12. Can the kinetic energy of an object be negative? Explain your answer.

13. Can the gravitational potential energy associated with an object be negative? Explain your answer.

14. Two identical objects move with speeds of 5.0 m/s and 25.0 m/s. What is the ratio of their kinetic energies?

Conceptual Questions

15. A satellite is in a circular orbit above Earth's surface. Why is the work done on the satellite by the gravitational force zero? What does the work–kinetic energy theorem predict about the satellite's speed?

16. A car traveling at 50.0 km/h skids a distance of 35 m after its brakes lock. Estimate how far it will skid if its brakes lock when its initial speed is 100.0 km/h. What happens to the car's kinetic energy as it comes to rest?

17. Explain why more energy is needed to walk up stairs than to walk horizontally at the same speed.

18. How can the work–kinetic energy theorem explain why the force of sliding friction reduces the kinetic energy of a particle?

Practice Problems

For problems 19–20, see Sample Problem B.

19. What is the kinetic energy of an automobile with a mass of 1250 kg traveling at a speed of 11 m/s?

20. What speed would a fly with a mass of 0.55 g need in order to have the same kinetic energy as the automobile in item 19?

For problems 21–22, see Sample Problem C.

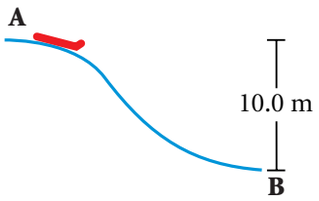
21. A 50.0 kg diver steps off a diving board and drops straight down into the water. The water provides an upward average net force of 1500 N. If the diver comes to rest 5.0 m below the water's surface, what is the total distance between the diving board and the diver's stopping point underwater?

22. In a circus performance, a monkey on a sled is given an initial speed of 4.0 m/s up a 25° incline. The combined mass of the monkey and the sled is 20.0 kg, and the coefficient of kinetic friction between the sled and the incline is 0.20. How far up the incline does the sled move?

For problems 23–25, see Sample Problem D.

23. A 55 kg skier is at the top of a slope, as shown in the illustration below. At the initial point **A,** the skier is 10.0 m vertically above the final point **B.**

- **a.** Set the zero level for gravitational potential energy at **B,** and find the gravitational potential energy associated with the skier at **A** and at **B.** Then find the difference in potential energy between these two points.
- **b.** Repeat this problem with the zero level at point **A.**
- **c.** Repeat this problem with the zero level midway down the slope, at a height of 5.0 m.



24. A 2.00 kg ball is attached to a ceiling by a string. The distance from the ceiling to the center of the ball is 1.00 m, and the height of the room is 3.00 m. What is the gravitational potential energy associated with the ball relative to each of the following?

- **a.** the ceiling
- **b.** the floor
- **c.** a point at the same elevation as the ball

25. A spring has a force constant of 500.0 N/m. Show that the potential energy stored in the spring is as follows:

- **a.** 0.400 J when the spring is stretched 4.00 cm from equilibrium
- **b.** 0.225 J when the spring is compressed 3.00 cm from equilibrium
- **c.** zero when the spring is unstretched

5 REVIEW

12. No, kinetic energy cannot be negative because mass is always positive and the speed term of the equation is squared.

13. yes, because potential energy depends on the distance to an arbitrary zero level, which can be above or below the object

14. 1 to 25

15. The gravitational force does not do work on the satellite because the force of gravity is always perpendicular to the path of the motion. The satellite's speed must be constant.

16. The work required to stop the car equals the car's initial kinetic energy. If speed is doubled, work is quadrupled. Thus, the car will travel 140 m. Its kinetic energy is changed into internal energy.

17. Work must be done against gravity in order to climb a staircase at a constant speed. Walking on a horizontal surface does not require work to be done against gravity.

18. The work done by friction equals the change in mechanical energy, so the particle's speed decreases.

19. 7.6×10^4 J

20. 1.7×10^4 m/s

21. 2.0×10^1 m

22. 1.4 m

23. **a.** 5400 J, 0 J; 5400 J
b. 0 J, –5400 J; 5400 J
c. 2700 J, –2700 J; 5400 J

24. **a.** –19.6 J
b. 39.2 J
c. 0 J

25. **a.** $(0.5)(500.0 \text{ N/m})(4.00 \times 10^{-2} \text{ m})^2 = 0.400$ J
b. $(\frac{1}{2})(500.0 \text{ N/m})(-3.00 \times 10^{-2} \text{ m})^2 = 0.225$ J
c. $(0.5)(500.0 \text{ N/m})(0 \text{ m})^2 = 0$ J