Chapter 7 – Machines, Work and Energy

Section Review 7.1

1. Explain how work is related to energy.

2. Who does more work: a) a person who lifts a 2-kilogram object 0.5 meters or, b) a person or lifts a 3-kilogram object 0.4 meters? (Show your calculation of work done by each person.)

   a.

   b.

3. While sitting in class, your body exerts a force of 600 N on a chair. How much work do you do?

4. Is your power greater when you run or walk up a flight of stairs? Explain your answer.

Section Review 7.2

1. Name two simple machines that are found on a bicycle.

   a. b.

2. Find the mechanical advantage of the crowbar shown in the illustration on page 182.

3. Classify each of these as a first-, second-, or third-class lever:
   a. See-saw
   b. Baseball bat
   c. Door on hinges
   d. Scissors

4. A large gear with 48 teeth is connected to a small gear with 12 teeth. If the large gear turns twice, how many times will the small gear turn?

5. What is the mechanical advantage of a 15 meter ramp that rises 3 meters?

Section Review 7.3

1. Why can the output work of a simple machine never be greater than the input work?

2. Use the concept of work to explain the relationship between input and output forces and lengths.

3. How does the efficiency of a car compare to the efficiency of a bicycle? Why do you think there is such a big difference?

Chapter 7 Review

Understanding Vocabulary

Select the correct term from the bank on page 188, to complete the sentences.

1. The _____ states that the work done by a system equals the change in kinetic energy for that system.

2. _____ is the rate of doing work.

3. The ramp, the lever, and the wheel and axle are examples of _____.

4. To calculate a machine's _____, you divide the output force by the input force.

5. _____ is the ratio of work output to work input and is usually expressed as a percent.

6. A process with less than 100% efficiency is _____.

Reviewing Concepts

Section 7.1

1. Why are work and energy both measured in joules?

2. If you lift a box of books 1 m off the ground, you are doing work. How much more work would you do if you lifted the box 2 m off the ground?

3. Indicate whether work is being done (using the physics definition of work) in the following situations:

   a. picking up a bowling ball off the floor

   b. two people pulling with the same amount of force on each end of a rope

   c. hitting a tennis ball with a tennis racket

   d. pushing hard against a wall for an hour

   e. pushing against a book as it slides across the floor

   f. standing very still with a book balanced on your head.

4. In which direction should you apply a force if you want to do the greatest amount of work?

5. What is the difference between work and power?

6. What is the meaning of the unit of power called a watt?

Section 7.2

7. List five types of simple machines.

    a.

    b.

    c.

    d.

    e.

8. Which two types of simple machines are in a wheelbarrow?

9. A certain level has a mechanical advantage of 2. How does the lever's output force compare to the input force?

10. Can simple machines multiply input forces to get increased output forces? Can they multiply work input to increase the work output?

11. Draw a diagram of each of the three types of levers. Label the input force, the output force, and the fulcrum on each.

12. You and a friend pull on opposite ends of a rope. You each pull with a force of 10 N. What is the tension in the rope?

13. A pulley system has four strands of rope supporting the load. What is its mechanical advantage?

14. A screw is very similar to which other type of simple machine? Explain.

Section 7.3

15. Why can't the output work for a machine be greater than the input work? Explain your answer.

16. Can a simple machine's efficiency ever be greater than 100%? Explain your answer.

17. List two examples of ways to increase efficiency in a machine.

    a.

    b.

Solving Problems

Section 7.1

1. Calculate the amount of work you do in each situation.
    a. You push a refrigerator with a force of 50 N and it moves 3 m across the floor.

    b. You lift a box weighing 25 N to a height of 2 m.

    c. You apply a 500 N force downward on a chair as you sit while eating dinner.

    d. You lift a baby with a mass of 4 kg up 1 m out of her crib.

    e. You climb a mountain that is 1,000 m tall. Your mass is 60 kg.

2. Sal has a weight of 500 N. How many joules of work has Sal done against gravity when he reaches 4 m high on a rock-climbing wall?

3. You do 200 J of work against gravity when lifting your backpack up a flight of stairs that is 4 m tall. What is the weight of your backpack in newtons?

4. A moving object has a mass of 2,000 kg and a speed of 10 m/s. A stopping force of 5,000 N is applied.
    a. What is the object's kinetic energy?

    b. What is the distance it takes to stop?

5. You breathlessly lift a 200-N suitcase packed full of money to a height of 2 m in 10 s.
    a. How much work did you do?

    b. What was your power?

