

**Questions**

1. Define work, the joule, and power.
  2. A student takes a 30-kg box from a table which is 1 m high and carries it down a long corridor 20 m in length. The student then places the box on another table which is the same height as the first. How much work was done on the box?
  3. In a factory, motor X lifts a 250-N engine a vertical distance of 20 m while motor Y lifts a 500-N engine a vertical distance of 10 m. Which motor performed the most work?
  4. If both motors in the preceding question were able to lift their loads in the same time how does the power of each motor compare?
  5. Which requires more work—the lifting of a 50-N crate 10 m or the lifting of a 50-kg crate 5 m? Why?
  6. In a factory, a large worker lifts three 500-N crates from the floor to a dock one meter above the floor. The lifting of the three crates takes a total of one minute. Another worker, who is much smaller lifts six 300-N crates from the floor to the same dock in one minute. Which worker is the more powerful?
  7. How many kilojoules (kJ) of work must be done on an electric generator to operate a 100-watt light bulb for one hour?
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14. A person uses a rope to pull a 1000-kg boat 50 m along a wharf. The rope makes an angle of  $45^\circ$  with the horizontal. If a force of 40 N is used to move the boat, how much work is done?
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15. It takes 12 000 J of work to pull a loaded sled weighing 800 N a distance of 200 m. To do this, a force of 120 N is exerted on a rope which makes an angle with the horizontal. At what angle is the rope held?
  16. A cable attached to a small tractor pulls a barge through a canal lock. The tension in the cable is 2500 N. It makes an angle of  $30^\circ$  with the direction in which the barge is moving.
    - a. What force moves the barge along the lock?
    - b. If the lock is 200 m long, how much work is done to get the barge through the lock?

## 10:3 Power

**Power** is the rate of doing work. The concept of power is important in physics in that it allows us to measure the rate at which work is done.

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

Power is measured in watts. A **watt** is one joule per second. A machine that does work at a rate of one joule per second has a power of one watt. Since a joule is a newton-meter, a watt is a newton-meter per second. A watt is a relatively small unit of power. The power needed to lift a glass of water is about one watt. Thus, power is often measured in kilowatts (kW). A kilowatt is 1000 watts.

### EXAMPLE: Power

A machine produces a force of 40 N through a distance of 100 m in 5.0 s. **a.** How much work is done? **b.** What is the power of the machine in watts and in kilowatts?

*Solution:*

$$\begin{aligned}\text{a. } W &= Fs \\ &= (40 \text{ N})(100 \text{ m}) \\ &= 4000 \text{ J}\end{aligned}$$

$$\begin{aligned}\text{b. } P &= \frac{W}{t} \\ &= \frac{4000 \text{ J}}{5.0 \text{ s}} \\ &= 800 \text{ W}\end{aligned}$$

$$\text{or, } P = \frac{800 \text{ W}}{1000 \text{ W/kW}} = 0.80 \text{ kW}$$

### PROBLEMS

18. A box that weighs 1000 N is lifted a distance of 20 m straight up by a rope and pulley system. The work is done in 10 s. What amount of power is used in watts and in kilowatts?
19. A diesel engine lifts a 225-kg hammer of a pile driver 20 m in 5 s.
  - a. How much work is done in lifting the hammer?
  - b. What is the power of the engine in watts and in kilowatts?
20. A hiker carries a 20-kg knapsack up a trail. After 30 minutes, the hiker is 300 m higher than the starting point.
  - a. What is the weight of the knapsack?
  - b. How much work in joules is done on the knapsack?
  - c. If the hiker weighs 600 N, how much total work is done?
  - d. During the 30 min, what is the hiker's average power in watts and in kilowatts?
21. An electric motor lifts a 2000-kg elevator 18 m in 40 s.
  - a. How much work is done?
  - b. What is the power of the motor in watts and in kilowatts?
22. A gardener applies a force of 150 N to push a wheelbarrow 60 m with a constant speed in 20 s.
  - a. How much work is done?
  - b. What is the gardener's power in watts?
23. A loaded elevator weighs  $1.2 \times 10^4$  N. An electric motor hoists the elevator 9.0 m in 15 s.
  - a. How much work is done?
  - b. What is the power in watts and in kilowatts?