energy

41. A 5.0 kg rock is dropped from a height of 92.0 m. What is the kinetic energy and the gravitational potential energy when the rock is 40.0 m from the ground?

42. A ball of mass 240 g is moving through the air at 20.0 m/s with a gravitational potential energy of 70 J. With what speed will the ball hit the ground?

43. A basketball rolls off the rim and falls to the floor from a height of 3.05 m. Then it bounces up and loses 15% of its kinetic energy. To what height will it rise this time?

44. The Jetscream amusement park ride at Paramount Canada's Wonderland is shown in Fig. 7.25. It starts off by swinging like a simple pendulum until its amplitude becomes so great that it swings completely around. If the diameter of the circle is 30.0 m, what speed must the ship have at the very bottom to just make it to the highest point and sit there with no residual speed?

Fig. 7.25

For image see student text.

7.8 Efficiency of Energy Transfer Processes

45. A water pump is run by an electric motor with a power rating of 750 W. It is used to pump water from a reservoir up to a height of 37.0 m and into a water tower at a rate of 1.48 kg of water per second.
    a) What is the useful energy output, $E_{\text{useful output}}$?
    b) How much energy does the water pump actually use?
    c) What is the efficiency of the water pump?

46. A karate blow can transfer 35.0 J of total energy to kinetic energy. If this transfer is only 25% efficient, what maximum velocity can the 70.0 kg target ever reach?

47. Several students in an auto shop class need to lift an engine out of a car using a rope and pulley system. The mass of the engine is 170.0 kg. By pulling as a team, the students can exert a force of about 1.72×10^3 N to lift the engine to the necessary height of 2.20 m.
    a) How much "useful work" was done by the students?
    b) How much work was done in total to lift the engine?
    c) What was the overall efficiency of the students in lifting the engine?
    d) One of the students recommends that all of her friends who helped lift the engine should receive a final grade equal to their percent efficiency. The shop teacher claims that this would be unfair to the students because none of them could ever achieve 100% efficiency. Explain.