6. One machine can perform 500 J of work in 20 s. Another machine can produce 200 J of work in 5 s. Which machine is more powerful? Explain.

7. Two cranes use rope and pully systems to lift a load from a truck to the top of a building. Crane A has twice as much power as Crane B.
    a. If it takes Crane A 10 s to lift a certain load, how much time does Crane B take to lift the same load?

    b. If Crane B can do 10,000 J of work in one minute, how many joules of work can Crane A do in a minute?

8. An elevator lifts a 500-kg load a distance of 10 m in 8 s.
    a. Calculate the work done by the elevator.

    b. Calculate the elevator's power.

9. A lever has an input force of 5 N and an output force of 15 N. What is the mechanical advantage of the lever?

10. A simple machine has a mechanical advantage of 5. If the output force is 10 N, what is the input force?

11. You use a rope and pulley system with a mechanical advantage of 5. How big an output load can you lift with an input force of 200N?

12. A lever has an input arm 50 cm long and an output arm 20 cm long.
    a. What is the mechanical advantage of the lever?

    b. If the input force is 100 N, what is the output force?

13. You want to use a lever to lift a 2,000 N rock. The maximum force you can exert is 500 N. Draw a lever that will allow you to lift the rock. Label the input force, output force, fulcrum, input arm, and output arm. Specify measurements for the input and output arms. State the mechanical advantage of your lever.

14. A rope and pulley system is used so that a 20-N force can lift a 60-N weight. What is the minimum number of ropes in the system that must support the weight?

15. A rope and pulley system has two ropes supporting the load.
    a. Draw a diagram of the pulley system.

    b. What is the mechanical advantage?

c. What is the relationship between the input force and the output force?

d. How much can you lift with an input force of 20 N?

16. For some strange reason, you decide to push a heavy car weighing 500 N up a ramp. At the top of the ramp, it is 2 m higher than it was initially.
    a. How much work did you do on the car?

    b. If your input force on the car was 200N, how long is the ramp?

17. A lever is used to lift a heavy rock that weighs 1,000 N. When a 50 N force pushes one end of the lever down 1 m, how far does the load rise? (See illustration on page 190.)

18. A system of pulleys is used to lift an elevator that weighs 3,000 N. The pulley system uses three ropes to support the load. How far would 12,000 J of input work lift the elevator? Assume the pulley system is frictionless.

Section 7.3

19. A 60-W light bulb uses 60 J of electrical energy every second. However, only 6-J of electrical energy is converted into light energy each second.
    a. What is the efficiency of the light bulb? Give your answer as a percentage.

    b. What do you think happens to the "lost" energy?

20. The work output is 300 J for a machine that is 50% efficient. What is the work input?

21. A machine is 75% efficient. If 200 J of work are put into the machine, how much work output does it produce?

Test Practice

Section 7.1

1. Work is done in all of the following situations except
   a. A crane lifts a heavy crate
   b. A person carries groceries up a flight of stairs
   c. A person pushes on a car which does not budge
   d. Two people push on a car which moves 1 m.

2. You push on a piano with a force of 50 N and move it 2 meters. How much work have you done?
   a. 2 J b. 25 J c. 50 J d. 100 J

3. Sonya performs 98 J of work against gravity while lifting a 10-kg barbell. How high does she lift the barbell?
   a. 1 m b. 10 m c. 20 m d. 50 m

4. Alex weighs twice as much as Bob. Bob weighs twice as much as Carlos. They each climb a flight of stairs in the same amount of time. Who has more power?
   a. Alex b. Bob c. Carlos d. They all have the same power

Section 7.2

5. Which of the following is *not* a simple machine?
   a. screw b. clock c. ramp d. gears

6. What is the mechanical advantage of the lever shown on page 190?
   a. 1/3 b. 2 c. 3 d. 6

7. The input force on the rope and pulley shown on page 191 is 2 N. What is the output force?
   a. 2 N b. 4 N c. 6 N d. 8 N

8. The mechanical advantage of the ramp shown on page 191 is 10. What is the height?
   a. 2 m b. 5 m c. 10 m d. 20 m

Section 7.3

9. You can increase a machine's efficiency by decreasing the
   a. power b. friction c. gravity d. energy

10. You build a machine which is 80% efficient. How many joules of work are put into the machine to produce 400J of output work?
    a. 50 J b. 320 J c. 400 J d. 500 J

11. An elevator carries a 50 kg person up 10 m. The elevator does 7,000 J of input work. What is the efficiency of the elevator?
    a. 50% b. 70% c. 90% d. 100%